

Power-Grid Balance Testing

using the WaveBook

Energy

Application Note #91

Application Summary

The ubiquitous power grid on the North American continent crisscrosses hundreds of thousands of miles, and yet is hardly noticed, except when bad weather, earthquakes, fires, or other calamities disable it. Few people realize how complex a system it is, and what's needed to keep it balanced. While many utility companies across the country are devoted to keeping the network up and running in spite of all kinds of threats, a few other firms are engaged in making certain new electric power generating and distribution systems are the most reliable and the safest in the world. One way to achieve this goal is to construct accurate computer models that simulate real-world situations and study their responses to a wide variety of perturbations. This effort requires the expertise of numerous engineers and scientists who collect critical data on existing turbine generator installations for system planners.

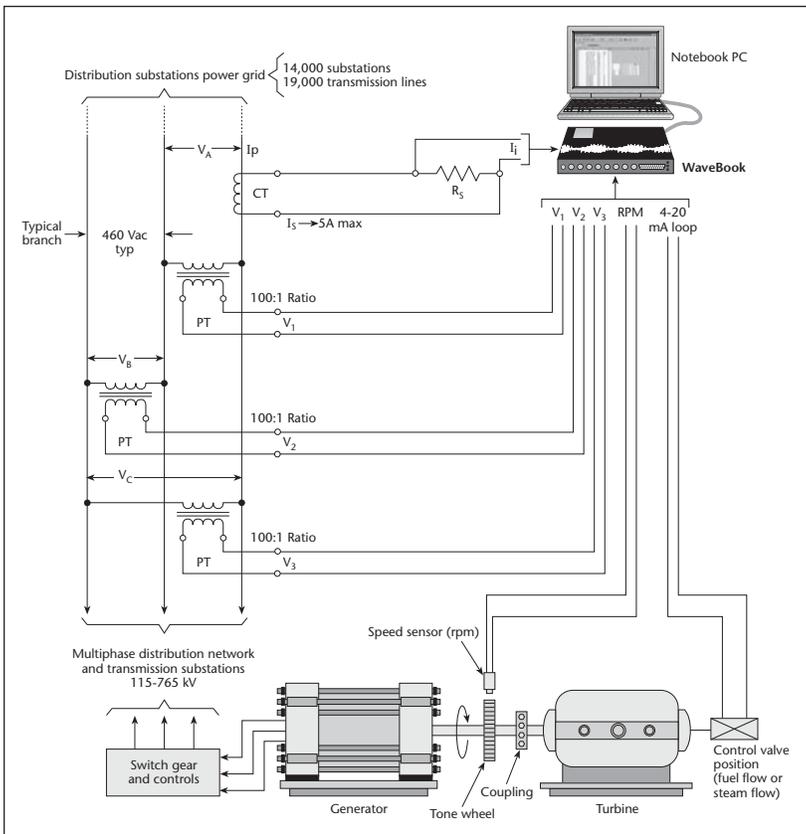
A large power and energy equipment manufacturing and consulting firm in the US, for example, employs such experts to monitor and record exact measurements of voltage, current, and harmonic content of existing and recently deployed systems to ensure that future power generating systems – designed and built by every company – are safe and reliable. One senior engineer in the group routinely travels the globe in search of data to record for characterizing various types of power generators and networks. She depends on special instruments consisting of accurate and portable data acquisition systems and various sensors to satisfy these goals.

Potential Solution

When the consulting team began gathering this data, it had not yet standardized on the test equipment it used to take electrical measurements. The consulting engineers assembled their own personal set of instruments and transported them among the power generation sites as needed. As a result, the reports that the engineers generated from these data were not necessarily uniform and could not be compared from the same type of measurements under similar conditions.

IOtech's Solution

In an attempt to improve on the uniformity of this data, the senior engineer investigated a few widely used, commercial data acquisition systems. As a result, she and her colleagues decided to purchase an IOtech **WaveBook™**. They now are able to measure a wide range of turbine generator output voltages and currents with potential transformers (PTs) and current transformers (CTs), which can be scaled down from any value of voltage or current to the input range required of the **WaveBook**. For example, potential transformers may be connected to more than 460 Vac, with primary-to-secondary ratios providing 5 Vac, full scale to match the signal conditioner's inputs. Regardless of input voltage magnitude a suitable potential transformer can be purchased off the shelf or easily and inexpensively custom made for an application. The same holds true for scaling current transformers, which typically operate at 5A for measuring instruments. Many of these CTs are clamp-on types and can reduce the measured variable to a mA range if needed.



Three IOtech **WaveBooks** are used by the consulting group to measure and record numerous currents and voltages in distributed power generation systems. The data acquisition systems are accurate, small, and portable, making the systems easy and convenient to ship around the world as they are needed at different installations.

In addition to voltage and current, the consulting engineer uses the **WaveBook** to measure turbine speed and control valve position with either a 4 to 20 mA current loop or the dc output of a linear variable differential transformer (LVDT). "The valve controls fuel flow or steam flow and thus turbine speed," she

says, "so its position is critical to synchronize speed, voltage, and current with the turbines' output power at any time. The WaveBook records these variables simultaneously, so perturbations and trends can be compared conveniently at the same point in time."

The software models developed from the data respond to load shedding (load flow) and ground fault (short circuit) simulations. Says the consulting engineer, "The results from such tests can accurately predict the outcome of a real-life situation under these parameters without the danger and expense of conducting an actual, full-scale test that has to redirect MWs of power within fractions of a second." She further explains that load and power factor studies include load-estimating factors to recommend feeder deployment, conductor selection, and capacitor bank ratings. Short-circuit studies help minimize the consequences of a potential short circuit in the system. For example, short-circuit interrupting equipment such as circuit breakers and fuses should have ratings greater than the short-circuit duties as calculated from system studies. Other results that come from the simulation studies include protective device coordination, impact load, transient stability, and motor starting. Yet others are reliability and availability, dynamic stability, harmonic analysis, and surge protection.

Conclusion

A large power and energy equipment manufacturing and consulting firm in the US uses an IOtech WaveBook to measure and record numerous variables in distributed power generation systems. The data that the group collects are used for helping systems analysts construct software simulation programs that can predict the behavior of systems under widely varying conditions and faults. Serious and dangerous events such as ground faults and load shedding can throw systems out of balance, but accurate simulations can predict the consequences without danger to property and human life. These software programs and services are available to all companies around the world that design, build, and maintain power generation systems.

WaveBook Series

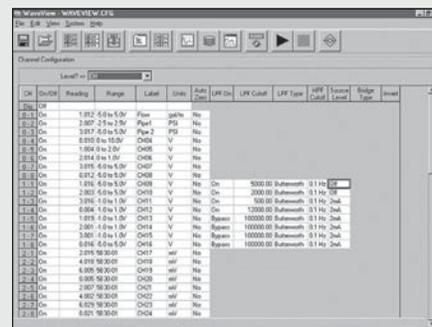
The WaveBook/516E™ digitizer offers multi-channel waveform acquisition and analysis for portable or laboratory applications. The WaveBook includes 8 built-in channels expandable up to 72 channels of voltage, accelerometer, microphone, strain gage, thermocouple, position encoder, frequency, high voltage, 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. You can also add up to 854 thermocouples, without consuming measurement bandwidth of the WaveBooks, using the WBK40™ series, and DBK90 signal conditioning options. The 12-bit WaveBook/512A™ and 16-bit WaveBook/516A™ attach to the WaveBook/516E via their built-in parallel port interface. Other than the interface, the WaveBook/512A and WaveBook/516A are identical to the WaveBook/516E.

Features

- PC connection via Ethernet
- 12-, and 16-bit/1-MHz A/D
- 1 µs/channel scanning of any combination of channels
- Single and multichannel analog triggering with programmable level & slope
- Digital TTL-level and pattern triggering
- Pulse trigger and external clock
- Programmable pre- and post-trigger sampling rates
- Sixteen digital inputs can be scanned synchronously with analog signals
- Operable from AC line, a 10 to 30 VDC source, such as a car battery, or optional compact rechargeable battery module
- Expandable up to 288 high-speed channels
- SYNC connection allows multiple units to sample synchronously
- Add up to 854 lower-speed thermocouple channels
- DSP-based design provides real-time digital calibration on all channels

Signal Conditioning

- ICP® dynamic signal inputs
- Strain gages
- Programmable filtering
- Simultaneous sampling
- Quadrature encoder inputs
- Pulse/frequency measurements
- Thermocouples
- High-voltage measurements
- Vehicle bus network



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

Software

- 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 DASLab®
- ActiveX/COM development tools

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