Solving power blackout problems

By Paul Skoog

There are few products more critical to a complex society than electrical energy. Wide area blackouts caused by uncommonly high usage, natural causes, human design, or operating errors are catastrophic, but could be reduced to a minor inconvenience if proper ways to pacify or calm the system grid were employed. Even before the last large blackout in 2003, power companies have always looked for ways to control the flow of energy efficiently and prevent the cause for blackouts. One such utility is the Bonneville Power Administration (BPA), Portland, OR. In this article Paul explains how a Time Frequency Process CompactPCI module helped BPA deploy a grid stabilization solution.

Introduction

Power grid measurement and analysis play a large role in analyzing system disturbances that can lead to a large scale blackout. Disturbances on a large grid propagate through the system in fractions of a second. Major blackouts occur when a system disturbance is not confined and cascades throughout the power grid. Such events can sometimes be prevented or at the least minimized beginning with precise measurements of the voltages and currents in the grid including both the magnitudes and the phase angles between them. With that data, pacifying the grid requires diagnosing the disturbance and taking countermeasures.

Grid stabilization

One of the better and most promising ways to stabilize the grid is to selectively shed load (or trip generators) and/or selectively switch reactive power compensation devices (capacitor/reactor banks). To do this and operate on a wide area requires:

- An infrastructure able to take measurements that are time-tagged to within microseconds

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- Transmission or latency times from these measurement sources to the control facility must be deterministic and as short as possible
- Suitable reactive power compensation equipment

A demonstration project called the Wide Area stability and voltage Control System, or WACS, for the Bonneville Power Administration (BPA) was designed to prevent or minimize outages and increase power delivery capability.

As one of its key components the WACS system uses a National Instruments (NI) real-time process controller to receive, analyze, and produce the control action. It was selected due to its robustness:

- PXI form factor
- Industry-wide use
- Highly adaptable

Working on WACS, the software development and integration company Ciber, Inc. selected NI's LabVIEW as the development language, as a direct link can exist between code development and the real-time operating system target.

Ciber needed to know the time latency of GPS time stamped data that originates from many measurement sites within a large geographical area. This data is useful in monitoring the power grid and preventing power blackouts. Should anomalous data occur, the system also provides data regarding the fault location.

"These measurements are sampled in such a way as to allow the phase angle between the voltage and current to be monitored both locally and across the region," said Dennis Erickson, Ciber's Senior Control Systems Engineer. "This allows slight changes in power flow, the exact system frequency, and the relative phase angles to be monitored at a central control center (or centers) with extreme accuracy every 2 power cycles (33.3 microseconds). This allows for systems that we are designing to analyze, in real time, system disturbances and prevent them from causing large scale power blackouts." See Figure 1.

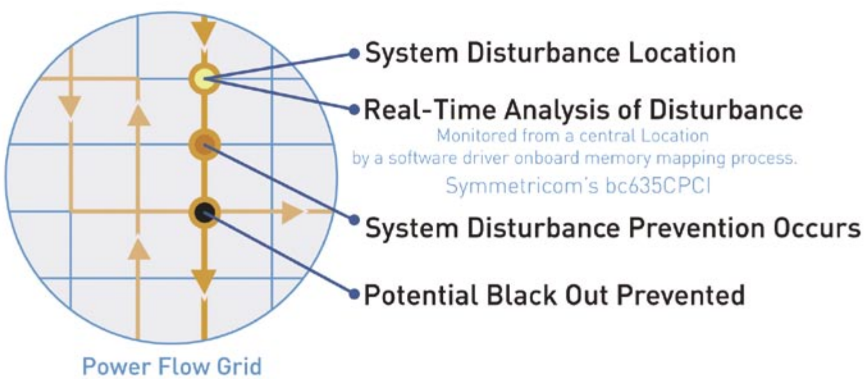

Figure 1

Ciber needed a CompactPCI (PXI) form factor module that could be used in NI's LabVIEW software environment.

"The specific problem was that useful drivers that would operate in the LabVIEW environment were not available," said Erickson. "We then turned to Symmetricom, who assisted us in the software driver process by providing us with important information on the operation of onboard memory mapping." Symmetricom is a leading worldwide supplier of network synchronization and timing solutions and atomic clocks.

WACS performs both system time synchronization and the latency tests with a Symmetricom Time and Frequency Process (TFG) model bc635CPCI module. The NI PXI-8176 control processor uses this CompactPCI module to do the latency testing and the synchronizing of the WACS processor to UTC time. Ciber wrote a driver for it in LabVIEW with assistance from Symmetricom. The Phasor Data Concentrator (PDC)/WACS site has a central GPS receiver available with an IRIG-B output, to which the TFG card is connected.

"The latency test compares the timestamp of the incoming PDC packet, which includes the exact time of measurement for all stations, with the TFG time," said Erickson. "If the difference is beyond a preset limit (established by the predetermined maximum wait time set in the PDC) or if the result is *impossible*, indicating a bad packet, then that packet is rejected. This is a fundamental error checking task of the WACS project that also provides a means to estimate the measurement to circuit breaker action delay. This delay affects control system performance and is used in model studies and in tuning the WACS algorithms."

One of the important reasons the software driver development work succeeded, and can succeed in most cases, is that system developers can configure Symmetricom's time and frequency processor modules within a wide variety of computing environments. The modules make customizing a system with interrupt driven algorithms possible, satisfying most timing requirements.

Paul Skoog *joined Symmetricom in 1997 with diverse experience in the engineering software and GPS markets. As product marketing manager, Paul manages Symmetricom's Bus Level Timing and Enterprise Network Time Server product lines. Prior to joining Symmetricom, he was product manager for precision GPS positioning instruments for Trimble. Previously he held application engineering and product management positions in the dynamic signal analysis software market. Paul holds a BSME degree from California Polytechnic University and an MBA from Santa Clara University Graduate School of Business.*

For further information, contact Paul at:

Symmetricom
3750 Westwind Blvd
Santa Rosa, CA 95403
Tel: 978-927-8220
Fax: 408-428-6960
E-mail: pskoog@symmetricom.com
Website: www.symmttm.com