Montenay Pacific Power Application Story

New vibration monitoring system for power turbines designed with open standard components to reduce costs and ensure life cycle management

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Summary

Product designers and end users can both benefit when a solution uses open standard components, as demonstrated by the design of a system to monitor vibration in power turbines.

The user benefits from having an assured upgrade path and maintenance capabilities that can be independent of arbitrary technology changes and from price increases or policies imposed by a manufacturer who may be indifferent to the market in which the user exists. Future upgrades can be incremental, using installed sensors, rather than requiring large capital investments to replace entire systems.

Use of open standard components enables the product designer to concentrate time and resources on adding the intellectual property that constitutes their chief value added benefit. This means he can also incorporate the latest technology and achieve high speed-to-market, both of which create a competitive advantage over proprietary solutions.

Open standard components

"Open standard" here refers to multi-use, general-purpose hardware and software used in a wide range of applications and generally available from multiple sources. Typical open standard components might include Ethernet networks, commercially available Windows-based software packages, and general-purpose control and data acquisition systems.

Vibration monitoring

Changes in axial and radial displacement of shafts and bearings is the most widely used parameter by which operating and maintenance staff predicts the need for non-routine maintenance on rotating machinery. Examples of this kind of machinery include:

- Steam turbines
- Industrial gas turbines
- Pumps including boiler feed pumps
- Generators / alternators / Exciters
- Plant air compressors
- Fans and Motors
- Electric motors and gearboxes

The challenge: eliminating the choice between safety and downtime

Changes in vibration levels on a power generating steam turbine, for example, may signal the need for an immediate shutdown in order to prevent catastrophic damage to the turbine and potentially to the entire facility. This kind of situation may arise within milli- seconds, necessitating the use of a high speed monitoring system with an automatic tripping mechanism.

However, monitoring at high speeds and automatically tripping a turbine simply based on exceeding a predetermined set point creates its own set of problems. Turbines do experience intermittent signal anomalies from an array of causes none of which have to do with the failure of the turbine itself. Known as nuisance trips, these cause loss of power to grid supplied by the generator. As most power producers are under contract a trip will not only result in loss of income but can also result in penalties—which could exceed the entire cost of a monitoring system.

During the startup of a turbine, it is common for the vibration levels at critical speed (about 50% of normal speed) to far exceed limits seen at normal speed. To compensate for this and to avoid a trip during ramp up, a time delay of several seconds or artificially increasing the set point has been the logic of choice. Some operators simply bypass the entire system during startup. Detuning the controls in this way reduces the nuisance trips but leaves the turbine unprotected during these periods.

The solution: an open standard vibration monitoring system

Vibration monitoring systems used in these applications are classic proprietary systems where hardware, software and installation are provided from a single source. This has lead to the emergence of 'orphan' systems where the sensors remain in place, but no upgrades or even maintenance of the control system is possible.

My company canvassed both large and small power producers to determine their requirements for a vibration monitoring system. Our research indicated that a new system had to meet these basic requirements:

• Provide for life cycle management and ensure an upgrade path to new technologies

• Interface with sensors from legacy systems

• Have easily set trip points that indicate true mechanical failures and eliminate nuisance trips.

• Not require set points to be set at levels to avoid trips while transitioning critical speeds, thereby compromising safety during normal operation.

• Be able to learn the base line values of each sensor and display them so that an operator could see changes before they reached warning levels.

Use of open standards components was determined to be the only way to achieve these objectives. In less than six months from original concept to first installation, we had created the Level 3 Engineering - L3V Vibration Monitoring System, complete with data logging, automatic report generation and statistical analysis. It is able to connect directly to existing vibration sensors.

At the heart of the new system is an RTP 2000 hybrid control system. The RTP 2000, manufactured by RTP Corporation, provides high reliability and has ultra high-speed scan rates with one millisecond time-stamping for first-out alarming. Its true 16-bit A to D conversion ensures high accuracy and it performs noise elimination of >140 dB CMRR Other features that drove choice of the RTP 2000 were its hot swappable, isolated analog I/O cards, and the fact that it is scalable and able to support thousands of inputs and outputs. This allows high speed monitoring of all types of machinery in one system. Redundant controllers are available and it is cost effective for even a single turbine. The RTP 2000 HCS has been used for many years in nuclear and military applications and is priced to compete in the high end PLC market, yet is powerful and reliable enough to replace those large DCS systems typically supplied by companies such as Honeywell, Westinghouse, ABB-Bailey and Rosemount at one third of their price.

For the front end of the system including the operator interface, we chose to use Citect, a Windows-based HMI/SCADA package from Ci Technologies. Citect provided a wide range of functionalities such as flexible display graphics, high resolution trending, alarming, and its own development language called Cicode. The Citect interface enabled us to create trend screens that provide current and historical data at a glance, alarm screens, and a plant overview screen that graphically indicates problems for multiple turbines and any other rotating devices in the plant. Because it is Windows-based development tools are familiar and speeded development of the interface.

Use of open standard components increased the networking and communications options available in the new system. Ethernet was chosen as the networking protocol of choice, but we could have had our choice of Modbus, RS232/485, or OPC. Data can be exported to Microsoft SQL or Oracle Server for integration with CMMS, e-mail, fax and WAP-enabled wireless devices and palm top computers. The L3V system also communicates directly to DCS systems such as ABB-Bailey, Westinghouse and Honeywell.

The Cicode language enabled us to create a software-based solution that provides intricate logic that analyzes the data being monitored. The L3V Vibration Monitoring System has been designed to easily set trip points that indicate true mechanical failures and eliminate nuisance trips. Set points are no longer set at levels to avoid trips while transitioning critical speeds compromising safety at normal conditions. Most important, the L3V automatically learns the base line values of each sensor and displays them so that an operator can see any changes before they reach warning levels.

We deliberately wrote a software solution to give the user the ability to pick combinations of three modes of trip to suit the application:

- Set point (time delay) with different delay times for ramping and running
- Set point multiplier—actually resets set points to a higher multiple during ramping
- Induced learning—a password protected process where the L3V maps vibration levels and speeds at which they occur during startup. When invoked, these values are stored in memory and used to compare vibration levels on subsequent startups. The trip is based on set deviation from learned levels. They can also be manually modified to suit the preferences of the plant engineer.

The use of commercially available building blocks for the system did not entail a compromise in functionality. The L3V monitors all parameters that a vibration monitoring system of twice the cost would track: X-Y radial displacement, differential expansion, dual voting thrust, zero speed, shaft eccentricity, key Phasor, sensor failure, sensor miscalibration, I/O card failure, high temperatures and differential temperatures.

Loss of control on an operating turbine could have catastrophic results. Because of the close marriage between the software and the RTP 2000 Hybrid Control System, all necessary data is downloaded directly into the controller nodes where it is always retained, so that even if the PC were to fail, the turbine is still monitored and will trip in accordance with the logic provided.

Initial L3V installation

The initial installation chosen for this new system was the Southeast Resource Recovery Facility (SERRF), a recycling and solid waste-to-energy plant. The City of Long Beach is the official lessee of the facility. Montenay Pacific Power Corporation functions as the facility's operations contractor. Level 3 Engineering of Irvine, CA. designed and installed the system. It was installed in the May, 2001 and has been operating with no unnecessary trips since startup. Based on this success, two other installations are currently in progress.

Project Profile

Montenay Pacific Power SEFF
Industry: Waste and Refuse
Process: Power Generation (Solid Waste-to-Energy)
System: Power Turbine Vibration Monitoring Systems
Technology: Hybrid Control System

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