What your mining operation needs from a power management system

by Frank Kling, ETAP

Managers understand the correlation between an unpredictable electrical system and its impact on profitability. In a perfect world a reliable and high quality power supply would be available to guarantee successful operation, profitability, safety, and environmental preservation. Often, this is not the case, and electrical systems are subjected to disturbances of various magnitudes and at various locations. These disturbances either cause minor interruption in the production process when they are not managed correctly, or may linger long enough to cause a more severe outage that has a substantial impact on revenue. For example, an electrical fault or any other type of electrical disturbance that disrupts the power supply in a 24/7 ball mill operation can lead to a major loss of revenue in a mining process especially in today’s high priced environment.

According to Dr. Ian Boake, MD of Applied Energy Solutions who distributes and supports ETAP in Southern Africa, if one can calculate the cost of an electrical failure that could have been avoided by anticipation using a real-time simulation and monitoring system and the savings attributable to observing consumption, then these systems more than justify their costs. Monitor training is required, but this additional investment cannot be avoided.

Intelligent monitoring

System monitoring is the base function for any power management software. In addition, seamless integration with metering devices, data acquisition, and archiving systems are essential to monitoring software. Real-time or snapshot data is linked to an online model of the system for proper presentation of actual operating status (Fig. 1). All this information should be accessible to the system operator through advanced man-machine interfaces such as an interactive one-line diagram that provides logical system-wide view (Fig. 2).

The next step is to process the telemetry data and determine the missing or faulty meter values using advance techniques such as state and load estimator (SLE). The system should also be able to compensate for absence of physical meters by providing virtual metering of devices. Graphic watch windows summarise and record alarm conditions in case of unusual activity and provide continuous visual monitoring of user-selected parameters in any mode of operation. This provision would allow early detection and display of problems before a critical failure takes place. Periodic validation of the measuring devices is critical to any power management solution. Online real-time validation of these devices with deviation alarming is part of the technology that differentiates the next generation power management solutions available today.

Online predictive simulation

Taking the intelligent monitoring a step further is the ability to analyse the acquired data. System engineers and operators must have instant access to energy information and analysis tools that allow them to predict an outcome before actions are taken on the system. In order to design, operate, and maintain a power system, one must first understand its behaviour. The operator must have first-hand experience with the system under various operating conditions to effectively react to changes. This will avoid the inadvertent plant outage caused by human error and equipment overload. The cost of an unplanned outage can be staggering.

Fig. 3 shows estimated production loss per outage event for large (50 MW) industrial users.

For industrial and generation facilities that utilise power system analysis applications, the ability to perform system studies and simulate “what if” scenarios using real-time operating data on demand is of the essence. For example, using real-time
data, the system operator could simulate the impact of starting a large motor without actually starting the motor (Fig. 4).

**Sequence of events playback**

The ability to recover from a system disturbance depends on the time it takes to establish the cause of problem and take remedial action. This requires a fast and complete review and analysis of the sequence of events prior to the disturbance. Power management software should assist the operation and engineering staff to quickly identify the cause of operating problems and determine where energy costs can be reduced. The software should also be able to reconstruct exact system conditions to check for operator actions and probe for alternative actions after-the-fact. This important tool serves as an on-going learning process for the operator.

Besides reducing losses and improving data gathering capability, such an application should assist in increasing plant reliability and controlling costs. The event playback feature is especially useful for root cause and effect investigations, improvement of system operations, exploration of alternative actions, and replay of "what if" scenarios. Event playback capability translates into savings. These savings for a typical 50 MW plant are illustrated in Fig. 5. For example, a conservative estimate of 10% reduction in downtime for an outage that lasts an hour yields about $33 000 (R300 000) in savings.

**Online control**

An advanced power management system should provide the options for full remote control to the system elements such as motors, generators, breakers, load tap changers, and other protection devices directly or through existing Supervisory Control and Data Acquisition (SCADA)
In addition, the software should provide user-definable actions that can be added or superimposed on the existing system for automating system control. This is similar to adding PC-based processors/controllers (kV, kW, kvar, PF, etc.) or simple breaker interlocks to any part of the system by means of the software (Fig. 6).

Supervisory and advisory controls
State-of-the-art supervisory and advisory control capabilities should be used to control, and optimize in real-time, various parameters throughout the system. Using optimization algorithms, the user could program the power management system (i.e. assist energy consumers by automatically operating their system to minimize system losses, reduce peak load consumption, or minimise control adjustment). For energy producers, this energy management system could be set up to minimise generation fuel costs, and optimise system operation.

In a recent study performed for a large industrial facility (150 MVA), advanced optimization algorithms, native to the energy management system, were utilized to reduce real and reactive power losses. Assuming a conservative power loss reduction of only 0.1% at an average electrical energy cost of R1.40/kWh, an energy management system would yield savings of more than R1.8-million per year and would pay for itself through the immediate realization of savings in operating and maintenance costs.

Intelligent energy management
An intelligent energy management software control system is designed to reduce energy consumption, improve the utilisation of the system, increase reliability, and predict electrical system performance as well as optimize energy usage to reduce cost. The next generation of mining energy management applications will use real-time data such as frequency, actual generation, tie-line load flows, and plant units’ controller status to provide system changes. There are many objectives of energy management software including an application to maintain the frequency of a power distribution system and to keep tie-line power close to the scheduled values. In intelligent energy management software scheduled values will be maintained by adjusting the MW outputs of the Automatic Generation Control (AGC) generators so as to accommodate fluctuating load demands. The energy management software application will also calculate the required parameters to optimize the operation of the generation units under energy management action, and provide a user interface that allows for interchange scheduling. The operator has the capability to schedule energy transfer from one control area to another while considering wheeling, scheduling ancillary services, and financial tracking of energy transactions.

Dedicated for electricity power exchange and scheduling, interchange scheduling incorporates energy scheduling, transaction management, and energy cost analysis and report creation of energy transactions for each location. This interface allows the user to specify separate contracts for each location and assign multiple non-overlapping schedules to each location (Fig. 9).

Intelligent load shedding (Fig. 10)
A major disturbance in an electrical power system may result in certain areas becoming isolated and experiencing low frequency and voltage, which can...
result in an unstable operation. The power management system should have the intelligence to initiate load shedding based on a user-defined load priority table (LPT) and a pre-constructed stability knowledge base (SKB) in response to electrical or mechanical disturbances in the system. Load shedding schemes by conventional frequency relays are generally a static control with fixed frequency settings. Based on neural networks, a power management system would be able to adapt to all real-time situations and provide a true dynamic load shedding control. This would allow the operator to optimize load preservation, reduce downtime for critical loads, and simulate/test the load shedding recommendations.

Another significant cost component of operations is demand charge of the energy bill. The demand charge can be 40 to 60% of the bill for sites without peak shaving generation. A single unmanaged demand charge can produce a very large hike in the power bill each month and with “ratcheting” demand charges (the Eskom network access (NAC) charge applies to the highest recorded demand above the notified demand for 12 consecutive months), the penalty then has a bearing for a whole year. An intelligent combination of smart applications can provide the current and predicted demand for each day thus managing peak demands on a continuous basis. Loads can be shed intelligently and automatically, peak-shaving generators can be started, load start-up can be postponed or sequenced, or penalty can be paid if certain processes are vital.

Conclusion
A typical power management system evaluates collected data in a non-electrical system environment without recognising the interdependencies of equipment. Extending the power monitoring system by equipping it with an appropriate electrical system context, simulation modules, and playback routines will provide the system operator and engineer with a powerful new set of tools. Using these tools, the user can accurately predict the behaviour of the electrical system in response to a variety of changes. The playback of recorded message logs into the simulator-equipped monitoring system provides the operator with an invaluable means of exploring the effects of alternative actions during historical events.

These simulation techniques will provide a revolutionary training tool to effectively prepare the mining operators of the future. Never before has the industry been able to take an electrical system model from the design environment and readily extend it as an operator training asset.

Finally, all of these capabilities should be included in one application with the flexibility and compatibility that allows one to expand and upgrade the power management system as their needs grow.

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