The Benefits of Intelligent Monitoring in the Modern Central Office and Critical Facliity

Eric Lischak
Verizon
Engineer IV
Maintenance Engineering
TSS-Power
Temple Terrace, FL
eric.lischak@verizon.com

Rahul Baliga
EnerSys
Strategic Accounts Manager
Burnaby, BC V5J 5M4
CANADA
rahul.baliga@alpha.ca

Victor Goncalves
EnerSys
Vice President of Engineering
Burnaby, BC V5J 5M4
CANADA
victor.goncalves@alpha.ca

Kevin Borders
EnerSys
Director of Marketing
Burnaby, BC V5J 5M4
CANADA
kevin.borders@alpha.ca

Abstract - The power components in a Central Office or Critical Facility are designed to overcome a single failure. Power to the load often traverses two separate, but identical paths (A/B). Rectifiers are operated with N+1 or better redundancy, are fed from diverse AC sources and are backed up by parallel strings of batteries that supply power during a short-term AC power outage. Standby generators provide power when the outage lasts more than a few hours. Data centers take a different tack, foregoing the DC approach in favor of large, 3-phase UPS systems backed up by redundant generators. For the most part, these offices are almost always on, except in the worst case manmade or natural disasters.

The various power components– the incoming AC service, power conversion systems, battery backup, generators and distribution networks – form an interdependent ecosystem that ensures reliable and resilient network operation. But for all its success, the power system is still basically reactive. Alarm conditions observed at the office or a Network Operations Center (NOC) result in a technician being dispatched to resolve the failure condition. There is very little predictive analysis or maintenance with these critical power systems. Battery monitoring is sometimes provided, and modern power conversion systems usually include intelligent controllers. But there is little ability to assess the performance of the entire power ecosystem in the office because the components are not connected to each other under a common monitoring and control platform.

While the offices have demonstrated remarkable reliability over the years, often under the harshest of conditions, there are still opportunities for improvement through intelligent monitoring. A properly configured intelligent monitoring system can increase operational efficiencies. It can automate many data collection and analyzation functions historically performed by onsite maintenance personnel. Unnecessary dispatches to verify site conditions can be reduced, improving technician utilization. This becomes even more important as downsizing creates more unmanned offices.

Intelligent monitoring is a force multiplier. During natural or manmade disasters or widespread interruptions of the commercial AC grid, NOC's can quickly become overwhelmed by the massive amount of generated alarms. Having a network of remotely accessible intelligent monitors allows for prioritizing dispatches and re-routing responding personnel in real time should commercial AC power restore to a facility or a new more critical alarm be generated.

In addition to the workforce benefits, sensors and actuators deployed throughout the power network can provide real-time data on voltage, current, power consumption, temperature, and breaker trip alarms. It provides a means for remotely measuring and minimizing system-wide power losses, predicting power usage and anticipating growth, load leveling and optimizing equipment usage and deployment, and reducing and optimizing routine power system maintenance.

While there are many benefits to monitoring the entire power network, there are many hurdles to overcome. Each device has its own method or alarm reporting and control. The communication protocols vary, from Ethernet to CAN to Modbus and others. An intelligent monitoring system must accommodate the variety of devices, interfaces, and communications protocols. And it must present the information with an easy-to-use GUI that addresses the needs of technicians, engineers, and managers.

This paper proposes an intelligent monitoring and control network that can improve the overall power ecosystem performance. It discusses how the user can benefit from the new concept. The paper sets the stage with background information on how current power networks are configured in Central Offices and Critical Facilities, and how the various components report alarms and performance. It also presents the main communications protocols in use today. Finally, it ties all this together with a proposal on the requirements for intelligent monitoring and control for power system networks.

In this era of ubiquitous communications and data analytics, the addition of intelligent monitoring and control to the power network is a long overdue development. The information provided through monitoring can make the robust power ecosystem even more reliable and less expensive to operate.

I. INTRODUCTION

August – September 2004. The State of Florida was struck by Hurricanes Charley, Frances and Jeanne. All three hurricanes not only caused significant infrastructure damage at their points of landfall, but far inland as well. Inland Central Florida was particularly hard hit, as that area was where all three hurricanes intersected the state.

Throughout each of these catastrophic natural disasters, the AC utility power infrastructure was severely damaged. No sooner were repairs made, then another hurricane barreled through and damaged the utility network once again. The telecommunications network emergency power systems were pushed to the very limits of their capabilities. The responding telecommunications personnel were taxed to the brink of human endurance in a pitched battle with Mother Nature using any and all means available to ensure that the Central Offices and Remote Facilities remained powered up so that communications and data services were available for emergency personnel and the civilian populous.

NOC and Dispatch Centers were overwhelmed with power and environmental related alarms. Technicians were being dispatched to locations in alarm as fast as possible, often to find that the alarm had cleared, or conditions had deteriorated far beyond the initially reported alarm condition.

Through it all, a small network of DC Power Plant Controllers accessed over dial up modems, was being utilized at the local level to monitor site conditions in real time, relay battery plant voltages, generator and incoming AC status, facility temperatures and rectifier outputs. All this data was then relayed to technicians in the field and used to re-route technicians if alarms suddenly cleared and the site returned to normal operation or to route additional technicians to a facility if the reported alarms indicated a far more serious condition than the dispatched technician could handle alone. This was all done over dial-up modem and predominately without the use of smartphones or tablets.

Fast forward fifteen years. Advancements in technology paint a very different picture of the scenario above. DC Power Plants and their associated controllers are extremely intelligent and are Ethernet accessible. Technicians are equipped with state-of-the-art smartphones and tablets allowing NOC and Dispatch Centers to provide detailed site alarm and condition information right in the dispatch ticket that can be updated in real time.

SNMP polling can be conducted on every DC Plant Controller continuously to look for alarms or abnormalities, during day-to-day routine operations or during an emergency. Communication protocols such as Ethernet, CAN, Modbus and others allow for the interconnection and communication between numerous pieces of critical infrastructure equipment like no other time in history to present a complete overview of facility conditions and status and in many cases provide some level of remote control or operation.

Yet, despite all the innovation, we still do not have a fully integrated monitoring and control system for the CO power ecosystem. This paper attempts to address this need. First background information on current operations is presented.. This includes a description of the ecosystem elements and how these components report alarms and performance. Second, we mention the main communications protocols in use today. Third, we tie this all together by defining the requirements for intelligent monitoring and control for the key components in power system networks.

II. BACKGROUND

The power ecosystem is a combination of multiple components, from the incoming AC power to power conversion equipment and batteries and backup generators to environmental elements like HVAC. The purpose of each component varies as do performance expectations and reporting mechanisms. While there will be variations based on office type, the power ecosystem generally consists of the following major components:

- Incoming AC electrical
- DC power plant (plus peripheral conversion devices)
- UPS
- Batteries
- Generators
- HVAC System
- Fire Suppression System
- Access & Security Systems

A brief description of each component follows.

Incoming AC Electrical

Utility AC enters a building at the house service panel (HSP). From there, it is distributed via AC breakers. For the power systems, the AC cabling is routed to Power Distributing Service Cabinets (PDSCs) that serve the rectifiers. The incoming AC is protected with Transient Voltage Surge Suppressors (TVSS).

DC Power Plant

The DC power plant consists of two or more rectifiers that are paralleled to provide a single DC output. While some older Ferroresonant rectifiers still exist in a few locations, the modern DC plant utilizes modular, high frequency switchmode rectifiers. In either case, the outputs are delivered to a Primary Distribution Bay for distribution to secondary devices such as Battery Distribution Fuse Bays (BDFDs) or directly to loads for larger devices or when an office is too small to support the BDFB. The modern DC plant may also include DCDC converters or AC Inverters for powering specialty loads. The plant is monitored and controlled by an intelligent system controller.

The intelligent DC plant controller is utilized to gather all DC plant related alarms, assign the correct criticality as determined by the end user and then relay those to a BMS or alarm aggregator for transmission to the respective NOC for analysis and dispatch.

Uninterruptible Power Supply (UPS)
Some offices are designed so that data/IT devices that operate on AC power are segregated from the rest of the DC powered telecom equipment. Often, a separate power system, called a UPS, is used to provide power to these loads.

Batteries
Standby batteries are the first line of defense during an AC power outage. Conventional Vented Lead Acid (VLA) batteries (also known as flooded or wet cell batteries) are still the dominant solution for larger offices. There 2V batteries are arranged in strings of 24, with multiple strings connected in parallel to produce longer battery reserve times.

In smaller offices, Valve Regulated Lead Acid (VRLA) batteries perform the same function, but the prevalent battery size is 12V. Four batteries connected in series provides the 48Vdc backup power, with parallel strings again adding reserve time.

New chemistries have entered the market over the past decade. These new battery types include a variety of Lithium Ion chemistries as well as Sodium Nickel Chloride, among others. These new batteries often include Battery Management Systems (BMS) that provide monitoring, diagnostics and data logging.

The intelligent DC plant controller is utilized to gather all battery plant related alarms, assign the correct criticality as determined by the end, user and then relay those to a BMS or alarm aggregator for transmission to the respective NOC for analysis and dispatch.

Generators
Generators are fuel-operated sources of power. The most common generators have diesel engines, although some use propane or natural gas as the fuel source. In all cases, the generators have the same responsibility – supply power during the AC outage. Permanent standby generators are designed for unattended operation. If a permanent standby generator is not installed at the site, portable generators have to be deployed once the outage has occurred.

AC power from the generator is delivered to the load (in this case, the rectifiers) via a transfer switch, an electrical device that switches from the electric utility power source to the generator. For permanent standby generators, most sites deploy an automatic transfer switch. The ATS is an electrical power unit that has the capability to transfer the site electrical loads from commercial power to the standby generator. The ATS monitors the commercial AC power and initiates the transfer when it fails to meet preset voltage levels.

HVAC/Fire Suppression/Access & Security
These elements are not directly part of the power system, but are essential for ensuring reliable power delivery in an acceptable equipment working environment. Alarms from each component are typically monitored by a BMS in larger facilities, or they are wired out individually to an alarm aggregation device within the office that then transmits the alarm to the respective NOC for analysis and dispatch.

III. MAIN COMMUNICATIONS PROTOCOLS

Utilizing modern intelligent monitoring and communications protocols, it is possible to create an interconnected ecosystem of a facility's critical infrastructure components (AC, generator, HVAC, fire, security, access, DC power, UPS, etc.). One of the key issues is the protocol used to communicate between these devices. Various standardized protocols such as Ethernet, MODBUS, SNMP, etc., could be utilized to interconnect equipment from different manufacturers to be presented through a single display. This paper does not attempt to recommend a protocol, but instead focuses on the need for the comprehensive approach and the requirements for each component.

IV. REQUIREMENTS FOR INTELLIGENT MONITORING AND CONTROL

Each component, or subsystem, has a set of unique requirements to be monitored and/or alarmed. These requirements are detailed below.

Generator & AC electrical
The most basic requirement for the AC sources is to monitor the power levels, in terms of both kW and kVA. An increase in reactive power leads to a lower Power Factor (PF), which in turn reduces efficiency. This applies to the incoming AC, where costs may increase due to poor efficiency, as well as the generator, where lower PF could indicate a need for maintenance, repair or replacement of the generator.

Another consideration is to monitor the output harmonic distortion/waveforms of the generator. Variations over time could indicate issues within the generator, calling for replacement or maintenance.

For the generator, monitoring fuel level, oil pressure, coolant temperature and RPM measurements is necessary to ensure the generator is available when needed.

The starter battery in the generator is another potential failure point. Monitoring the battery with a Battery Management System (BMS) assures the operator of the health of the generator starter battery.

Monitoring AC breakers is another key area. First, remotely monitoring breaker inventory allows the operator to optimize management and allotment of resources. Second, monitoring the temperature of breakers & busbars, voltage drop across breakers, runtime and toggle frequency of breakers helps provide an indicator of the life of the AC components.

DC Rectifier Plant

Because the DC plant is the key subsystem in a DC office, there are a variety of monitoring requirements. To avoid potential load imbalances, the AC input parameters of the DC plant should be monitored.

Inside the power plant, it's important to look at the operating time of rectifiers, along with the amount of DC energy delivered. Other attributes include the runtime operations of fans, temperature measurement of key components, and leakage current on MOVs. Each of these measurements help to estimate the life expectancy of the power supplies.

The DC plant can also be an indicator of facility performance. For example, monitoring ground current imbalances enables the operator to check for leakage current for the entire office. Likewise, measuring the total BTU output of rectifier provides insight into the real time temperature of the facility.

As with the AC subsystems, remotely monitoring the breaker inventory enables better use of technicians and overall allotment of resources. This helps prevent unnecessary dispatches or even those when the wrong breaker/fuse size and type is unknown. Again, as in the case of the AC subsystem, monitoring the temperature of breakers & busbars, voltage drop across breakers, runtime and toggle frequency of breakers help predict the life of the DC distribution ecosystem.

HVAC

Real time temperature monitoring of Central Offices helps the operator detect hot spots. Knowing the problem area, the operator can respond by efficiently deploying cooling units at precisely the right location.

Monitoring the electrical characteristics of the cooling units helps provide insight into the overall power consumption characteristics within a facility. Likewise, monitoring the air and water temperature of the supply and return could indicate efficiency of the system and potential maintenance or replacement schedules. Ultimately, this information is beneficial in understanding the performance of the HVAC equipment, and whether or not upgrades are required for greater cooling capacity or higher efficiency.

Batteries

When power system monitoring is discussed, batteries are often at the top of the list. There are many parameters than can be monitored and evaluated to determine if the batteries are operating properly. Some of these attributes include float current, individual cell temperature, leakage voltage, electrolyte levels and impedance/conductance measurements. The results can point the operator in the right direction regarding the need for potential maintenance or replacement.

V. BENEFITS

The benefits from an overall network monitoring perspective are easily understood. Alarms can be dispatched in a timely manner to the closest available technician to resolve the issue as quickly as possible. But there is also an operational component that can directly impact corporate earnings.

The implementation of a robust intelligent monitoring network within the Central Office or Critical Facility can pay dividends in a short period of time. Many routine maintenance functions that required a technician site visit to collect the required data can now be either automated or the data collected from a remote location, negating the need to roll a truck and technician to the facility specifically for that task. The technician can remotely collect the required data quickly and easily and is then free to perform other tasks at another facility or is then free to devote time to other repairs and maintenance at the monitored facility upon arrival.

Should an alarm occur after hours, the intelligent monitoring system can be remotely accessed to determine the severity of the alarm and potential facility impacts. Decisions can then be made to determine if the reported alarm requires an immediate technician dispatch or if the issue can be deferred to the next day during normal business hours.

HVAC systems can be remotely tuned to optimize cooling thereby reducing utility costs by only having to run those units required to maintain required temperatures within the monitored space.

Planning and Growth Engineers can access the monitored systems and pull real time load data to determine if capacity is available to add new revenue generating equipment or if an augmentation project is required to support the new loads. Alarm thresholds can be programmed to alert Operations and Engineering personnel when a system is nearing capacity and an upgrade or augmentation is required to support additional loads or to maintain required levels of redundancy.

VI. CONCLUSION

For Central Offices and Critical Facilities, the primary goal is to always power the load, regardless of the circumstances.. Whether the power comes from the rectifier plant, a UPS, or batteries, the load must not drop. Today's belt and suspender approach of diversely routed AC inputs, N+1 rectifier deployment, 4- to 8-hour battery reserve, and onsite standby generators is very effective at keeping the site operational. But taking advantage of the intelligence built into modern equipment can help the service provider take the next steps – creating highly efficient power system performance, predicting failure conditions, optimizing utilization of technicians and physical resources, and improving communications with field technicians during crises.

The goal is to predictively maintain critical facility equipment within central offices and avoid preventative maintenance. Adding sensors allows one to capture the required information. However, this requires an analytics tool to compile the information and present it in a useful format through an intuitive GUI.

The need is obvious, and the tools are available. It is time for the industry to develop standards that govern facility-based monitoring and control for power ecosystems.