Micrologic Trip Units

Intelligent use of electrical distribution monitoring

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Executive summary

As requirements expand in the modern electrical distribution system, there has been a growing need for solutions in the areas of coordination, configurability, monitoring, and maintenance. Furthermore there is a desperate need to fill these requirements with a product that is simple, cost effective and compact.

Schneider Electric

Introduction

As the capacity of electrical systems expand, so do the requirements in functionality to meet growing needs to control and maintain electrical distribution systems properly. Modern systems are designed with energy conservation and reliability as primary concerns. The Schneider Electric PowerPact™ with Micrologic™ line of molded case circuit breakers (MCCBs) are the first in the industry to address these problems with 3 frame sizes ranging from 150 to 400 Amperes. These devices allow for:

- Creation of a power monitoring point, which can be used to provide power quality data, energy management data, system capacity information, input to a facility supervisory control and data acquisition (SCADA) system, and preventative maintenance.

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- Enhanced selective coordination between the protective devices of the system with single amp adjustment capabilities in the trip unit.

- Capacity for zone selective interlocking (ZSI), for reducing arc flash hazard at high energy locations and for coordination of similarly sized protective devices, without reducing system capacity.

- Reducing the cost of installation. The PowerPact MCCB combines the functionality of a protective device with a meter capable of power quality readings and alarm functionality, into a single package. This creates savings by reducing cost of equipment, installed equipment size, and installation time.

- Advanced communication compatibility, allowing the units to communicate directly to a user's computer screen with embedded Web pages, or to external software systems such s SCADA, BMS, central monitoring, or other analytic software solutions. Using the speed and convenience of Ethernet, along with Modbus TCP/IP, network performance is maximized

Energy Management

As demand for electrical energy increases, the cost of that energy has increased and will continue to increase. Intelligent use of an electrical distribution monitoring system helps to reduce the cost of energy at a facility by reducing energy consumption and lowering energy costs. It has been estimated that through proper monitoring activity combined with a proactive response initiative, facilities can save as much as 30% on the costs of their energy consumption. Typically in the past, metering has only been cost effective at the incoming distribution board. This is in part due to installation complexity and/or space limitations. By integrating the metering functionality into the molded case circuit breaker itself, the meter can be accommodated in approximately the same amount of space as a standard molded case circuit breaker in the 15 to 3000 ampere range, providing an increased amount of data for a facilities energy management program.

Reducing Energy Consumption

Metering at each circuit breaker distribution point provides a major advantage in helping to identify large consumers of energy. By identifying loads that are high consumption, it reveals operations that could offer the most improvement. It also helps a facility break down the cost for various processes, which can help accurately track the production costs for management/accounting. This can be used to raise awareness of consumption and to identify cost savings.

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Optimizing Energy Costs

The metering of the entire system allows a facility to track energy usage at multiple distribution points. Monitoring this data allows a facility to balance loads and manage peaks to avoid penalties which can help lower energy costs. Typical industrial utility bills are comprised of many parts, but the three largest typical costs are kilowatt hours, power demand, and power factor penalties. With energy monitoring at low levels in the distribution system, a facility can identify energy consumption of individual loads, helping to identify who, when, and where the large energy consumers are and the loads driving low power factor in the system resulting in non efficient energy usage.

Remember, all kilowatts are not equal; often utilities have a tiered billing system, with energy used during peak business hours costing a premium and energy consumed during off peak hours costing much less. If there are high energy usage processes that have low personnel requirements identified, many times a facility can generate savings by moving those processes to off peak hours when possible.

Demand charges provide another opportunity to save energy costs through proper monitoring. Demand charges are associated with the average power consumed in a specific time frame, usually 15 minutes, over the billing month. Sometimes the demand charge is based on the worst case in the last 3 months. If there are large intermittent loads that cause large spikes in power usage, identifying those loads and shifting them to off peak times can save thousands of dollars on a monthly electrical bill.

In certain areas of the country utilities charge a heavy penalty for a power factor outside of the accepted range. Metering and tracking the power factor of a facility can allow this issue to be identified, and help determine the best method of correcting it. If power factor correction capacitors are determined to be necessary, this data would assist in determining the most effective size and location for the units, maximizing their efficiency and potential savings.

Power Quality

As electrical systems and automated production becomes more and more dependant on electronic devices, the electrical systems also become more sensitive to electrical disturbances. Integrating metering functionality in each circuit breaker provides a cost effective solution to monitoring the entire electrical distribution system, from the incoming source to individual loads. By placing meters throughout the system it is possible to track usage, loading, voltage, total harmonic distortion (THD) and many other useful parameters, to insure system reliability. Monitoring and tracking the system provides a methodology for predicting system reliability and creating a predictive maintenance schedule.

Improving System Reliability

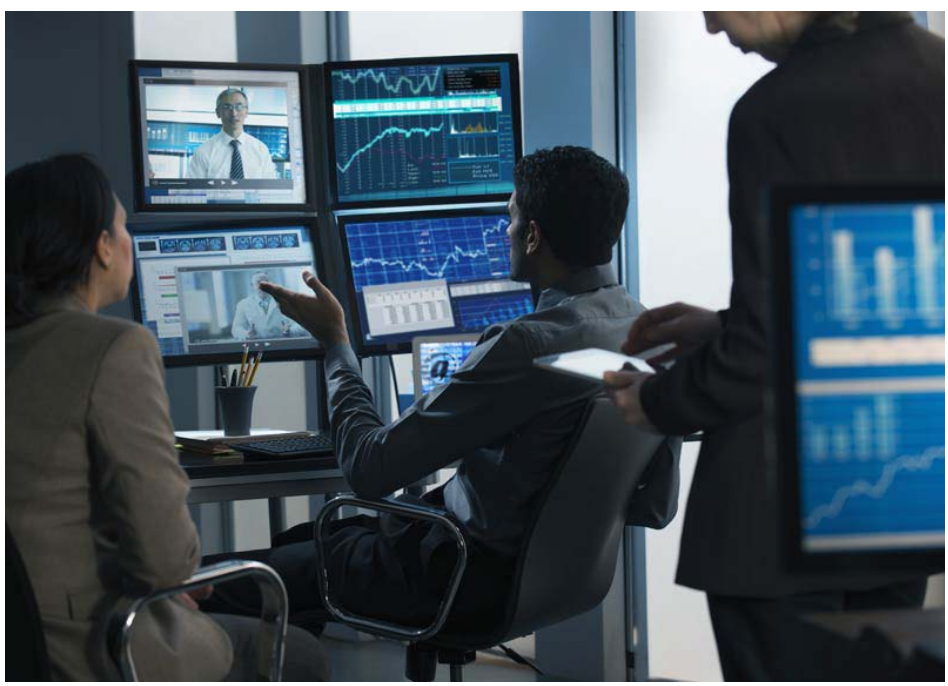
For molded case circuit breakers with Micrologic trip units feeding machinery, it is possible to collect power quality values and hours online which is a useful guide for maintenance of the equipment being fed. Time stamped historical logs allow analysis of system operational parameters: including number of operations and peak trip currents. This data can be used to trigger required maintenance in a proactive and timely manner, instead of relying on only routine maintenance on motors, belts, contactors and other machinery components.

To enhance the existing preventative maintenance program a PowerPact molded case circuit breaker with Micrologic can be configured to have two “pre-alarms” associated with steady state current. These alarms will help identify overloaded equipment before the operation of the protective device. There are also ten customizable alarms built into the advanced metering trip unit, which can be set to operate on any one of over 100 available alarm functions. This allows each circuit breaker to be configured to trigger an alarm locally at the equipment or to the SCADA system in a way that is meaningful to that location in the system.

With the use of the ‘Smart Systems’ communication technology, some of these alarms can be automatically e-mailed directly from the equipment. This is especially relevant to facilities which may not have advanced SCADA software or other monitoring systems to handle these messages. This allows quick detection of potential events, and quick analysis and action on issues before an event forces an outage or equipment is damaged, minimizing downtime and maximizing the capacity of the system.

Harmonic information, measured in total harmonic distortion (THD) is also available on the Micrologic trip unit and is calculated to the 15^{th} harmonic. Facility harmonic guidelines exist for the US, however, there are no standards for equipment. Excessive harmonic distortion can reduce the life of electronics, over heat motors, disrupt timing circuits, and in the case of resonance, cause damaging situations. By tracking the harmonic content of a system, it can be determined if it is acceptable to install a specific type of unit at a designated location or to determine if corrective measures need to first take place.

Harmonics can also cause heating in conductors, especially in the grounded conductor. In order to monitor this the Micrologic trip units have an optional Neutral CT which allows for direct measurement of the neutral conductor current, providing the ability to alarm or trip the circuit breaker in response to an overload on the neutral prior to damage occurring.



System Protection

System Coordination

As electrical distribution systems have become more complex, one of the most important aspects of the overall protective system is the proper coordination between devices. Proper system coordination is necessary not only at instantaneous levels but at long time, short time and ground-fault levels as well. Selective coordination is the capacity of the system to protect the facility and equipment if there is a fault, while still isolating the loss of power in the case of a trip to the smallest area of the system possible while maintaining power to the unaffected area of the system.

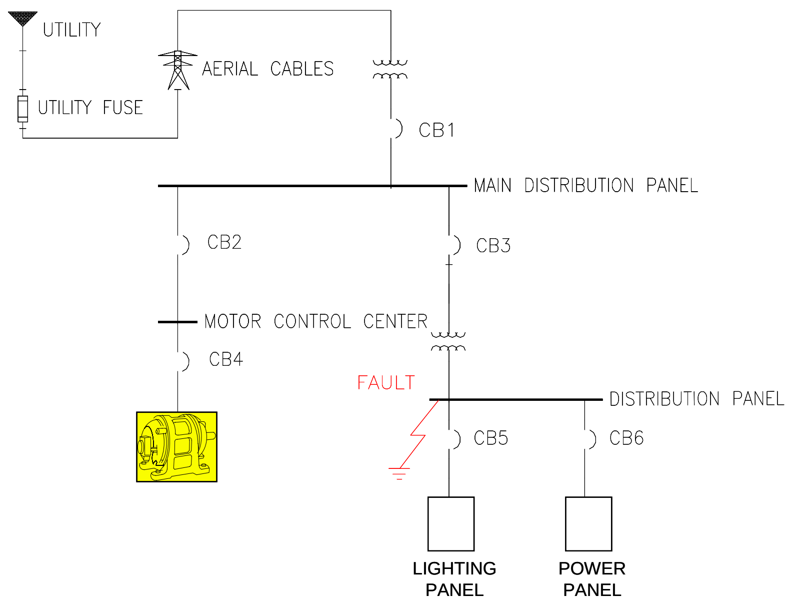


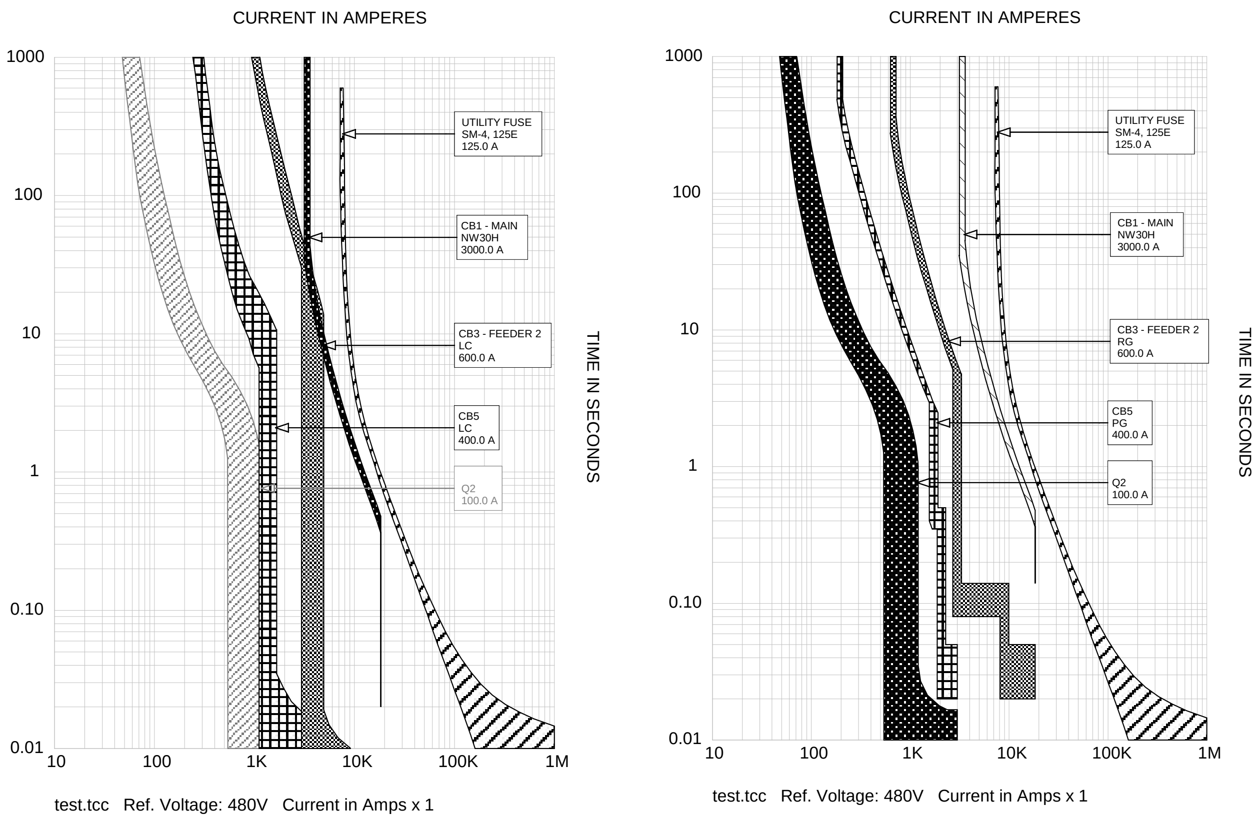
Figure 1: Diagram of typical system with an electrical fault.

For a large distribution system, it is important that the protective device directly upstream of the fault clear the event. If there is miscoordination between protective devices, a larger area of the system might needlessly be removed from service. This is a huge issue for hospitals where the loss of power for unaffected portions of the system might put patients in danger.

Selectivity is also important for extremely sensitive processes like in the manufacture of silicon chips for the computer industry or in safety systems for the Petrochemical industry. This problem has been emphasized since the release of the 2005 National Electric Code, when selective coordination became a requirement for specific circuits in hospitals.

Optimum selectivity is hard to achieve in many locations with the use of traditional thermal-magnetic circuit breakers. This was especially true for locations of less than 600 amperes, due to the lack of availability of circuit breakers in that ampere range with electronic trip units for these smaller distribution points. In this example, suppose that in the system shown in Figure 1, circuit breaker CB6 feeds a lighting panel with a 100A main breaker. If the system is installed with standard thermal-magnetic breakers as shown in
Figure 2 (a), a fault as shown in Figure 1 could result in the operation of CB1 instead of CB3, which would remove the whole system from service, including both lighting panels and the Motor Control Center.

By replacing the standard thermal-magnetic circuit breakers with breakers equipped with electronic trip units as shown in
Figure 2 (b) a phase fault at any point along that branch of the system will trip the appropriate protective device insuring non-effected areas remain in service.



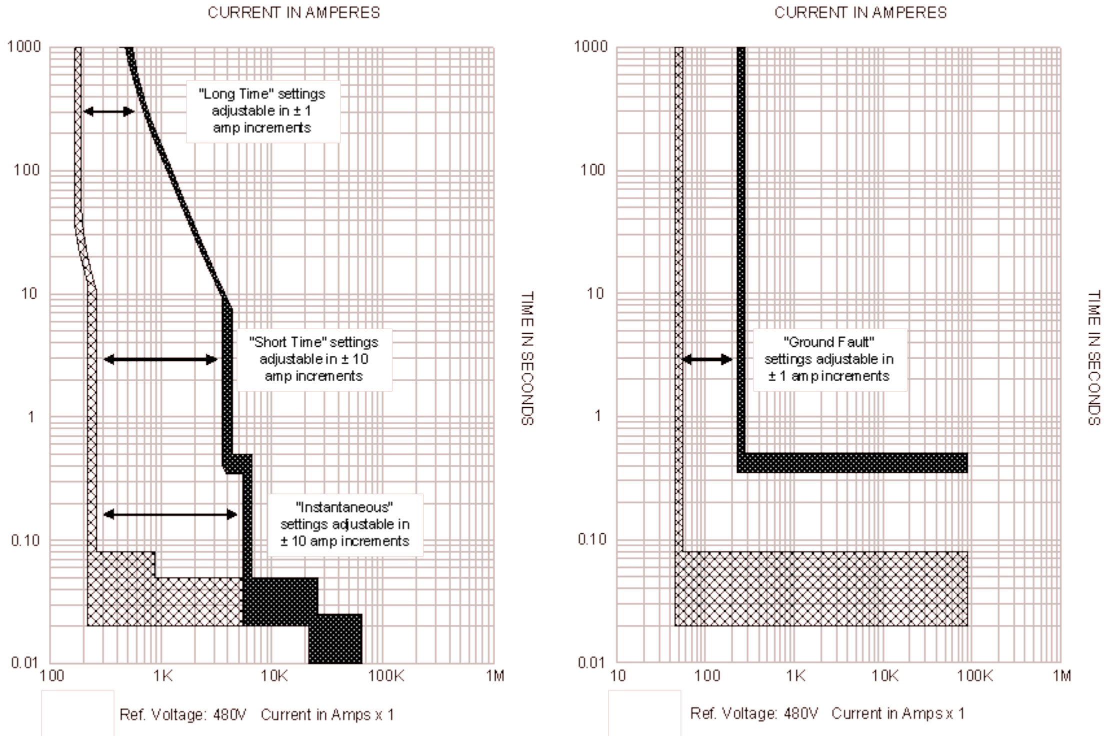
(a) Uncoordinated System **(b) Coordinated System**

Figure 2: Examples of time current curves for devices in system

The PowerPact molded case circuit breakers have improved on the options for coordination by adding a wider range of potential settings for long time, short time, instantaneous and ground-fault. Electronic molded case circuit breakers before the introduction of these trip units, were available with predetermined set points usually selected by a dial switch in increments of the handle rating.

The Micrologic trip units on PowerPact molded case circuit breakers provide traditional dial set-up capabilities and through an on board electronic keypad and/or remote software they allow the trip settings to be adjusted in fine increments. As shown in Figure 3, the long time and ground fault pick up values can be adjusted in 1 amp increments, and the short time and instantaneous pickup values can be adjusted in 10 amp increments.

This is a huge step forward in flexibility of protection, which has rarely been available before in large frame breakers, and has never before been available in a small frame breaker down to a 150A frame. This feature can now be found on molded case circuit breakers from 15 to 3000 Amperes.



(a) Phase current trip curves (b) ground current trip curves

Figure 3: Time current curve of 400 amp, PG frame breaker with LSIG options: minimum to maximum settings.

Micrologic trip units also have an optional zone selective interlocking (ZSI) function. In zone selective interlocking, smaller breakers are equipped with an output that allows them to send a restraining signal to an upstream protective device when a fault is detected. When the upstream device receives the restraining signal, it initiates a change in the trip characteristics of that device. For example, the upstream breaker, when observing a restraint signal, will use the short time and ground fault delay times selected, but will employ the short time and ground fault settings with no delay when the restraining signal is not observed.

All Micrologic trip units have the capacity to send out a restraining signal, for use as the downstream breakers in a zone selective interlocking system. In addition PowerPact L, P and R frames, can be used as either upstream or mid-system devices (both receiving and sending restraining signals).

This function might be used most commonly both to reduce arc flash hazard at a location and when a load is so large that it is not possible to coordinate the device while still providing correct ampacity for a load or when providing that coordination might expose the distribution equipment to an unacceptably long delay. It allows upstream circuit breakers to be set with a larger short time trip delay setting for coordination but still allows it to reduce arc flash and electrodynamic stress on equipment under a local fault condition.

An example might be a distribution panel feeding a large motor such as circuit breakers CB1, CB2, and CB4 in Figure 1. In the example shown in Figure 1, A 3000A main distribution panel feeds a 1000A motor control center, with a 400 amp motor circuit. The starting current of a motor can be six times the full load current of the motor. This may cause an overlap in the two protective devices due to the higher required setting of the CB4 to allow the motor to start.

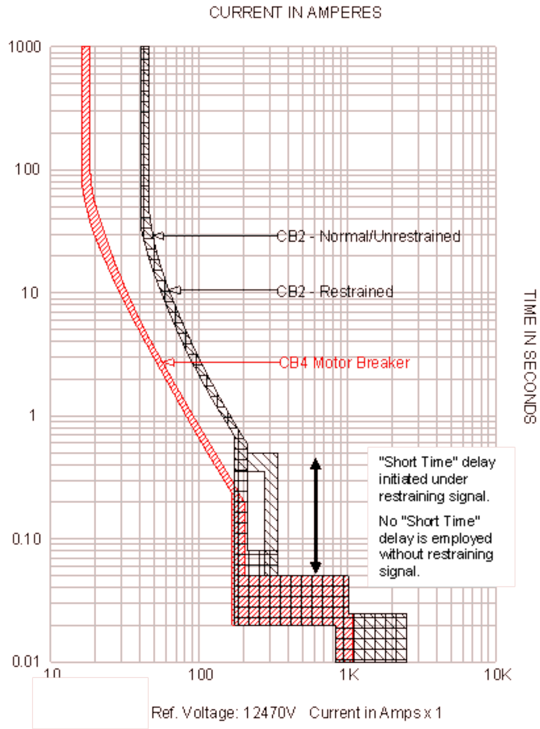


Figure 4: Time current curve of CB2, with and without restraint signal.

By using ZSI in the event of a fault downstream of CB4, both protective devices will see the fault at the same time, and CB4 will send a restraint signal to the trip unit on circuit breaker CB2, which will allow the CB2 set short time delay to time out, see Figure 4. In the case of a fault in the busbars of the motor control center itself, there is no restraining signal sent to CB2 so the short time delay is removed and clears the fault without any intentional delay. This may significantly reduce the arc flash energy available for a fault in the bus of the panel and allow the electrodynamic stress on the equipment to be kept to a minimum, while still maintaining selective coordination.

Advanced Communications

Smart Systems, the new communication architecture for Micrologic trip units, allows the user to have seamless transparency into the available data provided by Square D Low Voltage circuit breakers using Micrologic trip units. This transparency is provided by an Ethernet communications module that allows the convenience of standard Ethernet connectivity, greatly improving communication speed and dependability over traditional (and slower) serial Modbus communication models.

With an Ethernet model, several hardware advantages emerge such as the convenience of utilizing standard RJ45 connections and off the shelf Ethernet communications devices, allowing a reduction in wiring and quick commissioning of the devices.

Using the new interface, all units can be connected to multiple systems using Modbus TCP/IP, allowing input into a facility's energy management, centralized monitoring, facility planning and maintenance program systems. This architecture allows the units to provide input simultaneously into any of these systems compatible with Modbus TCP/IP, the industry standard, whether they are on the same computer or 4 different computers.

Using the available embedded preconfigured Web pages included in the Smart Systems Ethernet interface, the user can also have local access to breaker data without the need of additional software.

Using a standard Web browser, available breaker data is displayed such as real-time and historic metering, breaker status, e-mail alarms and on/off breaker control capability and maintenance logs. The Ethernet interface conveniently utilizes Device Profile for Web Services (DPWS) for ease of locating the interface on a PC.

Along with TCP/IP data and local embedded Web pages, data can also be sent to Cloud applications for external software access to a remote location. This can be sent over a standard Ethernet network, or with a GPRS (cellular) connection for remote locations with no Ethernet access. A typical use-case for this cloud-based approach would be a service provider who monitors multiple facilities and provides necessary service as needed or when critical issues arise.

Cost Effectivenes

Combining the functionality of electronic trip units, with advanced power quality metering, zone selective interlocking, and alarming options, has created a considerable opportunity for cost savings. It is no longer necessary to purchase several devices from multiple manufacturers or take up space in panels for extra CT's.

This saves on installation and maintenance time not to mention procurement efforts. The increased metering capabilities provide an effective way to meter each power distribution point of the system. This makes it possible to know where capacity exists in the system as new loads are added, possibly averting the need to purchase new distribution equipment which can have a significant impact on potential future expansion costs.

The Ethernet communication system utilizes a plug and play design with auto discovery to reduce installation costs and minimize startup issues integrating new units into existing energy management, centralized monitoring, facility planning or maintenance program systems. Having the power to protect, monitor and analyze your electrical distribution system at every main and branch circuit puts you in control of your energy.

Conclusion

PowerPact molded case circuit breakers with Micrologic trip units and the Smart Systems communication system, provides you with the ability to coordinate your system protection, monitor your energy consumption, and effectively execute your preventative maintenance programs resulting in a cost effective solution to meet your energy needs today and in the future.

About the author

C J Joshlin, PE, CEM is a staff power systems engineer for Schneider Electric Engineering Services. She is responsible for engineering services including power system analysis services and recommendations focusing on short-circuit, coordination and arc flash, design work, and risk assessments. C J is a licensed professional engineer in the states of Iowa, Kansas, Missouri, Nebraska, and Tennessee. She is also certified as a Certified Energy Manager by Association of Energy Engineers and a Professional Energy Manager by Schneider Electric.