**Joel Benzing, Eaton,** details the application of dashboards in electrical equipment operation.

# Displaying the Benefits

## Introduction

Switchgear and motor control centre technology has progressed dramatically over the years, mainly due to advances in electronic devices that monitor and protect the assemblies in which they are mounted. Protective relays, breaker trip units, meters, transformer fan controllers, and diagnostic devices are installed in switchgear and control assemblies to provide protection and quick access to useful data. Communications technology provides the ability to access and control these devices remotely. Engineers and maintenance personnel are looking for ways to improve both the safety and efficiency of electrical equipment. Human machine interface (HMI) Dashboards can provide many benefits by displaying information and allowing safe distance control in or near an electrical equipment room.

## Traditional systems

Over the years many engineers have created custom supervisory control and data acquisition (SCADA) systems by applying software to a touchscreen HMI or computer. These systems have been very effective in displaying information from intelligent electronic devices, such as protective relays, trip units, meters, programmable logic controllers, and remote terminal units. These systems may have varying degrees of sophistication, with graphics and symbols either user-created or selected from a library. The typical challenge with a system like this is the field development and testing time required to configure all the appropriate data points from the various devices. Incorporating those data points on screens that provide useful information to users is also challenging and time consuming. Since
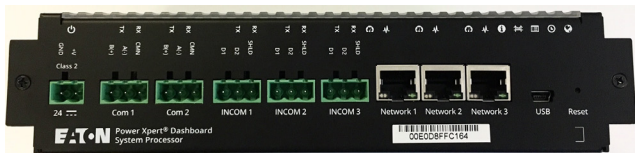
Figure 1. Dashboard processor.



Figure 2. Medium voltage breaker racking.

the system can be customised to the application, very relevant information can be included on the screens, but this requires extensive forethought and planning. Normally these systems will go through multiple iterations of programming at the site, until all the desired functionality is provided and tested. Depending on the system topology, computers or HMIs can be placed at various accessible locations throughout a facility to allow access to data, where it can be used by engineers and maintenance personnel.

### New developments
Recently, electrical equipment manufacturers have created application specific processors that can be housed in a lineup of low- or medium-voltage electrical equipment (Figure 1). These processors connect to all of the electronic devices in a lineup to provide a configurable dashboard user interface to that lineup. This allows the following benefits:

1.  The processor can be factory installed and configured with the electronic devices, before it ships from the manufacturing facility.

2.  The system may be fully factory tested, since all the components are present.
3.  Purchasers can validate the functionality of the system during a factory witness test.

The processor is typically web enabled and provides both a local and remote dashboard interface, usually through an HMI located on the electrical equipment or nearby, and back at an engineer's desk or control room. In addition to their visualisation capabilities, these processors also have the ability to pass data from the electronic devices to a system-wide SCADA or Distributed Control System (DCS) using standard protocols. Cyber security has become critical for these types of components, as the consequences of unintended access can be high. Controlling access to the processor is a vital component in any effort to secure it. Many regulatory agencies and standards organisations now recommend/require Role-Based Access Control (RBAC) password management and previous login notification as part of any access control effort. Password protection and management RBAC should be supported by a robust set of tools that can be used to create the set of authorised users and role-based permissions, as well as a comprehensive set of password management features that can be used to comply with security policies in effect at various sites. Secure Sockets Layer (SSL) Encryption options ensure that information and passwords exchanged with the processor's web server cannot be intercepted on the local area network. An access control/trusted host list provides an additional layer of security by limiting access to the communication ports by authorised trusted hosts' IP addresses.

Since engineers and maintenance personnel are looking for ways to improve both safety and efficiency of electrical equipment, this type of local display and control interface adds significant value to the already installed, intelligent electronic devices.

### Safety
A key issue facing engineers and maintenance personnel today is how to build in electrical workplace safety practices for employees, who are subject to hazards arising from their proximity to electrical equipment. The main hazard concerning the industry is arc flash. An arc flash event releases a tremendous amount of energy in the form of thermal heat, toxic fumes, pressure waves, blinding light, sound waves, and explosions that can result in serious injury including critical burns, collapsed lungs, loss of vision, ruptured eardrums, puncture wounds, and even death. An arc flash hazard analysis is critical to the safety of plant personnel working on or near exposed, energised electrical equipment. The analysis, completed in accordance with the Institute of Electrical and Electronics Engineers Standard IEEE 1584-2002 "Guide for Performing Arc

Flash Calculations", quantifies the release of thermal energy associated with potential arc flash hazards and includes workplace safety recommendations, such as establishing protection boundaries and specifying protective equipment for personnel (PPE). Hazards are indicated by the level of incident energy to which the worker's body is exposed, measured in calories per centimeter squared (cal/cm$^2$), due to an arc flash event at a defined working distance. This incident energy level is used to determine the appropriate level of PPE for work in that area. The US Occupational Safety and Health Administration (OSHA) and the National Fire Protection Association (NFPA) have adopted specific requirements around arc flash hazards. NFPA 70E 2018 article 130.5 (D) details requirements for equipment labelling. These labels should include the following:

1. Nominal system voltage.
2. Arc flash boundary.
3. Available incident energy and working distance or PPE category.

Many of the recorded arc flash events have occurred when personnel are opening or closing circuit breakers or racking withdrawable circuit breakers in or out of an energised cell (Figure 2).

There are a number of ways to decrease hazards due to arc flash events. Some of them, like arc-resistant equipment, involve containing an arc event and exhausting the gasses away from the operator. Others, such as bus differential relays, current limiting fuses, zone selective interlocking, light sensing relays, and maintenance mode switches, involve shortening the time of an arc event, which lowers the incident energy. Another very effective way to limit hazards from arc flash events is to remove operators from the hazard area. Remote operation can be achieved by creating a mimic panel that sits outside the arc flash boundary. This panel can be wired with control switches and indicator lights to allow circuit breaker operation outside the arc flash boundary.

A more effective method for creating a remote operator panel involves installing a processor in the electrical equipment, as described above, and then placing an HMI either on the wall or on a kiosk outside the arc flash boundary, as determined by the arc flash study. The HMI is connected to the processor through one ethernet cable, dramatically reducing the amount of wiring required, compared to the traditional mimic panel. The HMI may then display the processor's dashboard user interface on the screen and allow access to both monitoring and control screens. Circuit breakers may be operated through the dashboard as shown in Figure 3.

The results of the arc flash study may be loaded onto the processor, and operators can see the incident energy levels and PPE requirements on the dashboard, before entering the arc flash boundary. Circuit breakers can be opened and closed and racked in or out through the communications connection to the breaker trip units, protective relays, and remote racking interface, while the operator remains safely outside the arc flash boundary. In this application, maintenance persons are able to establish a verified zero-energy condition, before entering the electrical switchroom. This functionality requires electrically-operated circuit breakers, with communicating trip units or protective relays, and a motorised racking system. Another interesting feature of this dashboard interface is that an operator may also initiate the circuit breaker trip unit's or protective relay's maintenance mode remotely, before entering the arc flash boundary. This mode dramatically reduces the amount of arc energy available by limiting the time it takes the circuit breaker to open should a fault occur. While using the maintenance mode, operators must make sure that the maintenance switch is disengaged after the scheduled maintenance work is completed, otherwise, there may be nuisance tripping of the circuit breaker. This requirement can be aided by an adjustable timed alarm in the processor that indicates that the maintenance mode has been left on. Another helpful feature of the remote activation of the maintenance mode is that the protected portion of the equipment may be highlighted on the dashboard graphic display to allow the operator to verify successful initiation of maintenance mode.
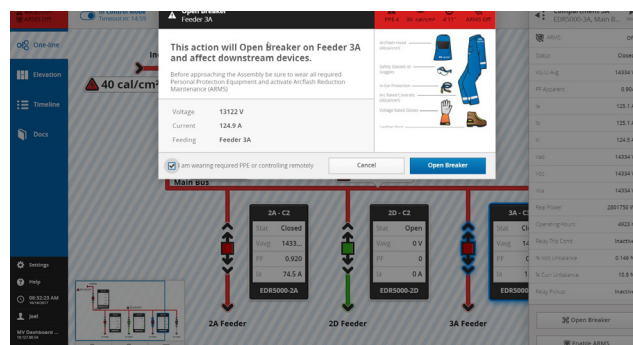


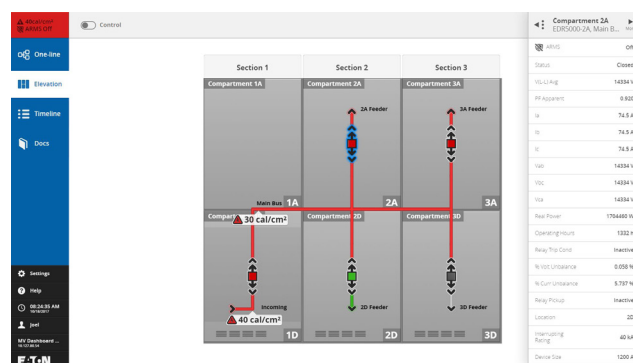Figure 3. Dashboard: remote circuit breaker operation.



Figure 4. Dashboard: switchgear elevation view.

## Efficiency

Intelligent electronic devices mounted directly on the switchgear or motor control centre allow electricians and maintenance personnel to access information at the location, where maintenance or service may be required. This is helpful, but requires some higher level of knowledge on the menu structure of the device to find and understand the information. Another issue with accessing information at the equipment is a concern for arc flash safety and having personnel inside the arc flash boundary to interact with these electronic devices. An equipment-mounted processor and remote HMI can remove the operator from the arc flash hazard area and provide useful information. Real-time metering information, breaker position, and source availability can be helpful in quickly determining the status of equipment and loads. Historical metering information can help with troubleshooting and capacity planning. The processor gathers data from trip units, meters, and protective relays on circuit breaker load, no load, and fault operations and can provide alerts, when breaker or motor maintenance should be completed.

NFPA Standard 70B-2016 "Recommended Practice for Electrical Equipment Maintenance" Article 6.2.2, says that "the availability of up-to-date, accurate, and complete diagrams is the foundation of a successful Electrical Preventive Maintenance (EPM) programme." The real-time data is displayed on an equipment one line diagram and on an equipment elevation view, as shown in Figures 4 and 5, and aids in understanding this part of the electrical distribution system.
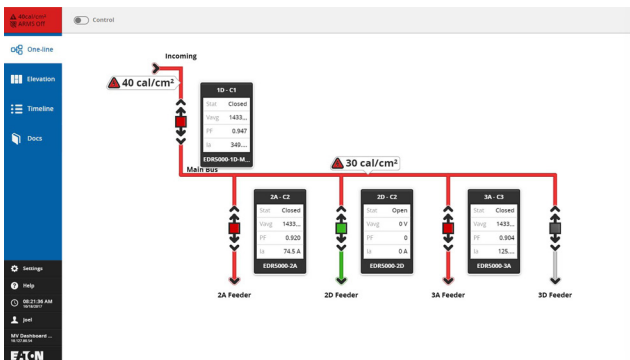


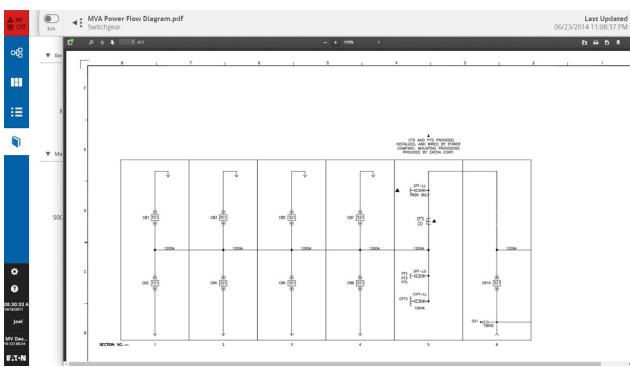Figure 5. Dashboard: switchgear one line diagram.



Figure 6. Dashboard: project documents.

Equipment and circuit breaker or motor ratings are included as part of these diagrams. This information can help to supplement information required for an EPM system, as described in NFPA 70B. An operational timeline logs events of system operation and actions taken by operators, providing a historical record during the life of the equipment.

Alarms displayed on the dashboard screen and communicated via email alerts provide direct, actionable information on electrical parameters that are out of spec or on trip events. Trip events are complete with details on metered values at the time of event, trip function that caused the event, and a waveform of the phase currents and voltages during, and just before, the event. Protection settings may also be viewed using the processor. This data can be very useful in determining the ultimate cause of the event and the troubleshooting steps necessary before restarting the process. If settings must be changed, this can be done remotely using the processor's settings tool. The tool allows offline settings changes, settings file management, and downloading of settings directly to the protective device.

Another improvement in efficiency by using the processor with a remote HMI comes from storing project documents associated with the electrical assemblies (Figure 6). The dashboard interface allows quick access to all construction drawings, wiring diagrams, bills of material arc flash studies, coordination studies, and instruction manuals that are stored on the processor and used for system troubleshooting.

As mentioned previously, OSHA requires that arc energy levels should be calculated through arc flash studies and the results placed on labels on the equipment to clearly mark PPE requirements for operators. These PPE requirements and arc flash values may also be shown on the dashboard to inform personnel of the arc flash hazard before they enter the arc flash boundary, where the labels are installed.

## Conclusion

Electrical equipment dashboards can provide many benefits by displaying information and allowing safe distance control in or near an electrical equipment room. Historical and real-time operational and metering data, status, maintenance information, PPE requirements, and easy document access improves efficiency. Safe distance switching device open and close, remote racking, and remote maintenance mode operation improves electrical workplace safety. Factory installation and configuration on new equipment reduces the cost and time for both installation and commissioning. 🌐

## About the author

Joel Benzing is Marketing Manager at Eaton.