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Leverage substation gateway hardware to host a substation HMI and reduce costs

Traditional substation human-machine interfaces (HMIs) are primarily used for visualization and control of all critical substation equipment. However, there are significant shortcomings associated with the expense and regular hardware and software maintenance and upgrades of this equipment.

It is becoming increasingly important that HMI systems provide fast system response and security, as time and access are critical in substation operations. An HMI system must also be cost effective, easy to use and provide more than an operator interface for visualization and control tasks. Utilities also expect rich animations and access to various substation information to facilitate information flow through utility personnel. This white paper presents tomorrow's smart substation HMI used for visualization, real-time control and as a management tool: the integrated substation HMI.

Substation HMI functionality

A substation HMI is a vital element to quickly, safely and securely visualize and control critical substation information. Local and remote access to the substation HMI have become today's standard. The basic elements expected of a modern substation HMI include:

• Substation general dashboard

• Substation's IED communication monitoring element

• Monitoring and control of switchgear equipment

• Measurement values monitoring

• Alarms and events management

• Commissioning functions for new equipment

However, utilities expect more than a basic substation HMI. Computer systems now have the capability and capacity to provide quick accessibility, rich animations in single-line diagrams and access to multiple substation information to allow utility personnel to optimize operation and maintenance as well as meet broader operational goals.

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Typical drawbacks of a traditional substation HMI

Traditionally, substation HMI software is installed on a separate workstation and often requires a third-party vendor. The traditional substation HMI can be accessed locally and is normally used to display basic substation operational functions and some historical data.

The drawback associated with this type of installation is the extra expense for utilities. These costs include:

- Host computer, operating system and other required software costs and maintenance fees for the initial installation

- IT man-hour involvement required for installation and maintenance of the computer, operating system and other third party software

- HMI software initial purchase cost

- Maintenance time and support to keep the software running

Additionally, the configuration and commissioning time may become expensive if the substation HMI software comes from a third party; setting up the data acquisition process is typically the source of additional commissioning and installation time. Finally, the cost related to the space rack allocation needed for hosting the computer.

A new approach: the integrated substation HMI

A new approach with enormous potential is now available to utilities—the integrated substation HMI. The system provides an interface with the substation gateway HMI, which is accessible locally and from a web browser; the HMI application resides on the substation gateway platform, eliminating the need for an HMI-dedicated computer. The massive processing power of today's state-of the-art substation gateways allows for fast response, elaborated single-line diagrams and instantaneous access to a wide range of substation information. Technological advancement also allows performing HMI maintenance without affecting SCADA communication, making things much simpler than before.

Benefits

Integrated substation HMIs provide significant advantages in terms of deployment, set up, commissioning and reliability. In the following sections, we explore the benefits for each of these areas.
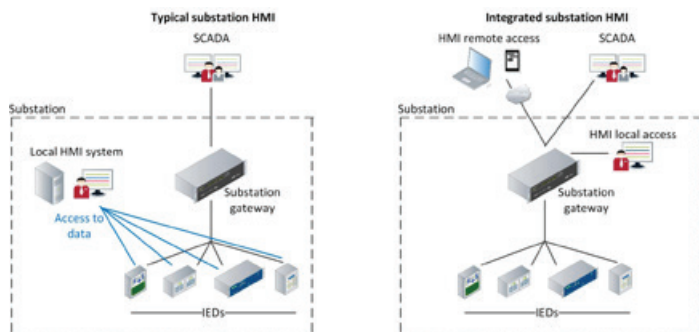
Hardware and costs reduction

As the integrated substation HMI eliminates the need for an additional computer to host the HMI software, all costs related to an extra computer and HMI software along with specific challenges (such as software installation, system setup and maintenance, and license management) are reduced to just the cost of buying the HMI license on the substation gateway and a touchscreen display for HMI local access.

Because the HMI software runs off the substation gateway and is part of the substation software version package, maintenance is minimal and the rack space requirement is reduced to the one needed for the substation gateway. This also allows seamless integration of the HMI with all technical advancement related to the substation gateway.

Flexible deployment

Local HMI access is achieved by connecting a touchscreen to the substation gateway. Remote HMI access is possible by simply connecting with a PC web browser and no specific setup or configuration is needed on the PC side; remote access is also supported by mobile devices. This kind of flexibility makes it possible for various utility employees to access a wide range of substation data from different locations.

As part of the substation gateway software system, the integrated substation HMI benefits from the substation gateway nested user access control function to provide flexible configuration for remote access permissions. The substation gateway system configuration file also allows granular control over available HMI features deployment, permitting substation information accessibility to be managed for both the remote and local HMI accesses independently.

Easy setup and configuration

The substation gateway uses a central system configuration file to setup the system. This configuration file is part of advanced PC based off-line configuration software which includes different tools for setup, configuration and maintenance.

Setup is simplified because some features are self-configured; these features simply need to be enabled in the configuration file to be automatically displayed on the substation HMI. Self-configured features include: the real time data points lists, the system and communication dashboards; the latter are based on the configured intelligent electronic devices (IEDs) in the substation gateway.

Real time data points lists are built directly and automatically from the substation gateway database, which depends on the IEDs configured in the substation gateway and all system and internal data points.

Single-line diagram pages are easy to setup and modify when needed. A design application specific for utilities, which belong to the substation gateway configuration software, allows to intuitively draw single-line diagrams using a complete substation object library. The objects being dragged and dropped on the single-line diagram drawing page and then, if required, customized to fit utility

standards. Standard shape templates are designed with aliases for copy/paste facilitation; manual or automatic alias resolution is based on the substation gateway point naming convention.

Any HMI-related modifications made via the substation configuration file or an upload of single-line diagram files on the substation gateway require simply a soft restart, which is almost instantaneous. Most importantly, this does not interrupt communication with the control center, which is critical since any outages must be planned and are considered a service interruption.

Fast and easy commissioning

The integrated substation HMI includes an embedded, pre-programmed module for commissioning; this commissioning tool is used for the initial substation HMI start up and helps expedite integration of new IEDs. The commissioning tool works together with the HMI real time points lists and permits forcing of digital and analog values, sending command control signals. Various simulation modes are available such as the simulated IED mode which allows for testing IED communication as well as testing logic and alarms before the IED is put into operation.

Multiple features are integrated into the substation gateway HMI to facilitate system commissioning as well as new IEDs integration. Single-line diagram pages provide an animation error function which displays information related to animation problems for a selected shape directly on the HMI screen. This function is used for debugging purposes and can speed up the commissioning process significantly.

Reliability

The substation HMI runs on an extremely reliable and rugged substation grade gateway (IEEE Std 1613™, IEC 61850-3 standards), which is built on a real time operating system (RTOS) and allows the gateway to be installed in a harsh environment. The substation gateway acts as a data concentrator and protocol conversion platform. With a proven history in data acquisition and distribution automation applications, the gateway has been used in thousands of utility applications worldwide.

The substation HMI advanced features

An HMI system must provide more than an operator interface for visualization and control tasks. It is also expected to provide quick and secure access to various substation data in order to facilitate information flow through the utility for optimized operation, maintenance, planning, and management purposes. To achieve this, fast response and security features are the key elements; an integrated substation HMI which has massive processing power capabilities and direct access to all substation gateway data, can easily provide that. Key features of the integrated substation HMI are detailed below.

Dashboards

Dashboards are often associated with local substation operation, but the information they provide also benefit management for planning purposes and enable faster decision-making based on real-time data. The integrated substation HMI system dashboard is self-configured and used for system health monitoring; it displays information such as clock synchronization and security statuses, system load, versions, hardware components and settings as shown in the first image in the right-hand column.

The communication dashboard provides users with a quick overview of the communication statuses of all IEDs configured in the substation gateway in a single page, as well as control center communication links. A summary and details pane, as seen in the right side of the second image, displays summary connection statistics and detailed statistics related to the selected communication link; reset operations are allowed on the latter.
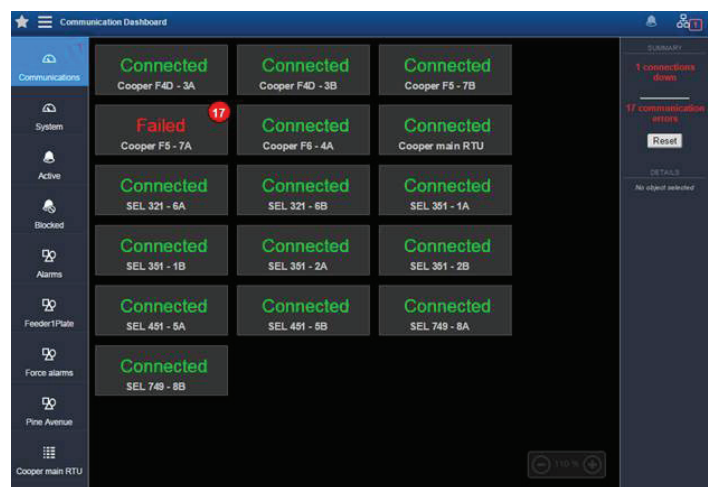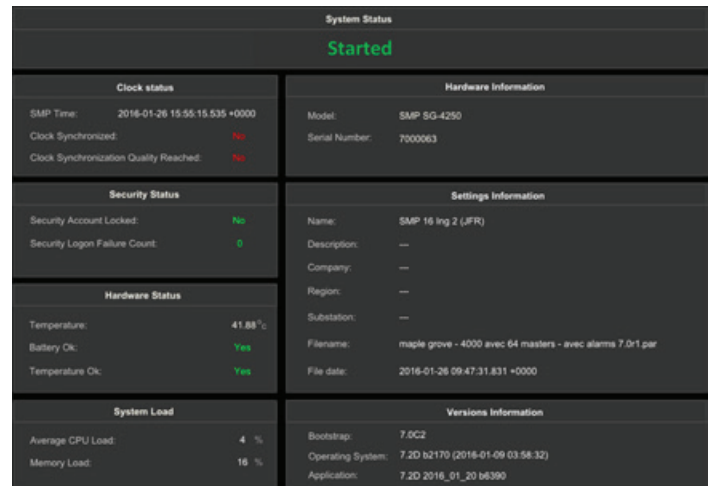

Alarm management pages

The integrated substation HMI provides prebuilt and easily configurable alarm pages. The active alarm page displays all active or non-acknowledged alarms organized according to the user's configuration. The system also provides alarm blocking capabilities to deactivate specific alarms at runtime. The feature prevents overloading the active alarms page under specific conditions such as during maintenance periods or when a specific known problem occurs repetitively. Blocked alarms are sent to the blocked alarm page until reactivation. A configurable single alarm display appears at the bottom of most HMI pages, it allows acknowledging alarms without having to leave the current page. All alarms are logged to an alarm log file available one the substation gateway HMI.

Single-line diagram capabilities

Single-line diagram pages are easy to setup with the use of the dedicated design application and alias resolution capabilities. The integrated substation HMI offers even more advanced features since customizable single-line diagram pages and metering displays are unrestricted, being limited only by the system's available resources.
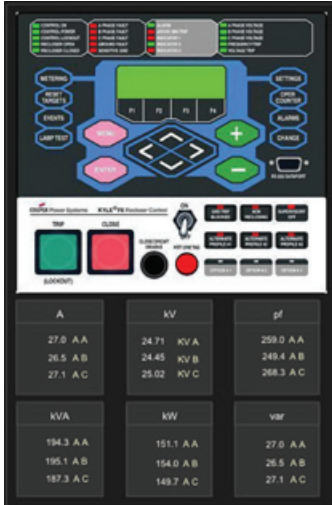
Outside from the provided substation object library, the design application supports JPEG, GIF and BMP images, which is very useful for inserting images of IED devices' front panel. These images can then be configured as virtual IED devices on the single-line diagram pages and then saved in the object library for further use. The standard library already includes a choice of prebuilt images of IED devices' front panel.

Configurable objects dragged from the substation library support select before operate (SBO) and direct operate control. All control operations are logged into a specific file, available with the substation gateway HMI log function. Alarm management is possible directly on the single-line diagram pages for points related to a selected object on the page.

Real time data visualization

The substation gateway HMI includes pre-configured data point lists that are selectable, so users are able to visualize data points according to their needs. It is possible to select from all points, by communication links, and types. The user can also pin different data points from the available lists to build a custom real time data points list. All lists provide advanced filtering and searching capabilities.

Non-operational data

In addition to supplying operational data, the integrated substation HMI has the capacity to provide users with non-operational data on substation gateway levels; archive, statistic and log files are available with just a click. Files such as alarm history log, sequence of events, clock synchronisation and distribution statuses, real time data exchange, start up, security and much more can be securely accessed from remote locations.

Display and configuration features

Some features such as the display language, sound enabling and zoom control for the single line diagram pages are configurable online to meet the users' preferences. The zoom function uses vectorial technology which allows zooming-in and zooming-out without losing resolution.

A permanent status bar, with specific icons, allows easy access to frequently used functions such as the alarm page, in case of new events. Additionally, an optional online configurable favorite bar can be used to keep HMI pages organized according to users' habits and needs. These two bars allow quick access to the most visited HMI pages.

Moreover, the integrated substation gateway HMI allows simultaneous web access for multiple users and multiple web pages for a single user which can be very useful in a commissioning session.

Realizing cost reduction by using an integrated HMI

An integrated HMI approach provides substantial savings compared with a traditional approach. Specific savings for various aspects are detailed below for a sample system containing approximately 10,000 data points.

Table 1. Sample Cost Savings From an Integrated HMI Versus Traditional Approach

Phase	Detail	Savings ($)	Explanations
Initial purchase price	Hardware	3,500	Use existing substation gateway–no extra cost is involved
	Software	8,400	Depending on the chosen options
Configuration	Computer (TI)	500	Use existing substation gateway–no extra cost is involved
	HMI software	1,000	Setting up the integrated HMI is much faster since the data is already available–no need to setup a data acquisition process
Commissioning		700	Commissioning of an integrated system is much faster than a separate HMI system
Maintenance	Computer	500/year	Use existing substation gateway–no extra cost is involved
	HMI	1,500/year	Following upgrades of the substation gateway

The total savings associated with the integrated HMI in this example are expected to be $13,200 plus an additional annual savings of $2,000 for maintenance. The cost reduction is significant especially when considered with the potential to improve system reliability.

Conclusion

Traditional substation HMIs are in the process of being superseded by integrated substation HMIs. The reasons are multiple and obvious; first the costs and time saved by not having to buy and maintain a dedicated HMI computer and software. Further, the technological advancement that brought us extremely powerful substation gateways with great capacity; this benefit allows substation gateways to integrate HMI functionalities into their platform for direct access to data and integrated functions—leveraging of the latest technologies, lowering downtime, setup time and increasing efficiency.

The advanced capabilities available from the substation gateway profit the integrated substation HMI. Some examples of capacities that can be exploited by the integrated HMI system include: secured connections capabilities, local/remote status protection, and advanced substation logic capabilities allow an internal data point to be used in the HMI. Finally, flexible, fast and secure remote access allows the user to act immediately when issues arise and to better plan for maintenance.

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