



# DIGITAL ENERGY SCADA SOLUTIONS

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# SCADA Overview

## SCADA at the core of power systems monitoring and control

Power systems monitoring requires increasing amounts of information coming from multiples sources, manually or automatically, and at different points in time, each with their own resolution and quality.

SCADA collects all this information in real time to:

- Process in terms of validity, usability, and accuracy and store them for future analysis.
- Combine into a flexible, simple or complex calculation.
- Provide operators and other control systems with flags and alarms, which are valuable for action and control.
- Feed advanced applications such as network security and generation dispatch.

Within data parameters, phasor measurement units generate a huge flow of points due to high scanning resolution (1ms). SCADA can now integrate phasor data.



### SCADA: the critical block for EMS

SCADA is the core of any monitoring and control system. This is where all information captured from the field via manual reading, automated control systems in substations and power plants, and from other control centers is processed in real time before being made available for further analysis and action by operators. Without SCADA running, EMS and operators have reduced network vision and cannot operate at full capacity. SCADA reliability is built-in by design with one or multiple redundancy levels to ensure 100% availability.



### Incorporating WAMS technology for increased awareness and network flexibility

Traditionally, SCADA receives data points scanned at 1s or higher resolution depending on communication bandwidth and local scanning capabilities such as RTU, a substation automation system, or a power plant control system. The latest WAMS technology, under deployment for the last 10 years, has reached a level of reliability and performance enabling it to manage a large number of phasor measurement units (PMUs) data scanned at 1ms from thousands of PMUs implemented across the network. Phasor Data Concentrator (PDC) and PhasorProcessor are also now part of the SCADA solutions GE offers to its customers.

Coupling existing EMS applications with a Phasor application inside an Advanced Energy Management System (AEMS) unlocks additional network flexibility in terms of blackout prevention and network power capacity required as intermittent renewable generation grows.



### SCADA Scalability

Originally, SCADA was designed to handle approximately tens of thousands of points, captured from multiple sources in the field. As transmission network instrumentation proliferates, SCADA can reach as high as one hundred thousand points. As utilities merge with larger networked areas, there is more instrumentation in power systems and distribution systems connecting to transmission systems. The interchanges with neighbor network control systems and the introduction of WAMS PMU points pushes SCADA solutions toward a million points or above. GE's SCADA has the capacity to handle above a million data points in real time.



### Advanced Applications for Network Monitoring and Control

GE's SCADA solutions offer a valuable set of applications which give insight to the state of the electrical network, even without advanced power systems applications. Applications such as Topology, Area of Control, Load Shedding and the ability to integrate WAMS and PMUs are extremely valuable, allowing grid operators to monitor, anticipate and improve the performance of transmission and distribution networks.



### SCADA access control and Cyber Security

SCADA is a critical component of any EMS, and access control is by design, a feature which allows operators to share network operating areas. Additionally, the login procedure (SSO authentication and certification) is embedded within SCADA IT software to prevent any unwanted intrusion. It logs, tracks, and reports all user access for auditing purposes, and meets NERC CIP 003 requirements.

# SCADA Applications: Monitoring

## Real-Time Data Acquisition and Processing

- Remote Terminal Units (RTUs) wired to specific devices are scanned in real time, at a specified rate. The RTUs send the raw data to the Front End, which performs conversion and checking. Data points can be measurements (analog), status (on-off, open-close), and count (pulse).
- Data scans are periodic and/or on demand.
- Data source tracking: field RTU, other SCADA, operator entry, calculation, state estimation result, or any EMS applications.
- Measurement processing: conversion in engineering unit (MW, Volt, etc.); multiple limits violation checking: normal, reasonability, forbidden range, deadband, rate of change; oscillation detection (unexpected changes during a defined time); stale detection and peak measurement storage.
- Status point processing: state change with time resolution (local or from RTUs if available) with Sequence Of Events processing (SOE).
- Count point processing: count the total changes, engineering unit conversion (Mwh, etc.).
- Calculated points: data calculated from any points combination.
- Data quality: flag data that may not be reliable (old, bad, un-initialized, not in service); Composite data flags (bad, suspect, replaced, and good); and remote site data flag (suspect, replace). The flag can also be inherited from a global substation flag or a bay flag in a substation. When remote site data changes, the new value and its associated data quality indicators are transferred to the receiving site.

## Operator and application control on data processing

Operators and applications can change the way SCADA processes and displays data.

For example, an operator can enter a value for a device where measurement is not retrieved from an RTU. Available actions:

- Removing or restoring a point from service: disabling, or enabling the scanning process.
- Entering a value manually for devices whose measurements are not telemetered.
- Overriding a telemetered value with a manually entered value.
- Manually entering limit values for an analog point.
- Inhibiting and enabling activities associated with alarmed and abnormal events.
- Operator acknowledgment of alarms.

### KEY BENEFITS

- Rapidly gain access to information and insight into any anomalies
- Power system control is shared with authorized operators
- Powerful and customizable calculations
- Standard displays set and adapt to real-case scenarios
- Historical replays for improvement and audits

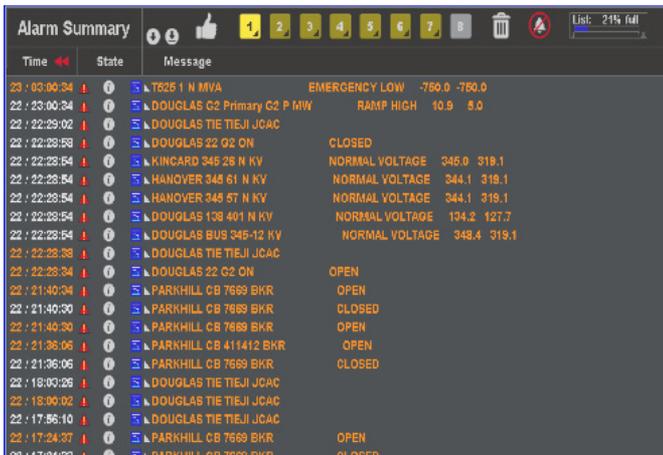
### KEY FEATURES

- Real-time performance
- Flexible calculations adapt to each situation
- Comprehensive processing aligned with network management and control site interactions
- Full operator control
- Integration with power system operation procedures (load-shed, topology, tagging, SBO, etc.)
- A complete catalog of RTU protocols
- Inter-site communication system standards (ICCP, ELCOM)
- NERC CIP compliant
- Full electric connectivity view in real time
- Tagging and safety procedure enforcement

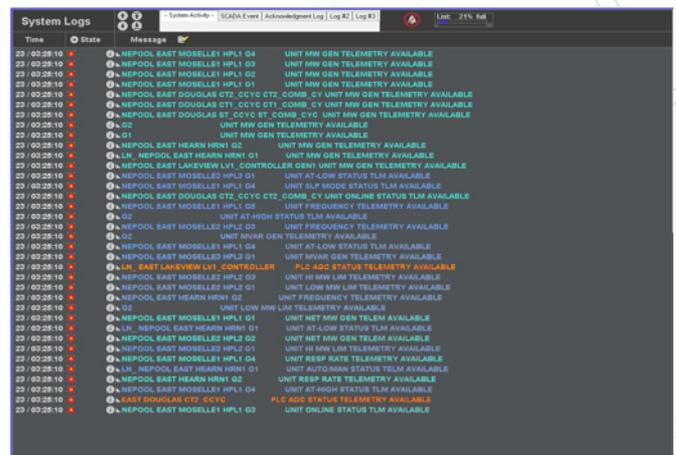
# SCADA Applications: Events and Calculations

## Events and Alarms

SCADA detects and notifies operators of events and conditions in the monitored system that can lead to operational problems associated with a change of state of a status point, measurements, and counts, as well as communication system issues and topology issues. A return-to-normal status may also be alerted. Alerts are provided on displays, the exception list, the system activity log, and the alarm list (and audible alerts if needed).



ALARM LIST



SYSTEM LOGS

## Area of Responsibility

SCADA allocates the control of monitored devices to specific control sites and to an individual operator. This allocation limits which control sites – and which operator consoles – can respond to alarms and events. One or more areas of responsibility are assigned to each device. It can be applied to inter-site data and voltage level.

## Calculations

Calculations can be defined and modified by users based on inputs from SCADA involving mathematical, logical, and comparative functions, as well as conditional branching. Calculated results can replace values from real-time data points.

## Historical data recording

SCADA records and stores data from selected status, analog, or accumulator points, devices, bays, and substations in historical files. Data from these files can later be retrieved in order to reconstruct the SCADA situation at a specific time in the past – or to display measurements for selected values over a specified period. Short-term history can also be saved for selected analog, count or status points.

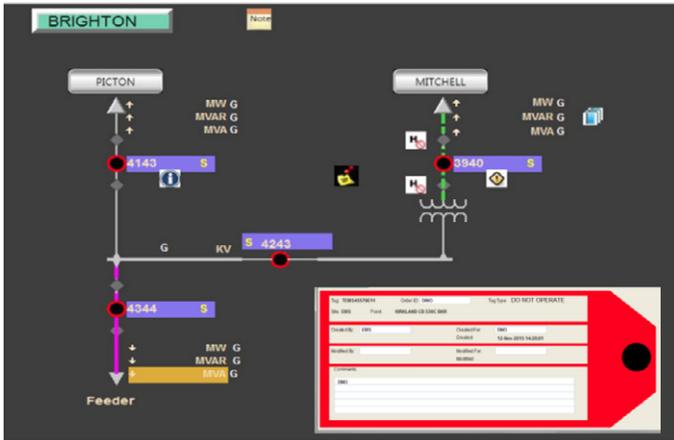
# SCADA Applications: Topology and Tagging

## Topology processing

Topology processing is a determination in real time of electrical connectivity. As input, topology processing uses the static model stored in its database – along with the real-time status of switches and breakers – to compute how they connect to each other. Topology processing results can be used in real time to alert operators in case of a loss of connectivity or de-energization of electrical devices, as well as to show such conditions on one-line displays.

## Tagging: a fundamental application for security

Tagging enables operators to label a device such as a breaker in order to constrain operation of the device – or to alert operators of special conditions in the power system such as maintenance. Tags can be used to alter processing (such as blocking supervisory controls), or they can be informational only. If configured, tags can be inherited from the parent bay and substation. Multiple tags can be configured on one object. Tags are visible and manageable on one-line displays, tabular displays and lists. Tag groups provide additional information on multiple tags (for instance, on a substation).



RED TAG SYMBOL ON SCADA DISPLAY

The screenshot shows a 'TagList (EMS)' window with a menu bar (File, Navigate, HABITAT Applications, EMP Applications, Grid, View, Help) and a toolbar. Below the toolbar, there's a search bar for 'TagList (EMS, LOCALHOST)'. A 'TAG' section contains a prompt: 'Drag a column header here to group by that column.' Below that, a table titled 'TAG LIST with 27 TAGS' is displayed.

	CREATION TIME	TAG TYPE	USER ORDER #	TAGGED OBJECT NAME	CREATED BY	CREATE
+	7/30/2013 5:43:58 PM	[Red Tag Icon]	4123	Switch NEPOOL NORT BRIGHTON 3940 BKR	EMS	tpus
+	7/30/2013 5:43:50 PM	[Yellow Tag Icon]	532	Switch NEPOOL NORT BRIGHTON 3940 STTS	EMS	tpus

TAG LIST SYSTEM LOGS

## Safety documents

A "safety document" is a report that confirms it is safe to perform work on a device in the field, for example, in the case of a line outage. A safety document guarantees that the safety rules have been applied for securing a portion of the network for field work. No work can start until a safety document is issued.

The safety document application tracks the following clearance points:

- When crews are authorized to work in protected areas.
- When crew authorizations have been returned to the dispatcher.
- The status of all tags associated with safety documents.

## Key Benefits

- Full electric connectivity view in real time.
- Tagging and safety procedure enforcement.

# SCADA Applications: Controls, Load-Shedding

## Supervisory control

SCADA allows operators and applications to issue commands to field equipment (RTU, substation automation system, etc.) to move the operating state of a device. Controls can be sent from one-line and tabular displays through a pop-up box. Control can be switching a device (on-off, open-close) or tap control (e.g., raise/lower controls to transformer tap changer). Multiple Controls can be grouped into a single action via a Control Group.

Select Before Operate (SBO) is the standard control sequence for device control:

- Select: designate the device to be controlled. Checks for communication availability, associated points are in service, no blocking tag is placed, device is not in local mode, no control is pending on the same device, and any interlocks are not placed.
- Before: Command is issued to the command chain, but not to the device. Same checks as above apply.
- Operate: the command is sent to the device.

## PID Setpoint Controller

This application provides the ability to control external process control devices – without a setpoint controller – to specific setpoints using SCADA standard outputs.

## Control Sequence Scheduler

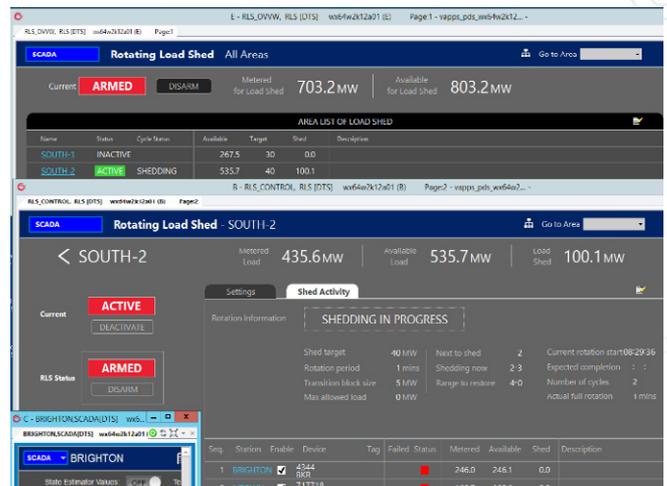
The Control Sequence Scheduler application is used to provide the ability to add, modify, and execute sequences of supervisory controls at scheduled times.

## Load Shed and Rotating Load Shed

The Load Shed application is used to quickly shed and restore load in the power system with many different combinations of loads. Load Shed records all actions and their consequences. Loads are grouped together for shedding or restoring by area, level, and group.

Multiple load-shedding options are available:

- Shed and restore all voltage reduction loads, called “Emergency Voltage Reduction.”
- Individual device shedding and restoration.
- An operator specifies the MW amount to be shed, and Load Shed decides which loads are to be shed.
- Rotating Load Shed allows the load to be shed and restored automatically from a group of loads on a rotating basis at an operator-specified cycle time.
- Rotational Load Shed

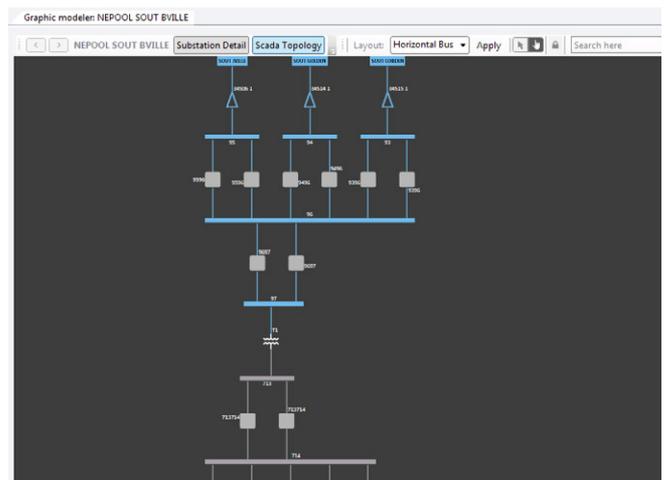


ROTATING LOAD SHED

## SCADA Applications: Modeling

### SCADA Modeling

SCADA data can be modeled using Source (Network Model Manager) or with the online database editor that allows configuration changes to the SCADA database directly on the online production system.



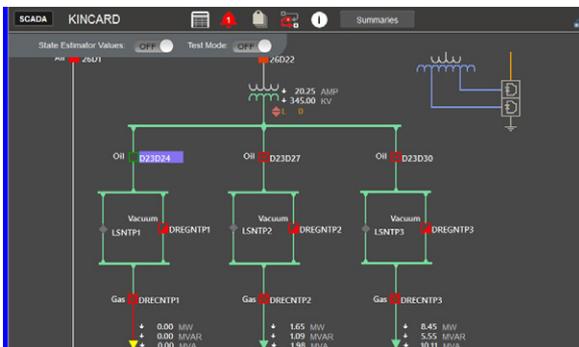
DISPLAY MODELING IN SOURCE

# SCADA User Interface

## Substation displays

SCADA presents substation data in a graphical one-line diagram, displays, and tabular displays.

Both provide operators the current view of the operating state of the devices and allows the operator to issue commands to move devices (such as breakers) or to control the way data is displayed.



SUBSTATION ONE-LINE

Equip Group	Name	ID	Value	Data Quality	INBkt Alarm	System Not in Service	TEST Mode	Mask Tag	Hide Tag
BUS	345-148	KV		Starvation					
BUS	345-149	KV		Starvation					
BUS	345-149	PPA		Starvation					
BUS	345-149	PKV		Starvation					
CB	145149	BKR	OPEN	Starvation					
CB	145149	D1	CLOSED	Starvation					
CB	145149	D2	CLOSED	Starvation					
CB	145149	STTS	OPEN	Starvation					
CB	146148	BKR	OPEN	Starvation					
CB	146148	D1	CLOSED	Starvation					

SUBSTATION TABULAR

## Related displays

From an exception list and summary displays, an operator can navigate to related displays in order to facilitate access to information.

## Operator Notes

Notes are free text an operator can enter on a one-line display, tabular display and exception list. Notes are attached to a point and can be visible or hidden on demand. The Notes application exists in two sets: Full Notes and Notes Light. Full Notes requires advanced service framework and infrastructure, while Notes Light does not and is limited to displays with no attachment. Notes can be comments entered in a comments field, or in a URL field for navigation to a web page or document management system. Notes are replicated on a backup system if configured.

Priority	Description	Created	By
1	...	...	...
2	...	...	...
3	...	...	...
4	...	...	...



User ID	Created	Display	NoteType	Comments
LSREM500	12-Jun-2017 15:44:56	SCADA	HUNTVLL	TEXT
LSREM500	12-Jun-2017 15:44:47	SCADA	MARTEDALE	RED
LSREM500	12-Jun-2017 15:44:39	SCADA	OFFALLE	BLUE
LSREM500	12-Jun-2017 15:44:39	SCADA	CHENAUX	GREEN
LSREM500	09-Jun-2017 12:42:39	SCADA	KIRKLAND	RED

## SCADA Alarms

Alarms are presented to operators who acknowledge an alarm or inhibit/enable alarms from an exception list, alarm display, one-line display, or tabular display. The operator can inhibit/enable an entire bay or substation. Main alarms include Analog limit violation alarms, Point status change alarms, Site communication alarms, Control, Setpoint timeout alarms, Substation, Bay, Device topology alarms, and Remote site or Front End communication alarms.

# SCADA Front End

## Gathering data from the field

The front end's main functions are to manage RTU communications and communication lines, concentrate RTU data, allow data gathering to continue if a SCADA fails, and initiate reporting alarms upon abnormal communications conditions. For SCADA, the acquisition front end provides RTU data acquisition, raw to engineering unit conversion, communications management, and abnormal communications list management. Scalability: each front end can support up to 100,000 measurements and 256 serial device connections.

## Front End RTU Communications and protocols

The Front End application supports both serial and network (TCP/IP) communications with RTUs.

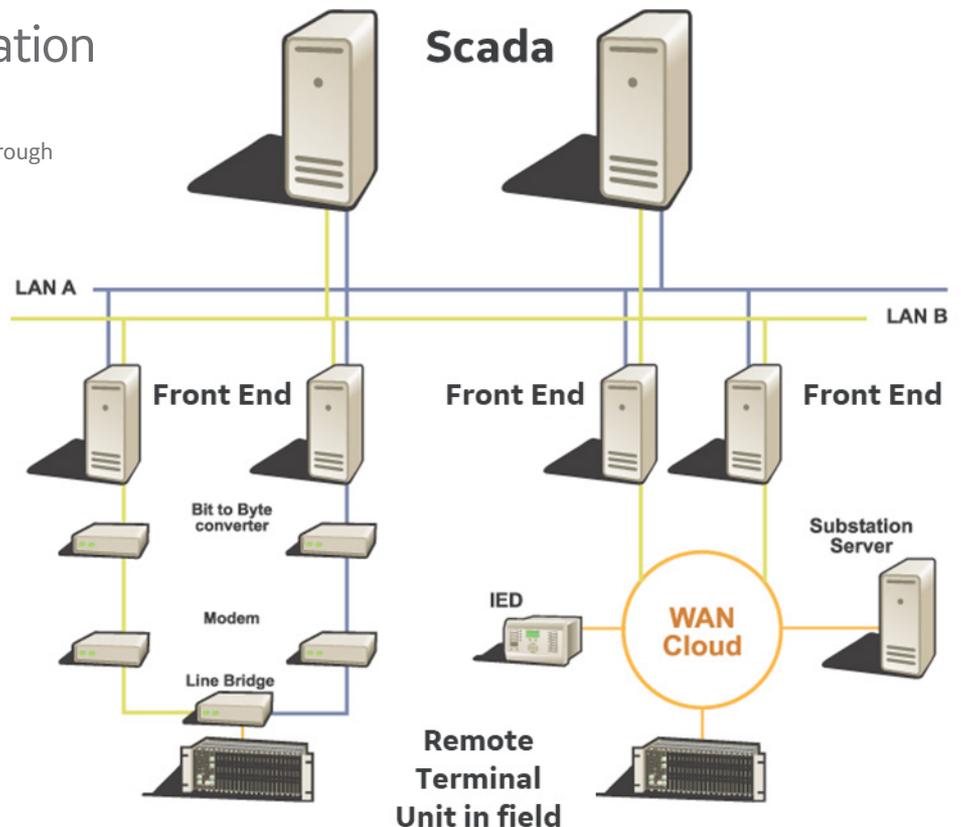
Serial I/O functions are provided by standard asynchronous commercial I/O modules. Isosynchronous RTU communications are provided by an external bit-to-byte (isosynchronous bit-oriented frame to asynchronous bytes) converter module.

Standard data exchange protocols:

- IEC 60870-5-101 Master & Slave (Serial)
- IEC 60870-5-103 (Serial)
- IEC 60870-5-104 Master & Slave (TCP/IP)
- IEC 60870-6 TASE.2 (ICCP) {TLS Security Option}
- IEC 61850 (TCP/IP)
- DNP 3.0 Master & Slave (TCP/IP & Serial)
- Modbus Master & Slave (TCP/IP & Serial)
- Additional 30 proprietary serial RTU protocols

## Front end communication with SCADA

The front end communicates with SCADA through InterSite Data (ISD) protocol.





## Inter-Control Center: Comm

### Communicate with other SCADA EMS control centers

The Comm products communicate monitoring and control data with external SCADA EMS systems. ICCP or ELCOM communications are the protocol used to link non-GE SCADA systems with GE SCADA systems. Intersite-ISM-communications is the protocol used to link GE SCADA systems together when Comm is not required.

Physical connections between sites vary from system to system, depending on data flow and reliability requirements, pre-existing communications equipment, and the distance between sites.

ICCP blocks supported: 1 Basic service / 2 Extended Conditions / 4 Information Message / SBO Device Control / 7 Events / 8 Accounts.

ELCOM 90: ELCOM and Secure ELCOM are supported.

### Comm redundancy with EMS

Each pair of Comm servers has one server (the enabled server) at one site and the other server (the standby server) at another site. The enabled Comm server communicates with the enabled EMS servers at both the active and alternate sites.

## WAMS Phasor Data Concentrator PhasorProcessor

### Capturing Phasor Measurement Unit data for Scada

A Phasor Data Concentrator (PDC) receives multiple PMU data streams and performs stream data rate conversion. Server-based PDCs are capable of supporting 5ms average processing latency for 5,000 PMUs. SCADA EMS Integration runs with the InterSite Data protocol.

Key features of PDC solutions include:

- IEEE C37.118 2005/2011/2014 compliant (including Configuration Frame 3).
- Support for diverse communication protocols (TCP, UDP, Spontaneous UDP, Mixed, Multicast).
- Multiple input/output streams from/to PMUs and PDCs.
- Option for data up-sampling and down-sampling.
- Modern HTML5 interface.
- Data manipulation and augmentation.
- Management of duplicate and redundant data.
- Monitoring of connection statistics and PDC network performance.

### WAMS applications

PhasorProcessor can be fully integrated into GE's PhasorPoint application layer to provide WAMS stability applications and historian capability.



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