

# Advanced Automation Applications

Addressing the digital transformation of power systems and related challenges, GE's know-how and experience has been leveraged to create **Advanced Automation Applications (AAA)**, a dedicated domain within Grid Solutions. Advanced Automation Applications offerings strengthen power system substations both inside and out, making power grids and critical electricity usage safer, more resilient, and smarter. Through Advanced Automation Applications products, GE provides flexible solutions to address the challenge of meeting ever-changing application demands, without any hardware limitations.

The **GE Power Gateway (GPG)** hardware platform is a key offering within the AAA domain, providing a trusted, powerful, and expandable platform. GE's **GPG** software completes the all-in-one solution - including the Configurator (database configuration tool), Concentrator communications driver, Viewer HMI, and Logic Box advanced real-time soft PLC - all in a single platform.

## Key Benefits

- **Cost-effective**  
Monitoring and control combined with advanced automation for a full range of utilities, industrial, and microgrid applications.
- **Scalable**  
Solutions for systems ranging in size from a single bay, to large industrial applications with complex automated functions.
- **Flexible**  
Custom solutions designed and specified by substation automation engineers, with customer-oriented adaptation and quick response times.
- **Ease of use**  
Simplified processes for connecting devices and creating project HMI screens. Short lead times for full monitoring systems supporting multiple devices.
- **Cloud Connectivity**  
Embedded communications provide seamless data transmission and storage.



## Applications

- **Gateway**  
Collects data downstream and sends data upstream through a comprehensive suite of protocols.
- **Monitoring & Control**  
Supports more than 1000 devices, with up to 500 custom views.
- **Disturbance Recorder / eRMT**  
Automatically retrieves oscillography, and saves event logs, metering, and control settings for further analysis.
- **Industrial Systems**  
Provides optimal monitoring, control and automation features to large LV & MV Motor Control Centers and Oil & Gas Plants.
- **Power Generation Monitoring and Automation Systems**  
Integrates power plant electrical components into a single system. A dedicated Electrical Control System (ECS) provides monitoring, control, and diagnostics in power plants.
- **Wide Area Monitoring and Control Systems (WAMCS) and Special Integrated Protection Schemes (SIPS)**  
Strengthening power systems both inside and outside of substations, making power systems and critical electricity usage safer, more resilient, and smarter. Across the Utilities. Across the Industry. Across Microgrids.



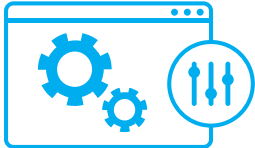
## Advanced Automation Applications - Products

Advanced Automation Application product offerings are all built on the solid foundation of **GE Power Gateway (GPG)** hardware and **GPG** software.

### GPG Software

GPG software is a **single platform** containing the **configurator, concentrator, viewer, and logic box**. This facilitates the functionality of fully-integrated components, and allows for simpler and faster future development. GPG software can run on any Windows-based operating system, providing the flexibility to adapt to a wide range of applications and site-specific demands without hardware restrictions. With easy-to-use GPG software, minimal training is required to achieve expert configuration of all substation automation solution levels. An HMI Server is not required since the GPG acts as a data concentrator, gateway, and HMI Server. This reduces the overall cost, and minimizes system downtime.

### CONFIGURATOR

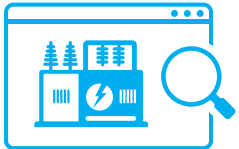


The **GPG Configurator** is used for programming HMI screens and configuring communications, both to downstream IEDs and upstream Level 3 clients (DCS and NCCs)

The Configurator database includes:

- Multi-language support
- Configurable HMI screens, reducing the lead time, cost, and complexity of building a complete system

### VIEWER



The **GPG Viewer** provides a GUI for controlling and monitoring substation systems from a station-level computer. The Viewer includes a series of screens where all substation components can be displayed.

Viewer features include:

- Multi-language support
- Navigation between screens with a single click
- **Vectorial drawings** allowing zoom and pan functionality
- Multiple screens displayed simultaneously, with an optional overview of all opening screens
- The ability to disable/enable communications to IEDs from the HMI client (useful during maintenance or testing operations)

### CONCENTRATOR

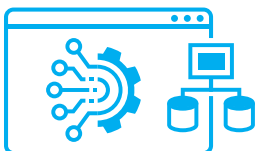


The GPG **Concentrator** runs on the GE Power Gateway (GPG) and is the communications driver that gathers data from IEDs and distributes the data to the different applications, including Level 3 clients and the GPG HMI.

Key Concentrator features include:

- IEC 61850 Ed.2 compliance
- KEMA certification
- Automatic configuration of communications between the data concentrator and HMI
- Monitoring & control of more than 1000 downstream sources and 6 upstream clients
- Database variable refresh of 1 second or less
- **Web server** for historic records and SOE
- **Cloud connectivity** built-in

### LOGIC BOX



The GPG **Logic Box** includes the latest generation of PLC, with a full set of programming tools to develop complex substation level logic using AFB (Automation Function Blocks), such as:

- Capacitor Bank Control
- Substation Reconfiguration
- Load Shedding
- Interlocks and Complex Logic

The Logic Box is directly integrated into the communications driver supporting IEC 61850 GOOSE, and has the PMUs capability for direct logic schemes. It also allows seamless third-party relay integration in the logic. As the engine of Advanced Automation Applications, the Logic Box embedded in an RTOS such as **VxWorks** achieves a cycle time of microseconds even for complex algorithms.

# GPG Software Platform

## CONFIGURATOR

### Projects

The project database is arranged in a folder structure with all project files (database, icd files, HMI images...) gathered together such that one folder contains all essential information needed to modify, update, or run a system.

### Tree Structure

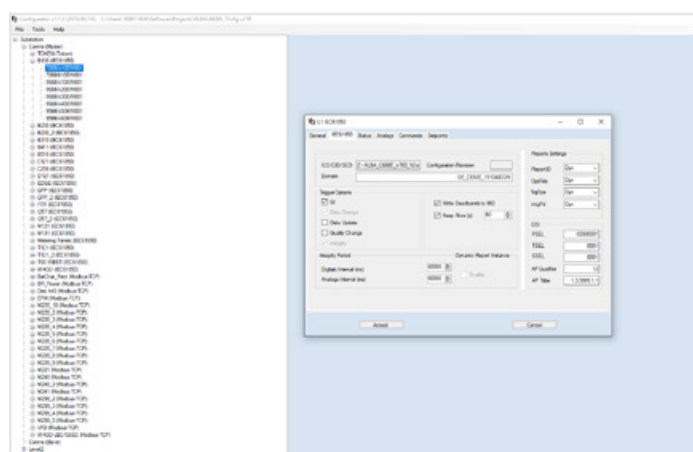
The tree structure allows the user to organize the different devices that conform the substation in groups according to their locations in the system and the communication protocols.

This design provides the user an overview of the system in just one look, simplifying the configuration of the database and reducing the engineering time.

The navigation between the different devices is user-friendly and intuitive, as all the devices and communication levels will be displayed under the same structure.

### Templates

The XML import/export tool helps decrease configuration time. Once one device has been completely configured, an XML file is created to use as a template for other IEDs.



### IED Menu

Under the IED menu, all information related to one device is gathered together in one window. The tab organization facilitates the localization of different IED variables and settings.

### IEC 61850 Ed. 2

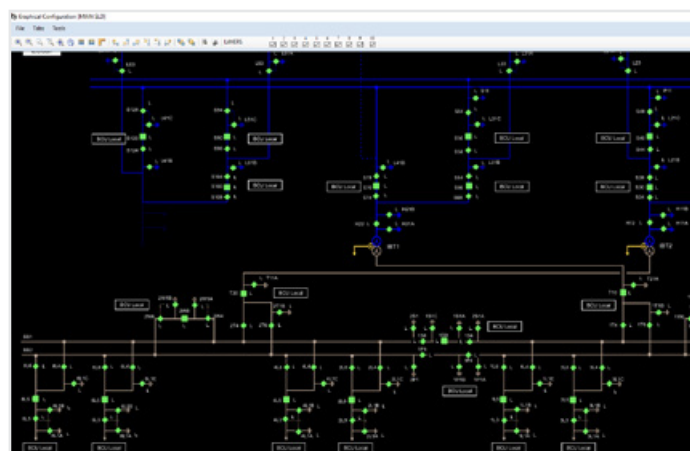
GPG software has been developed according to the second edition of the IEC 61850 Standard.

### Vectoral Graphics

Vectoral graphics (.png, .svg) can be used to represent objects on different screens, with a resolution of up to 1600x1200 pixels.

### Zooming and Panning

The zooming and panning settings can be used during configuration, in order to optimize final HMI views with objects configured to display at different zoom levels. Zooming and panning can be activated by the decluttering option in the tools menu.



# GPG Software Platform

## VIEWER

### Multi-Window

HMI screens can be displayed in a tab or window format. In the window mode, displays can be cascaded, in horizontal or vertical styles, for multiple screen views. This display flexibility along with the GOTO object feature allows the user to switch from one screen to another with just one click, simplifying the navigation process. When the tab structure is selected, a preconfigured tab window displays all active tabs.

### Overview

Zooming and panning functionality allows the operator to view the entire substation within a single display. Graphical objects shown on the overview screen can be viewed in more detail depending on the zoom level.

### Interlocking Representation

A new interlocking display format has been developed, as shown below. The graphical representation of the interlock is done automatically, and the status is refreshed in real time.

### Trending Objects

The trending object function allows for immediate analysis of online measurements being retrieved from the system. Combining various select high-resolution measurements from a complete range of graphical objects in the same screen, along with frozen captures, trending objects provide a flexible tool for data tracking and display. Measurements can be exported directly to an excel file or other format (html, xml) for further analysis or display.

### Alarm Management

The Alarm panel includes a range of useful filtering, grouping, freezing, and sorting options, making it easier to identify and follow sequential alarms related to a single event. Alarm management features are also useful during maintenance and testing operations, when alarms can be filtered out as needed.

Alarm filtering can be applied to a single IED or a group of IEDs, by priority or by time. Different logic operators can also be applied to time filtering:

- Equal to a time stamp
- Greater or less than a time stamp
- By time periods

A color-coded representation of alarms within the alarm panel provides a clear graphical view of alarm status, with automatic updates when alarms are deactivated or acknowledged. Alarms can be acknowledged one by one, for one IED, or for the entire system.





# GPG Software Platform

## CONCENTRATOR

The Concentrator is the communications driver of the GPG Solutions. It creates communication links between the system and the process devices downstream, connecting IEDs, RTUs, PLCs, and so forth, using different protocols as needed. Each protocol has its own characteristics and physical media, therefore interfaces must be constructed accordingly. Use the Concentrator to connect to a remote SCADA or DCS within the plant, or to a Dispatch Center using a variety of available protocols. Configured as a communication gateway, the Concentrator routes information from downstream to upstream.

An online simulation feature within the Concentrator allows any point in the database to be forced, validating the functionality of the system and the upstream communications links.

**GE POWER 5.7.0**  
Exit Alarms Events IED Users Tools Help

**DIGITAL ENERGY** imagination at work **FLEXEFICIENCY 50 - ECS DEMO**

### G60 - GENERATOR PROTECTION RELAY

**STATUS**

- IN SERVICE
- TROUBLE
- TEST MODE
- TRIP
- ALARM
- PICKUP

**EVENT/CAUSE**

- VOLTAGE
- CURRENT
- FREQUENCY
- OTHER
- PHASE A
- PHASE B
- PHASE C
- NEUTRAL/GROUND

RESET USER 1 USER 2 USER 3

CLOSE 52G  
OPEN 52G  
RESET  
RETRIEVE OSCILLOGRAPH

**RELAY**

G60  
T60  
MM300\_lab  
ML 2400-1  
sr350\_Panel  
DC1

Number 50  
Comms: ON OFF

**DIGITAL SIGNALS** ON OFF

Element States - PHASE IOC1  
Element States - PHASE IOC2  
Element States - PHASE IOC3  
Element States - PHASE IOC4  
Element States - PHASE IOC5  
Element States - PHASE IOC6  
Element States - PHASE IOC7  
Element States - PHASE IOC8  
Element States - PHASE IOC9  
Element States - PHASE IOC10  
Element States - PHASE IOC11  
Element States - PHASE IOC12  
Element States - PHASE TOC1  
Element States - PHASE TOC2  
Element States - PHASE TOC3  
Element States - PHASE TOC4  
Element States - PHASE TOC5  
Element States - PHASE TOC6  
Element States - PH DIR1  
Element States - PH DIR2  
Element States - NEUTRAL IOC1

**EVENTS/ALARMS** ON OFF

87G PHASE-B TRIP  
Contact input 3G  
87G TRIP  
87G PHASE-A TRIP  
87G PHASE-B TRIP  
87G PHASE-C TRIP  
51V TRIP  
40 TRIP  
47 TRIP  
32 TRIP  
81U TRIP  
81O TRIP  
59 TRIP  
50/51 TRIP  
100% STATOR TRIP  
87G PKP  
87G PHASE-A PKP  
87G PHASE-B PKP  
87G PHASE-C PKP  
51V PKP  
40 PKP

**INPUT/OUTPUT** ON OFF

Digital I/O States - LED Column x State 1  
Digital I/O States - LED Column x State 2  
Digital I/O States - LED Column x State 3  
Digital I/O States - LED Column x State 4  
Digital I/O States - LED Column x State 5

**MEASURES** Value 78.00 SET

SRC V1 - Auxiliary Voltage RMS  
SRC V1 - Phase AB or AC Voltage Angle  
SRC V1 - Phase BC or BA Voltage RMS  
SRC V1 - Phase CA or CB Voltage RMS  
SRC V1 - Phase AB or AC Voltage Magn  
SRC V1 - Phase BC or BA Voltage Magn  
SRC V1 - Phase DC or BA Voltage Angle  
SRC V1 - Phase CA or CB Voltage Magn  
SRC V1 - Phase CA or CB Voltage Angle  
SRC V1 - Auxiliary Voltage RMS  
SRC V1 - Auxiliary Voltage Magnitude  
SRC V1 - Auxiliary Voltage Angle  
SRC V1 - Zero Sequence Voltage Magn  
SRC V1 - Zero Sequence Voltage Angle  
SRC V1 - Positive Sequence Voltage Magn  
SRC V1 - Positive Sequence Voltage Angle  
SRC V1 - Negative Sequence Voltage Magn  
SRC V1 - Negative Sequence Voltage Angle

**ACTUAL VALUES**

PHASE A CURRENT	14296.2	A	FREQUENCY
PHASE A CURRENT	14294.1	A	REAL POWER
PHASE B CURRENT	14001.1	A	REACTIVE POWER
VOLTAGE Vab	24011.2	V	APPARENT POWER
VOLTAGE Vbc	24111.3	V	
VOLTAGE Vca	24084.0	V	
NEUTRAL CURRENT	150.0	A	
NEUTRAL VOLTAGE	0.0	V	

Nov/20/2011 12:50:44.691 G60  
Nov/20/2011 12:50:38.354 G60  
Nov/20/2011 12:43:08.226 G60

12:51 PM 11/20/2011 EBOP - EPE CONTROL System status 1.3 comm Alarms

# GPG Software Platform

## LOGIC BOX

GE's strong technical background in Advanced Automation Applications has been leveraged to create the engine of the GPG software platform. The IEC 61131-1 compliant Logic Box, embedded in GPG Gateway, makes custom logic easy using the IEC 61850 SCL editor integrated within the PLC editor.

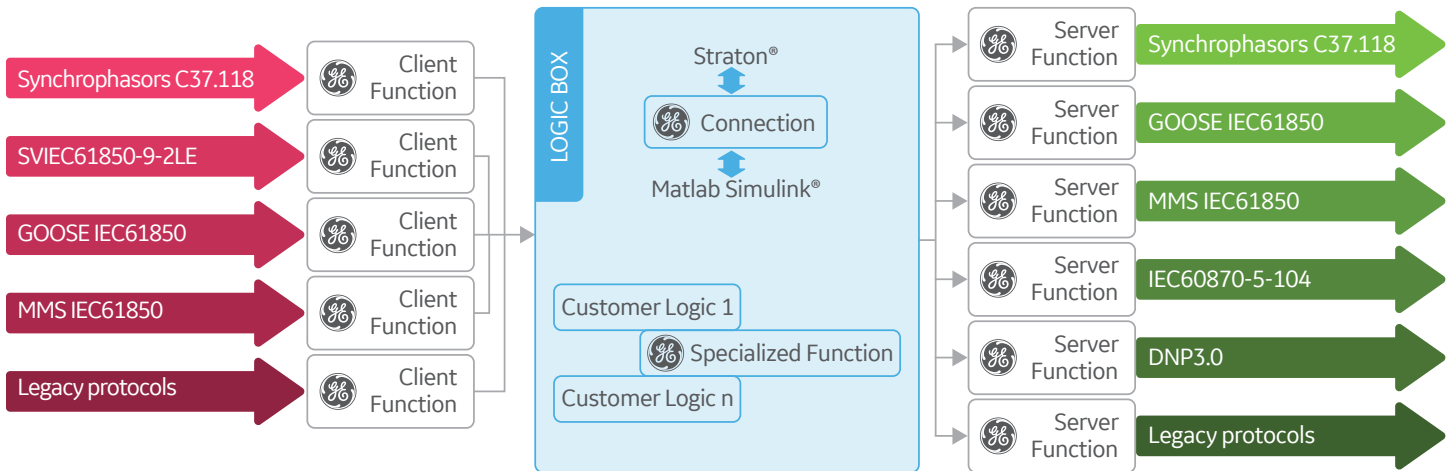
- **Client Functions** allow datasets from different protocols to be combined in the Logic Box.
- **Tailor-made logic** for different applications, through Matlab Simulink and a powerful interconnected SoftPLC.
- **Server/Client functionality** enables communications peer-to-peer, to other clients, or to the dispatch center.

Logic Box supports all five programming languages in the IEC 61131-3 standard:

- Sequential Function Chart (SFC)
- Function Block Diagram (FBD)
- Ladder Diagram (LD)
- Structured text (ST)
- Instruction List (IL)

Powerful tools are available for online debugging and simulation of IEC 61131-3 applications, all within Logic Box. The Log window displays run-time messages sent by targets or the simulator when testing an application. The Spy List is a powerful monitoring tool enabling spy variables in an application at run-time, and builds a list of variables that can be saved and reopened. Simple data-type variables, as well as arrays, data structures, and statements, risk being spied upon. Additional Logic Box debugging tools include:

- Diagnostic information
- Step-by-Step debugging
- Digital Sample trace
- Soft scope



## GE Power Gateway (GPG) hardware



The GE Power Gateway (GPG) is an embedded Application Ready Platform (ARP) designed to shorten development time, while offering rich networking interfaces to fill wide-ranging needs. The GPG series is designed as a total solution for network-enabled Application Ready Platforms.

Leveraging field-approved real-time OS technology, the GPG series provides a Windows-embedded ready solution using RTOS VxWorks 7 with hypervisor Technology, supporting several standard networking interfaces such as Ethernet, RS-232/422/485 and more. Because of its open system, expansion capabilities, and reliable design (fan-less and diskless), GPG hardware forms an ideal embedded platform for implementing the core drivers of Advanced Automation Applications.

### Data Server and Communication Gateway for Substations

The GPG series has been defined and designed to be compliant with IEC 61850-3, which has in turn been described as an international hardware standard for communication networks and systems in power substations.

### 2 Expansion Slots for Substation I/O

The GPG series offer 2 expansion slots for modularized IO plug-in cards. With these expansion slots, the GPG series has the option to become equipped with isolated serial ports, IRIG-B, and a fiber-optical Ethernet interface.

For some applications, a second SSD is required. The GPG series provides an optional SSD kit to install a redundant SSD in the expansion slot.

### Robust I/O Isolates System from Electrical Noise

The GPG series is designed for substation applications requiring a very specific electric interference. Equipped with isolated power and isolated communication ports, the GPG series has a high resistance towards electrical noise. It has proven to not only work well in substations, but it is also suitable for harsher applications in more rugged environments.

### An Industry-Proven Design

Industrial applications require controllers with high-vibration specifications and a wide temperature range. Controllers in industrial environments require flexible and stable mounting, and many machine builders underestimate the need for rugged controllers because their applications are mounted in an industrial enclosure. GPG is specially designed to overcome the weaknesses of standard PCs. To prevent dust and vibration problems, it has no fan, and no HDD. With a smart mechanical design, GPG series can be met with up to a 50 G shock (with CompactFlash), a 2 G vibration (with SSD), up to 70° C operating temperature (tested under 100% CPU loading), and almost any other conditions that an industrial environment demands.

### Designed to Fit in Standard Racks

The GPG series has a standard 2U/19" rack size for easy rack mounting. There are rear I/O connections and indicator LEDs on the front panel for all ports and modes, simplifying monitoring during operation and maintenance.

# GE Power Gateway (GPG) hardware

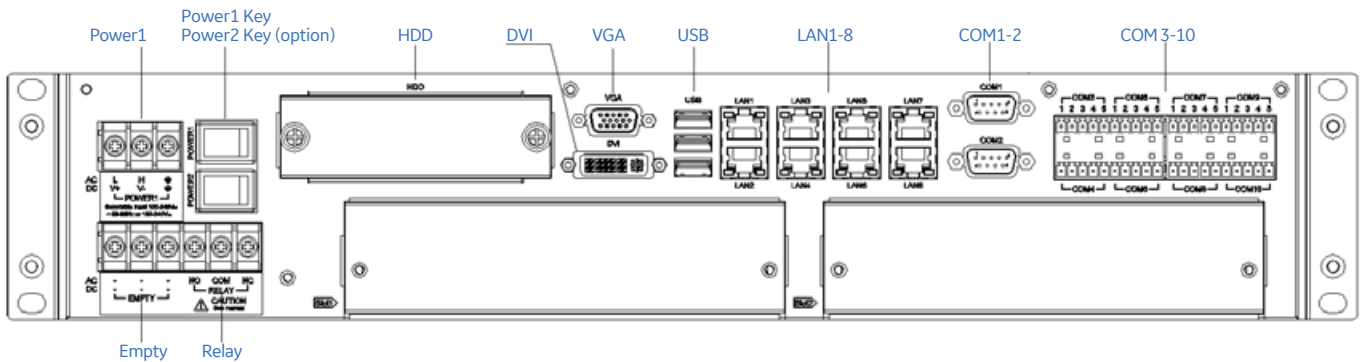
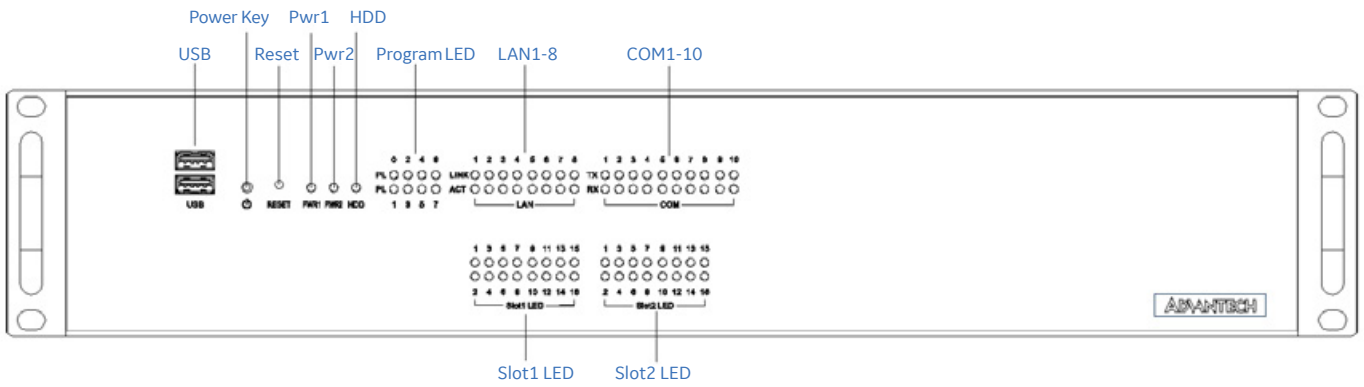
## SPECIFICATIONS

### General

- Certification: IEC 61850-3, IEEE 1613, CE, FCC Class A, UL, CCC
- Dimensions (W x D x H): 2U (440 x 280 x 88) mm (17.3" x 11" x 3.4") fits into a standard 19" rack
- Enclosure: SECC & Aluminum
- Mounting: 2U/19" Rack mount
- Power Consumption: 19W/220VAC or VDC (Typical) Power Requirements:
- AC: 100 ~ 240 VAC (47 ~ 63 Hz) DC: 100 ~ 240 VDC DC: 48VDC with isolation protection, AT
- Weight: 6.0 kg (13.2 lbs)
- System Design: Fanless, with no internal cabling
- OS Support: Windows Embedded RTOS VxWorks for critical real time applications, such as fast-load shedding logic.

### System Hardware

- CPU: 2 options: Intel Haswell Core i7 1.7 GHz (used for high demanded Advance automation applications; Microgrid, WAMS) / Intel Haswell 2980U 1.6 GHz
- Memory: i7 series 16Gb RAM / Haswell Series 8Gb RAM
- Indicators: LEDs for Power, IDE, Programmable LEDs, LAN (Active, Status), power-fail indication and Serial (Tx, Rx) Keyboard/Mouse: 2 x PS/2 connector for Keyboard & Mouse
- Storage SSD: Built-in one SSD 128Gb. Extended temperature. Write protection system. Designed for industrial environments. Display: DB15 VGA connector, 1600x1200 @ 85 Hz. 1 x DVI-D, 1920 x 1200 @ 60 HZ





# GE Power Gateway (GPG)

## GPG TECHNICAL SPECIFICATIONS

### GATEWAY / GPG HMI SERVER (SEE ORDERING CODE)

OS. Windows 10 IOT (embedded)  
 RTOS. VxWorks 7 with Hypervisor for AAA applications  
 OS write protected  
 PRP  
 HSR  
 IEEE 1588 (PTP)  
 IRIG-B  
 Ethernet SFP ports. Up to 8  
 Ethernet RJ45 Ports. Up to 16  
 Serial Ports. RS232/RS485 (Up to 26)

### COMMUNICATION DRIVERS

IEC 61850 Server Ed.1 and Ed.2  
 IEC 61850 Client Ed.1 and Ed.2. KEMA Certified  
 IEC 61850 GOOSE.  
 C37.118 Synchrophasor Protocol. PDC Application and Logics.  
 50 PMUs downstream / 1 PMU upstream.  
 IEC 60870-5-101/104 Server/Client. KEMA Certified  
 DNP3 Master/Slave RTU and TCP  
 SNMP Client  
 NTP client. With Redundancy  
 Modbus RTU/TCP Master/Slave.  
 IEC 6070-5-103 Master.  
 SPA-Bus Master.  
 OPC DA & AE Server/Client.  
 OPC UA  
 EGD Producer  
 Avalanche performance. Tested with 700 events/sec for 48 hours.  
 7,000 events in less than 2 secs  
 Programmable logic  
 Simulation mode  
 Predix and other cloud connection embedded  
 Redundancy. Hot-Hot; Hot-standby (Zero lost)  
 Historic Data Retrieval. Events, Metering, oscillography.

### CYBERSECURITY

Encryption. Between gateway and HMI (TLS 1.2)  
 Authentication. Between gateway and HMI  
 User Management. Radius and LDAP / Pwd encrypted (hash HMACSHA256)  
 Hardening  
 Whitelisting  
 FTPS service  
 Database protected with encrypted pwd  
 Database Signed and encrypted  
 Achilles level 1 pass  
 OS write protected

### HMI FEATURES

In House Solution  
 Scalability. Real Applications for 1 IED up to > 1000  
 Embedded HMI Solution (in GPG gateway)  
 External HMI Solution  
 Resolution. UHD compatibility  
 IEDs Monitoring. >1000  
 Number of points. Unlimited. Tested with >200,000 points  
 Multi HMI. Tested Up to 50 HMI clients  
 Multiwindow  
 Popups  
 SO supported. Win 7, Win 10, Windows Server.  
 Vectoral Drawings  
 Zooming  
 Panning  
 Decluttering  
 Number of Screens. Tested with +400 Screens  
 Interlocking  
 User Management levels per functionality: 10 groups.  
 Unlimited numbers of users Configurable Rights per user  
 5 Rights individually configured per user  
 (Navigation, Operation, User admin, Program Exit, settings)  
 Alarm Management  
 Alarm Groups. Unlimited Groups  
 Alarm Priority. 10 Sound Priority Groups  
 Events Filter  
 Alarms Filter  
 Remote Alarm Notification (SMS)  
 Off/On service function  
 Template screens (For Multiple IEDs)  
 Dual-Language configuration  
 Multilanguage Software  
 Analog Trending objects  
 Historian (events, measures)  
 Historian data export tools. CSV and database files  
 Remote Access  
 Refresh time. < 1sec  
 Simulation tool to validate the database  
 Busbar Coloring  
 Right-Click Menu  
 Operator Dialog. "Yes", when executing commands

### ENVIRONMENT

Operating Temperature -25 – 70 °C (-13-158 °F)  
 IEC 60082-2-2 with 100% CPU/I/O  
 Loading, 24 hrs  
 Operating Humidity 5-95% RH (Non-condensing)  
 Storage Humidity 5-95% RH (Non-condensing)  
 Shock Protection IEC 68-2-27 CFast . 30 G half sine, 11 ms  
 Vibration Protection IEC 68-2-64 (Random 1 Oct./min, 1hr/axis.) CFast.  
 2Grms @ 5-500 Hz

### CERTIFICATIONS

IEC61850-3:201  
 IEEE1613:2009

# GE Power Gateway (GPG)

## GPG CYBERSECURITY

### Security control

- Realization example, notes

### Authentication

- Strong user-to-device and user-to-application authentication (local and remote)
- HMI. User-authentication and single sign-on (SSO), either using user-id and password, e.g. by accessing a directory (ISO/IEC 9594 or LDAP plus SSO addition) or using Kerberos
- HMI. Support of two-factor user authentication technologies
- Device-to-device authentication, e.g. Client-Server-Authentication via X.509-based certificates
- Enforcement of mutual authentication according to IEC/TS 62351-3 in IEC-based communication protocols

### Access control

- Definition of a logical security perimeter, supported through the application of firewalls, remote access gateways, etc. (for local and remote access)
- Enforcement of least-privilege escalation
- Definition and enforcement of role-based access control (RBAC)
- Application of IEC/TS 62351-8 RBAC for access-controlled engineering and operation
- Password policy, e.g.: complexity criteria, aging, etc.; e.g. as provided by ISO/IEC 9594
- Network Segmentation (applying Firewalls and DMZ)

### Integrity

- Application of integrity protection options in SCADA and ICS protocols
- Integrity protection of stored data (e.g. disk, tape)

### Confidentiality

- Application of confidentiality protection options in SCADA and ICS protocols
- Confidentiality protection of stored live data; disk encryption for engineering and control systems
- Confidentiality protection of stored backup data (e.g. disk, tape)
- Application of IEC/TS 62351-3 and -5 confidentiality protection using TLS in IEC based communication protocols
- Access to confidential data following the need-to-know principle

### Monitoring and Logging

- Maintenance and monitoring of computer and network security components, e.g. system event log auditing
- or SNMP v3 application to monitor system events
- Login/account management on control and engineering systems
- Auditing/logging of all automated/scripted login sessions
- Logging of control application access, including user ID, event time
- User activity on control systems while logged in

### Management

- System hardening according to security measurement plans
- Regular security assessments of components (e.g., vulnerability scans)
- Definition and maintenance of roles to support IEC/TS 62351-8
- Incident response (events and alarming)
- Backup and recovery of business and operation-relevant information
- Patch management (organizational part)
- Definition of identification and authentication procedures

### Availability and robustness

- Redundancy concepts for IT infrastructure
- Firewall concepts (DoS protection)
- Connection limitations (Bandwidth, number of connections, etc.)
- Malware protection software/appliances, white-listing
- Backup and restore concepts and procedures
- Application of products supporting a secure lifecycle (product selection should obey security requirements covering the complete product lifecycle)

### Protection

- Protection of business relevant data (e.g. generation data, system status)

## GE Power Gateway (GPG)

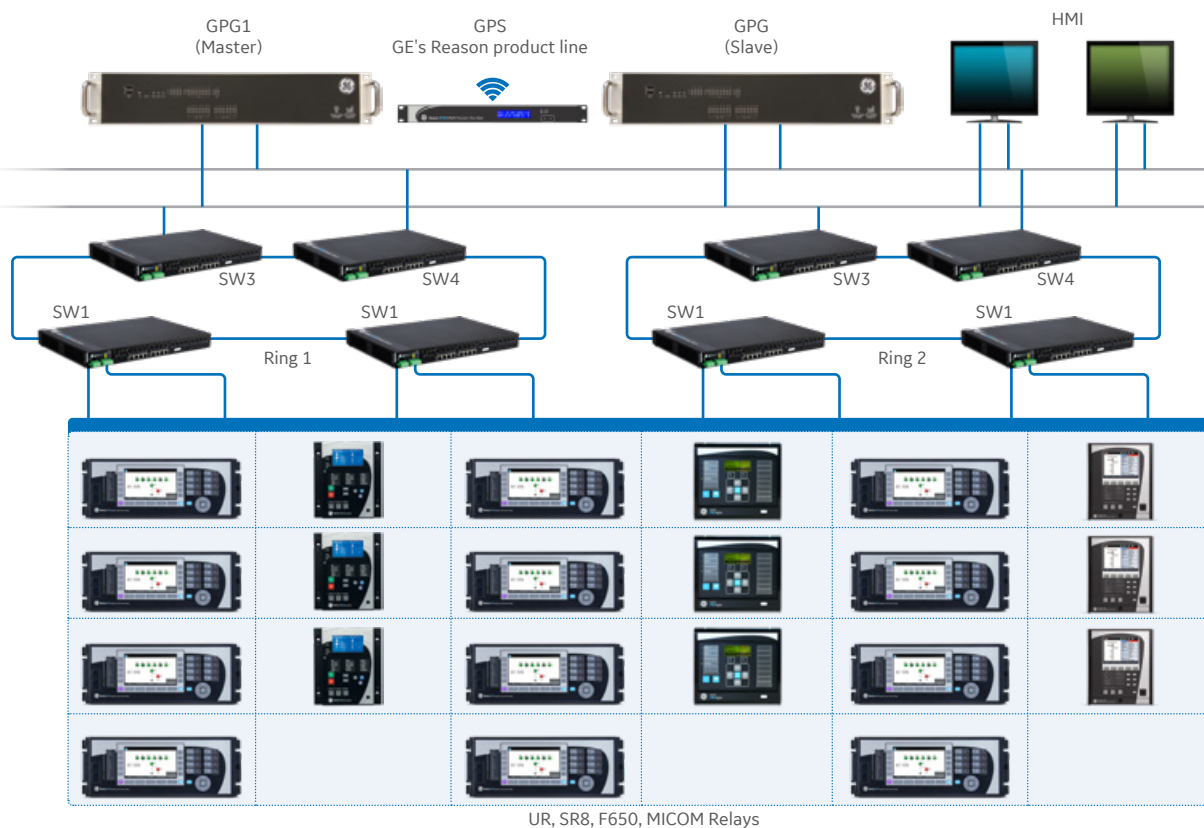
### GPG SYSTEM REDUNDANCY

The GPG Software running on the GE Power Gateway (GPG) offers different types of redundancies, aligning to customer requirements. Combining its specially-designed redundancy with the robustness of the hardware platform, GPG Solution achieves availability ratios of 99.99%.

PRP and HSR are both supported for use in communication architectures, and GPG gateways can be set up in one of two different ways:

- Hot-Standby: With GPGs arranged in a master and slave configuration, the link through which tokens are passed can also be redundant. The master collects data downstream and sends data upstream, with a switching time as low as 250 ms.
- Hot-Hot: Both GPGs work in parallel, collecting data from devices downstream and sending data upstream.

GPG Solution supports up to 50 HMI instances collecting data from the GPG. When using redundancy in GPGs, the HMI running in a separate computer detects automatically the GPG Master. The configuration of more than one IP address for downstream communication is supported for devices that support multiple IP addresses, or for redundancy in downstream IEDs. In this case, the GPG Software communication driver running on the GPG establishes communications through the first IP address, and if no data is received, it switches to the second IP address. When communicating upstream, GPG Solution also provides redundancy through different communication interfaces.













# Applications

GPG is modular solution with an expandable set of functions that can be used aligned with individual needs, resulting in a single-box customized solution.

	UTILITY	INDUSTRIAL	GENERATION	RENEWABLES
SEGMENT				
APPLICATIONS	Monitoring & Control Advanced Automation Gateway Microsystems Cloud connectivity Historian	Monitoring & Control Control > 1000 IEDs Microsystems Gateway eRMT	Monitoring & Control Control > 1000 IEDs Monitoring > 500 Screens eRMT	Monitoring & Control Advanced Automation Cloud Connectivity MICROGRID WAMS SIPS AFBs

## Microsystem Application

The GPG software platform's key compatibility with Windows machines, combined with its effective scalability, make it the perfect application for use in smaller systems where a GPG and real-time applications are not required. One such application is bay-level monitoring and control for microsystems (<10 IEDs) with GPG-licensed software running on a built-in touch-screen computer.

For small applications, GPG capabilities scale appropriately, providing the following main features:

- Panel-mounted resistive multitouch screen or standalone workstation for SCADA control.
- Multi-protocol system to interface with IEDs and DCS/PMS.
- Automatic retrieval of oscillography from P&C relays, generation of a complete SoE list, and analog sampling of historical data.
- Fully customizable HMI for local monitoring and control.
- Redundant Ethernet and Serial communication ports available.
- 1 ms resolution time-stamping with IEC 61850 Ed2.



## eRMT Applications

Electrical Remote Monitoring Tool (eRMT) applications provide a centralized event-logging and disturbance recording system, aligned with remote monitoring strategies, all through the GPG software platform. This ensures SLA response times for electrical asset events. In this application, licensed software runs as a Windows service, centralizing events, while oscillography and settings modifications run on locally monitored HW.





# Monitoring & Control Systems with Embedded Advanced Automation Applications

Supporting a vast variety of legacy protocols and compliant with IEC 61850 Ed.. 1 and 2, GPG-based systems collect data from downstream devices and report data to remote control centers, such as National Control Centers (NCC), while the HMI generated by the GPG Solution graphical editor empowers operators with complete monitoring and control of the system. The configuration of a GPG-based system consists of one single database file, including the Master/Client interface downstream, the Slave/Server interface upstream, and graphical configuration of the HMI. This single-file design reduces engineering effort and simplifies maintenance.

The GPG software platform includes an IEC 61131-3-based Programmable Logic Controller (PLC) module for maximum data processing and control. GPG effortlessly links the PLC with the unique database facilitating system engineering, the development of Automation Applications, and the interactions and relative priority between such applications. Automation Applications include the following:

### Automatic Transfer of LV disconnectors:

An automatic function controlling the supply of the LV auxiliary services board. In case the incomer connected to the LV board is tripped or open, the function automatically closes the alternative incomer to maintain the supply of the LV board.

### Sequential Controls:

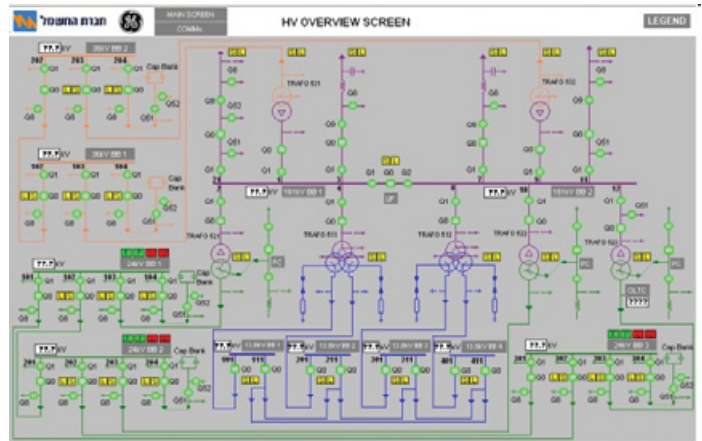
A pre-defined sequence of controls run to open and close a set of disconnectors and/or circuit breakers. The running sequence is continuously monitored, and if any control fails to execute, the sequence is automatically stopped and an alarm is raised.

### Power/Voltage/Frequency Load Shedding and Restoration:

In the event of pre-defined under-voltage/frequency conditions, the function automatically sheds loads to preserve stability of the power system. Once the voltage/frequency magnitude is recovered, the function restores the loads previously shed following a pre-defined priority sequence. Load Shedding and Restoration functions can run in one or over several busbars, including isolated busbars, coupled busbars, etc.

### Date/Time Control of Capacitor Banks:

A timer function initiates controls on a pre-defined date/time basis to automatically close or open the circuit breaker of the Capacitor Bank. Operators can define multiple date/time periods when the Capacitor Bank is meant to automatically close or open, after having confirmed that all the interlocking conditions are fulfilled.



This is a control panel for 'SE QUALIFICACAO - AUT. GERAIS'. It displays several status indicators for different parts of the system, such as 'Automatizacoes MT', 'Destacado / Repeticao Tensao', and 'Destacado / Repeticao Frequencia'. Each indicator has a green 'Desligado' (Off) button and a red 'Ligado' (On) button. There are also numerical displays for 'T. Contato Repetido' and 'Tempo Passageiro'. The interface is clean and professional, with a clear layout for operator interaction.

This block contains two control panels for capacitor banks. The top panel is for 'BATERIA CONDENSADORES 1' and the bottom for 'BATERIA CONDENSADORES 2'. Each panel includes a 'TABELA HORARIA ESCALAO 1' and 'TABELA HORARIA ESCALAO 2'. These tables show the status of capacitor banks across different time periods (1st and 2nd periods) for various days of the week. The tables have columns for 'Dia Semana', 'Ligado', 'Desligado', 'M', 'Mn', and 'Mx'. The interface also includes a 'REGULADOR TENSAO' section with various control parameters and buttons.

This is a control panel for 'SE QUALIFICACAO - AUT. MT1'. It features a detailed status table for capacitor banks. The table has columns for 'Fase' (Phase), 'Modo' (Mode), 'Estado' (Status), 'Prioridade' (Priority), and 'Modo' (Mode). The rows represent different capacitor banks (C1 to C10). The interface includes various control buttons and a legend. The overall design is consistent with the other automation screens shown.

## Industrial Systems Applications

GPG Software provides a simple, cost-effective, and technically complete solution for protection and control integration in Motor Control Centers, Oil & Gas Plants, and Industrial plants. System architecture is distributed and scalable, and consists of IEDs, a communication network, one or various HMIs, and a set of optional remote links to dispatching centers (DCS), maintenance operators, engineering offices, etc.

When IEDs in an MCC are linked through communications within a GPG system, the protection and control capabilities extend to the whole system, with tools to manage any MCC or dispatch center, as well as retrieve all necessary states, measurements, events, and records independent of system integration software. GPG solution is scalable, supporting both small systems (20 devices or less) and very large systems (more than 1000 devices).

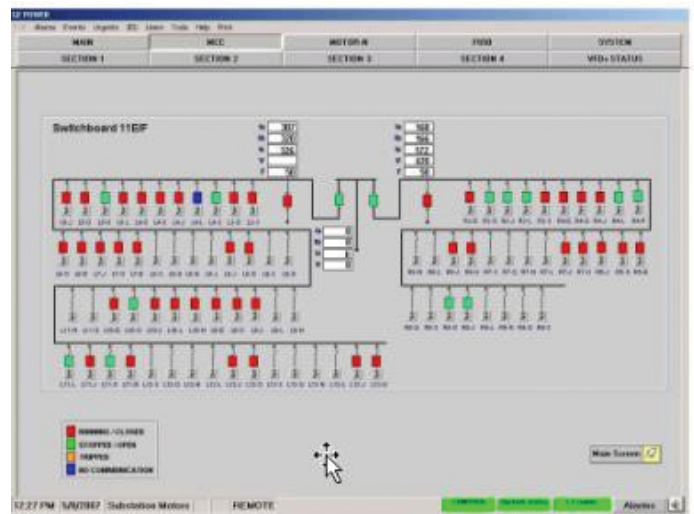
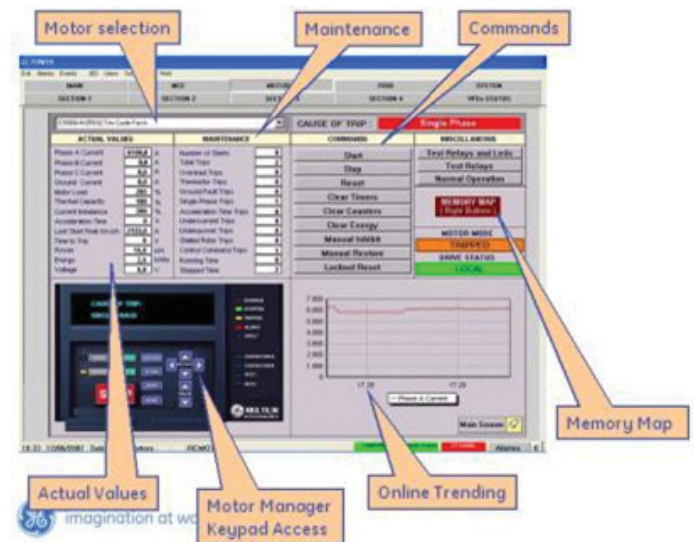
Thus, there are GPG architecture solutions for single/multiple system concentrators, with HMI and communication channels at every level. The operator HMI includes a graphical display of MCC one-line diagrams, and other user-configurable screens, equipment statuses, integrated alarm and event recorders (per IED and MCC level), metering and waveform records, and access to setting changes and command execution.

The GE Power Gateway (GPG) plays a key role covering and mixing different types of communication architecture, such as multiple serial devices (up to 26) over RS232 or RS485, or multiple Ethernet interfaces in RJ45, or fiber optics in multimode and single mode.

Optionally, connections to remote dispatching centers can be provided within a GPG system. Advanced Automation Applications have proven experience communicating with Honeywell, Hyundai and Yokogawa DCS systems when sending information upstream, with connections established using different protocols: Modbus RTU/TCP, DNP3, IEC101/104, OPC-UA.

In general, GPG systems replace the following conventional equipment:

- Local and remote mimic panels, and related equipment
- Synchronization equipment panels and related equipment
- Alarm panels
- Event recorders
- Remote data collecting units





# Power Generation Monitoring Applications - ECS

Today's power plants are following the market move to digital, using smart distribution incomer/feeder breakers, as well as MCC starters, such as Intelligent Electronic Devices (IEDs) with electrical dedicated protocols (IEC 61850, for example), and moving their processes to smart instrumentation and values (protocol Foundation Fieldbus and Can open, for example) managed by a Turbine Controller platform. The move to digital power plant design provides the data necessary for remote advance monitoring, predictive signals, and remote configuration.

GPG software and GPG Hardware form the basis of GE's **Electrical Control System (ECS)**, a complete solution including software and distributed logic for the automation and monitoring of electrical systems. ECS collects, controls, and monitors electrical data from IEDs, such as protection and control relays from HV Switchyards to LV motor starters and DC/UPS sub-distribution. The multiprotocol ECS platform provides the flexibility and scalability necessary to integrate multivendor devices, and a level of adaptability that allows it to be used regardless of scope, integrating from 1 to 1000 IEDs. With ECS, processing and electrical worlds are independent, all the while remaining highly integrated, using the same Control Room Engineering and Operator Workstation HMIs, alarm management system, and historian. ECS does not interfere with Mark Vie's platform process control, which remains focused on daily plant processes. ECS significantly reduces the wiring required for control, supervision, and automation functions, with IEDs now communicating through various protocols and an Electrical Data Highway (EDH) connecting all devices together.

The concept of ECS is not new. It is an application of the well-established GE GA Standard Scada used in substation automation since 1999, later expanded to power plant applicability with the first-generation release of 9HA GE turbines.

The ECS system can be implemented at any frame size and is conveniently available in three packages, ranging from minimal to full digital plant solutions.

**ECS Package 1** provides advanced control and monitoring for the smart equipment in a conventional plant, such as Generator and Transformer Protection Panels (GPP/TPP) and HV switchyards. Package 1 is fully integrated within Workstation HMIs used by the gas turbine/steam turbine controller.

**ECS Package 2** expands to include gas turbine, steam turbine, and generator auxiliary distribution with smart MCCs, in addition to the features provided by Package 1.

**ECS Package 3** is a full digital plant solution, and includes complete plant BOP auxiliary distribution supplied by GE and optional partner products (when the BOP and DCS use the Mark Vie platform).

**Package 3**  
Full digital plant

**Package 2**  
package 1 + GT / ST smart auxiliary distribution

**Package 1**  
ECS for GPP / TPP and optional HV switchyard

**Control Room**
**LEVEL 3**

- Engineering / operator workstations, gateways, historian, alarm management...
- Operator interfaces
- Shares data to other (NCC, Predix...)

**Concentrator**
**LEVEL 2**

- Packages data and sends it to workstations
- Transmits operator-initiated commands from HMI to IEDs
- Converts data using different protocol (keeping source time stamping)

**IEDs including relevant protection, control, and communication**
**LEVEL 1**

- IED ← Mark Vie for motors only
- IED ← ECS concentrator for all IEDs
- IED ← IED (e.g. ATS)

**Hardwired I/O**
**LEVEL 0**

- Sensors collect data from plant (CTs, VTs, position feedback...)
- Actuator provides commands to plant (Close / Open command, permission...)

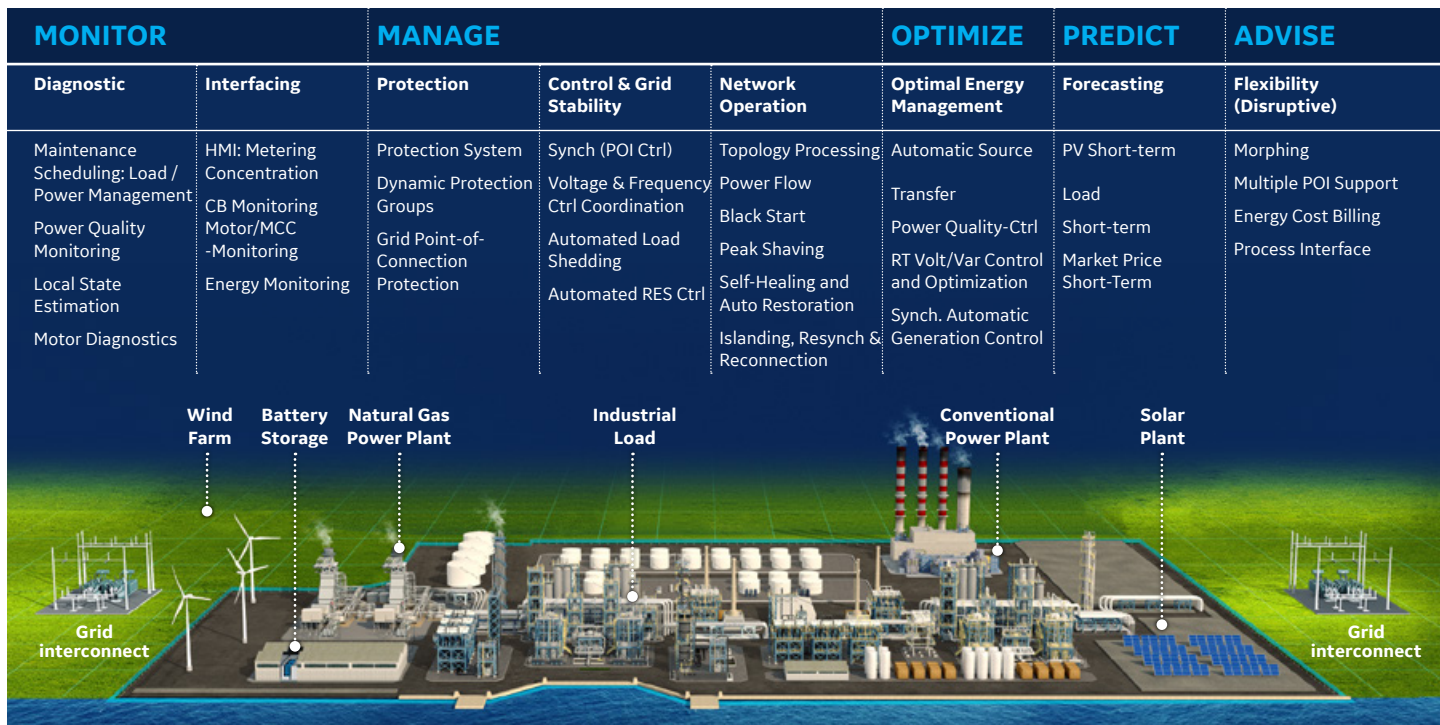
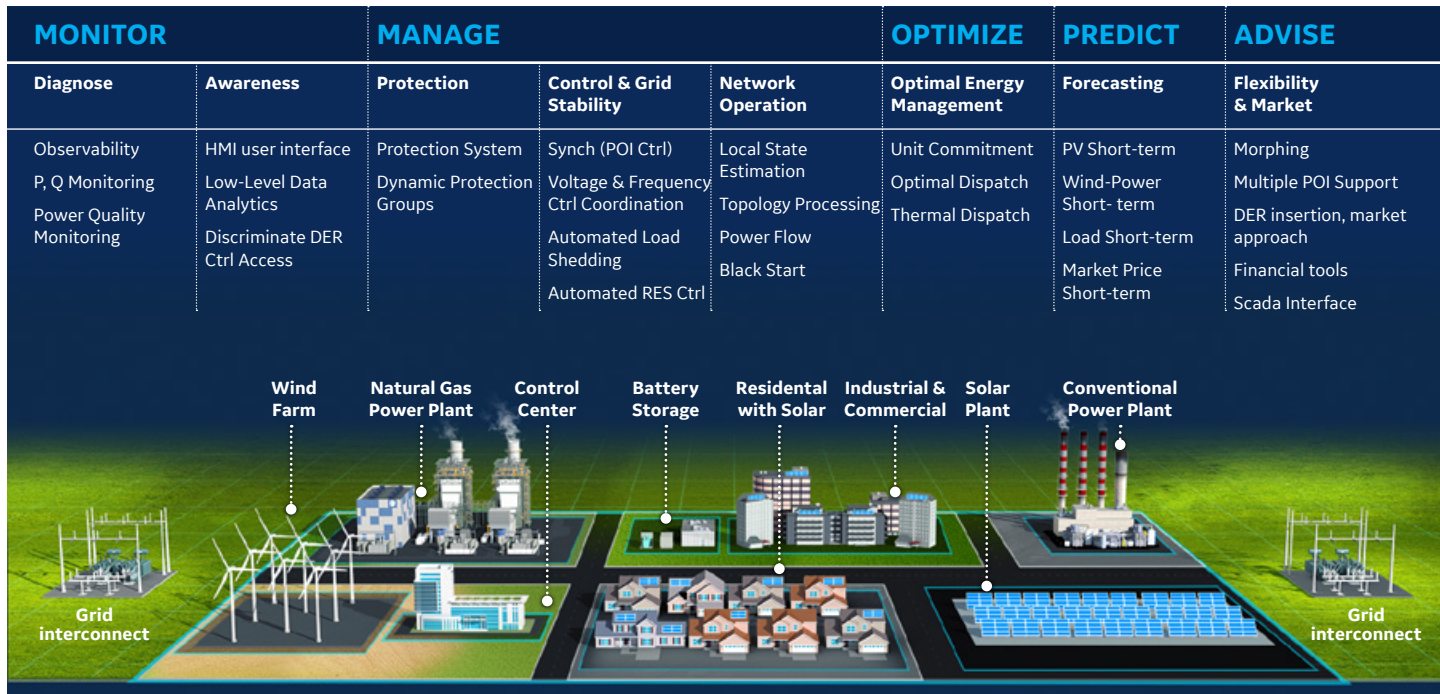


# Advanced Automation Applications in Utilities and Industrial

With the proliferation of renewables and distributed energy resources, the growing use of electronic power elements such as HVDC links and FACTS, new market requirements, and a need for more intelligent asset-monitoring, customers are facing new complexities and system challenges. As a trusted partner, utilities and industrial customers globally are working with GE to implement solutions that will deliver power system reliability, security, efficiency, and the cost controls needed to operate the modern grid.

To address today's challenges, GE Grid Automation offers a flexible set of Advanced Automation Applications (AAA) embedded in the expandable GE Power Gateway (GPG) hardware platform. An engine within the GPG running on VxWorks as RTOS, with GOOSE, C37.118 and IEC 61850-9-2 stacks - a very powerful PLC engine and an embedded or external HMI with the latest features- makes the GPG a reliable, fast, and deterministic solution. Logic, algorithms, and HMI are fully-configurable, with settings that can be customized to be sent from the HMI as settings tailored to completely different algorithms.

Across utilities, GPG Solution includes the following functionalities, as well as a Wide Area Monitoring & Protection Systems (WAMPS), SIPS:



# Advanced Automation Applications in Microgrid

GPG Solution is suitable for Microgrid applications, acting as a Microgrid Central Controller (MGCC), customizing applications to maximize Microgrid value, optimizing operations using simple load forecasts (electric), and forecasting power production capabilities. The optimized operating scenario is achieved by controlling micro sources within the Microgrid, sending control signals through IEC 61850 Ed.2 to individual generation units (Wind Farms, Hydro Power Plants, PV plants, and Fossil thermal plants). Using GPG along with the customizable GPG HMI, the system can be customized to configure any possible settable values to be read by the algorithms, as well as event recording, alarms, and a single-line diagram view of the Power System. Using GPG as an MGCC, the following Microgrid Applications are available:

## OPTIMAL DISPATCH

GPG includes a supervisory control layer for the Microgrid, monitoring the state of all resources within the system. The dispatch algorithm is processed and resulting control actions are sent back to each DER. Inputs to the system include the power generated by each DER and the power consumed by each load. Control actions include starting/stopping a DER.

## VOLT/VAR CONTROL

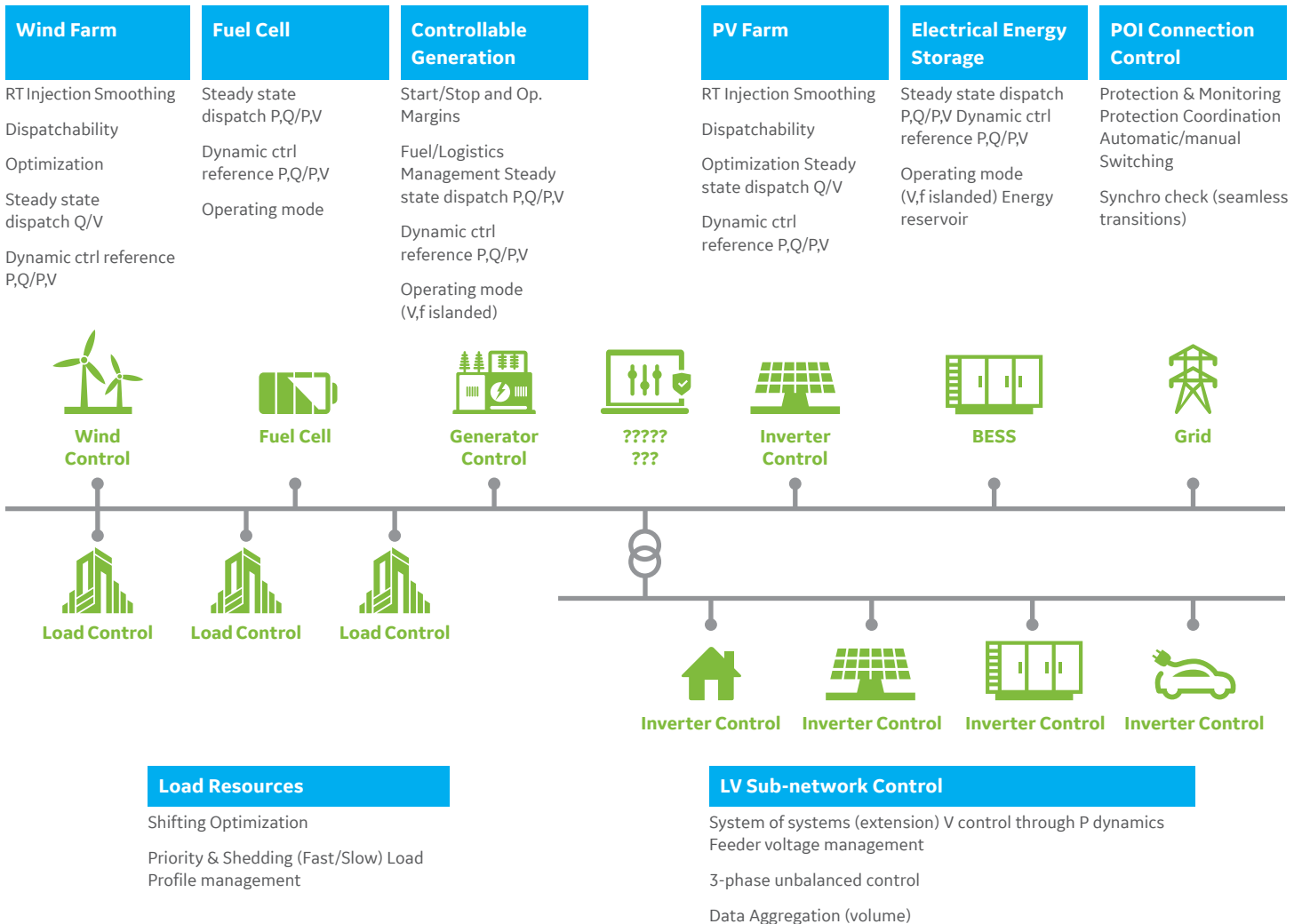
GPG includes applications for Volt/VAR compensation for the voltage drop caused by reactive power flows over an inductive line. Actions to the generators or inverters can be executed, complemented with control signals to the capacitors or the tap changers, which are able to inject reactive power to the grid.

## ENERGY EFFICIENCY

All functionality provided by the GPG system works to obtain the highest possible energy efficiency in terms of power management, optimizing power generation, and power consumption inside the Microgrid. Using Volt/VAR control, for example, it is possible to increase local distribution network efficiency by optimizing and flattening the voltage profile, and by maximizing reactive power injection into the local distribution network.

## AUTOMATION AND CONTROL

GPG monitors and sends commands to each generating source and energy storage unit through an IED located locally at DER locations. These IEDs perform real-time measurements of load or generating units and communicate back to the GPG, as well as receive commands from the GPG to control parameters, such as active and reactive power combined with voltage on dispatchable generators.





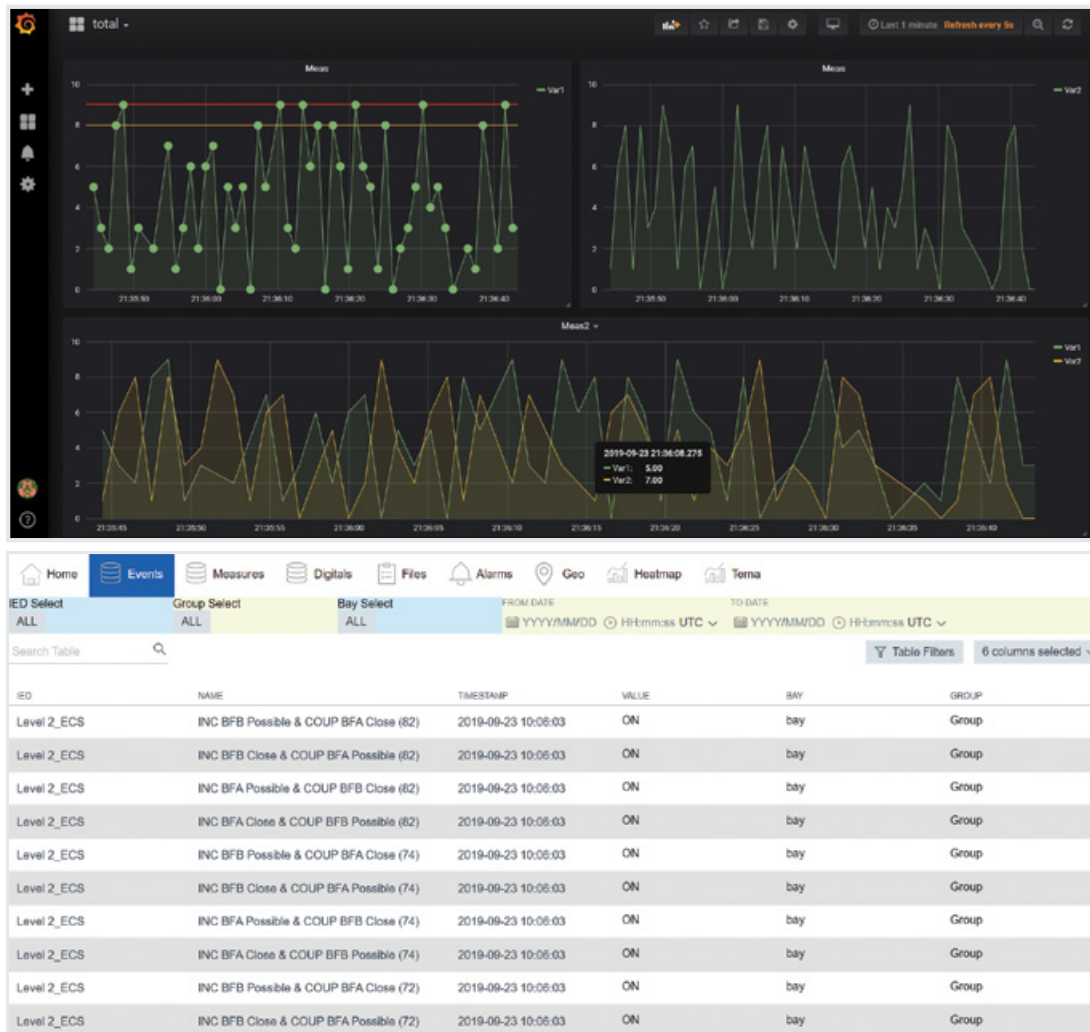
# Web Server & Cloud Connectivity

GPG has a built-in Web Server that allows real-time monitoring of events, digital and analog signals, and analysis of historic data from any computer or mobile device with a web browser. As an option, this Web Server can be installed in the Cloud.

Events, and digital & analogs signals are saved in the Cloud, allowing the operator to access them from any computer or mobile device using a web browser.



Historic files and oscillography files can also be stored in the Cloud, making them available to download for further analysis.



# Order Codes

## ORDER CODES FOR GPG HARDWARE

POSITION	GPG	-	-	--	--	XX	--	000	DESCRIPTION
		1							HW Revision. 8x 10/100/1000Mbps 10BaseT RJ45 + 5x USB + 2x DB9 RS232 serial ports + 8x Isolated Terminal Block RS232/422/485 serial ports
5		S							Standard Applications
		E							Enhanced Applications (including RTOS and Advanced Automation)
6,7 (Slot 1) 8,9 (Slot 2)				XX	XX				None
				IB	IB				IRIG-B + 4x Isolated DB9 RS232/422/485 serial ports
				RS	RS				8x Isolated DB9 RS232/422/485 serial ports
				SC	SC				4x 100Mbps SC Multimode Fiber Optic ports
				G1	G1				2x SFP 1Gbps LC Multimode F.O. ports + 2x PRP/HSR SFP 1Gbps LC Multimode F.O. ports *
				G2	G2				2x SFP 10/100/1000Mbps RJ45 ports + 2x PRP/HSR SFP 10/100/1000Mbps RJ45 ports *
				M1	M1				2x SFP 1Gbps LC Multimode F.O. ports + 2x PRP/HSR SFP 100Mbps LC Multimode F.O. ports *
12,13							HI		Redundant AC: 100~240 VAC (47~63 Hz) DC: 106~250 VDC
							LO		Redundant DC: 38~58 VDC
14, 15, 16								000	Application Type

\* Delivery time could be affected. Please refer to your GE sales contact for further details.

\*\* For GE internal use.

## ORDER CODES FOR GPG SOFTWARE

POSITION	LIC	-	-	-	-	000	DESCRIPTION
5			M				Main license: Drivers, HMI, Configurator
			L				Lite (< 15 IEDs)
			A				Additional license: additional HMI
7					S		Software license
					D		Dongle license

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