

GE
Digital Energy

Modular Substation Automation Systems Overview



imagination at work

Today's Environment

More than ever, utilities around the globe are facing an increasing number of challenges related to maintaining aging assets, improving grid stability, reducing costs, and complying with regulatory policies.

Aging Infrastructure: With the majority of electrical infrastructure approaching or at the end of its design life, innovative monitoring and control is required to ensure reliable power flow across the networks.

Grid Stability: Generation / load imbalance is driving the need for advanced monitoring and control of network devices and loads to maintain grid voltage and frequency stability.

Legacy Intelligent Electronic Devices (IEDs): Legacy IEDs are approaching or at the end of their design life, driving utilities toward replacements.

Aging Workforce: The transfer of domain knowledge and expertise is impacted by experienced workers who are retiring.

Changes in Environmental Regulation and Policies: Increasing awareness regarding environmental and climate change is influencing how solutions are implemented.

Cost Reduction: Utilities need to limit capital and operating expenditures without impacting reliability and security of supply.

Proliferation of Technology: Faster adoption and penetration of modern technology is driving utilities to make quicker business decisions in regards to infrastructure and ever-evolving technology options.

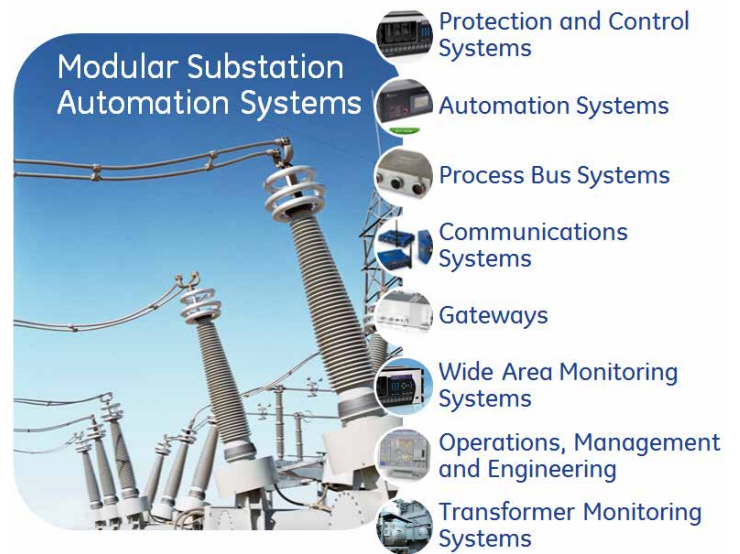
During the planning phase of a substation project, GE works side-by-side with customers to ensure that the system addresses the organization's business and technical objectives.

Business Objectives	Technical Objective
Increased asset utilization	System performance
Increased life extension	Safety
Cost reduction	Reliability
Reduced project duration	Network efficiency
Changing workforce	Adoption of open standards
Compliance to regulations, standards and policies	Cyber security
Reduced outage times during construction Ingress protection	

GE's Solution

GE's Modular Substation Automation Systems offering brings together an extensive portfolio of products, services and engineering excellence to deliver the next generation of substation systems for our customers that address the challenges of legacy substation systems.

GE's Modular Substation Automation Systems offering can be pre-designed, pre-packaged and pre-tested to suit our customers' philosophy and needs.



Designed with scalability in mind to support a broad scope of projects ranging from large transmission to small distribution substations, the systems are also flexible to support several applications including power generation, transmission and distribution, wind and solar collector substations, heavy industries, mining and oil and gas.

Working in partnership with customers, GE's engineers have developed the Modular Substation Automation System offering based on critical customer requirements to address both technical business objectives and unique application requirements.

Customers have experienced several benefits as a result of deploying GE's Modular Substation Automation Systems including:

- A 30% reduction in project design cost compared with traditional substation solutions.
- Reduced operating and maintenance costs through integration with multiple vendors using GE's open architecture and standards adherence.
- Reduced design costs using GE's architecture and tools to standardize the design for a range of substations.

Our Experience

Pioneering key advancements for the past 100 years, GE continues to lead the way in protecting, monitoring and managing substation systems, providing industry-leading global experience to our customers.

GE continues to be a world leader in substation automation by continually introducing advanced products and systems, and providing experienced engineering teams for system design and installation. Coupled with local knowledge, GE helps ensure the needs of customers are met.

GE's Modular Substation Automation System Offering Summary

GE's Modular Substation Automation Systems include a wide range of solutions to suit customers' specific requirements and provide benefits such as improved network reliability, improved service restoration, reduced operating and maintenance costs, and enhanced visibility and control.

Integrated Protection and Control, Modular Automation System	Integrated Automation System	Modular Protection and Control Systems with or without Process Bus
<p>A pre-engineered, pre-packaged and pre-tested system that delivers:</p> <ul style="list-style-type: none"> • A protection & control (P&C) system • Communication systems • Automation systems • Process Bus system • Cyber security compliance 	<p>A pre-designed, pre-packaged and pre-tested system built on gateways, remote terminals units (RTUs) and communication devices that delivers:</p> <ul style="list-style-type: none"> • Automation gateways • Secure communication • Modern HMI 	<p>A fully integrated, modular solution set comprised of:</p> <ul style="list-style-type: none"> • Pre-engineered protection modules • SCADA gateways • Legacy IED integration • IEC 61850-9-2 Multilin HardFiber Bricks • Panel mounted HMI

Did you know?

GE was one of the first to introduce the modular platform concept of protection relaying with the development of the Multilin™ Universal Relays (UR).

Did you know?

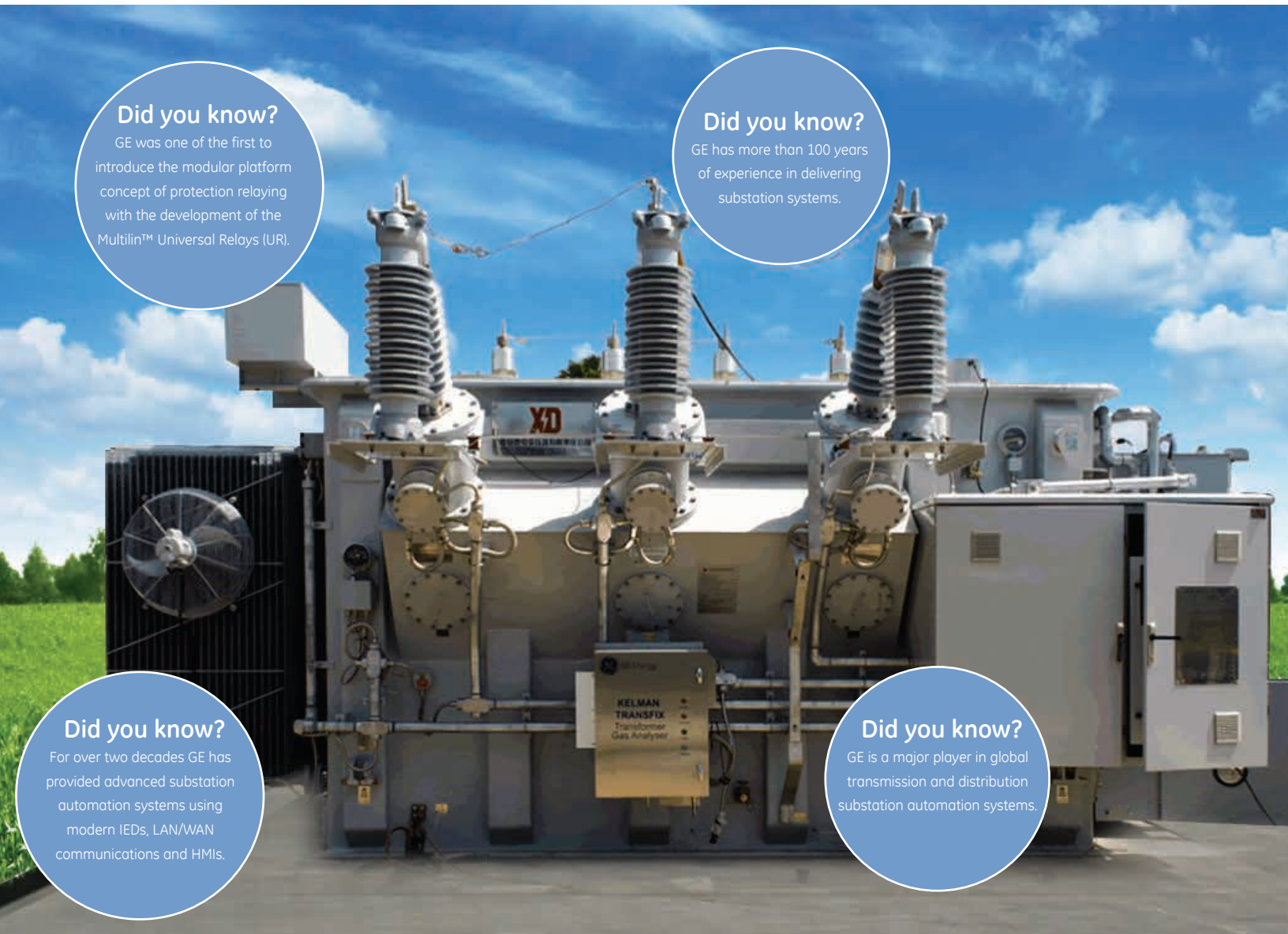
GE has more than 100 years of experience in delivering substation systems.

Did you know?

For over two decades GE has provided advanced substation automation systems using modern IEDs, LAN/WAN communications and HMIs.

Did you know?

GE is a major player in global transmission and distribution substation automation systems.

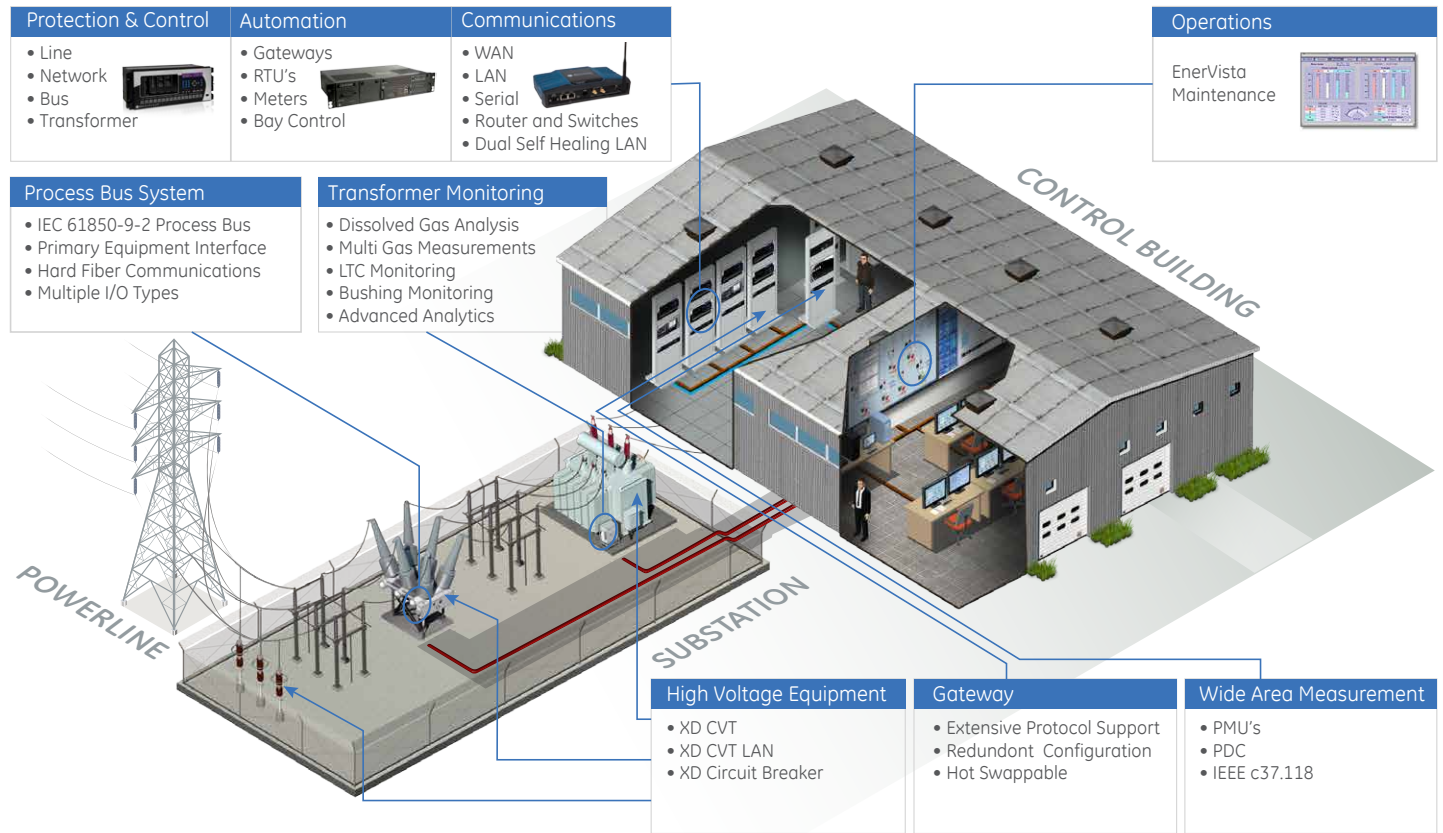


Integrated Protection and Control, Modular Automation System

GE's Integrated Protection and Control Modular Automation System is a pre-engineered, pre-packaged and pre-tested system that is:

- Designed using GE's modular Multilin™ Universal Relay (UR) and UR^{Plus} relays, the system is connected with GE's Multilin HardFiber system eliminating the extensive use of copper wires in the control room and in the field. Customers can realize a 50% saving in cabling, trenching and conduit and this system can be deployed faster than legacy methods. The system can be pre-packaged in a modular control house and dropped in or built to reside in a control room.
- A communication architecture built on industry leading MultiLink™ Ethernet switches that can deliver higher network availability, redundancy with Parallel Redundancy Protocol (PRP) and high throughput.
- An automation System built on GE's cyber secure Multilin D400 gateway delivering IED station bus integration with capabilities to integrate the substation to an enterprise Energy Management or Distribution Management System.
- Cyber security compliant across the entire system design.

Integrated Protection & Control System Capabilities



Key Benefits

- Reduced engineering, testing and maintenance requirements with highly reliable and virtualized P&C schemes
- Increased network communications reliability with built in redundancy and abstracted communication technology in the P&C system
- Advanced cyber security automation complying to NERC® CIP standards and providing advanced substation interlocking and alarm systems
- Improved situational awareness through the advanced HMI
- Up to 30% reduction in engineering resources, up to 70% reduction in design and construction resources and up to a 40% reduction in project cycle time

Features

- Modular and pre-packaged P&C engineered systems
- Drop in control houses
- Cyber security compliance
- Validated communication architecture
- Redundant fiber optic self-healing WAN and LAN (PRP)
- Virtualized protection and control schemes
- Substation human machine interface (HMI) for monitoring and control
- Substation automation and enterprise integration

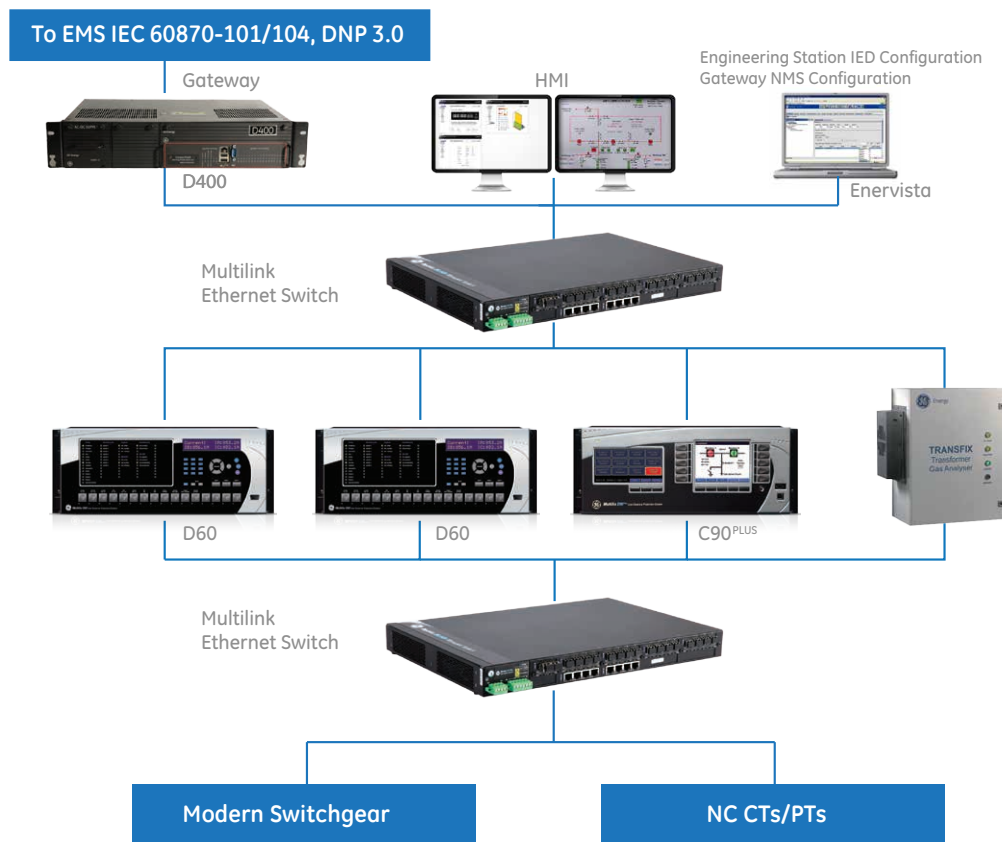
Integrated Automation System

GE's Integrated Automation System provides the next generation substation system with pre-designed, pre-packaged and pre-tested automation system designed for transmission and distribution-type applications in new substation builds and retrofit projects. Approximately 30% of global transmission and distribution systems around the globe have been automated using a variety of GE technology, allowing customers to accelerate project implementation and increase cost savings.

Built on industry leading gateways, RTUs and communication products, such as GE's MultiLink Ethernet switches, the Integrated Automation System provides:

- A highly available and reliable network for connecting substation IEDs using MultiLink Ethernet switches.
- Automation gateways that can integrate modern IEDs to legacy IEDs to electromechanical devices for collecting both operational and non operational data.
- Flexible and secure WAN communications utilizing GE's MDS™ industrial wireless devices and Lenronics™ JungleMUX Multiplexers for SCADA EMS integration as well as teleprotection applications.
- A modern HMI which delivers real time view and control of the substation and IT assets complying to IEC® 61850 and other standards.

Integrated Automation System Components



Features

- Highly interoperable automation system
- Simplified configuration and redundancy
- Merging of P&C, Automation and IT departments

Station Bus - P&C

- Virtualization of P&C schemes and interlocking
- Interoperable with Process Bus
- Multi vendor interoperability

Process Bus - P&C

- Non conventional signal measurements
- Virtualization of measurement and control
- Interoperable with Station Bus
- Transformer monitoring
- Dissolved gas analysis
- Multi gas measurements
- LTC monitoring
- Bushing monitoring
- Advanced analytics

Key Benefits

- Improved service restoration
- Enhanced network visibility and control
- Secure and highly available communications network with PRP support that is simple and easy to configure
- Pre-configured to accommodate legacy systems
- Simplified system alarms and complex substation interlocking throughout the system
- Compliant NERC CIP architecture

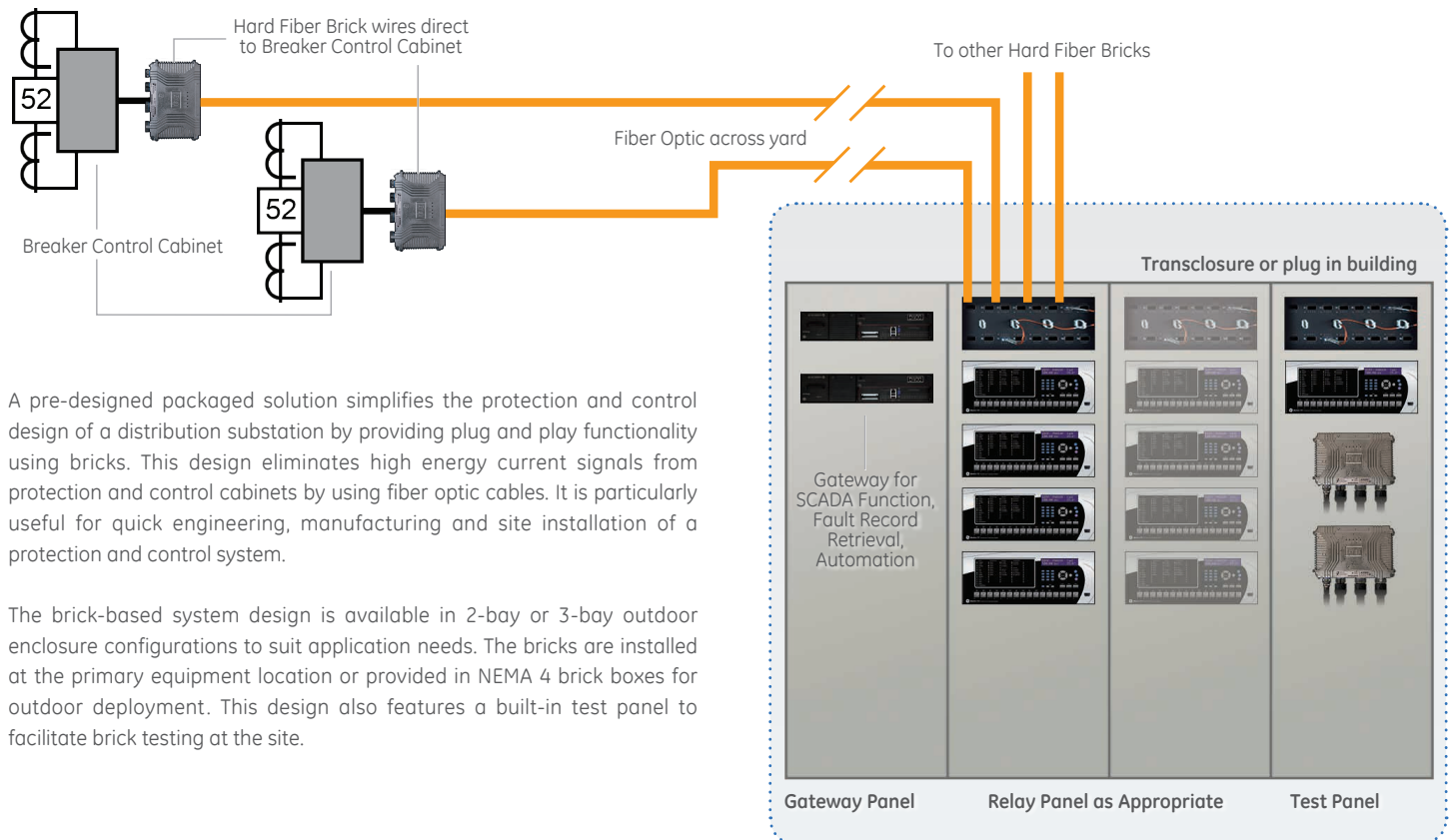
Modular Protection and Control System with Process Bus

GE's Modular Protection and Control System with Process Bus consists of a pre-built and pre-commissioned protection and control system based on the Multilin HardFiber system and includes protection and control schemes for transformer, bus bars, and feeders. The offering is designed for transmission, distribution, solar and wind interconnect and collector and industrial substation applications.

This system uses pre-commissioned HardFiber Bricks in mounting cabinets connected to pre-commissioned relay panels using fiber optic cables. The system can help customers reduce costs for cabling, trenching and conduit as well as decrease installation and commission costs due to less labor-intensive installation. The modular approach of this system allows customers to drive down project costs and reduce project cycle times. Once installed, the system provides customers with reduced maintenance and total cost of ownership.

IEC 61850-9-2 Brick-Based Optional Design

An IEC 61850-9-2 brick-based solution with pre-packaged plug-in protection and control, typically used in distribution applications to simplify the protection and control design and to provide overall accelerated project delivery cycles.



A pre-designed packaged solution simplifies the protection and control design of a distribution substation by providing plug and play functionality using bricks. This design eliminates high energy current signals from protection and control cabinets by using fiber optic cables. It is particularly useful for quick engineering, manufacturing and site installation of a protection and control system.

The brick-based system design is available in 2-bay or 3-bay outdoor enclosure configurations to suit application needs. The bricks are installed at the primary equipment location or provided in NEMA 4 brick boxes for outdoor deployment. This design also features a built-in test panel to facilitate brick testing at the site.

Key Benefits

- Decreases project costs, such as engineering design and site acceptance, resulting in substantial economic benefits
- Reduces cycle time driving accelerated customer acceptance and project duration
- Integrates multi-vendor legacy protection relays and devices to advanced technologies
- Provides a platform for additional levels of automation, reducing cost and enhancing efficiency
- Enables faster service restoration and improves system reliability through better visibility and control
- Reduces total cost of ownership by using the modular designs, significantly lower than custom panel design

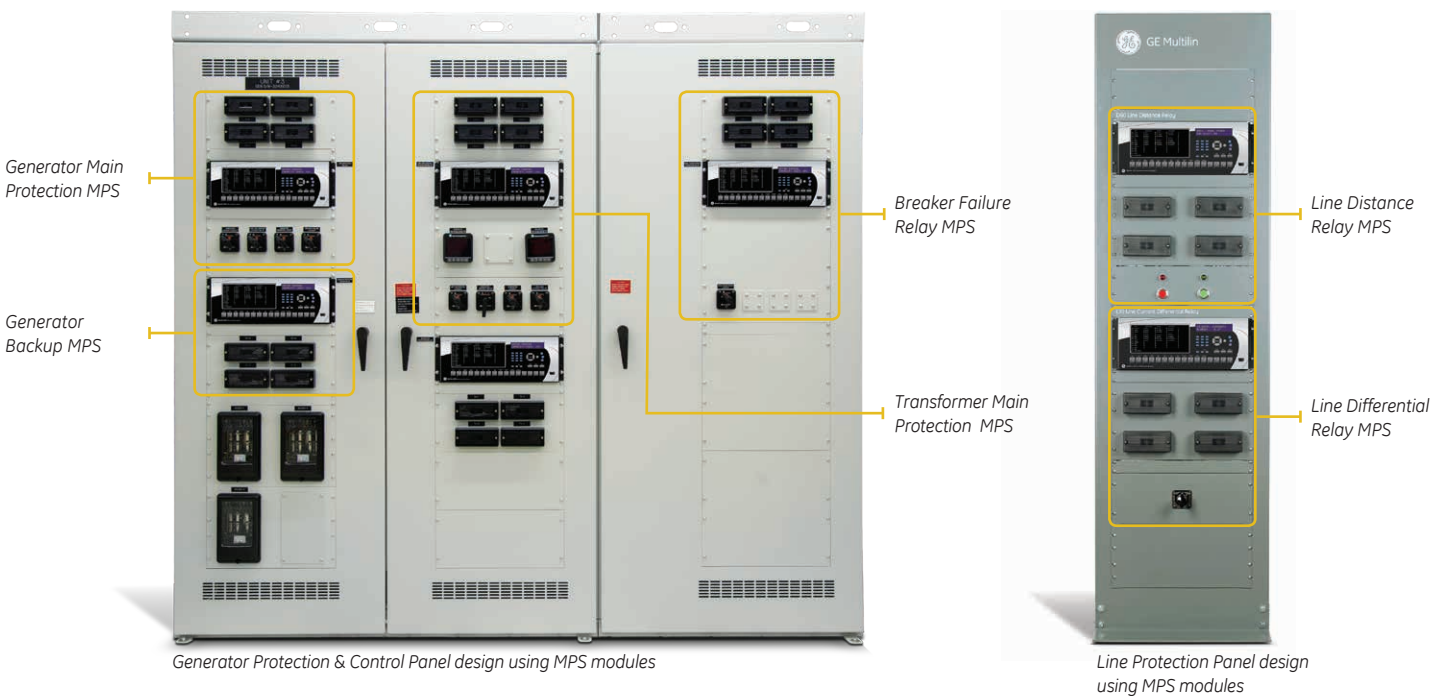
Modular Protection and Control Systems without Process Bus

GE's Modular Protection and Control System without Process Bus provides a flexible and fully integrated modular solution set based on GE's Modular Packaged Solutions (MPS). Modular Packaged Solutions are comprised of engineering, design, manufacturing assembly, wiring, testing and commissioning support for protection and control of power system applications. Adhering to GE's world class quality and control standards, MPS features seamless integration with legacy and multi-vendor devices and systems.

Steps to Customize Protection Panels with MPS Modules

Step 1	Step 2	Step 3
<p>Select pre-designed, configurable MPS modules for your application</p> <p>Select the MPS modules from the following typical application library to best fit your application needs. Configure your panels with one or more (typically up to three) MPS modules for your application and desired functionality.</p>	<p>Select auxiliaries from extensive GE device libraries</p> <p>Select auxiliary devices such as Ethernet switches, RTU gateways, meters, etc. to best fit your needs. GE provides a typical range of the above mentioned devices, but more options and devices are available for your protection and automation applications.</p>	<p>Select an enclosure for your panel from variety of available options</p> <p>Select the enclosure from typical protection panel enclosures and racks to best fit your application. The selection below provides a typical range, but we can also support more types/designs as needed.</p>

Demonstration of Modular Packaged Solutions for Protection Panel Design



Key Benefits

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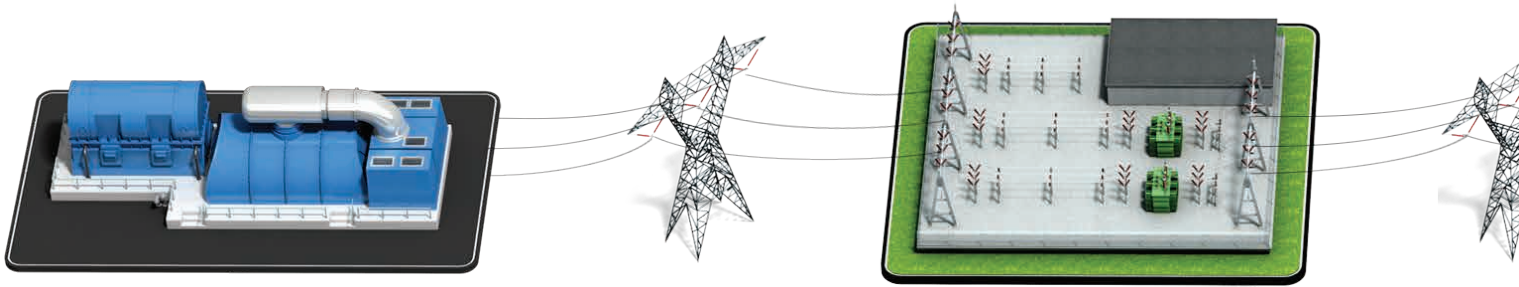
Packaged Solutions for a Wide Range of Applications

Generation

GE provides fully integrated protection, control and automation packaged solutions for a range of small to large size generators, ensuring safe operation, and protecting these key power system assets from a variety of fault conditions and anomalies. GE's Packaged Solution's generator protection and control solution features ANSI and IEC compliant main protection devices and auxiliary components and subsystems.

Transmission

GE provides protection, control and automation packaged solutions for variety of power transmission applications such as HV/EHV line protection, large transformer protection, and high or low impedance bus protection systems to name a few. These solutions are designed and manufactured to address a multitude of customer challenges ranging from installation constraints to rugged environmental applications.



Generator Protection and Control Solution

- Leverages advanced GE protection relays
- Fully integrated, tested packaged solution
- High quality workmanship and accelerated delivery cycles

Advanced Bus Protection and Control Solution

- Pre-designed, configurable advanced protection schemes
- Bus differential protection and control package
- Engineered solutions for custom transmission applications



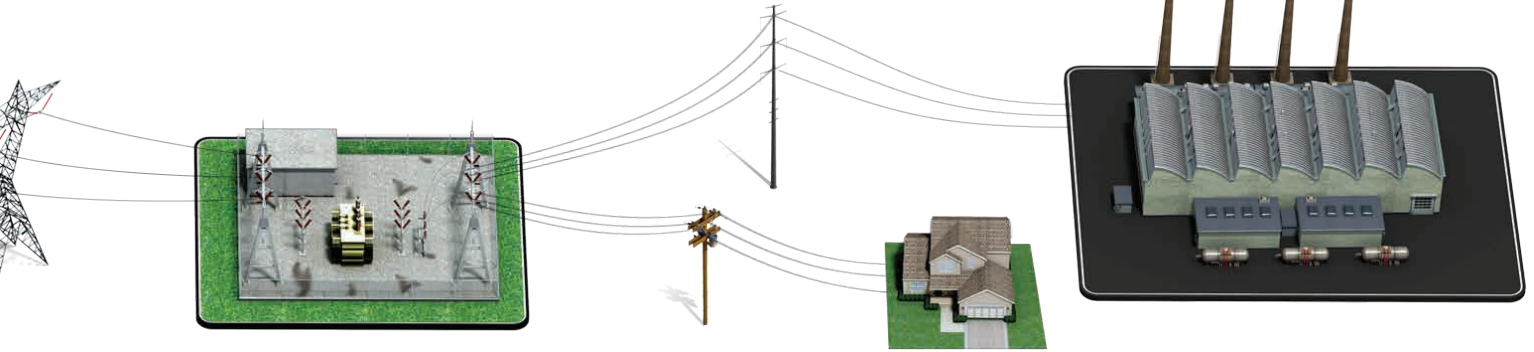
Advanced GE Generator Protection and Control Packaged Solution used for protection of large gas and steam turbines.



Advanced Low Impedance Bus Protection and Control Packaged Solutions used for complex bus topologies.

Distribution

GE's Packaged Solutions offer smart distribution applications minimizing customer downtime and improving safety and reliability in power distribution networks. The standard pre-designed modular packaged solutions reduce the total solution cost while providing state-of-the-art protection, control and automation capabilities.



Automation & Industrial

GE provides a range of RTU automation and industrial protection and control packaged solutions for medium to large industrial and utility applications. These solutions are provided as indoor, outdoor or pole-top solutions and are used for green-field and brown-field installations.

Pre-designed Distribution Solutions

- Pre-configured modular protection and control solutions for distribution applications such as feeder, transformer and breaker
- Designed for indoor or outdoor applications
- Library of designs for common distribution applications to pick from

Automation and Industrial Solutions

- Customized RTU solutions for variety of applications
- Supported by large host and IED protocol libraries
- Fully configured, factory tested solutions reducing installation and commissioning time at site



Distribution Protection and Control Packaged Solutions.



Industrial RTU Automation and Protection Packaged Solutions examples.

GE Modular Substation Automation Systems Core Technology Components

Protection and Control



Multilin UR Platform

The Multilin UR platform refers to the hardware, protection, software and communications features common to all UR family members. The UR platform is the building block for modern substation protection, control and data communication solutions.



Multilin UR Plus

Based on the Multilin UR platform, the Multilin URPlus delivers high-end solutions for complex protection, control and automation applications.



Multilin F60

The Multilin F60, a member of the UR family of protection relays, provides feeder protection, control, monitoring and metering in one integrated package.

Communications



Lentronics Fiber Optic Multiplexers

Lentronics is a leading global supplier of rugged telecommunications solutions for electric utility, pipeline, transportation and industrial applications. The Lentronics Multiplexer family offers T1, SONET and SDH standards based solutions for both short and long range applications over optical fiber and other media.



MultiLink Ethernet Switches

The MultiLink family is a line of industrial and substation hardened Ethernet switches that deliver secure, reliable communications. Designed for the protection and control industry, the MultiLink Ethernet Switches ensure networks are always available, fast, and secure.



MultiNet1000 Router

The MultiNet1000 is purpose-built for extremely harsh environments such as power utility substations, and meets IEEE® 1613 and IEC 61850-3 specifications for EMI/ESD protection.



MDS Industrial Wireless Communications

MDS is the world's leading single-source, end-to-end wireless solution provider. From wellhead monitoring to utility substation automation, our wireless devices are packaged for industrial environments and have been rated and tested to harsh industrial specifications.

Gateways and RTUs



Multilin D400

The Multilin D400 is a secure, substation-hardened gateway that collects metering, status, event, and fault report data from serial or LAN based Intelligent substation devices.



Multilin D20MX

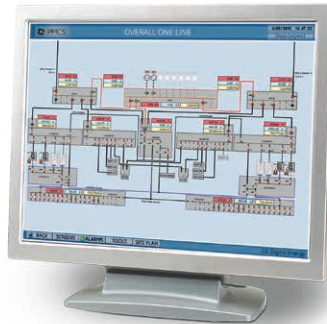
The Multilin D20MX Substation Controller is backwards compatible with earlier versions of D20 RTUs. The D20MX enables users who have standardized on Multilin D20 architectures to implement cost effective life cycle management programs, extending the life of legacy D20 infrastructure, while migrating to current Substation Automation and cyber security industry standards.

Management Software



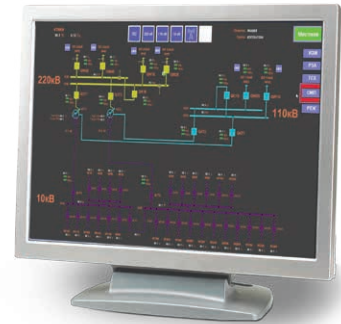
PowerLink Advantage

PowerLink Advantage (PLA) from GE is a HMI solution for high point count requirements providing an up-to-date, live view of the substation in near real-time.



Power Management Control System

Power Management Control System (PMCS) is a highly customizable, fully integrated end-to-end Energy Management Solution providing tools for Monitoring, Power Quality, Control and Automation and Cost Allocation.



GE Power

GE Power is an open, standards (IEC 61850) SCADA solution that is easy to configure. It is designed for substation automation and P&C applications.

GE's Professional Services Process

Based on years of experience and several deployments across multiple applications and industries, GE has developed a Professional Services Process. The process is comprehensive, application specific, and includes customer collaboration for successful project implementation.

GE's Professional Services Process is based on a common set of building blocks, utilized and tailored for each customer's unique communication network requirements. While GE uses well documented and repeatable processes, we realize that flexibility is also key to accommodate our customer's specific requirements and needs unique to their environment.

Elements of a Successful Project

GE's number one priority is helping customers successfully implement projects that meet their operational and economic goals. Based on our experience, we have identified a number of factors that are critical to the success of a well-implemented project:

Dedicated Project Management

GE assigns a project manager at the beginning of each project to lead the team throughout the project lifecycle. The project manager acts as an extension of the customer's team to coordinate and drive all aspects of the project to a successful outcome.

Open Communication and Team Work

The most effective way to drive project performance is proactive communication with our customers. This is a priority for our projects team. A strong and collaborative relationship between the customer and GE increases the chances of a successful project.

A Well-Defined Execution Framework

Project success depends on up-front planning as well as a mutually agreed upon execution framework that includes clearly defined deliverables.

GE's Global Capabilities

GE's dedicated engineering teams are located in regions around the world and bring a wealth of international experience to every project. Customers benefit from GE's local systems subject matter experts who drive compliance with regional/local requirements ensuring our customers business and technical objectives are met.

GE has an excellent track record in planning, executing and delivering a broad range of projects. GE's systems subject matter experts work in state-of-the-art facilities that include design, research and development, manufacturing and testing capabilities. Customer are supported with 24/7 field and application support.

GE's Professional Services Process and Key Activities



Implementing a Project

Below are highlights demonstrating the project implementation process customers experience once they have decided to engage with GE's Systems Center of Excellence to implement a Modular Substation Automation System.

Phase 1: Defining Scope of Work

The first phase of the project is to gather information about the customer's project requirements. During the definition phase of a project, GE will:

- Capture the strategic objectives of the project.
- Meet with customers and key stakeholders to collect system requirements which can range from latency and throughput, specifications to required coverage areas, and end-points.
- Provide customers with a requirements document and initial systems concept design.



Phase 2: System Analysis

The analysis phase of the project allows engineers to validate the initial concept design and verify that it meets customer expectations. During this phase, GE can provide:

- Protection and control system analysis to ensure reliable and efficient power flow
- Automation system analysis to provide optimal network reliability and efficiency
- Communications system analysis to ensure proper bandwidth and response times
- Operator requirements analysis to ensure maximum situational awareness
- Remedial action analysis to eliminate outages or minimize impact of outages
- Asset management requirements
- Provide customers with a requirements document and initial systems concept design.



Phase 3: Final System Design Development

During the design phase, GE finalizes a system design that can be implemented to meet the customer's scope of work and requirements. During this phase, GE can provide:

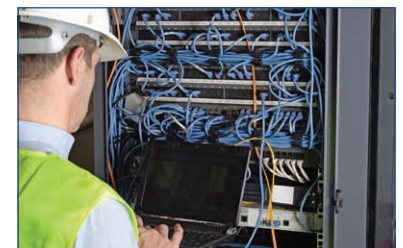
- Protection and control of primary equipment design
- Automation system design
- Communications system design
- Substation gateway design
- Substation operator HMI display and database design
- Application selection



Phase 4: Project Implementation

Regardless of the size or scope of a project, GE assigns a project manager to oversee all of the activities and associated details to ensure successful project implementation. During project implementation, GE can provide:

- Procurement of all equipment and services
- Panel construction
- Integration of all equipment
- Factory acceptance testing
- Commissioning
- Training



Phase 5: Supporting our Customers

GE's commitment to customer satisfaction is a primary goal – just because the project is complete, GE's job is not done. A primary responsibility is continued support of the implemented system throughout its lifecycle, where GE provides:

- Access to regional teams available for on-site troubleshooting and equipment testing and replacement
- 24/7 field and applications support



Digital Energy Systems Portfolio Summary

Digital Energy has designed and delivered thousands of projects and systems in every region around the world addressing customer challenges across the energy value chain. GE's projects and systems consist of components that provide robust technology solutions that are readily available with a proven track record of delivery, reducing both risk and complexity for customers.

Grid Automation Systems

GE's Substation Automation devices offer a seamless and scalable solution for automating and providing visibility to power system networks. Led by a team of seasoned industry experts, GE can develop, integrate and deliver a complete automation system that is tailored to a customer's specific needs and requirements.

GE's Grid Automation Systems Offerings Include:

- Packaged protection and control for utilities and industrial substations
- Substation automation for transmission and distribution substations
- Industrial energy management system for Oil & Gas and Mining
- Micro grid control systems for grid/off grid connected applications
- Communications systems for utilities (LAN, WAN), industrial and specialized communications backhaul system for transportation and oil and gas
- End-to-end AMI systems
- Distribution Automation Systems delivering reliability and efficiency



Software Systems

GE's Software Solutions provides a range of innovative software technologies offering customers end-to-end visibility, management, control, and analytics capabilities. GE's software offerings enable critical network assets with geospatial systems, mobile workforce applications, and communications management. GE's PowerOn™ suite delivers end-to-end grid control for security and stability of supply, enabling operators to restore power faster when unforeseen problems cause outages.

GE's Software Solutions Offerings Include:

- Asset Management including Geospatial Information Systems
- Asset Control including Energy, Distribution, Outage, and Demand Response Management Systems
- Grid IQ™ Insight Analytics
- Grid IQ Solutions as a Service (SaaS)



Power Delivery Systems

GE's Power Delivery business provides high and medium voltage power equipment to support a wide range of applications. GE can deliver these solutions in a variety of ways that best support our customers needs, delivered as products, engineered equipment packages, or as complete turn-key projects.

GE's Power Delivery Systems Offerings Include:

- Electrical Balance of Plant
- Flexible AC Transmission Systems (FACTS)
- Utility and Industrial Substations





Please visit our website for more information about
GE's Modular Substation Automation Systems

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