Your Trusted Partner in Automation

Moxa is a leading provider of edge connectivity, industrial computing, and network infrastructure solutions for enabling connectivity for the Industrial Internet of Things (IIoT). With over 30 years of industry experience, Moxa has connected more than 65 million devices worldwide and has a distribution and service network that reaches customers in more than 80 countries. Moxa delivers lasting business value by empowering industries with reliable networks and sincere service. Information about Moxa’s solutions is available at www.moxa.com.
Moxa is a global leader in IEC 61850 and IEEE 1588 smart substation solutions and provides a wide range of networking and computing products for substation automation. As an active participant in Work Group 10 of the IEC TC57, a Collective Member of CIGRE, and Director-general of the Taiwan Smart Grid Industry Association, Moxa is applying its innovative technological expertise to the creation of practical, market-specific networking and computing solutions for the smart substation industry. With over 30 years of experience in industrial networking, Moxa solutions now manage over 1,000 successful substation applications around the world, including the world’s first fully integrated IEC 61850 and IEEE 1588 smart substation.

Take a close look at the benefits and advantages offered by the IEC 61850 standard. While the prospect of implementing such a complex set of rules, regulations, and stringent specification requirements may at first seem daunting, the advantages by far outweigh the disadvantages.

Look in detail at how to handle three of the main challenges engineers face when building a new IEC 61850 substation from the ground up.

- Determinism
- Reliability
- Manageability

Create rock-solid and future-proof substation networks by partnering with Moxa. You can rely on our over 30 years of expertise in proven substation solutions. Moxa products are being used in over 1000+ successful transmission and distribution deployments around the world.
Introduction
Power substation technology has evolved considerably since the first power distribution system went into service in the late 1800’s. Today, several hundred thousand substations of various sizes and varieties are in operation around the world, with both retrofit and new substation projects being initiated with increasing frequency.

Let’s take a close look at the benefits and advantages offered by the IEC 61850 standard. While the prospect of implementing such a complex set of rules, regulations, and stringent specification requirements may at first seem daunting, the advantages by far outweigh the disadvantages. For example, whereas the thousands of devices making up a traditional substation use hard-wired device-to-device connections running relatively low speed serial connections over copper wiring, the IEDs (intelligent electronic devices) in a modern IEC 61850 substation connect to a high-speed Ethernet bus, making it relatively easy to implement a comprehensive management, maintenance, and control strategy via a centralized power SCADA system.

Why Invest in an IEC 61850 Substation?
Whether you’re looking to retrofit an existing substation, or build a new one from the ground up, the advantages of implementing the IEC 61850 standard are the same:

Simplified Architecture: The thousands of IEDs in a modern substation use localized intelligence to handle much of the decision making required at the local site, and communicate with other devices via Ethernet switches which themselves are connected to the substation’s Ethernet network.

Reliability: By design, the IEC 61850 standard places great emphasis on reliability. Not only are many of the devices required to be rugged enough to withstand extreme environmental conditions, you can expect the network itself to be redundant on many different levels.

Future-proof: One of the major advantages of implementing an Ethernet network is that it is easy to expand when the need arises. In addition, any new products that connect to an existing IEC 61850 substation are required to be fully compatible with what’s already there.

Vendor Independence: The fact that IEC 61850 products produced by different companies are all required to speak the same language gives substation system integrators (SIs) a huge advantage, since they can pick and choose the best products from different vendors.
What is IEC 61850?
The non-proprietary IEC 61850 standard uses modern object-oriented programming principles to define a complete virtual model of the substation, which can be tested and tweaked in a computer model before being implemented with actual devices. Since the standard is open, any hardware vendor can provide IEC-61850-compliant products, giving substation engineers the freedom to pick and choose the best products for their particular project. Highlights of the standard include:

- The main data pathways use Ethernet-based communication, with high bandwidth trunk lines used to transmit data packets from/to multiple devices connected to the substation network.
- Guaranteed compatibility with IEC 61850-compliant products from different vendors, making it much easier to expand a substation’s operation when the need arises.
- The IEC 61850 standard makes heavy use of the XML-based substation configuration language (SCL) to define the configuration parameters of the multitudes of IEDs used in the substation.
- High speed IED-to-IED communication with transfer times guaranteeing priority tagging of the Ethernet frames.

The transfer time requirements for different types of transfers

<table>
<thead>
<tr>
<th>Transfer Time Class</th>
<th>Transfer Time (ms)</th>
<th>Type of Transfer</th>
</tr>
</thead>
<tbody>
<tr>
<td>T0</td>
<td>&gt;1000</td>
<td>Files, events, log contents</td>
</tr>
<tr>
<td>T1I</td>
<td>1000</td>
<td>Events, alarms</td>
</tr>
<tr>
<td>T2</td>
<td>500</td>
<td>Operator commands</td>
</tr>
<tr>
<td>T3</td>
<td>100</td>
<td>Slow automatic interactions</td>
</tr>
<tr>
<td>T4</td>
<td>20</td>
<td>Fast automatic interactions</td>
</tr>
<tr>
<td>T5</td>
<td>10</td>
<td>Releases, status changes</td>
</tr>
<tr>
<td>T6</td>
<td>3</td>
<td>Trips, blockings</td>
</tr>
</tbody>
</table>

Reference: IEC 61850-5

IEC61850 Substation Architecture

IEC 61850 is a substation automation standard that is part of the International Electrotechnical Commission’s (IEC) Technical Committee 57 (TC57) reference architecture for electric power systems. The IEC 61850 standard divides substation operation into three distinct levels and two communication buses, as illustrated in the diagram on the right:

- **Process Level:** The process level comprises devices such as circuit breakers and data acquisition equipment used to measure the current, voltage, and other parameters in different parts of the substation.
- **Bay Level:** The bay level consists of the IEDs that collect the measurements provided by the process level. The IEDs can make local control decisions, transmit the data to other IEDs, or send the data to the substation SCADA system for further processing and monitoring.
- **Station Level:** The station level is where you’ll find SCADA servers and HMIs, as well as the human operators (if needed) who monitor the status of the substation.

**Process Bus:** The process bus handles communication between the process level and the bay level.

**Station Bus:** The station bus handles communication between the bay level and the station level.

IEC 61850 Communication

The transmission protocols used to handle specific types of data transfer are one of the main aspects of the IEC 61850 standard. The abstract data models defined in IEC 61850 can be mapped to a number of protocols:

- **MMS:** Using the Manufacturing Messaging Specification protocol to send substation status for monitoring purposes.
- **GOOSE:** Using the Generic Object Oriented Substation Event protocol to send critical data, e.g., control signal and warnings.
- **SMV:** Using the Sampled Measured Values protocol to send power line current and voltage values.

These protocols can run over high speed Ethernet networks to ensure the fast response time (< 4 ms) needed for protection relays.

The example in the following figure illustrates how the three protocols contribute to substation communication:

- **Step 1:** After sensing that the current in the power line is too high, a merging unit sends a message using the SMV protocol to a protection relay.
- **Step 2:** The protection relay uses the GOOSE protocol to notify the intelligent control unit to trip the circuit breaker.
- **Step 3:** After switching the power off, the intelligent control unit uses the GOOSE protocol to notify the protection relay that the power has been cut.
- **Step 4:** The protection relay uses the MMS protocol to notify the power SCADA server that the power line has been cut.
- **Step 5:** The power SCADA server issues an alarm.
In the 1960’s a conventional substation was rather bulky, with copper or fiber wiring used to hard-wire one device to another.

The release of the IEC 61850 Station Bus protocol in the 1980’s was a big first step forward on the way to implementing a substation-wide all-purpose network.

In 2005, the IEC 61850 standard was greatly improved by defining a Process Bus to connect the Process Level with the Bay Level.

The latest development in the IEC 61850 standard was the inclusion of the PRP/HSR protocol in 2010. PRP/HSR (parallel redundancy protocol/high-availability seamless redundancy) specifies how to use two Ethernet networks to ensure seamless failover if one of the redundant networks fails.
IEC 61850 Substation Retrofits
Go from wire-crazy to wire-smart with IEC 61850

When we shifted our retrofit substations from conventional hardware to automated, intelligent IEC 61850 equipment, we needed to find a reliable partner with products that could handle the complexities of protocol conversion. In particular, we were looking for serial-to-Ethernet solutions for connecting legacy Intelligent Electronic Devices (IEDs) and other serial communications devices to an Ethernet network. Serial-to-Ethernet solutions allowed us to extend the lifetime of our equipment, and significantly reduce the cost of upgrading to a smart-grid-ready communications system.

Substation Retrofitting
Existing substations that use hundreds or thousands of legacy serial devices, some of which could be as much as 20 or 30 years old, can benefit greatly from an IEC 61850 facelift. However, executing such a facelift requires connecting the legacy devices to a modern TCP/IP network, as well as implementing the protocol conversion functionality needed to enable the devices to communicate with each other.

Let’s look at the three main challenges engineers face during the process of retrofitting a substation, and how to handle them.

Device Variety
Existing systems may have been developed over the years, at different time periods, making it difficult to migrate legacy devices to a single system.

Integration
Substation system engineers may have limited communication domain know-how or less time to bridge devices for system integration.

Operation
How can I optimize, perform daily maintenance on, and troubleshoot an established system?

Device Variety
One of the main aspects of modernizing an existing substation involves disconnecting legacy devices from a serial network (which could be as simple as “one or more serial devices connected directly to one or more PCs”), and then re-establishing the connections through a modern TCP/IP network. The goal may sound simple enough, particularly with the plethora of serial-to-Ethernet device servers available on the market today, but the fact that so many options are available also complicates the process since you need to identify which devices are suitable for your particular application.
From One Protocol to Another

One of the problems you’ll face is that legacy devices from different vendors will undoubtedly use different communication protocols. We can classify the problem into three distinct categories:

**Devices that use standard industrial protocols**
In this case, the precise structure of the data packets is known only to the owner of the protocol. To handle this kind of situation, Moxa’s serial-to-Ethernet products like NPort S9000 Series support what is referred to as “tunneling,” which simply involves packing data from the device into TCP/IP data packets and then sending the data packets over the network to a computer. A Moxa driver installed on the computer intercepts the TCP/IP packets, unpacks the proprietary data packets, and then presents the data to the proprietary software. In effect, the NPort S9000 Series device works together with the driver server to fool the proprietary software running on the computer into thinking that it’s still connected directly to the proprietary device.

**Devices that optimize performance with custom software applications**
If your organization has invested in customized software applications to add value to and optimize the substation system, then you’ll need a special-purpose computer positioned between the network and your devices to run the applications. In some retrofitted substation systems, operators use their own customized protocols instead of standard or proprietary protocols. In such cases, they will require fanless embedded open computing platforms to develop unique applications for these customized protocols. The data acquired through the customized protocols must also be stored in a meaningful way.

**Different Specs for Different Folks**
Depending on the size of your operation and the performance requirements of your system, the specification for the devices installed can vary from one system to another. For example, the input voltage range can be defined in AC (100 to 240 V) or in DC (12 to 48 V, up to 300 V). The Ethernet connection interface could be either copper or fiber, depending on EMC and distance requirements, and whether DIN-rail mounting or rack mounting is used could also vary from one project to another.

**Time Is of the Essence**
SCADA systems used to monitor and manage a modern substation work by continuously collecting and analyzing huge quantities of data from the many devices and computers making up the substation system. There are two time-related aspects of this process that are extremely important:

**Meaningful timestamps**
As events occur at different locations throughout a substation, the local device that records an event will add a timestamp, based on the local time of the device, before sending the event information for analysis. For this reason, it is extremely important that timestamps coming from different parts of the system are based, essentially, on the same clock. To achieve this, time synchronization protocols are used to keep all of the clocks in the system in sync.

**Real-time data transmission**
We all know that information, even when travelling at the speed of light, takes a finite amount of time to get from point A to point B, so “real time” generally refers to keeping the transmission time at the millisecond level. This is particularly important for control systems; any significant delay in getting control signals to the controller in response to sensor-readings can throw the entire system out of whack.

In a retrofit project, existing serial-based devices will probably be using the IRIG-B serial time synchronization protocol. In contrast, an IEC 61850 network will be using Ethernet-based IEEE 1588 time synchronization protocol. To get around this problem you should use devices that are able to convert between the two protocols as the time-sync signals make their rounds.

### Existing Devices Use a Variety of Protocols

#### Diagram:
- **Ethernet backbone**
- **Standard Protocols (Gateway)**
- **Proprietary Protocols (Tunneling)**
- **Other Customized Protocols (Computer)**

#### Ethernet backbone Diagram:
- **Serial**
- **Ethernet**

### A Mix of Time-synchronization Protocols

- **IEEE 1588 TC Ethernet Switch**
- **IEEE 1588 to IRIG-B Conversion Serial-to-Ethernet Converter**

#### Diagram:
- **Serial**
- **Ethernet**
- **IRIG-B**

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**www.moxa.com/substation**
Certification Standards Can Make or Break the Deal

IEC 61850-3 Class C3 Certified

The IEC 61850-3 and IEEE 1613 standards precisely define EMC and communication requirements for network equipment used in substations. Substation computers and Ethernet switches must have IEC 61850-3 and IEEE 1613 certifications to guarantee adequate protection against a variety of environmental conditions. These minimum requirements include:

- Level-4 EMC for strong protection against electrical interference
- High tolerances for constant vibrations and shocks

Wide Range of Operating Systems

Engineers who deal with retrofit projects have always faced a wide variety of operating systems due to the fact that existing substations were built over a period of time. Sometimes, the limitation comes from needing to retain the legacy operating systems because the drivers used to read the end devices only work on these systems. Sometimes, end users might want to use up-to-date operating systems because of their longevity. Therefore, an IEC 61850 solution must support a wide range of drivers for serial-to-Ethernet devices on multiple operating systems.

A Platform Is Not Just a Platform

Since embedded computers are often used for customization, optimization, and multitasking, choosing a suitable hardware platform is extremely important.

Native Compilation Support

Engineers have to deal with specific tool chains, source code, and binaries to compile software for multiple platforms. A platform that supports a native compiler will make things much easier.

Operating Systems

The embedded computer used in a serial-to-Ethernet solution is expected to do more than just protocol conversion. The operating system and the packages supported will determine the time required to develop any solution.

Expansion Capability

IEDs are deployed in a retrofit substation project to make the primary equipment more intelligent. A solution that provides expansion slots for installing different expansion cards to connect with a variety of devices make it easier to expand the system. The key success factor is the ability to connect to all types of devices.

Easy Configuration in Three Steps

Dealing With Configuration Issues

A common issue seen in the installation phase is the configuration of serial-to-Ethernet devices. Especially in retrofit projects, engineers would prefer to spend more time on performing system functional tests, rather than deal with communication issues. Therefore, making the configuration as simple as possible would definitively improve the configuration efficiency of the entire project.
Optimizing SCADA Systems Using a Modbus Gateway

In a substation control center, one of the goals for Supervisory Control and Data Acquisition (SCADA) systems is to monitor the power quality. As a complex web of electrical parameter statuses needs to be collected from numerous serial-based devices, ideally, Modbus gateways with multiple serial ports (8 or 16 ports) are required. However, traditional Modbus gateways run in the transparent mode, which has a lower data-update frequency because of a limitation in Modbus. Moxa’s high-density gateways with the agent-mode technology can boost the performance of SCADA systems.

Transparent gateways can only deal with simultaneous requests and responses one by one.

Serial-based Devices

Agent gateways act as data concentrators that deliver multiple requests and responses to/from PSCADA at the same time.

Serial-based Devices

Performance and Security

Protocol conversion is only one of the functions sought while choosing embedded computers for a retrofit substation project. Most of the time, embedded computers in a substation are used to run independent virtual machines (VMs) with the following benefits:

Reduced Costs
VMs increase the efficiency and utilization level of your existing x86 hardware platform.

Application Isolation
Depending on the capability of your hardware platform, you can run each application on a separate VM for complete isolation of the applications. You can also run critical and non-critical application workloads on separate VMs to ensure that if one set of applications fails, the other applications will continue to run.

Troubleshooting System Crashes

A smart OS recovery system is an essential function in a remote substation. Without an OS recovery system, corruption of system software—whether in the OS or in local substation applications—can mean catastrophic failure. According to some estimates, the percentage of computer failures attributable to software corruption is as high as 30%. However, most of the substation engineers who are experts in their field do not have enough computer domain knowledge on troubleshooting and fixing operating system problems. To minimize downtime, an automated BIOS-level software recovery system is an extremely valuable addition to the design of a power substation computer.

A good example is Moxa Smart Recovery™, a tool that facilitates automatic system recovery by triggering OS rewrites. The system triggers a recovery process using a tagged copy of the entire system created when the embedded computer was first deployed successfully, and which is stored locally on the computer or on an external drive. The following recovery methods are available to help ensure minimum downtime when there is a system crash:

1. For unmanned sites where troubleshooting is not easy, OS rewrites can be fully automated to restore the system from a tagged copy.
2. For sites that are monitored by substation engineers where the requirement is to double-check the parameters before the OS-recovery process starts, engineers can provide the location of the image file and just run a power cycle to complete the process.
Building a New Substation from the Ground Up
Start off on the right foot with IEC 61850

When upgrading to Ethernet-based communications, we were on the lookout for a relatively reliable and standardized solution that supported recognized redundancy standards. For mission-critical, time-sensitive substation applications, network interruptions as short as a few milliseconds can have a severe impact on system operations and jeopardize the safety of onsite personnel. For this reason, we needed a solution that could quickly connect our legacy devices to networks guaranteed to provide bumpless operation, even in the face of single points of failure.

New IEC 61850 Substations
Engineers given the task of designing a new power substation have the luxury to start from scratch. When comparing conventional hardwired solutions with modern IEC 61850 solutions, many power companies are opting for the IEC 61850 solution, which can provide the same performance and reliability as a hardwired solution, but with the added benefit of scalability. Let’s look in detail at how to handle three of the main challenges engineers face when building a new IEC 61850 substation from the ground up:

► Determinism
Will the performance of an IEC 61850 Ethernet-based substation compare favorably with that of a hardwired peer-to-peer substation?

► Device, Network, and Data Reliability
Will the devices be able to operate reliably in environments with high EMI and how to implement network redundancy to ensure that critical packets are reliably transmitted?

► Manageability
How can substation system engineers optimize, perform daily maintenance on, and troubleshoot an established system?
The Key to Deterministic Operation: Accurate Time Stamping for Time Synchronization.

Accurate time synchronization is required in a substation to ensure that measuring devices connected to the grid have accurate clocks. Accuracy of the clocks is measured relative to a national standard and can vary from the order of milliseconds to microseconds, depending on the application.

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Device Reliability

Devices in a substation are constantly subject to extreme temperatures, high electricity interference, and airflow restrictions. Hence, it is critical to ensure that the devices can operate reliably in harsh operating environments.

Basic Reliability: IEC 61850-3 Compliance

The IEC 61850-3 and IEEE 1613 standards precisely define EMC and communication requirements for network equipment used in substations. Substation computers and Ethernet switches must have IEC 61850-3 and IEEE 1613 certifications to guarantee adequate protection against a variety of environmental conditions. These minimum requirements include:

- Level-4 EMC for strong protection against electrical interference
- High tolerances for constant vibrations and shocks

Accurate Time Stamping

Accurate Time Stamping for Time Synchronization.

The Key to Deterministic Operation: Prioritization of Critical Data

One way to assure critical data gets first priority is to manage the network bandwidth so that data is only sent to the requestor device and not broadcasted to the entire network. The typical approaches are QoS, VLAN, and IGMP snooping.

VLANs provide substation networks with the following benefits:

- Traffic Filtering

A network switch should identify data with highest priority and transmit those first. Quality of Service (QoS) is the common approach to transmit data based on priority tags marked on the IP packets. However, the standard QoS does not distinguish between GOOSE and SMV packets—the crucial data that require real-time transmission—and other data. Moxa has tailored the QoS function for IEC 61850 communication, which is available in our switches.

IEC 61850 QoS

In IEC 61850 substation communication, GOOSE and SMV are 2 critical packet types that require high-priority attention. To guarantee that these messages are not corrupted, they are transmitted with the highest priority, regardless of what other messages are queued up in the network. When an IEC 61850 queuing scheme is used, the Ethernet switch knows that GOOSE and SMV packets are critical, and hence always gives these messages the top priority in the sending queue.

Wire Speed Zero Packet Loss Technology: NoiseGuard™

In order to ensure no data packets (GOOSE/SMV/PTP) are lost in EMI-intensive environments, Moxa’s switches are designed with NoiseGuard™ technology that can guarantee zero packet loss in most networks. NoiseGuard™ technology is an EMC-immunity technology that exceeds the requirements of IEEE 1613 Class 2 and uses an optimized mechanical design with integrated housing for better conduction. Customized components include a fiber transceiver, and an enhanced, optimized power circuit design.

IEC 61850 Makes Substations Smarter
OS Recovery: Smart Recovery™ Technology
Stable system operation is important for ensuring reliable substation management. However, when the system is unstable, how do you restore the system to normal operation as quickly as possible? Engineers are often stymied by a lack of domain knowledge and unfamiliarity with what could be a long list of complicated recovery steps. Moxa’s computers come with Smart Recovery™, which is an automated BIOS-level software recovery tool that allows engineers to automatically trigger OS recovery to minimize downtime.

Two-step Manual Recovery Process
Supports an easy 2-step recovery process either from the tool or using a USB storage device, which helps the engineer to quickly restore system operations.

Withstand Harsh Environments: Fanless Thermal Design
Extreme temperatures ranging from -40 to 75°C, dust, and restricted airflow are conditions commonly found in substation environments that can greatly affect the performance of substation computers. Computers that rely on fans to keep their CPU cool are particularly vulnerable to these kinds of conditions. A substation computer should be fully sealed from the outside environment and not require any type of fan. Not requiring a fan extends a computer’s life significantly, provided the computer is able to survive in the extreme heat often experienced in substation environments. Engineers must therefore work to situate the PCB’s highest thermal concentration in the very center of the device, so that heat has the largest immediate area available to dissipate into. With fanless systems, generally the entire outer shell is utilized as one large heat sink, with fin heights, gaps, thicknesses, and points of contact carefully analyzed and adjusted to further optimize dissipation. What this means is that designing a fully fanless computer is a nontrivial engineering challenge, with fanless computers inevitably more expensive than fan-cooled solutions. But the additional cost is more than justified by the huge increase in reliability, as well as the additional benefits of reduced size, complexity, and protection against dust, heat, and corrosion.

Network Reliability
Packet losses of any kind are not tolerated in substation communication. Ensuring that critical packets are reliably transmitted is a key for any substation, so it is critical to implement network redundancy to prevent data loss when failure occurs.

Network Redundancy Technology
Network redundancy is a method for ensuring network availability in case a network device or path is unavailable. There are many existing mechanisms that can enhance fault-tolerance in an Ethernet network. The most common ones are RSTP, proprietary ring redundancy, and PRP/HSR. However, in today’s complex substation automation industry, even millisecond long network interruptions cannot be tolerated because they may severely impact system operations or jeopardize on-site safety. IEC 61850 edition 2 clearly states that the transmission of GOOSE and SMV packets in substation automation systems are required to be bumpless. Moxa also provides PRP/HSR technology for zero packet loss network redundancy technology to ensuring on-site safety and quality of service.
**Using Native PRP/HSR Computers for Efficient Network Management**

Another concern of substation engineers is that if they use PRP/HSR technology, they will have to deal with multiple protocols (MMS, PRP/HSR supervision frame, SNMP) in their system, thereby increasing the complexity of management.

A native PRP/HSR computer is the best choice when it comes to ensuring high reliability while monitoring a PRP/HSR network with built-in PRP/HSR management middleware that supports both SNMP and MMS interfaces. Various substation devices that run different communication protocols, including PRP/HSR devices, can be connected to this computer. The supervision frame from the PRP/HSR devices is converted to SNMP or MMS format at the device level and then sent to the middleware for analysis. The integration of the middleware and PSCADA system enables all data to be effortlessly used and read in the substation PSCADA system via the MMS protocol. Substation operators find it easy to manage all devices on the PRP/HSR system via the PSCADA visual tools. In addition, troubleshooting can be easy since any single-point-of-failure can be shown on the PSCADA system, making the PRP/HSR application more reliable and stable.

**Enhancing Cybersecurity in Substations**

In an age where cyberattacks on public infrastructure are increasing, protection of substation networks and assets cannot be taken lightly. To protect your mission critical networks, Moxa provides a portfolio of Gigabit secure routers that provide secure remote access to field devices through public networks and facilitate layered defense-in-depth network security for substation networks.

- **Industrial Transparent Firewall for Protection of Critical Devices**

- **Industrial Encrypted VPN Tunnels for Secure Remote Access**

**Data Reliability**

Critical data such as control signals and warnings are sent in GOOSE messages from the PSCADA to the designated IEDs. A built-in mechanism in switches to detect delay, loss, or tampering of GOOSE packets can facilitate quick troubleshooting in substation networks.

**GOOSE Check and GOOSE Lock Technologies for Packet Monitoring**

GOOSE Check is a type of packet inspection where the status of each GOOSE packet passing through the Ethernet switches is continuously monitored. Substation operators can then use MMS to send this information to a PSCADA system to visualize dropped, delayed, out-of-sequence, and tampered GOOSE packets, and trigger system alarms when the status of a packet changes.

GOOSE Lock creates a whitelist of legitimate GOOSE packets passing through the Ethernet switches in a network. It is a protection mechanism against malicious packet-based attacks from unknown sources.

**Manageability**

How can substation system engineers optimize, perform daily maintenance on, and troubleshoot an established system?

**Configuration Wizard With Less Than 7 Steps**

Configuring network devices correctly can be a major headache for substation engineers, particularly since incorrect configurations can result in an unstable or nonfunctional communication infrastructure. That’s where Moxa’s proprietary Substation Configuration Wizard can make all the difference. Because substations are such a specialized environment, IT teams will only require a few key features. For this reason, it makes a lot of sense to simplify and streamline the configuration process. Reducing the configuration interface to only the relevant network features, makes setup and maintenance much more efficient. As is illustrated in the accompanying graphic, engineers can use Moxa’s browser-based configuration wizard to deploy our network devices in as few as 7 steps.
Built-in MMS Server for PSCADA Integration
Upgrading multiple peer-to-peer communication connections on the same network, and finding communication errors can be an extremely complicated exercise. With Moxa’s MMS support based on IEC 61850-90-4 modeling, substation IEDs and automation engineers can display their entire network of automation devices right alongside process-level information, all in a single SCADA view, which makes managing the Ethernet switch the same as managing IEC-61850 electrical devices. Therefore, you will no longer need to install and configure separate NMS software for IT devices on your substation system. Administrators can use MMS to:

• Monitor and control IEDs, switches, embedded computers, device servers, and process data from a single power SCADA interface
• Eliminate redundant SNMP systems for IT hardware while decreasing network congestion
• Configure devices for event triggers, polling reports, or both
• Precisely locate devices relative to other devices within the network hierarchy in a single software view
• Directly configure and control IT hardware from the SCADA system

Proactive Diagnosis of ST/SC/SFP Fiber Issues: FiberCheck™ Technology
How can a mechanism that anticipates when fiber components are reaching the end of their life cycle be implemented, allowing engineers to replace the components before they fail?

Optical fiber, which is used in substation networks to protect Ethernet connections from electromagnetic interference, may deteriorate after long years of usage. FiberCheck™ Technology uses Digital Diagnostic Monitoring technology to diagnose deterioration of signals before the signals are too weak and drop off, offering early error detection and fault isolation for predictive maintenance. Most substations currently support only SFP-type optical-fiber monitoring.

Moxa FiberCheck™ can be used by substation switches to monitor ST/SC (as well as SFP) connectors, and notify the PSCADA system via SNMP or MMS when abnormalities are detected, allowing operators to quickly initiate maintenance procedures. Reports and alarms can be transmitted using any one of the following methods: a network port, a serial console, CLI, MMS reporting, SNMP traps, digital relay, entries written to the system log file. The FiberCheck™ function also allows system operators to monitor transmission and reception power, temperature, and voltage/current along optical-fiber connections in real time.

Performance and Protection
A powerful and secure management platform is crucial to substation automation. However, with a variety of applications operating on a single system, overall performance can experience significant degradation. What substation engineers would like to avoid is the need to maintain multiple management platforms, which can be costly and difficult to implement and maintain.

Protocol conversion is only one of the functions sought while choosing embedded computers for a retrofit substation project. Most of the time, embedded computers in a substation are used to run many different applications and operating systems. In such cases, engineers would prefer to use virtualization technology such as VMware to run independent virtual machines, with the following benefits:

Reduced Costs
VMs increase the efficiency and utilization level of your existing x86 hardware platform, thereby saving the cost of acquiring new hardware.

Application Isolation
Depending on the capability of your hardware platform, you can run each application on a separate VM for complete isolation of the applications. You can also run critical and non-critical application workloads on separate VMs to ensure that if one set of applications fails, the other applications can continue to run.

Extend the Life of Your Legacy Applications
You can use VMs to run your legacy applications on computers with new hardware platforms or operating systems.
Monitoring the Status of Key Components for Advance Alerts: Proactive Monitoring

How do you improve the performance of your industrial computers and get advance alerts on the key performance indicators to help reduce unexpected equipment downtime? Proactive Monitoring, Moxa’s innovative software visualization tool for industrial computers, monitors the computer’s health by keeping an eye on CPU usage, memory usage, storage partition usage, the operating temperature of the CPU and motherboard, and the redundant power monitor, and can trigger relay outputs to provide either visual or audio alarms. What’s more, you can configure the tool to trigger these alarms based on user-defined criteria.

<table>
<thead>
<tr>
<th>Predefined Event</th>
<th>Threshold</th>
<th>Default Activation</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
<td>Description</td>
<td>Min.</td>
<td>Max.</td>
</tr>
<tr>
<td>CPU</td>
<td>CPU usage alert</td>
<td>When CPU usage reaches the predefined threshold.</td>
<td>1%</td>
</tr>
<tr>
<td>Memory</td>
<td>Memory usage alert</td>
<td>When memory usage reaches the predefined threshold.</td>
<td>1%</td>
</tr>
<tr>
<td>Disk</td>
<td>Storage partition usage alert</td>
<td>When storage partition usage exceeds the predefined threshold.</td>
<td>1%</td>
</tr>
<tr>
<td>Temperature</td>
<td>CPU temperature alarm</td>
<td>When CPU temperature exceeds the predefined threshold.</td>
<td>60°C</td>
</tr>
<tr>
<td></td>
<td>Mainboard temperature alarm</td>
<td>When mainboard temperature exceeds the predefined threshold.</td>
<td>-40°C</td>
</tr>
<tr>
<td>Network</td>
<td>Ethernet link status alarm</td>
<td>When an Ethernet link is down, a relay is triggered.</td>
<td>N/A</td>
</tr>
<tr>
<td>Power</td>
<td>Redundant power monitor and alarm</td>
<td>When one of the power modules fails or both power modules do.</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Legacy-to-hybrid Network Deployment

Substation retrofit projects require integration of existing RSTP ring networks with PRP/HSR architecture to bring DANs (dual attached nodes) to a bumpless redundant communication backbone and to enhance system availability. With Moxa’s IEC 61850-compliant devices specifically calibrated for PRP and HSR redundancy, seamless control and monitoring can be achieved, to help customers construct or retrofit their network infrastructures as required for time-sensitive and mission-critical applications.

High Interoperability Between the Communication Backbone and Management Platform

IEC 61850 Makes Substations Smarter

Legacy-to-hybrid Network Deployment

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Create rock-solid and future-proof substation networks by partnering with Moxa. With years of expertise in the substation industry, we have delivered digital solutions to over 1,000 substation communication and computing projects worldwide.

In this chapter, we share success stories from all over the world. The success stories are grouped into four categories: Generation Substations, Transmission Substations, Distribution Substations, and Enterprise Substations. Take a close look at these success stories to see how Moxa can help you overcome critical issues that arise when you’re building your own smart substation.
### HSR Solution for an Energy Storage System

#### Power Conversion System in Korea

- **Type of Substation:** Transmission Substation
- **Customer Needs:** Build an IEC 61850 substation with a high-reliability design, including IEEE 1613 devices and a zero packet loss solution.
- **Why Moxa:**
  - Comprehensive PRP/HSR solution
  - Solution includes MMS communication

#### Thermal Plant IEC 61850 Terminal Substation

- **Type of Substation:** Generation Substation
- **Customer Needs:** Implement ESS (Energy Storage System) to enable remote monitoring of the state of the energy stored.
- **Why Moxa:**
  - Easy-to-configure HSR solution
  - One dedicated Ethernet port for monitoring and troubleshooting

#### World’s First IEC 61850 3-Layer 220 kV Substation

- **Type of Substation:** Transmission Substation
- **Customer Needs:** Build the world’s first IEC 61850 digitalized substation "HV" in a subgrid in Jiangsu province that utilizes the IEC 61850 GOOSE/SMV and IEC 61850 standards.
- **Why Moxa:**
  - Consulting service for substation networking design
  - PT-7728-PTP is IEC 61850-3 and IEEE 1613 compliant
  - IEEE 1588 nanosecond-level accuracy

#### IEC 61850 161 kV Substation With a PRP/HSR Network

- **Type of Substation:** Transmission Substation
- **Customer Needs:** Build an IEC 61850 substation with a high-reliability design, including IEEE 1588 devices and a zero packet loss solution.
- **Why Moxa:**
  - KEMA certification for IEC 61850-3
  - Good consulting and technical support
  - Comprehensive PRP/HSR offering
  - Solution includes MMS communication

---

**Background and Requirements**
- **Substation Voltage:** 345 kV
- **Type of Substation:** Generation Substation
- **Customer Needs:** Implement ESS (Energy Storage System) to enable remote monitoring of the state of the energy stored.

**Why Moxa**
- Easy-to-configure HSR solution
- One dedicated Ethernet port for monitoring and troubleshooting

---

**Background and Requirements**
- **Substation Voltage:** 765 kV
- **Type of Substation:** Generation Substation
- **Customer Needs:** Flexible port configuration with 4 fiber gigabit ports to form a redundant ring

**Why Moxa**
- IEC 61850 Ethernet Switch
- PT-7728 provides the best cost-performance ratio

---

**Background and Requirements**
- **Substation Voltage:** 110 kV
- **Substation Type:** Transmission Substation
- **Customer Requirements:**
  - Implement ESS (Energy Storage System) to enable remote monitoring of the state of the energy stored

**Why Moxa**
- KEMA certification for IEC 61850-3
- Good consulting and technical support
- Comprehensive PRP/HSR offering
- Solution includes MMS communication

---

**Background and Requirements**
- **Substation Voltage:** 161 kV
- **Type of Substation:** Transmission Substation
- **Customer Requirements:**
  - Build an IEC 61850 substation with a high-reliability design including IEEE 1613 devices and a zero packet loss solution
  - Protection devices (SAN and DAN)

**Why Moxa**
- IEC 61850 Ethernet Switch
- PT-7728 provides the best cost-performance ratio

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- **Customer Requirements:**
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  - Protection devices (SAN and DAN)

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**Why Moxa**
- Easy-to-configure HSR solution
- One dedicated Ethernet port for monitoring and troubleshooting
The Largest State Grid Substation in Colombia

Integrated With Leading PSCADA Software

PRP Network for Station and Process Bus

05

Background and Requirements

- Substation Voltage: 380 kV
- Substation Type: Transmission Substation
- Customer Requirements:
  - Control stations for a 340 km 380 kV HVAC line with a transmission capacity of 2 million MVA
  - Support for synchronous coupling mode and management functions
  - State-of-the-art PTP support
  - IEC 61850 compliant, flexible, high-performance computers

06

Background and Requirements

- Substation Voltage: 380/132 kV
- Substation Type: Transmission Substation
- Customer Needs:
  - A complete PRP/HSR portfolio that meets IEC 61850 compliant computing needs

Why Moxa

- A complete PRP/HSR portfolio that meets IEC 61850 compliant computing needs
- Fast adoption of latest PRP/HSR coupling mode
- Quick adoption of latest PRP/HSR standard requirements and fast response to specific firmware needs

07

Electrical Grid Monitoring Solution for Italy’s State Grid

08

Medium-level Unmanned Substation Retrofit

Why Moxa

- Total IEC 61850-3 computing and communication solution
- PT-7528’s main management features: Diagnostic data (port status, power supply) via MMS or SNMP
- Proactive Monitoring: Predictive maintenance function supported on the DA-820

Why Moxa

- Ethernet and fiber ports to set up a redundant network backbone using Moxa’s Turbo Ring technology
- Two-in-one solution that replaces a switch and a device server, enabling easy maintenance
- DIN-rail mountable devices that save space in installation cabinets
- iReal COM mode driver support for Windows 7 and Windows 2012

Why Moxa

- Moxa’s Turbo Ring technology
- A solution that can enhance remote monitoring and management functions
- IEC-61850 compliant, fanless, high-performance computers
- Proactive Monitoring: Predictive maintenance function supported on the DA-820

Customer Requirements:

- Substation Type: Transmission Substation
- Customer Needs:
  - Protection relay should only have serial interfaces (RS-232)
  - IEC 61850-3 compliant devices for automation applications
  - Ethernet-to-fiber interface for long-distance communication
  - Ethernet and fiber ports to set up a redundant network backbone using Moxa’s Turbo Ring technology
  - Two-in-one solution that replaces a switch and a device server, enabling easy maintenance
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  - iReal COM mode driver support for Windows 7 and Windows 2012
ADNOC (Abu Dhabi National Oil Company) Substation

IEC 61850 Makes Substations Smarter

Why Moxa
- Ethernet switches that can be easily integrated into existing RSTP ring based on Turbo Chain technology
- PT-508 supports voltage range up to 60 V
- Customized Firmware: Customized web navigator to monitor the status of Ethernet switches (MAC Address, FW, Serial Number)

China Southern Power Grid Distribution

Why Moxa
- Turbo-chain technology that provides easy mass-deployment capability with the ability to expand the network based on system requirements
- Easy integration with Turbo Chain and RSTP backbone
- Cost-effective with Turbo Chain deployment

Background and Requirements
- Substation Voltage: 33 kV/11 kV
- Type of Substation: Distribution
- Customer Needs: Ethernet switches that are secure and that can be integrated into legacy systems with many restrictions

Background and Requirements
- Substation Voltage: 10 kV
- Type of Substation: Distribution
- Customer Requirements:
  - An integrated platform capable of handling multiple devices running on CANbus, CANopen, AO/DO, and Ethernet
  - Consulting service for easy integration

Background and Requirements
- Deployment: 700 units
- Type of Substation: Distribution
- Customer Needs:
  - Scalable and flexible mass deployment
  - Interoperability with existing power network
  - Interoperability of various Ethernet equipment

Background and Requirements
- Substation Voltage: Mid to low level
- Type of Substation: Enterprise Substation
- Customer Needs:
  - Integration of IEC 61850 Ethernet switch and Protocols into the Experion process server and IEC 61850 SCADA server

Why Moxa
- Wide expertise in computing, fieldbus, and I/O, and can provide prompt and customized service
- Consulting services: To fine tune AI/AO, serial, and Ethernet running on CANbus, DI/DO, and can provide easy mass-deployment

One Embedded Computing Module Simplifies Power Distribution Systems

Enterprise Substation: PRP/HSR Solution for Factory DCS

Why Moxa
- PT-508 supports both PRP and HSR for flexible configuration solutions
IEC 61850 Makes Substations Smarter

Russian Substation: 10 kV Semiconductor Substation

- **Substation Voltage:** 10 or 35 kV
- **Type of Substation:** Enterprise Substation
- **Customer Needs:**
  - Reliable hardware platform with a flexible design
  - Flexible modular design for easy expansion (LON communication protocol)
  - Customized consulting service

Why Moxa:
- RSTP Grouping technology helps easy integration of existing IEDs into PRP/HSR network
- Full serial ports to convert Modbus RTU data to Modbus TCP
- PRP/HSR portfolio that includes switches and routers for flexible integration
- Building in a switch to simplify the network

China Substation: 35 kV Steel Factory Substation

- **Substation Voltage:** 345 kV
- **Type of Substation:** Enterprise Substation
- **Customer Needs:**
  - Compact hardware that can fit in a small cabinet
  - IEC 61850-compliant solution

Why Moxa:
- Variety of hardware platforms to meet customer requirements
- Proven track record in providing solutions for IEC 61850 substations
- Rugged design

Korea Substation: 10 kV Semiconductor Substation

- **Substation Voltage:** 10 or 35 kV
- **Type of Substation:** Enterprise Substation
- **Customer Needs:**
  - Rugged design hardware that can fit in a small cabinet
  - IEC 61850-compliant solution

Why Moxa:
- RSTP Grouping technology helps easy integration of existing IEDs into PRP/HSR network
- Full serial ports to convert Modbus RTU data to Modbus TCP
- PRP/HSR portfolio that includes switches and routers for flexible integration
- Building in a switch to simplify the network

Background and Requirements
- **Substation Voltage:** 150/255 kV
- **Customer Requirements:**
  - Easily integrate RSTP-based protocols with hundreds of IEDs into Pro/HSR networks
  - Convert Modbus RTU devices into Modbus TCP for easy management
  - Preced to filter IEC 61850 packets
  - Transmit IEC 61850 packets and messages to PRP/HSR networks

Why Moxa:
- RSTP Grouping technology helps easy integration of existing IEDs into PRP network
- Four serial ports to convert Modbus RTU data to Modbus TCP
- PRP/HSR portfolio that includes switches and routers for flexible integration
- Building in a switch to simplify the network

Electrical Equipment Control and Monitoring System (ECMS) for Power Substation with 780 MW Capacity

- **Substation Voltage:** 345 kV
- **Type of Substation:** Enterprise Substation
- **Customer Needs:**
  - Rugged design hardware that can fit in a small cabinet
  - IEC 61850-compliant solution

Why Moxa:
- Variety of hardware platforms to meet customer requirements
- Proven track record in providing solutions for IEC 61850 substations
- Rugged design

Background and Requirements
- **Substation Voltage:** 10 or 35 kV
- **Type of Substation:** Enterprise Substation
- **Customer Needs:**
  - Rugged design hardware that can fit in a small cabinet
  - IEC 61850-compliant solution

Why Moxa:
- RSTP Grouping technology helps easy integration of existing IEDs into PRP network
- Four serial ports to convert Modbus RTU data to Modbus TCP
- PRP/HSR portfolio that includes switches and routers for flexible integration
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- Building in a switch to simplify the network

www.moxa.com/SmartGrid www.moxa.com/substation
**Protocol Gateways for Substations**

<table>
<thead>
<tr>
<th>Feature</th>
<th>MGate MB3660</th>
<th>MGate 5114</th>
<th>MGate 5114</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LAN Interface</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(10/100BaseT(X) Ports)</td>
<td>2 ports (8-pin RJ45 connector)</td>
<td>2 ports (8-pin RJ45 connector)</td>
<td>2 ports (8-pin RJ45 connector)</td>
</tr>
<tr>
<td><strong>Magnetic Isolation Protection</strong></td>
<td>1.5 kV</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Protocol</strong></td>
<td>Modbus TCP Client/Server</td>
<td>Modbus TCP Client/Server</td>
<td>Modbus TCP Client/Server</td>
</tr>
<tr>
<td><strong>Serial Interface</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>LAN Interface</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protocol</td>
<td>Modbus RTU/ASCII Master/Slave</td>
<td>DNP3 Serial Master/Ontstation</td>
<td>IEEE 60870-5-104 Client/Server</td>
</tr>
<tr>
<td>RS-232/422/485 Ports</td>
<td>8/16</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Connectors</strong></td>
<td>DB9 male</td>
<td>DB9 male</td>
<td>DB9 male</td>
</tr>
<tr>
<td><strong>Communication Parameters</strong></td>
<td>Data Bits: 7, 8; Stop Bits: 1, 2; Parity: None, Even, Odd, Space, Mark</td>
<td>Data Bits: 7, 8; Stop Bits: 1, 2; Parity: Even, Odd, Space, Mark</td>
<td>Data Bits: 7, 8; Stop Bits: 1, 2; Parity: None, Even, Odd, Space, Mark</td>
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<tr>
<td><strong>Flow Control</strong></td>
<td>RTU/CTS, DNP3, RTS Toggle (RS-232 only)</td>
<td>RTU/CTS, RTS Toggle (RS-232 only)</td>
<td>DNP3 Serial Master/Ontstation</td>
</tr>
<tr>
<td><strong>EIA-422 Data Isolation Protection</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>RS-485 Serial Interface</td>
<td></td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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</tbody>
</table>

**Advanced Features**

- **Serial Data Log**
- **Offline port buffering**
- **MDM Switch**
- **Security Protocols**
  - Radius
  - HTTPS
  - SSPI
- **Configuration Options**
  - Web console
  - Serial console
  - Telnet console
  - Web console
  - Serial console
  - Telnet console
- **Driver Support**
  - Windows
  - Linux
- **Configuration Options**
  - Transparent Mode
  - Intelligent Mode
  - Agent Mode
  - Transparent Mode
  - Intelligent Mode
  - Agent Mode
- **Software Configuration Options**
  - Management
    - SNMP
    - HTTP
    - HTTPS
- **Management**
  - Web console
  - Serial console
  - Telnet console
- **Reliability**
  - MTBF
    - MGate MB3660-8-2AC: 716,647 hrs
    - MGate MB3660-8-J-2AC: 616,505 hrs
    - MGate MB3660-8-2DC: 706,783 hrs
    - MGate MB3660I-8-2AC: 429,807 hrs
    - MGate MB3660-16-2AC: 487,416 hrs
    - MGate MB3660I-16-2AC: 256,208 hrs
    - MGate MB3660-16-2DC: 482,835 hrs
    - MGate MB3660-16-J-2AC: 437,337 hrs
    - MGate MB3660-16-1AC: 1,140,815 hrs
    - MGate MB3660-16-1DC: 1,140,815 hrs
- **Warranty**
  - 5 years

**Software**

- **Security Protocols**
  - Radius
  - HTTPS
  - SSH
- **Configuration Options**
  - Web console
  - Serial console
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  - Web console
  - Serial console
  - Telnet console
- **Driver Support**
  - Windows
  - Linux
- **Configuration Options**
  - Transparent Mode
  - Intelligent Mode
  - Agent Mode
  - Transparent Mode
  - Intelligent Mode
  - Agent Mode

**Maintenance Characteristics**

- **Housing**
  - Metal, IP20
- **Dimensions (mm)**
  - 440 x 45 x 198 mm
- **Environmental Limits**
  - Operating Temperature
    - Standard Models: 0 to 60°C
    - Wide Temp. Models: -40 to 75°C
  - Storage Temperature
    - -40 to 85°C
  - Ambient Relative Humidity
    - 5 to 95% (non-condensing)
- **Power Requirements**
  - Rated Voltage
    - DC models: DC 20 to 60 VDC (1.5 kV isolation)
    - AC models: Dual 100 to 240 VAC, 47 to 63 Hz
  - Standby Voltage
    - 12 VDC to 48 VDC
  - Standards and Certifications
    - FCC: UL 508
  - CE: EN 60950-1, EN 60601-1
  - C-Tick
  - UL 508
  - EN 60601-1
  - UL 60950-1
  - EN 60601-1
  - EN 60950-1
  - Safety Protocols
    - UL 508
  - EN 60950-1
  - EN 55022/24
  - EN 55032/24
  - EN 55032/24
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  - Warranty
    - 5 years

Moxa’s products are specifically designed for substation transmission and distribution systems. Moxa’s solutions include the advanced technologies that are fueling the power revolution. For example, PRP/HSR for seamless redundancy, SNMP/MMS management for power SCADA integrated network monitoring, IEEE 1613 and IEC 61850 certifications for substation applications, and IEEE 1588 compliance for precision time synchronization are key features that upgrade large-scale electric power networks to the next level of reliability and efficiency. All of Moxa’s products are toughened to overcome harsh environments, ensuring consistent operations even in the most demanding conditions. Tap into Moxa’s expertise in communication and computing to easily build an efficient and effective power grid.
# IEC 61850 Makes Substations Smarter

**IEC 61850-3 Ethernet Switches**

<table>
<thead>
<tr>
<th>Number of Ports</th>
<th>PT-G7728/G7828</th>
<th>PT-T7292</th>
<th>PT-T7292-PTP</th>
<th>PT-7728</th>
<th>PT-7710</th>
<th>PT-3000/10D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. Number of Ports</td>
<td>28</td>
<td>26</td>
<td>26</td>
<td>10</td>
<td>8 or 10</td>
<td></td>
</tr>
<tr>
<td>Max. Number of Hardware PTP Ports</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Gigabit Ethernet, 10/100/1000 Mbps</td>
<td>1G to 26</td>
<td>1G to 4</td>
<td>1G to 4</td>
<td>1G to 2</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Fast Ethernet, 10/100 Mbps</td>
<td>1G to 26</td>
<td>1G to 26</td>
<td>1G to 10</td>
<td>8 or 10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Power Supply**

- 24VDC, isolated
- 48VDC, isolated
- 24/48VDC, isolated
- 12/24/48VDC
- 12/24/48/48VDC
- 48VDC or 80-350VAC isolated

**Input/Output**

- Rack Mounting
- Wall Mounting
- DIN-Rail Mounting

**Operating Temperature**

- 0°C to 55°C (32°F to 131°F)
- 0°C to 40°C (32°F to 104°F)
- 0°C to 70°C (32°F to 158°F)
- 0°C to 85°C (32°F to 185°F)

**Relay Warning**

<table>
<thead>
<tr>
<th>Protocol</th>
<th>PT-7728-PTP</th>
<th>PT-7728</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEC 61850 QoS</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>VLAN</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>DHCP</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>IGMP/GMRP</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>IGMP</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>TACACS+/RADIUS</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>IEEE 802.1X</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Port Trunking</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Redundancy and Backup Options</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>DIN-Rail Mounting</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Wall Mounting</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Rack Mounting</td>
<td>–</td>
<td>–</td>
</tr>
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<tr>
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<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Redundancy and Backup Options</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>DIN-Rail Mounting</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Wall Mounting</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Rack Mounting</td>
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<td>IGMP</td>
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<td>IEEE 802.1X</td>
<td>–</td>
<td>–</td>
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<tr>
<td>Port Trunking</td>
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<td>–</td>
</tr>
<tr>
<td>Redundancy and Backup Options</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>DIN-Rail Mounting</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Wall Mounting</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Rack Mounting</td>
<td>–</td>
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</tr>
</tbody>
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## Power Computers

### DA-820C Series

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU</td>
<td>i5-7442EQ, 4C/4T, 2.1GHz</td>
</tr>
<tr>
<td>Display</td>
<td>1x VGA</td>
</tr>
<tr>
<td>Storage</td>
<td>1x SATA 3.0 Interface, 2x 2.5 inch SSD/HDD</td>
</tr>
<tr>
<td>Expansion Bus</td>
<td>5x slots (Proprietary PCIe)</td>
</tr>
<tr>
<td>USB</td>
<td>2x USB 2.0, 2x USB 3.0</td>
</tr>
<tr>
<td>Ethernet Interface</td>
<td>4x 10/100/1000 Mbps ports</td>
</tr>
<tr>
<td>Power Consumption</td>
<td>60 W (max.)</td>
</tr>
<tr>
<td>Environment Limits</td>
<td>-40 to 85°C (-40 to 185°F)</td>
</tr>
<tr>
<td>Input Voltage</td>
<td>100 to 240 VAC/VDC, 50/60 Hz</td>
</tr>
<tr>
<td>Power Requirements</td>
<td>100W max.</td>
</tr>
<tr>
<td>Standards and Certifications</td>
<td>IEC 61850-3, IEEE 1613, IEEE 60255</td>
</tr>
<tr>
<td>Warranty Period</td>
<td>3 years</td>
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</table>

### DA-682A Series

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU</td>
<td>i5-6300U Processor, 2C/4T, 2.4GHz</td>
</tr>
<tr>
<td>Display</td>
<td>1x VGA</td>
</tr>
<tr>
<td>Storage</td>
<td>1x SATA 3.0 Interface</td>
</tr>
<tr>
<td>Expansion Bus</td>
<td>2x 2.5 inch SSD/HDD</td>
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<tr>
<td>USB</td>
<td>2x USB 2.0, 1x USB 3.0</td>
</tr>
<tr>
<td>Ethernet Interface</td>
<td>4x 10/100/1000 Mbps ports</td>
</tr>
<tr>
<td>Power Consumption</td>
<td>60 W (max.)</td>
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<tr>
<td>Environment Limits</td>
<td>-40 to 85°C (-40 to 185°F)</td>
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<tr>
<td>Input Voltage</td>
<td>100 to 240 VAC/VDC, 50/60 Hz</td>
</tr>
<tr>
<td>Power Requirements</td>
<td>100W max.</td>
</tr>
<tr>
<td>Standards and Certifications</td>
<td>IEC 61850-3, IEEE 1613, IEEE 60255</td>
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<tr>
<td>Warranty Period</td>
<td>3 years</td>
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### DA-662A Series

<table>
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<tr>
<th>Feature</th>
<th>Specification</th>
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</thead>
<tbody>
<tr>
<td>Power Consumption</td>
<td>60 W (max.)</td>
</tr>
<tr>
<td>Environment Limits</td>
<td>-40 to 85°C (-40 to 185°F)</td>
</tr>
<tr>
<td>Input Voltage</td>
<td>100 to 240 VAC/VDC, 50/60 Hz</td>
</tr>
<tr>
<td>Power Requirements</td>
<td>100W max.</td>
</tr>
<tr>
<td>Standards and Certifications</td>
<td>IEC 61850-3, IEEE 1613, IEEE 60255</td>
</tr>
<tr>
<td>Warranty Period</td>
<td>3 years</td>
</tr>
</tbody>
</table>

---

### Other Specifications

- **Control Systems**: DA-820C Series
- **Power**: 100W (max.)
- **Environmental Limits**: -40 to 85°C (-40 to 185°F)
- **Input Voltage**: 100 to 240 VAC/VDC, 50/60 Hz
- **Power Requirements**: Single power supply
- **Power Consumption**: 100W (max.)
- **Standards and Certifications**: IEC 61850-3, IEEE 1613, IEEE 60255
- **Warranty Period**: 3 years

---

### Additional Features

- **Display**: HDMI, DVI-D
- **Expansion Bus**: 5x slots (Proprietary PCIe)
- **USB**: 2x USB 2.0, 1x USB 3.0
- **Ethernet**: 4x 10/100/1000 Mbps ports
- **Power**: 100W (max.)
- **Environmental Limits**: -40 to 85°C (-40 to 185°F)
- **Input Voltage**: 100 to 240 VAC/VDC, 50/60 Hz
- **Power Requirements**: Single power supply
- **Power Consumption**: 100W (max.)
- **Standards and Certifications**: IEC 61850-3, IEEE 1613, IEEE 60255
- **Warranty Period**: 3 years

---

**See also**: [www.moxa.com/SmartGrid](http://www.moxa.com/SmartGrid) [www.moxa.com/substation](http://www.moxa.com/substation)
### Serial Device Server for Substations

<table>
<thead>
<tr>
<th>Model</th>
<th>XPort 6000 Series</th>
<th>CHX2700 Series</th>
<th>XPort 6053/8X</th>
<th>XPort 8330</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/100BaseT(X) Ports</td>
<td>2 ports (8-pin RJ45 connection)</td>
<td>2 ports (8-pin RJ45 connection)</td>
<td>2 ports (8-pin RJ45 connection) with the option for 2 more 8/24-pin EtherCAT (52 ports)</td>
<td>5 ports (8-pin RJ45 connector with the option for 3 more 8/24-pin EtherCAT (52 ports)</td>
</tr>
<tr>
<td>Magnetic Isolation Protection</td>
<td>5.5 kV</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Warranty</td>
<td>5 years</td>
<td>5 years</td>
<td>5 years</td>
<td>5 years</td>
</tr>
<tr>
<td>Dimensions (mm)</td>
<td>440 x 195 x 44 mm</td>
<td>440 x 195 x 44 mm</td>
<td>Without ears: 440 x 363 x 44 mm</td>
<td>Without ears: 160 x 80 x 109 mm</td>
</tr>
<tr>
<td>Housing</td>
<td>Metal</td>
<td>Metal</td>
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</table>

#### Standards and Certifications

<table>
<thead>
<tr>
<th>Standard and Certification</th>
<th>UL 60950-1, EN 60950-1</th>
<th>UL 60950-1, EN 60950-1-3-302</th>
<th>UL 60950-1, EN 60950-1-3-2014</th>
<th>UL 60950-1, EN 60950-1 (LV)</th>
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<tbody>
<tr>
<td>IEC</td>
<td>CE, RoHS</td>
<td>CE, RoHS</td>
<td>CE, RoHS</td>
<td>CE, RoHS</td>
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<tr>
<td>C-Tick</td>
<td>UL 60950-1, EN 60950-1</td>
<td>UL 60950-1, EN 60950-1-3-302</td>
<td>UL 60950-1, EN 60950-1-3-2014</td>
<td>UL 60950-1, EN 60950-1 (LV)</td>
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#### Power Requirements

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<tbody>
<tr>
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<tr>
<td>Power</td>
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#### Interfaces

<table>
<thead>
<tr>
<th>Model</th>
<th>Connectors</th>
<th>Security Protocols</th>
<th>Configuration Options</th>
<th>Protocol</th>
<th>Magnetic Isolation Protection</th>
<th>Serial Data Log</th>
<th>Advanced Features</th>
<th>Physical Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8-pin RJ45</td>
<td>DES, 3DES, AES, SSL, AESS, SSL, AESS</td>
<td>N/A</td>
<td>Modbus TCP, DNP3 TCP</td>
<td>1.5 kV</td>
<td>64 KB</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>CN2610/2650</td>
<td>HTTP, HTTPS, SSH, PAP, CHAP</td>
<td>N/A</td>
<td>Modbus TCP, DNP3 TCP</td>
<td>–</td>
<td>–</td>
<td>–</td>
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<tr>
<td></td>
<td>CN2650I-16-HV-T</td>
<td>RADIUS, HTTPS, SSH, PAP, CHAP</td>
<td>N/A</td>
<td>Modbus TCP, DNP3 TCP</td>
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<td>–</td>
<td>–</td>
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<td>CN2650I-8-HV-T</td>
<td>RADIUS, HTTPS, SSH, PAP, CHAP</td>
<td>N/A</td>
<td>Modbus TCP, DNP3 TCP</td>
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<td>–</td>
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<td>CN2650I-8-2HV-T</td>
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#### Connect to the Smart Grid Today

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