Automating Substation and Distribution Systems for a Smarter Grid

- Expertise in communications, computing, and control
- Designed for substation environments
- IEEE 1588 version 2 precision timing
- IEC 61850-3 and IEEE1613 certified (KEMA tested)
- Zero-packet-loss Ethernet switches
Modern electricity providers must navigate a precise course between business realities, the energy demands of modern society, and the sustainability requirements of the environment in which we live. This has produced a revolution of “Smart Grid” technology that draw on advanced monitoring, control, and communications technologies. This revolution provides new ways of thinking about how to deliver energy efficiently and reliably in the future.

Power substations transport electricity from power plants to homes, businesses, and factories, and are a critical component of the smart grid. The modernization of legacy Transmission and Distribution (T&D) systems to provide reliable T&D information for electric power management is a key goal for today’s smart grid applications.

**IP/Ethernet Substation Networks — The Cornerstone of a Smart Grid**

The smart grid will be more intelligent, responsive, and adaptable than power grids that exist today by becoming more decentralized. Information gathering and decision making will occur further down, at the substation level. The electricity dispatching control center supervises the grid intelligence strategic management, while the transmission and distribution automated management conducts operations. Information then goes to intelligent substations. The intelligent substation will report electricity consumption, switchboard operation, information gathering, and station decision making back to the electricity dispatching control center. In addition, smart grid substations will play a larger role in AMI backhaul and distribution automation initiatives to secure private networking for advanced metering.

An intelligent grid will require a smart backbone made up of a strong network and communications infrastructure. The requirements of the communications network are inextricably tied to those of the smart grid itself, encompassing issues such as scalable bandwidth, robust security, high network reliability and availability, and cost–effectiveness. There is an ongoing and gradual convergence of power transmission systems towards a common IP and Ethernet infrastructure at both the local substation LAN level and in wide area substation WAN connectivity. Ethernet-based substation networks will become an indispensable tool to revolutionize power system communications.
Complete Substation-specific Functionalities

- IEEE 1613 and IEC 61850-3 EMI Immunity (KEMA tested)
- Wide operating temperature -40 to 85°C (fanless)
- Fast ring recovery time (< 20 ms) with a full load of 250 Ethernet switches
- Isolated dual redundant power supplies
- High integration between serial devices, LANs, and WLANs

PowerTrans Series
IEC 61850-3 Ethernet switches

PTC-101 Series
IEC 61850-3 media converters

CN 2650 Series
RS-232/422/485 terminal server

DA-681 Series
IEC 61850-3 embedded computers

Grid intelligence strategic decision, T&D automated management

Electricity consumption, switchboard operation, information gathering, station decision making feedback
Moxa’s Networking and Computing Solutions for Substation Environments

IEC 61850-3 Ethernet Switches

- IEC 61850-3, GOOSE, and IEEE 1613 Class 2 compliant (KEMA tested)
- Zero packet loss under harsh EMI stress
- Nanosecond-precise time synchronization with IEEE 1588 v2
- Isolated redundant power inputs at 24/48 VDC or 110/220 VDC/VAC
- Fast ring recovery time (20 ms with 250 switches)
- -40 to 85°C operating temperatures

19” Rack Mounting
- PT-7828 4G+24-port, Layer 3 switching
- PT-7728-PTP 4G+24-port, 14-port IEEE 1588 v2 support
- PT-7728 4G+24-port
- PT-G7509 9G-port, full gigabit
- PT-7710 2G+8-port, panel mounting options

DIN-Rail Mounting
- PT-508 8-port, with 2 fiber ports
- PT-510 10-port, with 2 fiber ports

IEC 61850-3 Media Converters

- 10/100BaseT(X) auto-negotiation and auto-MDI/MDI-X
- Link Fault Pass-Through (LFP)
- Power failure alarm by relay output (LV model only)
- -40 to 85°C operating temperature range
- Redundant dual DC power inputs
- Integrated high-reliability power supply eliminates the need for external power transformer

Industrial Embedded Computers

- DA-710 series
- DA-682 series
- DA-681 series
- DA-660 series

Industrial Embedded Computer Features and Applications

1 Protocol Converter
- Basic data processing ability
- Connects to many serial devices
- Converts protocols from many different sources

2 Protection and Management Computer
- Converts protocol from different IEDs
- Manages the system
- Can connect IEDs using different protocols
- Instantly reacts and deals with emergencies

3 Front-end Communication Computer
- Collect information from other protocol converter computers and deliver them to the control center
- More powerful processor than normal protocol converters
- HMI support (depends)

Serial to Ethernet Servers

Connecting Legacy Devices to Ethernet

- Connect legacy serial RTUs, PLCs, and meters to Ethernet networks
- Complete virtual COM drivers for Windows and Linux
- Versatile operation modes to customize application behavior
- Ruggedized design to extend operating temperature
- Varied mounting options to adapt to different installation scenarios

Device Server
- NPort 5000A Series 1/2/4-port RS-232/422/485 with surge protection for serial/Ethernet/power lines

Terminal Server
- CN2600 Series 8 and 16-port RS-232/422/485 terminal servers with LAN redundancy

Combo Switch/Serial Device Server
- NPort® S8000 Series 4-port RS-232/422/485 serial device server with built-in 5-port managed Ethernet switch
Product Offerings

IEEE 1588 v2-based Technology to Synchronize the Sampled Values

**Tele-control Communication Computer**
- Support for 4 to 6 LANs
- High-performance processor required
- High system reliability and fanless design
- IEC 61850-3 certified

**Backend Host**
- HMI interface/display function
- Control function
- SCADA software support
- Powerful processing ability

**Multi-port Mirroring**

Tomorrow’s substation automation systems will increase electric efficiency and uptime by improving monitoring and fault isolation capabilities. In China, IEEE 1588 Ethernet ensures precise time-synchronization from protection function to system.

**RISC-based Rackmount Embedded Computers**
- DA-660/661/662/662-I
  - 8 or 16 serial ports, Ethernet LANs, PCMCIA, CompactFlash, USB

**x86-based Rackmount Embedded Computers**
- DA-710
  - 2 serial ports, quad LANs, VGA, 4 DIs, 4 DOs, and 6 peripheral expansion slots
- DA-681
  - 4 isolated RS-232 and 8 isolated RS-485 ports, 6 LANs, VGA, CompactFlash, USB, IEC 61850-3 certified (DPP model only)
- DA-682
  - VGA, 4 Gigabit Ethernet ports, 2 peripheral expansion slots, CompactFlash, USB

**Redundant COM with Zero Switching Time**

The “Redundant COM” operation mode can be used to set up a redundant LAN between the CN2600’s COM ports and the host computer. If either of the two LANs fails, the other LAN will continue transferring packets between the serial devices and the host through the Ethernet. The switching time in Moxa’s redundant COM mode is zero, which means that if one of the LANs fail, data transmission between the PC host and the serial devices will not be interrupted.

**Power T&D Success Stories**

- China’s State Grid Corp.
- Efacec

**Optical Fiber Twisted Pair Serial Station Bus**

- Station Bus
- Process Bus
- Process Level
- Bay Level
- Station Level

- 500/220 kV Substations in China
- 400 kV Substation in Africa
IEC 61850-based Substation Automation System

IEC 61850-based standards enable most state-of-the-art substations to be deployed with EtherCAT, but they fail to address the requirements of substations, including redundant components, and require additional systems for maintaining legacy devices.

Enhanced Reliability

Zero Packet Loss Under Harsh EMI Stress

When high voltage circuit breakers open, they generate extremely strong electromagnetic fields that violently collide with and often damage the standard IEC 61850-based systems. This problem is so significant that the IEC 61850 standard is being revised to include protection against EMI. Moxa’s PT-7728-PTP IEC 61850-3 fast Ethernet switches support the latest version of IEEE 1588 v2 technology to fulfill the requirements of substations.

Discover Moxa’s Business Benefits

Substations are extremely demanding environments, so the Ethernet networks that operate in them must be rugged enough to deliver high communications reliability, availability, and uptime. To meet the strict requirements of substations, Moxa has introduced IEC 61850-3 and IEC 61850 compliant Ethernet switches designed to work reliably without experiencing any communications loss under a variety of EMI phenomena commonly found in substations.

Adding Intelligent Coaxial Cables Dramatically Extends Efficiencies and Reliability of Networks

Two heads are better than one. Moxa’s Media MUX technology uses media multiplexers of exceptional efficiency and reliability. Without Moxa’s solutions, substation control systems often have their Ethernet backbone networks directly connected to transformer protection and control systems. These systems are resilient to work reliably without experiencing any communications loss under a variety of EMI phenomena commonly found in substations.

Increased Availability

A substation Ethernet system is one of the most critical components of a substation. These systems must perform reliably under a variety of environmental conditions, often in extremely complex and critical environments. The IEC 61850 standard includes safeguards for redundant systems, but it does not specify how redundancy should be implemented. Moxa’s PT-7728-PTP IEC 61850-3 fast Ethernet switches support the latest version of IEEE 1588 v2 technology to fulfill the requirements of substations.

Precise Time Synchronization

IEEE 1588: The Actual Time to Synchronize the Sampled Values on the Substation Process Bus

IEEE 1588-2008 (IEEE 1588 v1.1) standard defines the time synchronization services for multiple devices. However, this standard is not practical in an application as large as a typical power distribution system. Moxa’s PT-7728-IPTP IEC 61850-3 fast Ethernet switches support the latest version of IEEE 1588 v2 technology to fulfill the requirements of substations.

Moxa’s innovative Turbo Ring technology offers a highly flexible self-healing Ethernet technology solution for substations. The PT-7728-IPTP IEC 61850-3 fast Ethernet switches support the latest version of IEEE 1588 v2 technology to fulfill the requirements of substations. Moxa’s PT-7728-IPTP IEC 61850-3 fast Ethernet switches support the latest version of IEEE 1588 v2 technology to fulfill the requirements of substations.

Today, utility systems have not only grown larger and more numerous, they have also forged connections between one another and with remote facilities such as substations. The substations system constantly delivers power from the transmission system and delivers it to consumers. Consequently, a typical power distribution system consists of a complex network with many power utility connections. Moxa’s solutions, substation control centers often have four different parallel systems—the protection management server, SCADA system, five-point prevention system, and a data logger server. By using Moxa’s DA-710 x86-based embedded computer, all of Moxa’s solutions, substation control centers often have four different parallel systems—the protection management server, SCADA system, five-point prevention system, and a data logger server. 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IEEE 1588 v2-based Technology to Synchronize the Sampled Values

Tele-control Communication Computer Backend Host

Multi-port Mirroring

The World's First IEC 61850-3-certified Rackmount Computer

x86-based Rackmount Embedded Computers

DA-710
- 2 serial ports, quad LANs, VGA, 4 DIs, 4 DOs, USB, and 4 peripheral expansion slots

DA-681
- 4 isolated RS-232 and 8 isolated RS-485 ports, 6 LANs, VGA, CompactFlash, USB, IEC 61850-3 certified (DPP model only)

DA-682
- VGA, 4 Gigabit Ethernet ports, 2 peripheral expansion slots, CompactFlash, USB

RISC-based Rackmount Embedded Computers

DA-660/661/662/662-I
- 8 or 16 serial ports, Ethernet LANs, PCMCIA, CompactFlash, USB

Redundant COM with Zero Switching Time

Optical Fiber Twisted Pair Serial Station Bus

Station Bus

Process Bus

Station Level
- Functions that take place within one bay are performed at this level.

Bay Level
- Protects and controls different bay IEDs.

Process Level
- Functions that include more than one bay are performed at this level.

Enabling High Availability and Reliability for SAS

500/220 kV Substations in China
400 kV Substation in Africa

Requirements

Why Moxa?

Products

• PT-7728
  - IEC 61850-3 24+4G-port rackmount modular managed Ethernet switches

Power T&D Success Stories

Enabling High Availability and Reliability for SAS
500/220 kV Substations in China

The State Grid Corporation of China (SGCC), the largest electric power transmission and distribution company in China, employed in its south China region a seven-switch solution for use in substations automation and unmanned applications. Hundreds of PT-7728 switches were installed in 500/220 kV high voltage substations to create highly reliable communications networks in harsh electric utility substation environments.

The PT-7728 series emerged as the clear leader after a rigorous and extensive selection process that evaluated several potential global suppliers of substation-hardened industrial networking equipment. Selection criteria included exacting requirements such as EMI shielding that can deliver error-free performance in a variety of destructive EMI scenarios.

Products
- PT-7728 IEC 61850-3 24+4G-port rackmount modular managed Ethernet switches

Why Moxa?
- Zero packet loss under harsh EMI interference
- IEC 61850 compliant networking devices

Requirements
- Non-stop operation for mission-critical applications
- Network devices that are IEC 61850-3 and IEEE 1613 compliant
- Modular rackmount capacity and rear cabling with front display for ease of installation and maintenance

400 kV Substation in Africa

Efacec is the largest provider of energy, engineering, and transportation solutions in Portugal; they employ around 4000 people and have a yearly revenue of almost 500 million Euros. As part of a modernization program for 400 kV substations, Efacec deployed Moxa’s PT-7728 IEC 61850-3 Ethernet switches in the transmission substation automation system. These switches connect with protection relays and other intelligent electronic devices (IED), and also form a ring topology that is highly self-healing in the event of a network failure. Several PT-7728 Ethernet switches connect to the local SCADA monitoring server and redundant substation central units so that operators can efficiently monitor operations at field sites.

Products
- PT-7728 IEC 61850-3 24+4G-port rackmount modular managed Ethernet switches

Requirements
- Non-stop operation for mission-critical applications
- IEC 61850-3 and IEEE 1613 compliant
- Modular rackmount capacity and rear cabling with front display for ease of installation and maintenance

Why Moxa?
- Isolated redundant power input with 68 to 300 VDC and fast recovery (< 20 ms) with 250 switches for fast network availability
- IEC 61850-3 certified (testing by KEMA)
- High EMI resistance without experiencing any communications loss
- Flexible installation for front or rear cabling method

Success Stories
Substation Modernization for an Aluminum Smelter Plant

A transmission company supplied three 132 KV power transmission lines to an aluminum smelter plant, each with its own power substation to convert the electrical energy for use in the smelting process. The existing network infrastructure was hub-based Ethernet and the network design was not redundant. In order to improve the reliability of the system, the operator sought to modernize the entire automation network, including a substation automation network that was originally installed in 2000.

Requirements
Build star network on top of the existing substation backbone to have direct connection to each substation in case of a blackout.

Why Moxa?
Moxa was able to provide a versatile solution with just one product that offers multiple different configurations. Using just one model of Ethernet switches reduces maintenance complexity and costs. Moxa's software also offered key competitive advantages; simple and straightforward, it also unlocks future expansion with Turbo Chain upgrades in the future. Non-redundant stars can be reconfigured to redundant Turbo Chains.

Products
- PT-7728 IEC 61850-3 24+4G-port rackmount modular managed Ethernet switches
- ABC-01 Configuration backup and restoration tool for managed Ethernet switches

Substation Modernization for a German City

A German utility company supplying electricity and services needed a reliable solution for their power grid. The company, with around 2500 employees, is responsible for roughly 530,000 subscribers, all of whom need constant, around-the-clock power. The utility company sought to create a resilient grid that could sustain a blackout at one substation without impacting other substations by deploying Moxa’s PT-7728 to each substation in a star topology. Furthermore, by standardizing around a single Ethernet switch model in the control center, small substations, and large substations, the customer saved maintenance costs on replacement parts and units.

Requirements
Build star network on top of the existing substation backbone to have direct connection to each substation in case of a blackout.

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Requirements
- A redundant Ethernet infrastructure with secure data communication
- Network devices that are IEC 61850-3 and IEEE 1613 compliant to ensure reliable operations in the harsh electrical environment
- Ethernet switches with modular connectivity to make PLC upgrades and configurations easier

Why Moxa?
- Moxa Turbo Ring redundancy with fast recovery (< 20 ms with 250 switches)
- The PT-7828 Layer 3 Ethernet switches support IP routing protocols
- Moxa's PowerTrans series Ethernet switches are IEC 61850-3 and IEEE 1613 certified (tested by KEMA)
- With the modular construction of the PowerTrans Ethernet switches, future upgrades will be effortless

Products
- PT-7828 L3 IEC 61850-3 24+4G-port modular managed Ethernet switches
- PT-7728 L2 IEC 61850-3 24+4G-port modular managed Ethernet switches
- PT-G7509 L2 IEC 61850-3 9G-port standalone managed Ethernet switches
Reliable Unmanned Power Substation Automation in China

Background
A steel plant in China deploys embedded computers to upgrade unmanned power substation. In 2006, the steel output of this steel plant in China was more than 12 million tons and ranked 6th in the nation. In 2007, they merged with other plants and became one of the top 3 steel producers in China. Despite a rapidly expanding business with over 100 power substations, they lacked a proper communication computer for data processing, relying instead on IPCs and multiport serial board connections for data acquisition. However, the IPC system had several problems including instability, processing inefficiency, and constant maintenance. Looking ahead, the customer decided to adopt embedded computers ensure reliability for their unmanned substation automation.

In fact, power substations use a variety of devices for transmitting and distributing power. In order to keep the operation running smoothly, it is absolutely essential to set up a reliable device monitoring system. In the past, engineers monitored device performance themselves, but this is a costly and unreliable solution since it takes time for engineers to locate which devices have failed. A more reliable solution would be to synchronize the management of different parts of the substation by channeling monitoring signals from all parts of the substation to one central location. In recent years, power substations have migrated to using automated monitoring systems.

System Solutions
The steel company decided to install Moxa’s DA-662 and UC-7408 embedded computers to ensure the reliability of their unmanned substation automation networks. The embedded computers are not only used for protocol conversion, but also function as front-end communication computers for data acquisition, processing, and transmission back to the control center.

Requirements
- Front-end communication computer for data processing and protocol conversions
-ability to handle multiple devices using different protocols for data communication
- Quick system response
- Defense against strong onsite EMI/EMS fields
- Support for 110/220 VAC and VDC power inputs
- Long MTBF to enhance system reliability
- Multiple built-in Ethernet ports for network redundancy to ensure system reliability and continuous operation

Why Moxa?
- Fanless, cableless, no hard drive, and low power consumption design offers a reliable solution for substation automation
- Ready-to-run platform provides greater flexibility, multi-level open data transmission, and stability for easy integration with third-party devices
- Moxa’s embedded computers use software to provide ready and effective protocol conversions that facilitate data communication between legacy devices using a variety of protocols
- Rackmount design for easy installation and system management
- Pre-installed real-time operating system for quicker system response
- DA-662 or UC-7408 conversions that facilitate web server for remote monitoring

Products
- DA-662: RISC-based 19-inch rackmount data acquisition computer with 16 serial ports, quad LANs, PCMCIA, CompactFlash, USB
- UC-7408: RISC-based data acquisition computers with 8 serial ports, 8 DI/DO channels, dual LANs, PCMCIA, CompactFlash
Flexible Turbo Chain Technology for Guangzhou City's Smart Power Distribution Networks

Background
Guangzhou is the third largest city in China and the capital of Guangdong Province, southern China’s largest city and a key transportation hub. With a population of eight million people in an area of over 16,000 square kilometers, it is the most populous city in the province and the third most populous metropolitan area in China. Guangzhou discovered that the reliability of Moxa’s PowerTrans IEC 61850-3 Ethernet switches was perfect for its demanding smart distribution automation project. Guangzhou’s power distribution system consists of a complex web of power utility network connections over several districts, with correspondingly complex wiring requirements. It was time to look at new technologies that would enable high-value, efficient and reliable operations to address the critical factors found in large-scale power distribution automation projects.

Moxa’s Solutions
Moxa’s breakthrough Turbo Chain redundancy technology dramatically simplifies the creation of multiple redundant connections over a widely dispersed power distribution network. With Turbo Chain, PowerTrans Ethernet switches can be daisy-chained together from one Ring Main Unit (RMU) to another, with each “chain” connected to the distribution substations. If a chain segment fails, the blocked path will rapidly activate within 20 milliseconds to ensure high network availability. Moxa’s breakthrough Turbo Chain flexible redundancy technology frees system builders from the costly limitations of conventional ring architecture. Compared with conventional ring topology, Turbo Chain eliminates the need for kilometers of extra cable and additional Ethernet ports to form ring coupling paths. In addition, the PowerTrans PT-7828 Layer 3 Ethernet switches also support Open Shortest Path First (OSPF), which uses “link state” instead of “hop count” to determine the network route. Compared to Routing Information Protocol (RIP), OSPF has faster network convergence and consumes less network traffic.

Requirements
• High network availability to ensure proper electricity transmission over different districts
• A cost-effective network architecture to simplify network connections over a far-ranging power distribution network
• Reliable performance under extreme temperatures
• Layer 3 switching capability for large scale networks

Why Moxa?
• Using Moxa Turbo Chain saves a significant amount on development cost, time, effort, cabling, and Ethernet ports over an extensive power distribution network.
• Beyond the limitations of conventional redundant ring technology, Moxa’s Turbo Chain addresses the challenging environment found in complex power distribution network connection and enables high network availability with its self-healing capability (recovery time < 20 ms).
• Moxa’s PowerTrans series is designed for fanless operations in a wide temperature range of -40 to 85ºC.
• Moxa’s PT-7828 Layer 3 Ethernet switches support Open Shortest Path First (OSPF) to improve traffic flow and network efficiency.

Products
PT-7828  IEC 61850-3 Layer 3 24+4G-port rackmount modular managed Ethernet switch
PT-7710  IEC 61850-3 8+2G-port modular managed Ethernet switch
Founded in 1987, Moxa is a total quality (ISO 9001:2000 and ISO 14001 certified) manufacturer of industrial communications solutions designed for continuous, reliable, and long-term operations in even the harshest industrial settings. One specific dimension of Moxa's expertise is application-specific solutions, including Class I, Div 2/Zone 2 solutions for hazardous locations, DNV/GL solutions for marine use, IEC 61850-3 and IEEE1613 solutions for substation, NEMA TS2 for road traffic, EN50155 and EN50121-4 for rail traffic, and more. These approvals guarantee high adaptability to any severe condition, such as vibration and shock, humidity, extreme temperatures, strong electromagnetic fields, a corrosive atmosphere, or explosive hazards.