

White Paper

**Data Communications for Critical
Power Management Systems**

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A Primer on Critical Power Management Networks

Critical power management systems provide advanced control and monitoring capabilities and interactive tools for assessing and responding to power system conditions. To do so, power system equipment and devices must be connected to a central platform that processes incoming data and provides resulting outputs using power management software. This document describes the networks used to carry communication signals, the protocols used to communicate power information, and the network devices needed to connect equipment and convert signals.

COMMUNICATION NETWORKS

In the broadest terms, signals and data are transmitted between power devices and a server over either copper wire, optical fiber, or wireless networks. Common characteristics and protocols for each are explained in the following sections.

Copper Wire

Digital, analog, serial, and Ethernet communications can be transmitted from sensors and devices to management systems over copper wire. Each is described as follows.

Digital Input/Output

The simplest inputs to management systems are digital signals, which have two states: off and on. If voltage is present, the circuit is on. If voltage is not present, the circuit is off. To complete a digital circuit, there must be a power source and a device, such as a switch for opening or closing a point on the circuit. An alarm signal is an example of a digital circuit – when a condition triggers an alarm, a switch closes contacts to complete the circuit and voltage becomes present.

Analog Communications

Analog devices send measured values to management systems by varying signal circuit voltage or current levels. In an elementary example, a 4-20 milliamp (mA) circuit might be used to signal temperature values measured by a component in power equipment, where a 4mA current indicates the lowest temperature the sensor is capable of measuring, and a 20mA current indicates the maximum sensible temperature. In operation, the current would continuously scale with the temperature measured by the sensor.

Serial Communications

Data can be transmitted sequentially along a single circuit, a process known as serial communications; or simultaneously along multiple circuits between two devices, a process known as parallel communications. Serial communications are typically used in industrial settings because they are less affected by electrical noise, and because they can span relatively long distances. Serial communications are deployed in two configurations.

- **Half-Duplex** configurations use a single wire pair, which requires that data be transmitted in only one direction at a time. Half-duplex circuits use one twisted pair of wires, shown in Figure 1.

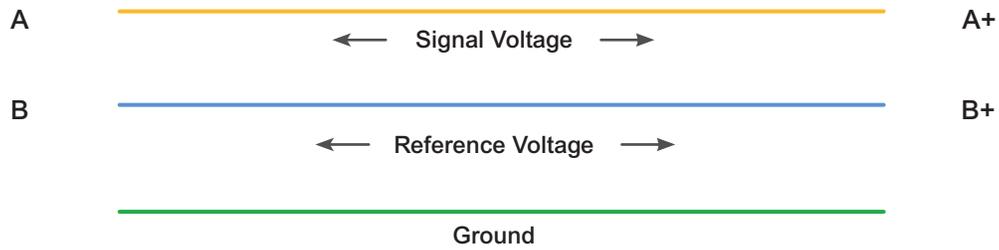


Figure 1: Half-Duplex

- **Full Duplex** configurations use two twisted wire pairs, where each pair can continually transmit data in opposing directions. Full duplex is shown in Figure 2.

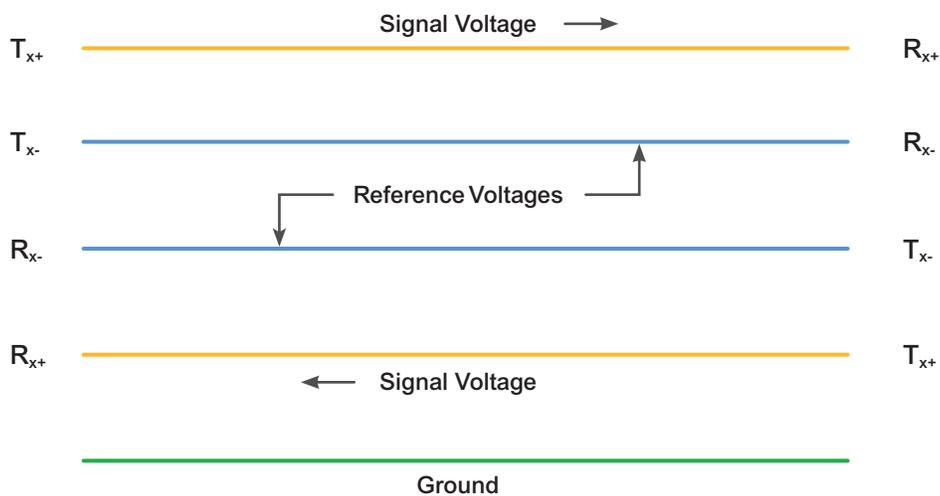


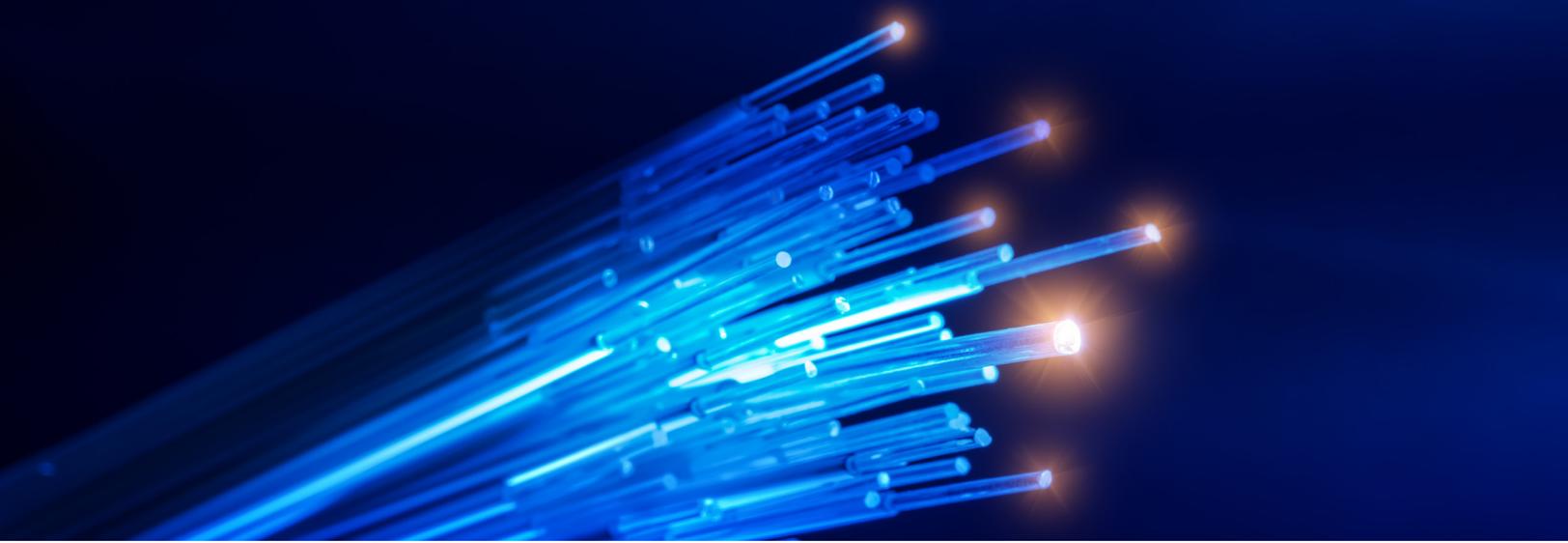
Figure 2: Full Duplex

RS-485 and RS 232 are the most common serial protocols for transmitting power system data.

Ethernet over Copper

Ethernet is a term used to denote Local Area Networks that use Transmission Control Protocol/Internet Protocol (TCP/IP) to transmit addressable packet data. Four cable types are used as follows, each terminated using RJ45 connectors:

- Category 5 supports data transmission at up to 100 megabits per second (Mbps) at 100MHz frequencies for up to 100 meters. Although considered obsolete for new installations, legacy networks rely on existing Category 5 cabling.
- Category 5e supports up to 350 Mbps for up to 100 meters.
- Category 6 uses thicker-gauge wire, increased shielding, and more pair twists per inch to reduce signal noise and interference. Category 6 uses a 250-megahertz frequency to transmit up to 1000 Mbps over 100 meters. Category 6 is certified to handle Gigabit Ethernet.
- Category 6e cable is similar to Category 6, but is wrapped in grounded foil shielding. It transmits up to 10 Gigabits per second at 500 megahertz up to 100 meters.



Optical Fiber

Ethernet communications can also be transmitted through optical fiber. Modern optical Ethernet provides full duplex operation. Two types are *Multi-Mode Fiber* and *Single-Mode Fiber*. Multi-Mode Fiber is the less expensive of these types, and uses 50-micron or 62.5-micron diameter fibers to transmit data over distances up to two kilometers. Consequently, Multi-Mode Fiber is commonly used for Local Area Networks in buildings and building complexes.

Using fibers that are 8 to 10 microns in diameter, Single-Mode Fiber is capable of transmitting data over distances exceeding 100 kilometers. More expensive than Multi-Mode Fiber, Single-Mode Fiber can be used in Wide Area Networks where segments extend more than two kilometers. With either fiber type, actual throughputs vary according to the fiber length, connector type, wavelength, and installation practices.

CLIENT-SERVER COMMUNICATIONS

Power equipment devices transmit signals and data to a central server, which aggregates and processes the information. To do so, the incoming digital I/O, analog, and serial data must be converted to the communication protocol used by the server, typically TCP/IP, so that it can be recorded, aggregated, and processed. Based on the content of this data, a server can supply power information to monitoring equipment, annunciators, and displays on clients. A server can also share data to third-party power and building monitoring systems. Multiplexed data aggregated from multiple devices can be supplied to ports on existing IT networks, where present.



Networked power management systems provide unparalleled insight into power systems conditions and events.

Based on the data they receive, servers can issue real-time notices of power conditions and events, and issue commands to controls for automatic transfer switches, load banks, generators, circuit breakers, and other devices. In advanced systems, real-time alarms and notices are transmitted via email to mobile communication devices. If the destination equipment requires a protocol other than TCP/IP, the data must be converted to the appropriate protocol. Figure 3 shows how inputs and outputs may be processed to serve a wide range of equipment and system types.

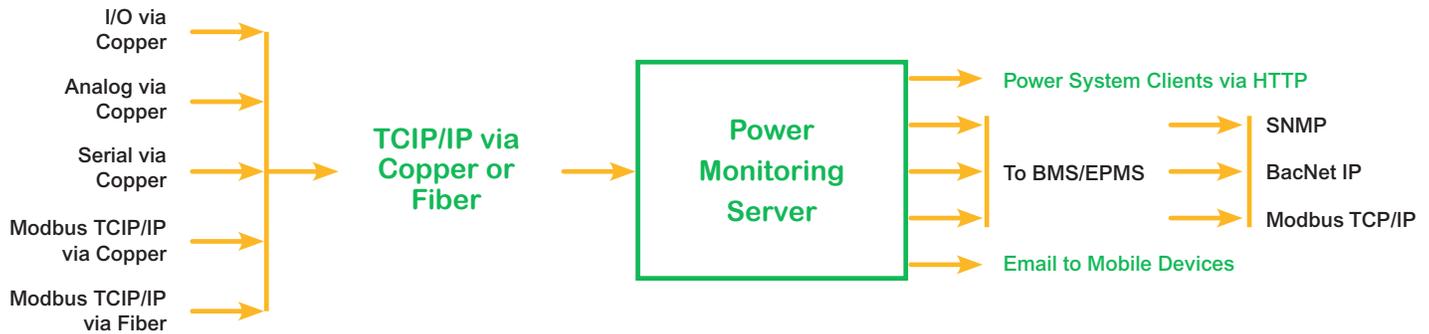


Figure 3: Data Flow through a Critical Power Management System

The work of converting network communications from copper and optical pathways from and to TCP/IP is a function of connectivity units. These units serve multiple purposes:

1. They convert signals and data to and from TCP/IP.
2. They aggregate, or *multiplex*, multiple inputs.
3. They relay communications when transmission distances exceed protocol limits.
4. They allow connected clients to monitor the other equipment in the power management system.

In Figure 4 below, five types of communication inputs have been fitted with connectivity units that relay communications and convert the respective data stream to and from TCP/IP. Readers should note that Figure 4 shows unidirectional information flow; however, bidirectional communication is implied for interactive peripherals. Where distances exceed protocol and rate limits, additional connectivity units should be used as repeaters. Of particular note, connectivity unit typically can aggregate inputs from multiple devices. In some cases, connectivity units can aggregate inputs that use differing protocols.

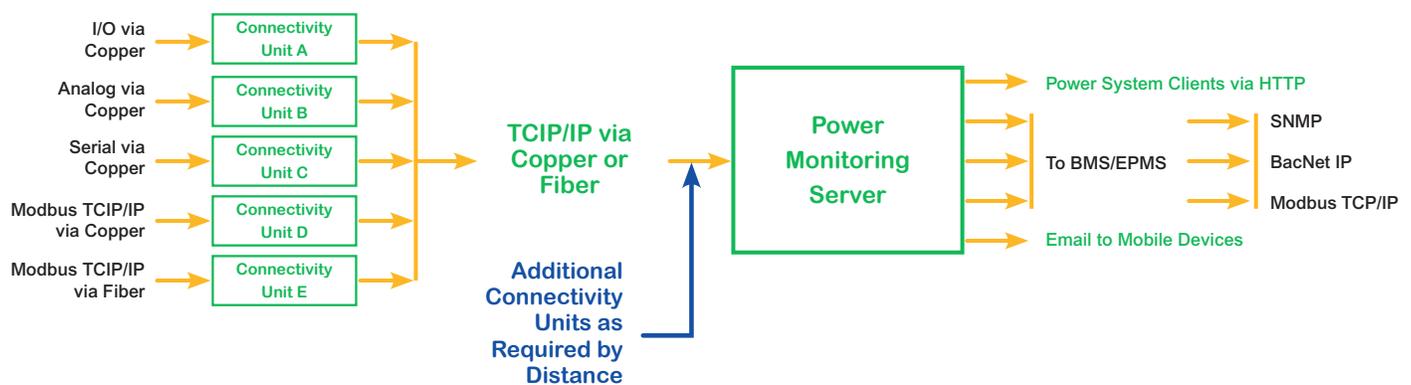


Figure 4: Communication Network with Connectivity Units

REDUNDANT NETWORK ELEMENTS

Connectivity units are available as Standard or Managed Connectivity Unit. The latter features an Ethernet switch that provides for bidirectional data travel through ring topologies. The following diagrams compare the capabilities of Standard and Managed Connectivity Units.

The simplest networks use a linear topology, such as that shown in Figure 5. While easy to install and operate, a malfunction of any connectivity unit or interconnecting link will isolate the system from all upstream equipment.

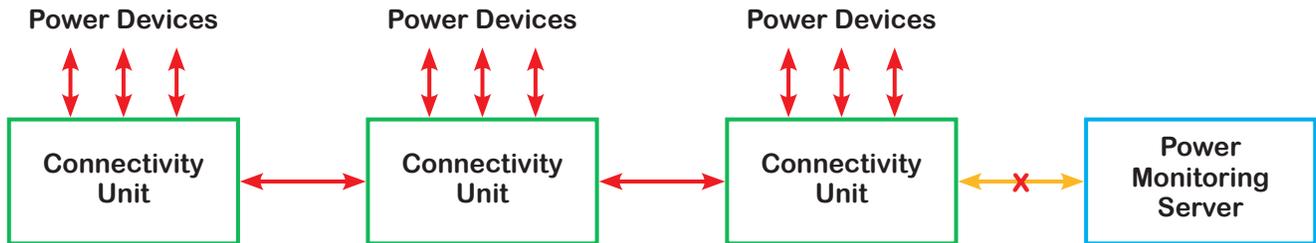


Figure 5: Linear Network with a Transmission Fault

To provide redundant communication pathways, each connectivity unit can be equipped with an added Ethernet switch that enables loop configurations. As shown in Figure 6, this enables all equipment on the network to communicate with all other equipment even when one link becomes inoperable.¹

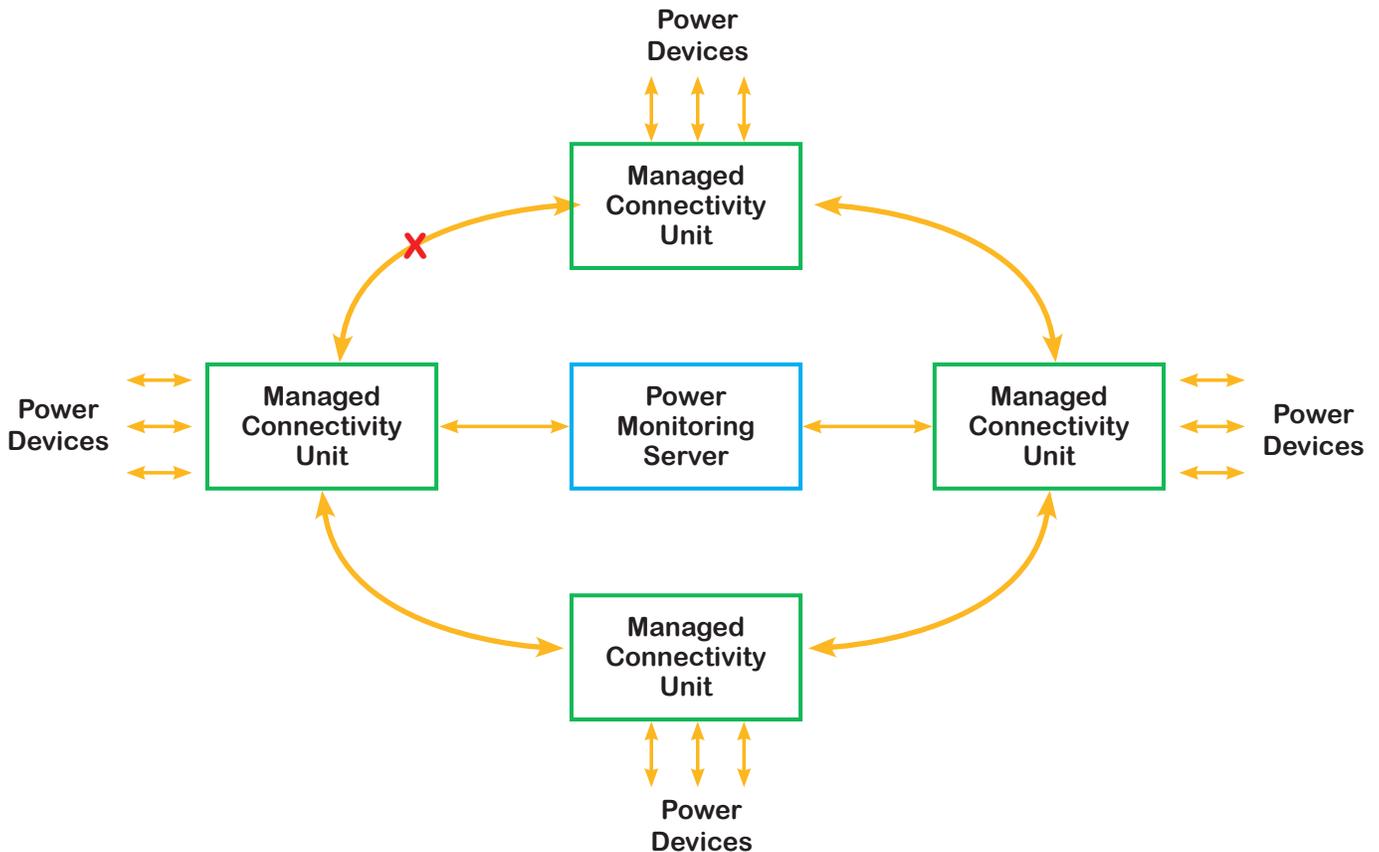


Figure 6: Ring Networks Provide Redundant Communication Pathways

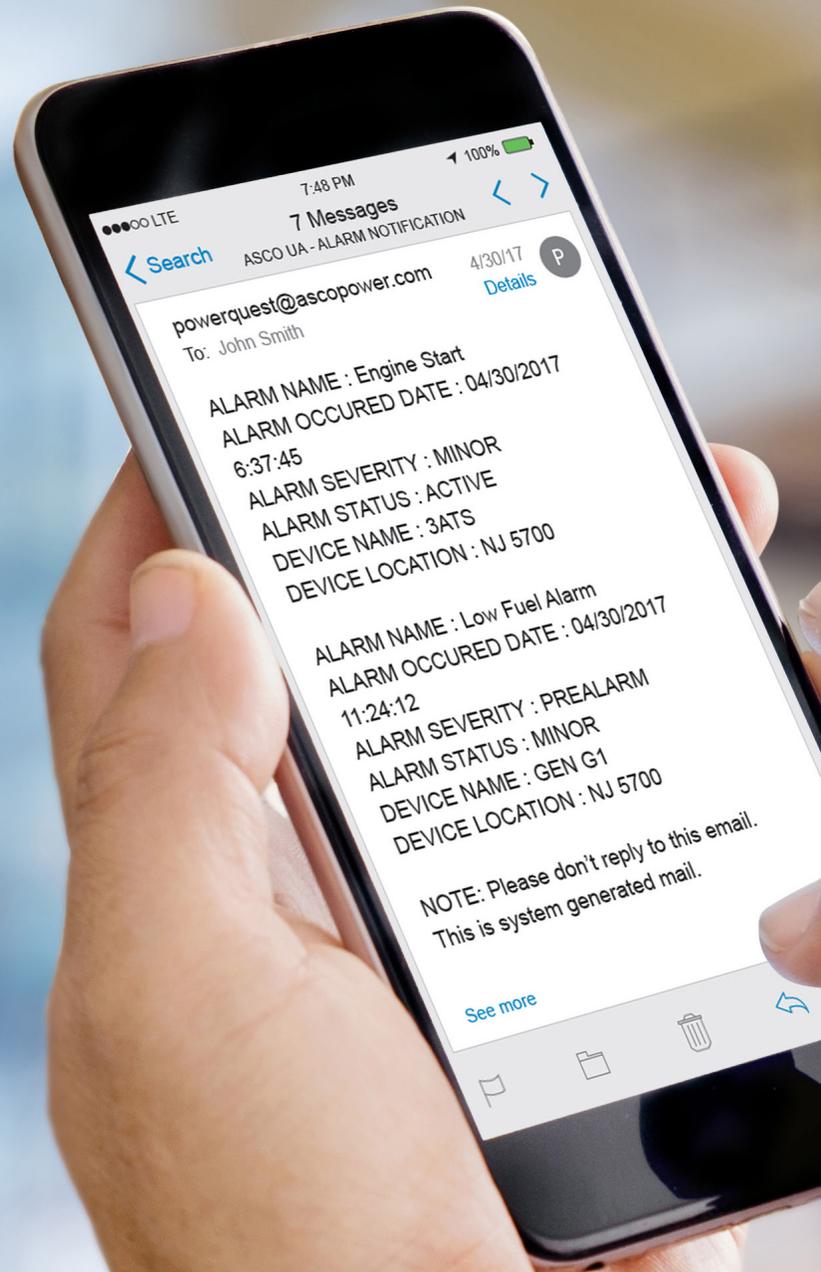
¹Many network topologies are available to optimize operations and provide redundancy. This paper provides examples for the sole purpose differentiating standard and managed switches in a power management network

To ensure operability during a transfer of loads to an alternate power source, connectivity units must be equipped with sufficient reserve power to “ride-through” momentary outages. For this reason, some connectivity units store power that is sufficient for very short power interruptions.

SUMMARY

In power management systems, power devices connect to a central platform that records, evaluates, and responds to power data. Inputs can consist of any combination of digital, analog, serial, and Ethernet inputs that are transmitted over copper wire or optical fiber. Because these systems typically receive and send data using TCP/IP, other types of inputs and outputs require conversion to or from this protocol.

To effect the necessary conversions, connectivity units are required to convert inputs and outputs to TCP/IP communications. Sufficient connectivity units are required to ensure that the length of any network element does not exceed the distance limits for its communication media and protocol. Providing managed connectivity units enables looped network topologies that provide redundant pathways for system communications. Ride-through power ensures that connectivity units function while loads are transferred to an alternate power source. Advanced systems offer real-time notification of power events and conditions using email messaging to mobile devices.



Advanced power management networks can transmit real-time information about power events and conditions using internet-enabled communications.

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