INTEGRATING POWER OVER ETHERNET and FIBER NETWORKS
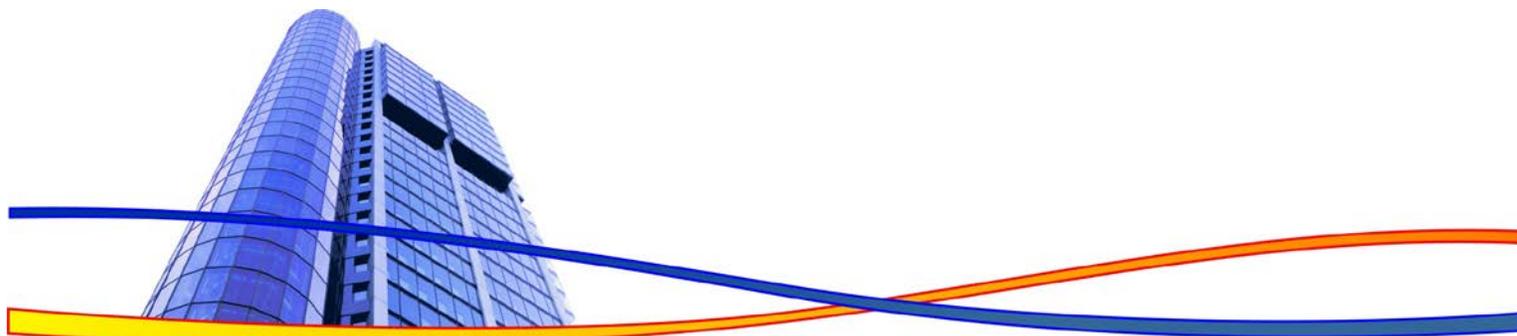
Overcoming the Distance Limitations of Copper Cabling to PoE Devices

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OST Omnitron Systems

Introduction

This white paper provides a comprehensive overview of Power over Ethernet technology and describes how to use fiber optic cabling to overcome the 100 meter distance limitation of copper network cabling.

PoE Overview

Power over Ethernet (PoE) is technology that enables the safe transfer of DC electrical power along with data over standard network cabling. Both the data and the power may share the same wire, and each is independent and unaffected by the other.

The Benefits of PoE

What are the benefits of using PoE and why would a network designer want to use this technology? PoE is presently deployed where access to AC power is inconvenient, expensive or infeasible to supply. PoE can power devices that are located in ceilings, on rooftops, light poles, along fences, pipelines, transit routes and other out-of-the-way locations. The cost of bringing electrical power to each device is eliminated by powering the equipment through the Unshielded Twisted Pair (UTP) cable.

Flexibility
- Easily move devices to wherever a LAN cable can go
- Install devices where it is difficult to get power

Simplicity
- Install only Ethernet cable to the end device
- Minimizes cable clutter and saves space

Safety
- No AC power is needed for outdoor applications
- No need to meet electrical building codes

Cost Savings
- No need to install power outlets
- No need to hire licensed electricians

Functionality
- End devices can be reset remotely

Copper Cabling and Ports

PoE utilizes standard network cabling. This network cabling is referred to as Ethernet cable, copper network cable, Category 5 or 6 cable, and Unshielded Twisted Pair (UTP). This cabling connects to a network device through an RJ-45 Port.

PoE Devices

Power Sourcing Equipment (PSE) is the device that provides, or injects, power in a PoE network. There are two types of PSE – endspan and midspan. As the names imply, the endspan is located at the end of a link segment, while a midspan is located in the middle of the link segment.

A Powered Device (PD) is a device that draws power from the PSE. One example of a PD is a desktop Voice over IP phone. There are many examples of PDs provided in this white paper.

An endspan PoE switch is an Ethernet switch with PoE capabilities built-in, so both data and power are sent over the UTP cable.

Endspan PoE Switch

AC

PSE

PD

UTP
UTP w/ PoE
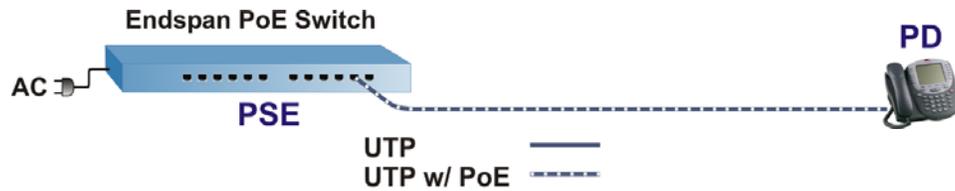
A midspan PoE injector is typically a two-port device that injects power at a point along the UTP cabling. Midspans are used to power PDs that are connected to switches that do not provide PoE. The midspan injects DC power to the cable, and the data passes through the injector transparently. With most midspan injectors, the 100m distance limit applies to the entire span – from the switch to PD.

UTP Switch

AC

Midspan
PoE Injector

AC

PSE

PD

UTP
UTP w/ PoE
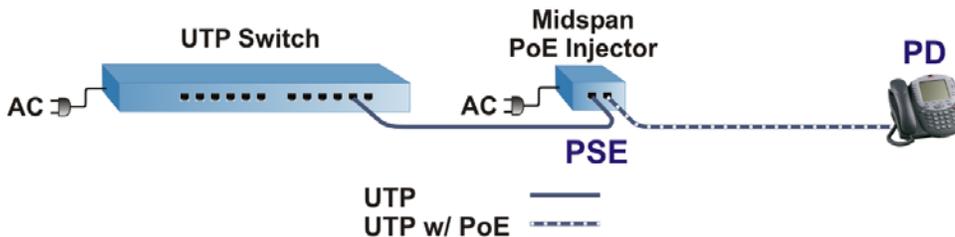
A valid PD (per the IEEE standards) presents an electrical signature to the PSE. Before the PSE sends power over the wires, it looks for this electrical signature. If not present, the PSE does NOT apply power to the wires. The PSE will, however, continue to send the data.

IEEE PoE Standards

Prior to these standards below, several device manufacturers were implementing their own proprietary implementations of PoE. The most common type is legacy Cisco VoIP.

IEEE 802.3af

In 2003 the IEEE ratified the 802.3af PoE standard that allows up to 15.4 Watts of power for each port.

IEEE 802.3at

Late in 2009, the IEEE ratified the 802.3at PoE Standard known as PoE+. 802.3at is necessary because PD vendors are starting to produce devices that require more power than the 15.4 Watts available with 802.3af. With 802.3at, PDs can be powered with up to 34.2 Watts.

802.3at is backward compatible with 802.3af. If a PSE is "at" and the PD is "af", it will work fine. The PSE recognizes that the PD is "af" and only gives it as much power as it needs. The reverse situation will not work however – if the PSE is only "af" it will not be able to power an "at" PD.

The PoE or PoE+ power level supplied by a PSE will vary, depending on the power requirement of the PD. For example, an IEEE 802.3af standard-compliant PSE can supply up to 15.4 watts of power, but if the PD is an IP phone that requires only 6 watts, then the PSE will supply 6 watts of PoE.

IEEE 802.3bt PoE Type 3 Work Group

At the time of this white paper, the IEEE standard for 60W is currently in development with the IEEE 802.3bt Type 3 Work Group, and has not been ratified. 60W PoE applies power to all four pair of wires.

IEEE PoE Powering Options over UTP Cabling

PoE supports four powering options using different combinations of the eight pins on a standard RJ-45 port that connect to four pairs of wire in UTP cabling.

IEEE Standard Based

- IEEE Alternative A (power on pins 1/2 and 3/6)
- IEEE Alternative B (power on pins 4/5 and 7/8)

The IEEE PoE standard specifies two modes of detection and powering different pins and wires: Alternative A or Alternative B. Both Alternative A and B support either Fast Ethernet or Gigabit Ethernet, and PoE or PoE+.

To be IEEE standards compliant, a PD must support both Alternative A and Alternative B, whereas a PSE may support either Alternative A or Alternative B, or both.

60W Implementation

At the time of this white paper, the 60W standard has not been ratified. In lieu of a 60W PoE standard, equipment manufacturers have developed their own implementations.

Cisco's Universal PoE (UPoE) and Microsemi's High Power over Ethernet (HpoE) are two commercial PoE technologies providing 60W PoE. They are backwards compatible with IEEE 802.3af PoE and IEEE 802.3at PoE+.

Typical implementations use both Alternative A and Alternative B for PoE power.

Legacy Non-Standard Based

Legacy non-IEEE is a proprietary detection and powering mode that Cisco implemented before the 802.3af standard was ratified in 2003. This mode uses pins 4/5 and 7/8 for the DC power, but the polarity is reversed.

Legacy "Large-Capacitor Detection" is available for both Alternative A and B powering. For legacy VoIP devices, "Large-Capacitor Detection" is typically Alternative B (power on pins 4/5 and 7/8), but the detection method does not follow the IEEE standards. Instead, the PSE looks at the PD for a unique large capacitance signature. If it sees that signature, then it applies power per Alternative B.

Legend for the following schematic illustrations:

|	
————	Unused Wire
————	Power Only
————	Data Only
—·—·—	Power and Data (Phantom Power)
·······	Potentially Powered (If provided by PSE)

10/100BASE-T Alternative A
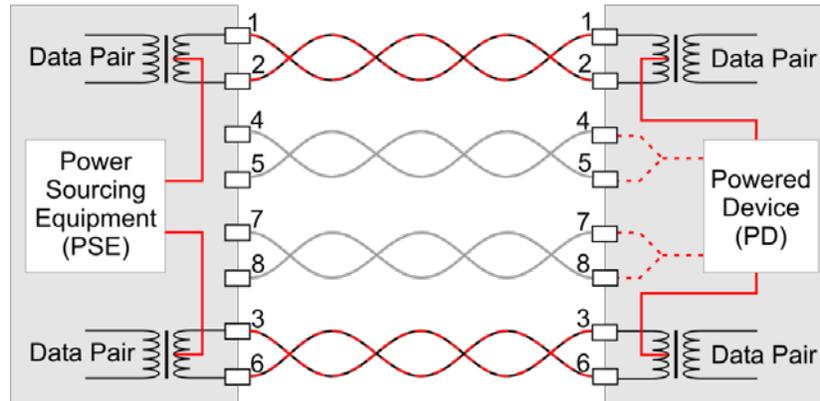
10/100BASE-T Alternative A injects the positive DC power on pins 1 and 2 and the negative DC power on pins 3 and 6. In Fast Ethernet, these are also the data pairs, so the data and power share the same wires. The "sharing" of the wire is accomplished using a technique called Phantom Power, which was originally used as a method for transmitting DC electrical power through microphone cables to operate microphones that contain active electronic circuitry.
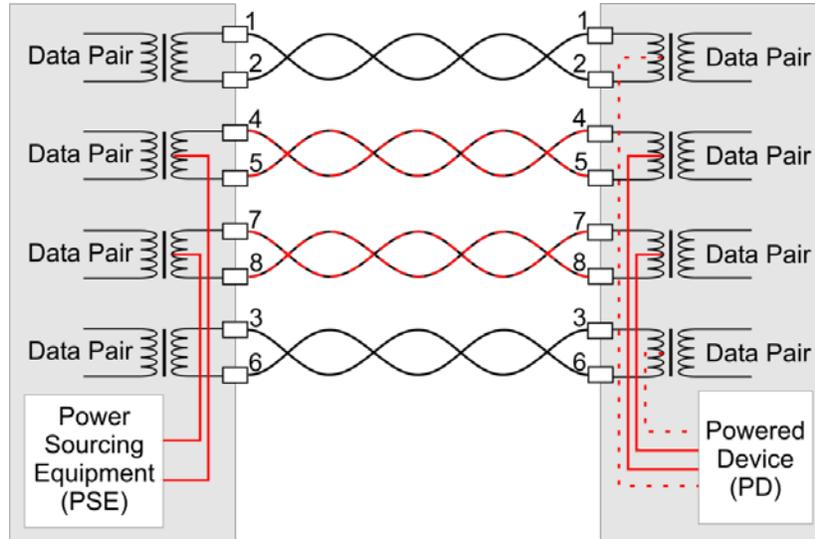
10/100BASE-T Alternative B
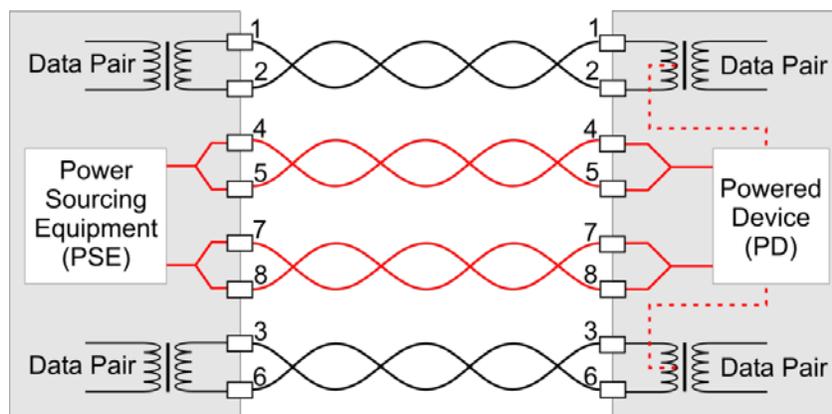
10/100BASE-T Alternative B puts the positive DC power on pins 4 and 5 and the negative DC power on pins 7 and 8. In Fast Ethernet, these are the "spare" pairs, so the electrical current is not sharing wires with data, and there is no Phantom Power.

1000BASE-T Alternative A
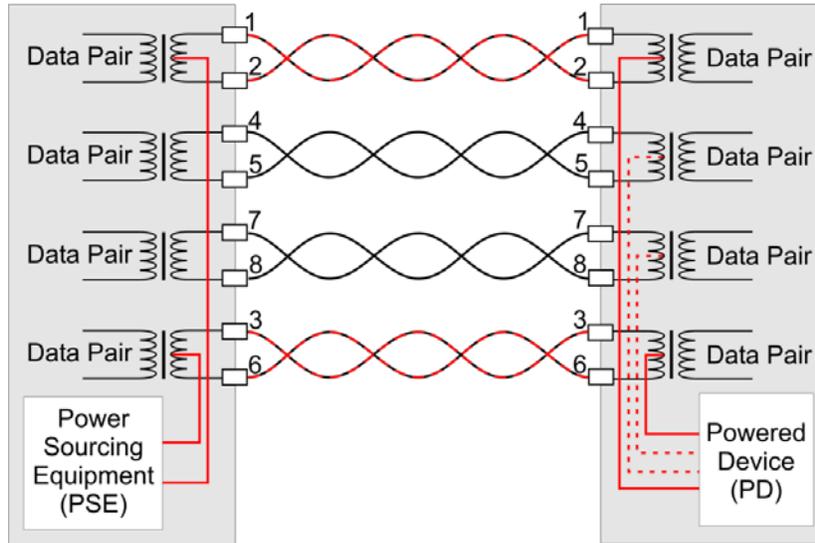
IEEE 1000BASE-T Alternative A puts the positive DC power on pins 1 and 2 and the negative DC power on pins 3 and 6. In Gigabit Ethernet, all four pairs carry data, so Phantom Power is always required for Gigabit PoE.

1000BASE-T Alternative B

IEEE Alternative B puts the positive DC power on pins 4 and 5 and the negative DC power on pins 7 and 8.

1000BASE-T High-Power 60W
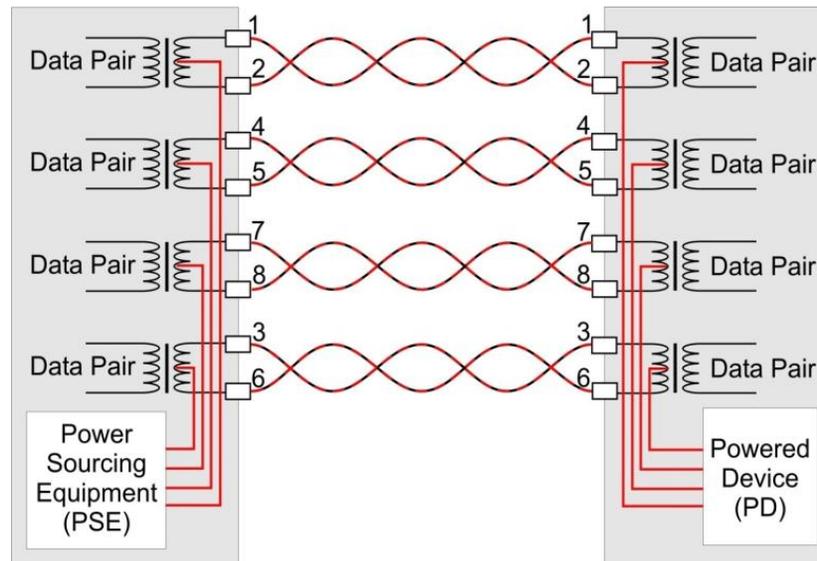
High-Power implementation applies power to all 4 pairs of wires (power on pins 1/2, 3/6, 4/5 and 7/8). This enables more power to be available to the high-powered PDs.

PoE, PoE+ and 60W Powered Devices

PoE, PoE+ and 60W enable the powering of a wide variety of network devices.

Powered Devices

IP Cameras

IP Network Cameras are used in security, surveillance and traffic monitoring applications where the cameras are installed in high, hard-to-reach locations. IP cameras are also used for quality assurance in manufacturing (assembly lines, paper and lumber mills, etc.) and food processing. These applications can utilize high-speed, high-resolution PoE cameras that can require Gigabit data rates. Pan-Tilt-Zoom (PTZ) IP cameras have additional motors to control the focus and direction of the camera lens and typically require additional (PoE+) power. Cameras used in extremely cold climates feature blowers and de-icers that often require the additional power supplied by PoE+.

Wireless Devices

Wireless technology is growing in applications and deployments. Wireless LAN and WAN access points are typically powered by PoE because they are installed in ceilings and rooftops. Many 802.11n wireless devices and small cells used to increase capacity of wireless networks in high-usage areas require PoE+ power to enable high-bandwidth connectivity over wide areas.

IP Phones

Voice over IP (VoIP) phones are widely adopted and used in businesses worldwide. Since they are network devices, they utilize PoE to draw power and voice data over the network cable.

Telepresence Video Phones and Video Consoles

Video Conference Terminals used in telepresence and teleconferencing applications can be powered by PoE, and require high-bandwidth connectivity.

Access Control Devices and Badge Readers

High security facilities like businesses, hospitals, airports and military facilities utilize door lock and badge-reader systems that require power at each door to control and monitor building access.

IP Clocks

PoE IP clocks are powered over the Ethernet cable, so there is no need for batteries or AC power. All clocks are synchronized to one Simple Network Time Protocol (SNTP) server, maintaining accurate and consistent time across all clocks. IP clocks can also save labor costs by automatically resetting after a power outage, and adjusting for daylight savings time.

Messaging and Digital Signage Systems

LED signs function as messaging systems that display routine announcements such as bus schedules, local news or weather feeds. LCD Digital signage can display the same types of information, plus advertising, building maps and directions, restaurant menus, etc. During a crisis, the displays function as an Emergency Alert System.

Thin Clients

Thin client computer terminals run applications from a server and function as virtual devices. They require less power than traditional PCs and can draw PoE power for both the thin client terminal and the monitor.

Challenges Deploying PoE

PoE is a useful technology in powering remote devices, but as we see with any copper network cable, the challenge lies in the limited distance and bandwidth of copper UTP cabling. According to the ANSI/TIA/EIA standard for category 5e cable, (TIA/EIA 568-5-A) the maximum length for a cable segment is 100 meters (328 ft). PSE power injectors, particularly midspans, do not increase the distance of the data network.

< 100 Meter Limit of Copper Cabling >

< 100 Meter Limit of Copper Cabling >
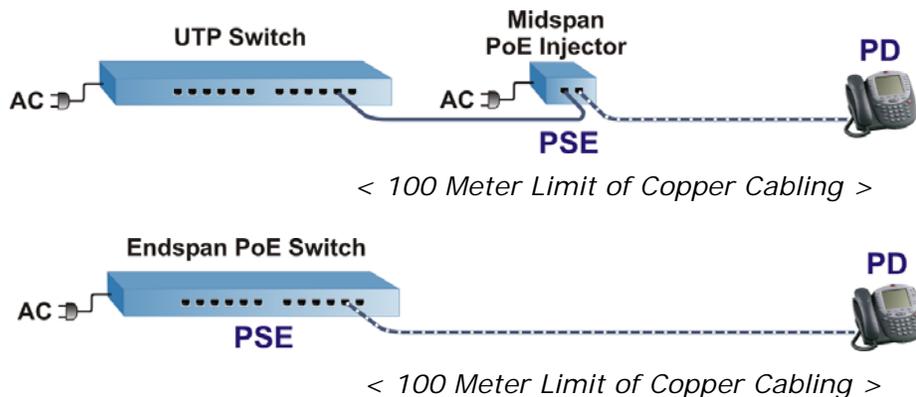
UTP ———
UTP w/ PoE -------

Integrating PoE and Fiber

A common solution to overcome the distance and bandwidth limitations of copper is to use fiber optic cabling.   Since DC power cannot be conducted over fiber, a media converter that functions as a PSE is used to inject power on the RJ-45 port(s). A media converter with PoE converts the fiber to copper, and sends DC power to the PD over the UTP cabling.

< "Unlimited" Fiber Distance >
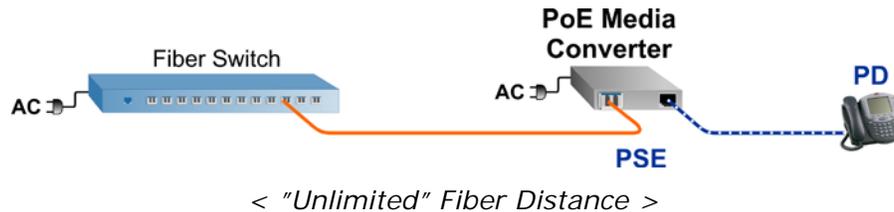
Media Converters with PoE/PoE+

- Convert copper to fiber
- PoE is injected over copper
- PoE **IS NOT** injected over Fiber
- Fiber is run to the AC or DC power source, and PoE is distributed over Cat 5 to the Powered Device.

Leverage the Benefits of Fiber

There are several solutions available to extend the distances of PoE network links, including LAN extenders that convert Ethernet to DSL, UTP to Coax converters, and wireless technology. Fiber optic cabling provides several distinct advantages to these technologies:

Longest Distance – Up to 160 kilometers
- 330 ft with UTP, up to 3000 ft with LAN extenders
- 1200 ft with Coax
- 40 Miles with 900MHz Wireless (requires line of site)

Highest Bandwidth Capacity – Gigabit +
- Future proof the network
- No data deterioration over distance (LAN extenders lose 90% of bandwidth over long distances)

Security
- No broadcasting or electro-magnetic emission
- Difficult to tap

Most Reliable
- Not susceptible to electrical interference, temperature or atmospheric conditions

Popular Applications That Utilize Fiber:

- Fiber connectivity to remote devices like 802.11n wireless access points and high-speed cameras that require data rates up to one gigabit
- Campus networks that require fiber connectivity for long-distance, high-bandwidth applications
- Fiber-to-the-Desk enables high bandwidth voice/data/video for a variety of military and business applications

PoE Media Converters

PoE media converters function like other media converters that convert copper to fiber, but they also inject power over the UTP cabling. PoE media converters are available in Gigabit Ethernet and Fast Ethernet and support PoE (15.4 Watts), PoE+ (32.4 Watts) and 60W.

PoE media converters function like a PoE mini-switches, and are available in a variety of multi-port configurations, including dual RJ-45 and dual fiber ports. They can support fixed fiber connectors or Small Form Pluggable (SFP) transceivers.
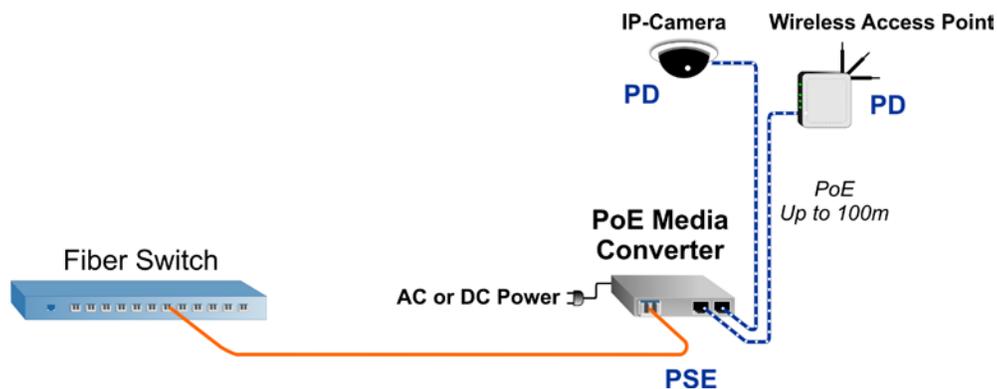

PoE Media Converters

Powering PoE Media Converters

PoE media converters are DC powered, and are available with an AC to DC power supply (100 to 240 VAC) that connects via a barrel connector. They can also be powered with direct DC power input.

How PoE Media Converters Work

Starting on the left side of the illustration, the fiber originates at a fiber switch. This could be in an IT center, server room, data closet, etc. This can also be a copper switch with a rack of media converters.


The fiber is brought to the PoE media converter located near a convenient AC or DC power source. Not only does the media converter convert the fiber to copper, but it also functions as a PSE and injects PoE power (DC power) over the copper Ethernet cable.

At the other end of the Ethernet cable are the PDs. These PDs can be IP cameras, wireless access points, IP phones, etc. The PDs are in locations up to 100 meters away from the PoE media converter.

## Network Architecture Options with PoE Media Converters

Multi-port PoE media converters provide flexible network designs. Single fiber ports are deployed in star topologies with a point-to-point style layout with the fiber switch in the center of the network.
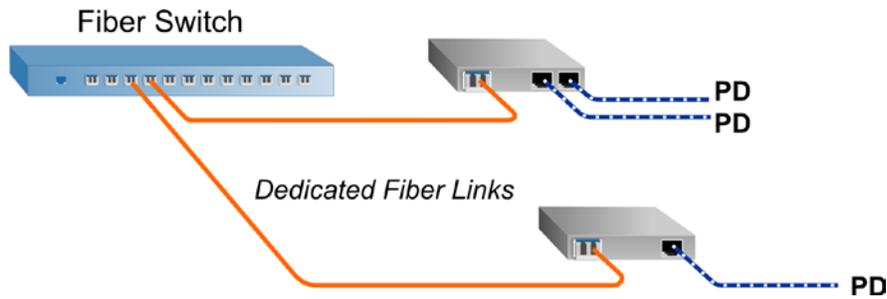
PoE media converters with dual fiber ports enable linking multiple media converters in a linear daisy chain configuration. This architecture can be used in a variety of outdoor applications where PDs such as IP cameras and/or wireless access points are installed along railroad and subway lines, highways, pipelines, mine shafts, perimeter fences, etc.

Dual fiber ports can be used to deploy redundant fiber links for mission-critical applications requiring fiber facility protection. There is an active fiber port, and a protection fiber port, that can support a fiber failure switchover of less than 50 milliseconds.
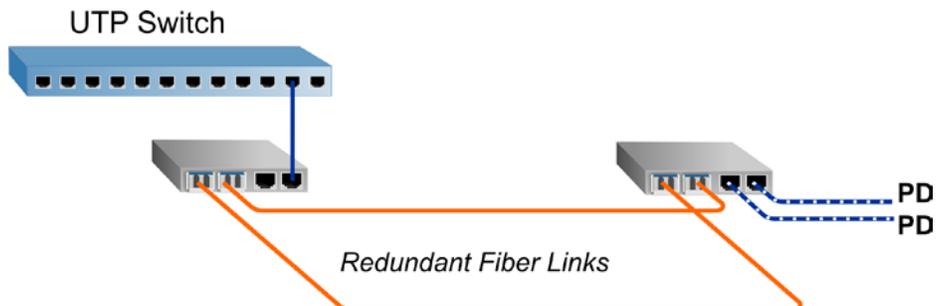
PoE Media Converter Application Examples

Fiber to IP Network Cameras

In this application example, IP cameras are installed throughout a facility. The cameras are mounted in remote locations far from the fiber switch video server, and where AC power is not readily available.

The fiber is distributed from a switch in the network core or main data closet. Daisy chained fiber links connect to remote locations where PoE media converters are installed near AC or DC power sources. The PoE media converters have fiber uplink ports and downlink ports, and dual RJ-45 ports for two IP cameras at each location.
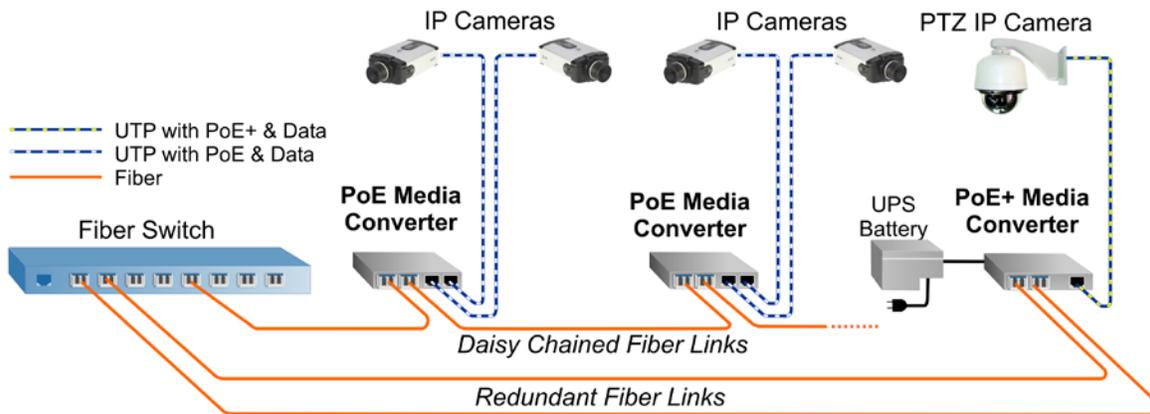
Redundant fiber links are used for a mission-critical security camera. The PoE+ media converter has one fiber port for the active fiber link, and one port for the protect fiber link, with fiber failure switchover of less than 50 milliseconds. The PoE+ media converter supplies power to a PTZ camera, and has power protection from an Uninterruptible Power Supply (UPS) Battery back-up.

Fiber to Wireless Devices

In this application, wireless access points are installed in remote locations in an office building, airport or mass transit system. PoE+ and Gigabit Ethernet is used for 802.11n access points deployed in a daisy chain topology. The number of access points on the daisy chain is limited by the aggregate bandwidth of all the devices.
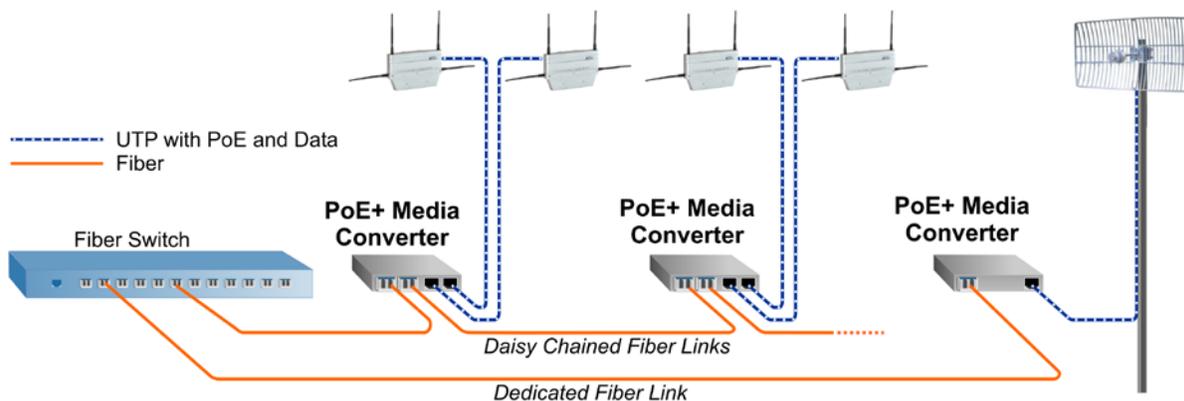

A dedicated point-to-point fiber link runs to another location where a PoE+ media converter provides data and power to a 802.11n access point.

Fiber-to-the-Desk: IP Phones, Video Terminals, Thin Clients and PCs

In this application example, a fiber-to-the-desk network is deployed to leverage the security, bandwidth and distance benefits of fiber optic cabling.

The network originates from a fiber switch in the data closet. This can be the network core in a physically secure area in the building. Fiber optic cables run to each office/desk, where they are terminated by PoE media converters that are powered by an AC or DC power source.

The PoE media converters provide fiber to copper media conversion, and they send data and power to desktop items such as IP phones and video conferencing equipment.
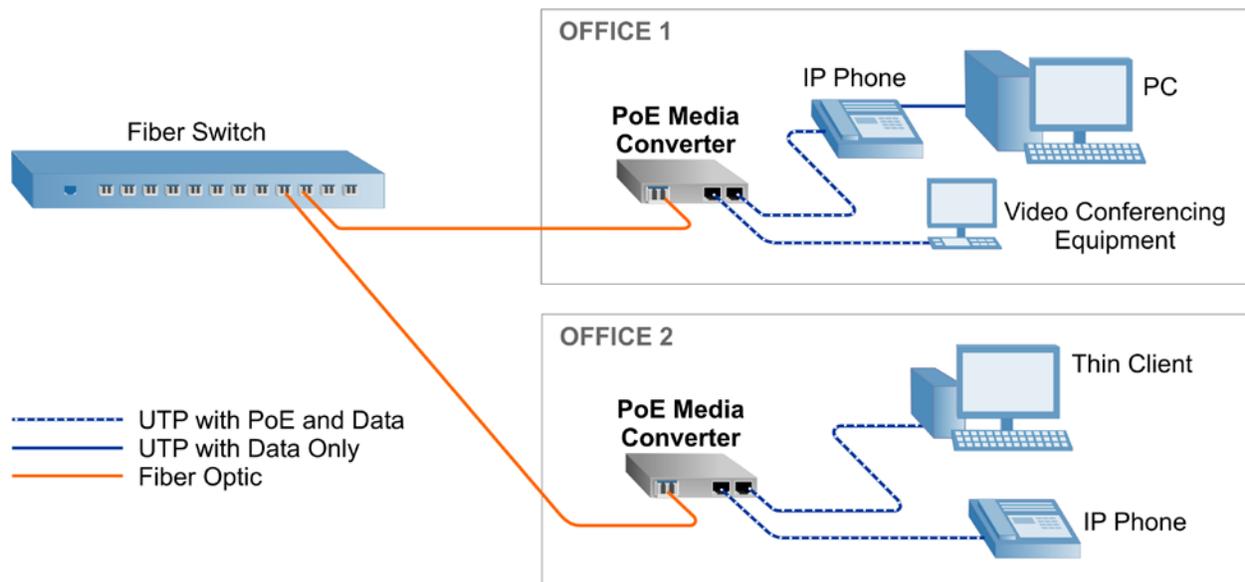
In OFFICE 1, a PoE media converter with two copper ports is used to deliver power and data to an IP phone and a video conferencing terminal. The PC is connected to an auxiliary Ethernet port on the phone, and will receive data but no power.

Non-PoE network devices can also be safely connected directly to the media converters. For example, the PC could be connected directly to the PoE media converter (not shown). The PoE media converter can automatically detect that the PC is not a PD, so it will send data, but not power.

In OFFICE 2, a PoE media converter with two copper ports is used to deliver power and data to an IP phone and a Thin Client. PoE can power both the Thin Client terminal and the display.

Building Automation: Access Controls, Clocks and Messaging Systems

Building Automation encompasses all the PoE applications in this white paper, and PoE is becoming an integral part of building networks and low-voltage systems. In addition, PoE networks reduce energy consumption and can earn points in LEEDs certification.

In this application example, IP clocks, badge-reader access devices, messaging signage and HVAC controls are deployed. The environment may be a school campus, office building, hospital, airport, military base, etc. Fiber is used because the required link distances across the building/campus often exceed the 100 meter limitation of UTP cabling.
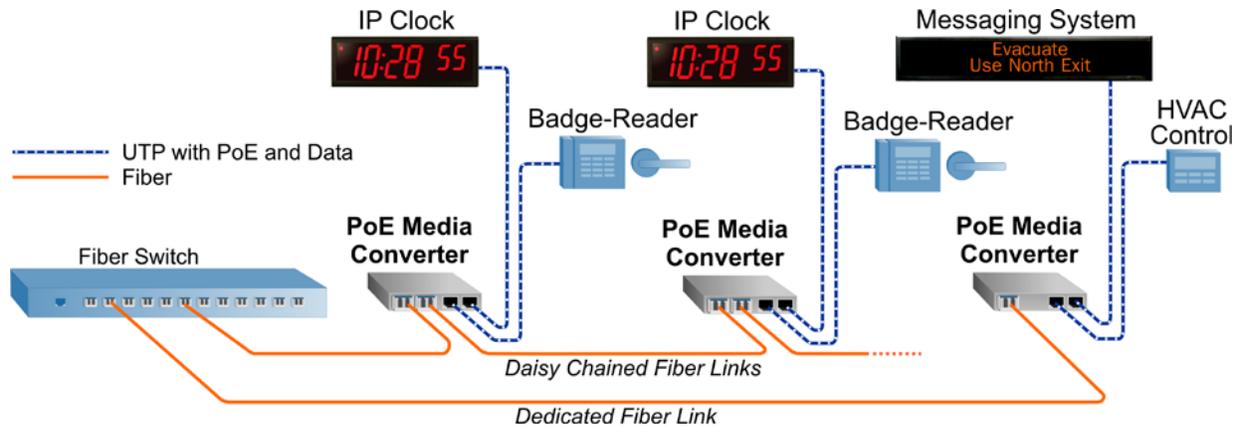
The fiber is distributed from a switch in the network core or main data closet. Daisy chained fiber links connect different rooms/offices, where PoE media converters are located near convenient AC or DC power sources. The PoE media converters have fiber uplink ports and downlink ports, and dual RJ-45 ports that provide data and power to the IP clocks and badge-reader access systems.

A dedicated point-to-point fiber link runs to another location where a PoE media converter provides data and power to an LED messaging sign and an HVAC thermostat control.

Summary

PoE media converters combine the benefits of PoE, PoE+ or 60W and fiber optic cabling in a compact, reliable and cost-effective device. Classified as Power Sourcing Equipment (PSE), the PoE media converters provide power to Powered Devices (PDs) using the same UTP cables that carry the Ethernet data. This enables powering devices in hard-to-reach locations where there is limited access to AC power outlets, or locations where AC power creates safety issues.

Key Features to Consider When Selecting a PoE Media Converter:

- PoE+ and 60W to future proof applications
- Out-of-the-box support for IEEE Alternative A and B, and Legacy Power detection options (without the need for jumper wires or external cables)
- Jumbo Ethernet Frames to enhance throughput for reliable data flow
- Multiple port configurations for deploying a variety of architectures and topologies:
  - Daisy chain media converters
  - Redundant fiber with less than 50ms switch over time
  - Dual UTP ports for powering two PoE devices per converter
- Ability to be powered by either AC or DC power source
- Industrial hardened temperature ranges for outdoor applications
- Determines and delivers the specific power level required by the PD
- Fully configurable DIP-switches for easy set up:
  - Link Fault Propagation Modes
  - PoE Power Reset on fiber Rx loss that automatically resets the remote PD

About the OmniConverter PoE Media Converters

OmniConverter PoE media converters support the IEEE 802.3af (PoE) or 802.3at (PoE+) standards and 60W. Models are available in Gigabit 1000BASE-X fiber to 10/100/1000 UTP and Fast Ethernet 100BASE-FX fiber to 10/100 UTP.

A variety of port configurations are available, including single or dual SFP and single or dual powered UTP ports. Models with dual SFP ports support critical applications that require redundancy and sub 50ms switch over in the event of a fiber failure. The product is DC powered and available with an optional external 100 - 240VAC universal power adapter.

OmniConverter GPoE+/SX

These are Gigabit Ethernet media converters with one or two fiber ports, and up to four 10/100 RJ-45 ports that provide IEEE 802.3af PoE (15.4W) or IEEE 802.3af PoE+ (34.2W). They support advanced features with DIP-switch configuration.

- GPoE/SX - Gigabit Ethernet Ethernet, PoE+, Four RJ-45 ports

OmniConverter FPoE/SL, FPoE/S and FPoE+/S

These are Fast Ethernet media converters with one or two fiber ports, and one or two 10/100 RJ-45 ports that provide IEEE 802.3af PoE (15.4W) or IEEE 802.3af PoE+ (34.2W). They support advanced features with DIP-switch configuration.

- FPoE/SL - Fast Ethernet, PoE, cost-effective
- FPoE/S - Fast Ethernet, PoE
- FPoE+/S - Fast Ethernet, PoE+

OmniConverter FPoE/SE and FPoE+/SE

These are cost-effective Fast Ethernet media converters with a smaller form factor. The /SE models have one fiber port, and one or two 10/100 RJ-45 ports that provide IEEE 802.3af PoE (15.4W) or IEEE 802.3af PoE+ (34.2W).

- FPoE/SE - Fast Ethernet, PoE, cost-effective
- FPoE+/SE - Fast Ethernet, PoE, PoE+, cost-effective

OmniConverter GPoE/S, GPoE+/S and GHPoE/S

These are Gigabit Ethernet media converters with one or two fiber ports, and one or two 10/100/1000 RJ-45 ports that provide PoE, PoE+ or 60W PoE. They support advanced features with DIP-switch configuration.

- GPoE/S - Gigabit Ethernet, PoE
- GPoE+/S - Gigabit Ethernet, PoE, PoE+
- GHPoE/S - Gigabit Ethernet, PoE, PoE+, 60W PoE

OmniConverter GPoE/SE and GPoE+/SE

These are cost-effective Gigabit Ethernet media converters with a smaller form factor. The /SE models have one fiber port, and one or two 10/100 RJ-45 ports that provide IEEE 802.3af PoE (15.4W) or IEEE 802.3af PoE+ (34.2W).

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- GPoE+/SE - Gigabit Ethernet, PoE, PoE+, cost-effective