Driving the Networked Industrial Plant – Power over Ethernet

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In the 1990s, industrial plants began to integrate and merge their "islands of automation" by networking devices to programmable controllers and controllers to control systems and HMIs (human machine interfaces). As the number of intelligent devices increased, the demand to supply power to these devices also increased.

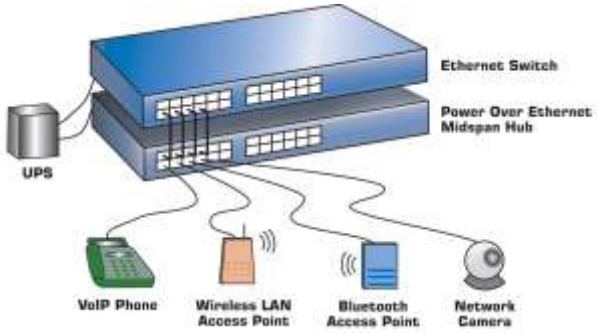
Many of these devices used 12, 24, or 48 VDC power, rather than 115 VAC, so they were often supplied with "wall wart" power supplies that needed a multiplex convenience receptacle to plug into. This was less than an optimum solution, because the wall warts were not industrially hardened, and could fall or be knocked out of the receptacle, and the proliferation of wall wart power transformers across an entire industrial plant (often numbering in the hundreds) was a maintenance management nightmare that could not be centrally managed or controlled.

Early attempts at fieldbus communications required separate power supplies, used the existing 4-20 mA power/signal lines (HART) or provided power though additional conductors in the communications cable.

As devices gained intelligence and were networked, the problem of supplying power to them increased exponentially. Furthermore, the cost of installing 115 VAC power or a DC power supply were compounded by the cost of wiring, distribution panels and circuit breakers. These costs could be significant, especially in really remote areas in the plant.

What industrial networking designers wanted was the ability to run power and network conductors in the same standard Ethernet cable. As industrial control systems have done repeatedly over the past twenty years, COTS (commercial off the shelf) came to the rescue.

In the 1990s, Cisco Systems needed a way to power Ethernet connected IP telephones, and they developed what is now known as Power over Ethernet (PoE). In 2003, the Institute of Electrical and Electronics Engineers (IEEE) ratified IEEE802.3af, which produced the first worldwide standard for distribution of power over standard Ethernet.



Originally, Cisco promoted PoE for commercial IT applications, including VoIP telephony and wireless access points. Quickly thereafter it became adapted to many other types of Ethernet connected devices including devices.

In the Industrial Ethernet networking environment, it was obvious that the same technology could be used for very similar applications, and PoE was immediately adopted.

How PoE Works

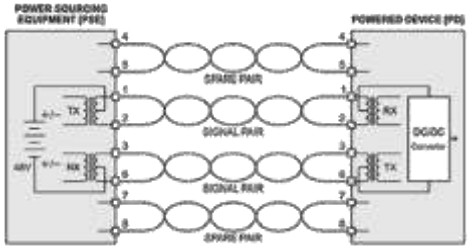
The IEEE802.3af standard provides for 48 VDC power and up to 15.4 W of power over standard Cat5/5e/6 Ethernet cable and connectors. The power is delivered over the same cable as the data—up to 100 meters (328 ft.) in distance.

The PoE standard provides for three types of devices. First there is the Power Sourcing Equipment (PSE). Then there is the Powered Device (PD) which receives power from the PSE, and there is also a PSE device called a Midspan device, or power injector.

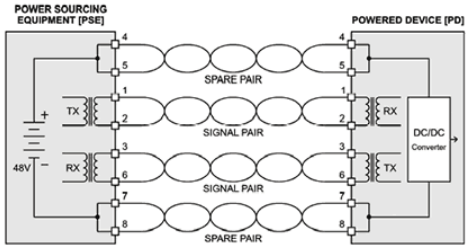
PSE devices are usually Ethernet switches, which can provide power on their Ethernet ports. They are provided in “endspan” or “midspan” configurations. Endspan devices are commonly called PoE switches, and are normally used in new installations, while Midspan devices are often used where the Ethernet devices already exist, but PoE is to be added to the system.

PD devices are the devices that use power provided by a PSE. They can be VoIP telephones, IP cameras, or wireless access points.

There are two operating modes for PoE. Power can be delivered over the same pairs as the data (Mode A) or over the spare pairs in the Cat5 cable (Mode B).



Mode A



Mode B

The PSE decides which mode to use, not the PD. Powered Devices that support only one mode are not allowed by the standard. Similarly, the PSE must be able to implement either Mode A or Mode B. At power-up or on connecting a device, the PSE looks for a signature termination resistor, to determine whether or not to supply power to the PD. This feature was specifically designed to protect non-PoE devices.

PoE for Industrial Applications

Since PoE was originally developed for, and is still widely used in commercial IT applications, standard PoE devices are not always suitable for industrial environments.

Industrial PoE devices must be ruggedized for use in factories and plants, which are much more electrically noisy than the typical office IT environment. Robots, welders, variable frequency drives, and other common industrial plant devices are significant sources of EMI and RFI. Industrial PoE devices must include enhanced EMI/RFI protection, reverse polarity polarity protection and vastly higher surge protection (3000 V) than is ever going to be necessary in the commercial applications. Also, electrostatic discharge (ESD) is common on the factory floor, and a PoE device must have enhanced ESD protection (4000 V).

Other factors that should be considered are shock and vibration. In the industrial environment, there are global standards for shock and vibration that industrial Ethernet devices should be capable of meeting, including IEC 60068. In order to meet shock and vibration standards, these devices need a metal chassis and ruggedized enclosures. Both DIN-rail and direct panel mount configurations need to be supported for ease in installation in most applications.

Also, where a typical office environment has a fairly consistent temperature, somewhere around 22° C (72° F), a factory floor or process plant's ambient temperature can vary considerably from that comfortable temperature. Industrially hardened PoE devices should meet the typical temperature range of -40° to +75° C (-40° to +167° F) for industrial equipment.

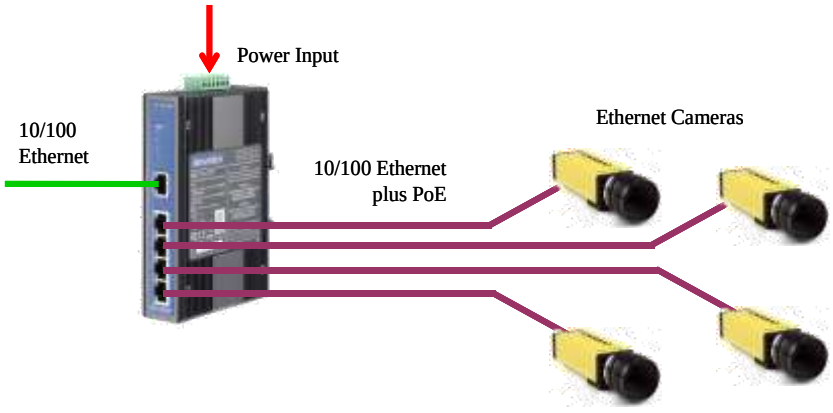
Finally, there is a huge difference between the life expectancy of networking devices in commercial IT environments, and in industrial applications. Typically, in commercial IT, switches and other networking equipment are replaced every two to three years, or sooner where there are significant performance improvements. In the industrial environment, change is much slower paced. Product availability must be two or three times as long. Parts, service, and product availability should be based on a 5 to 7 year lifecycle.

Industrial PoE Devices and Applications

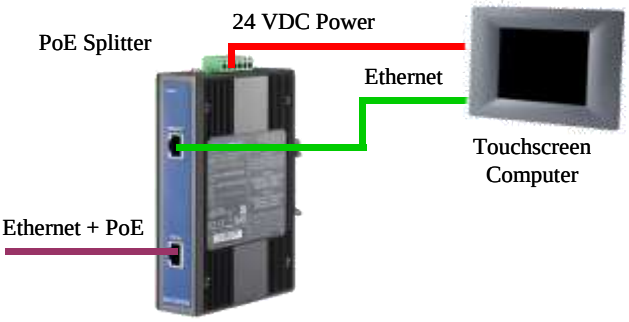
There are significant numbers of industrial PoE applications and devices that can be used to satisfy those applications. Many plants are moving to Ethernet-based plant-wide communications so that all communications can be managed from a central location using centrally provided hardware and software.

In the plant environment, there are many applications that can take advantage of PoE, including network security cameras, wireless networking, radio frequency identification (RFID), and vision systems.

Here's an example of a PoE vision system. In this system, Ethernet attached cameras are connected and powered by a PoE switch, which is then connected to a PC-based system. The PoE switch supplies both power and connectivity to the cameras with standard Cat5e cables.

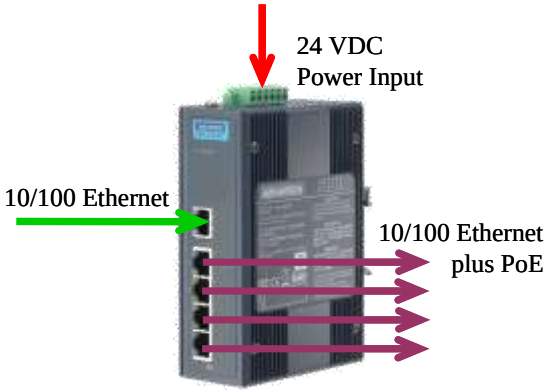


For applications where non-PoE devices need to be connected, a PoE "splitter" may be used to convert 48VDC PoE power to usable 24VDC. Terminal block connections on the splitter provide convenient connections to power the attached device. The example shows a touchscreen computer being powered by 24 VDC derived from the PoE splitter.



Recent Developments in PoE Technology

New developments in industrial PoE technology include 24 VDC powered PoE switches. Previous generation products require 48 VDC, and the extra power supply adds unnecessary cost and panel space. Newer PoE switches require only 24 VDC, and are equipped with a step-up DC/DC converter to provide 48 VDC output power as required by the PoE standard.



While PoE was originally developed for copper cable, new devices are integrating PoE with fiber optic technology. With these devices, PoE powered devices can be located thousands of meters (or feet) away with the added benefit of protection from ground faults and total electrical isolation. Fiber also provides intrinsic lightning protection in outdoor and building-to-building applications.

Another new development is the addition of PoE to managed switches. This provides a managed switch with multiple PoE outputs, which permits redundant network connections for high availability applications, advanced network traffic management and remote monitoring and diagnostics. It also provides a managed switch with specific PoE functions like the ability to monitor powered device (PD) power consumption, to monitor PoE negotiation with the PD, and to limit the power available to the PD.

In an effort to expand the range of devices that can be powered by PoE, the new IEEE802.3at-2009 standard provides for output power of up to 25W, as compared to the 15.4W available under the 802.3af standard. PoE switches supporting the 25W 802.3at standard are available today, laying the foundation for expanded support for industrial network devices utilizing PoE.

PoE usage in industrial networking is growing quickly and significantly. It simplifies powering network "edge" devices and field instruments with Ethernet connectivity. It is convenient, since a single cable carries both power and communications, and offers significant installation cost saving over separately powered devices. The use of PoE replaces all those bulky and expensive external power supplies, providing centralized power with the ability of optional power backup, and enhances safety by using low-voltage DC power.

As industrial automation users and equipment manufacturers seek solutions from commercial sources, network equipment suppliers are embracing open standards with industrially hardened solutions, to meet these needs. PoE will soon become as ubiquitous as Ethernet itself.

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