Impact of Power-over-Ethernet (PoE) on Industrial-based Networking

Ethernet-based communication, Transmission Control Protocol/Internet Protocol (TCP/IP), is emerging at all levels of the mass communications market. The introduction of Power-over-Ethernet (PoE) is poised to transform industrial-based networking systems.

The success of Ethernet-based technologies is, in part, due to a common standard developed by members of the IEEE802.3 Standards Committee. Success can also be attributed to the ability of Ethernet technology to constantly evolve over time, protecting customers' investments and allowing them to keep the same cabling system, topology, packet format and drivers that exist within installed Ethernet networks. An example of such investment protection is the ability of Ethernet networks to transport data rates from 10 Mbps (Megabits per second) to 1,000 Mbps, Gigabit speeds (10/100/1000BASE-T), using existing 100 ohm Unshielded Twisted Pair (UTP) cabling architecture. The evolution of PoE, a self-powered Ethernet connection, is yet another example of the adaptability of Ethernet technology that uses the inherent ability of a copper based connection to transmit both data and power from point A to B over UTP cable. The list of applications for self-powered Ethernet connections is long. A relevant example is the adoption of Ethernet technology within industrial-based networking systems. Prior to looking at this example it is necessary to explain how PoE systems evolved as an alternative solution to a Plain Old Telephone Service (POTS).

Supplying power over an Ethernet UTP cable was originally developed to duplicate the functionality of the POTS, where the analogue telephone is self-powered via a UTP connection from a remote Central Office (CO) or local Private Branch Exchange (PBX). For new installations, Information Technology (IT) managers prefer to install a Voice over Internet Protocol (VoIP) telephone system rather than the alternative, the outdated POTS. The deployment of a VoIP telephone system allows IT managers to significantly reduce the complexity of the system and the number of systems they need to maintain and repair. More importantly, a VoIP telephone system reduces installation costs by deleting the need for a separate analogue telephone system and a PBX. Maintenance costs are similarly reduced by utilizing the power of an Internet Protocol (IP) address, allowing users greater facility to move desks without the need of a telephone technician to swap wiring loom connections within the Main Distribution Frame (MDF) telephone patch panel.

The majority of installed VoIP telephones and wireless Local Area Network (LAN) access points are already equipped to receive operating power via their Ethernet connection. The market up-take for VoIP-based telephone systems has been slow, primarily for two reasons. First, the Quality of Service (QoS). Second, the fact that power for the VoIP telephone is supplied separately via a mains adaptor. QoS issues have been addressed by the installation of Virtual Private Networks (VPN). A VPN is a private network using a public network (usually the Internet) to connect remote sites or users together. Instead of using a dedicated, real-world POTS connection such as a leased line, VPN uses "virtual" connections routed through the Internet from a company's private network to a remote site or employee. QoS is addressed by upgrading the router to prioritise packet-based telephone communications over normal day-to-day packet-data transfers where a continuous connection is not essential. In the case of a telephone call, the lack of a continuous connection makes or breaks the system. The second issue is addressed in the same manner by supplying power over the Ethernet network to the remote VoIP telephone, removing the need for a separate mains adaptor at the users location. Installing an Uninterruptible Power Supply (UPS) within the server or router unit allows a VoIP telephone system to duplicate the function of the CO equipment or the PBX, allowing the VoIP telephone to operate during emergency or power outage situations.

The implications of a powered Ethernet connection are enormous for network infrastructure and end-users. Using the same UTP cable to supply both data and power not only simplifies installation, but also impacts implementation costs. The new scheme allows a large number of applications to reap rewards such as wireless LAN access points, remote security cameras, VoIP protocol, fire alarms, access control and security devices - a long list. A cogent example for discussion is the adoption of Ethernet technology within industrial-based networking systems.

Industrial-based networking systems are adopting Ethernet as the preferred communication bus structure. The adoption of Ethernet-based communications accelerated by the development of Compact PCI PICMG 2.16, offers the additional feature of a redundant switch configuration and improving system efficiency in the event of system or power outage failures. Using Ethernet-based TCP/IP protocols within an industrial network environment allows unrelated Processor Line Device Cards (PLDC) to communicate directly with one another for the first time using each manufacturer's TCP/IP protocol, eliminating the need to implement expensive software or hardware to interface the competing systems together.

In the past, for field-based devices, the preferred communication method for connecting a sensor or transducer to the central control or management system was via an RS485 or RS232 bus connection. Using a RS485 or RS232 connection was simple and cost-effective to set up with no expert knowledge required for cable installation.

RS485 and RS232 bus connections are gradually being displaced with the emergence of Smart Device Servers (SDS). The presence of a self-powered Ethernet connection is driving the adoption of a SDS. A powered Ethernet connection gives the field device or SDS the ability to be self-powered via the same Ethernet connection. A SDS is an embedded PC located at the device that converts serial data into Ethernet packets, providing a bridge between the proprietary device data and an open environment. This allows standard IT tools to communicate directly with the field device. Providing a remote field device with an Ethernet connection offers the same benefits as a RS485 or RS232 connection, namely, low installation and commissioning costs. But an Ethernet connection gives field devices the additional feature of direct access to the Internet which permits more complex tasks and algorithms (normally too complex to carry out in the field) to be performed on the raw data.

PoE is an innovative technology that allows next generation SDS to receive power and data over the same UTP cable, eliminating the time, cost and effort required to install a separate 110/220 Volts Alternating Current (VAC) power to the remote SDS. Using the power derived from the Ethernet connection eliminates the need for a localized battery back-up, preventing any data loss or security breaches. All SDS devices can be protected by a single, centralized, UPS, Figure 1B.

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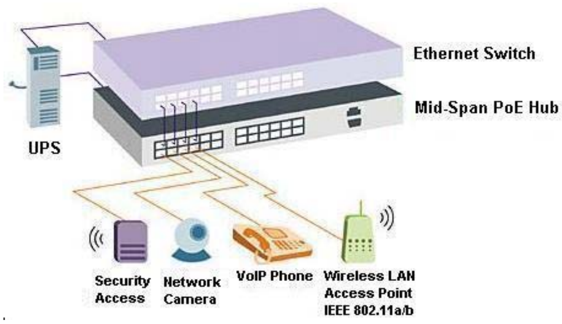

Fig 1A Mid-Span Powered Hub

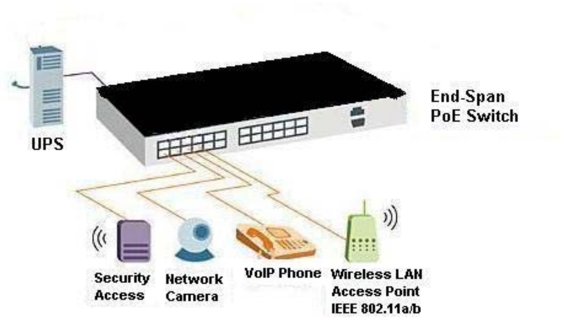

Fig 1B End-Span Powered Switch

There are two methods of interfacing power to the Ethernet cable. First, a mid-span-powered hub is connected in cascade to the Ethernet switch (refer to Figure 1A). Second, the end-span (end-point) power module is fully integrated within the Ethernet switch, delivering power without the need for additional components (refer to Figure 1B). The end-span system approach is preferred to reduce cost and system component count. The resulting power delivered via an Ethernet connection is specified by IEEE802.3af and rated at 15 Watts (W) with an injected PoE Voltage (V) of 44 to 57 Volts Direct Current (VDC), typically 48 VDC. The use of a higher voltage decreases the maximum current flowing through the UTP cable reducing the maximum length of the cable run. Therefore, it is important to marry each piece of equipment to the available power over the UTP cable. In practice, the maximum available power is 13 W due to inherent cable and connection losses.

The IEEE802.3af focus group is primarily focusing on 10 Mbps to 100 Mbps Ethernet operating over UTP cable where the Powered Device (PD) is located within 100 meters of the end-span or mid-span server unit. To eliminate the possibility of damaging the receiving device, the IEEE 802.3af standard incorporates an enabling detection system that prevents power being supplied to a non-power ready device. The mechanism for identifying an 802.3af compatible device is achieved by detecting the presence of a 25 kilo ohm resistor. If the resistor is identified, Direct Current (DC) power is automatically applied to the line.

Ethernet switch manufacturers offer two methods of transporting power along an RJ45 cable, either by injecting power onto the signal pairs, Transmit (TX) 1, 2 and Receive (RX) 3, 6, or via the spare wires (4, 5 and 7, 8). Server manufacturers prefer to use the TX/RX signal pairs for carrying power to the remote field device; because, the TX and RX wire pairs are protected by an isolating transformer. The use of the spare wires to transmit power is not preferred, as it limits the ability of the system to be upgraded from 10/100BASE-TX to 1000BASE-T (Gigabit) operation. For Gigabit operation the switch or router requires access to both the spare and signal wires to transmit and receive data. Therefore, it’s best to use the signal pairs in the beginning, rather than complicating the issue later-on, easing a future upgrade to a Gigabit Ethernet connection. Referring to Figure 2, PoE begins with a CAT5 “injector” or Power Sourcing Equipment (PSE) that inserts DC voltage onto the CAT5 UTP cable TX (1, 2) and RX (3, 6) signal pairs. The PSE is typically installed within the Ethernet switch or hub (Figure 1B). Receiving devices that are not “PoE compatible” can be converted by way of a DC “Picker” or “Tap.” These devices are sometimes called Active Ethernet “Splitters.” Using a splitter to pick off the DC voltage injected into the CAT5 UTP cable allows power to be supplied to equipment through a regular DC power jack. Two basic types of splitters are available; one is a passive splitter, for example Pulse H2005A, which takes the voltage from the UTP cable and directs the power into the power device (equipment) connected as shown in Figure 2. The other is a regulated splitter that takes the voltage on the UTP cable and converts it to another voltage, typically 12 or 24 Volts (V), allowing a wide variety of non-PoE equipment to be powered through the UTP cable.

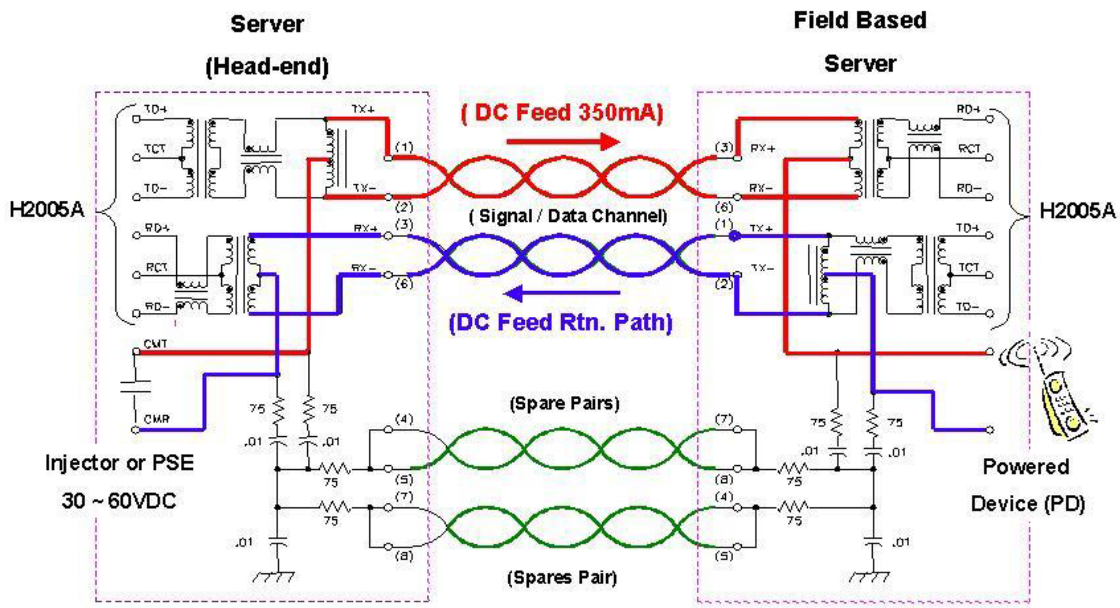

Figure 2 Power-over-Ethernet Example
(VoIP application use Pulse H2005A products)

Conclusion

PoE allows remote devices such as security cameras, VoIP phones, printers, wireless peripherals and RS485/RS232 field transducers and sensors, to receive power and transmit and receive data via a single UTP connection. Deploying PoE within an industrial-based networking environment allows field-based devices to be installed without the need for a separate power cabling supply. PoE also provides a method of supplying continuous service during power outages by centralizing an uninterrupted power supply within the centralized server unit. When deploying or upgrading an Ethernet-based communication system, investing in PoE architecture is a cost-effective upgrade for industrial based Ethernet switch systems, as it reduces the need to maintain numerous separate remote interruptible power supply units to guard against data loss during power outage situations.

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