Applying Power-over-Ethernet in Industrial Networking

SINCE ITS INTRODUCTION, INTEREST IN UTILIZATION OF POWER-OVER-ETHERNET technology has grown within the IT community as a more efficient way to provide backup power for telephones and to power remote devices without calling for an electrician. More recently, it is being viewed as an innovative solution in industrial applications as a way of providing redundant power to remote sensors and actuators; powering control and measure systems with a single cable on the factory floor; connecting IP sensors, actuators and other instruments; powering surveillance cameras both indoors and out; and powering fire alarm access controls and security devices.

What is PoE?

Power-over-Ethernet allows both power and data to be carried over a single Ethernet cable, enabling a device to operate entirely from the power it receives through the data cable. A midspan is used to implement PoE into an existing network where power can be inserted on the data cable without corrupting the data, between the data switch and the PD (powered device). This innovation allows greater flexibility in plant floor design, higher efficiency in systems design, and faster turnaround time in set-up and implementation, and reduced cost to install.

Benefits of PoE

The most significant benefits of using PoE for industrial networking include the ease of utilization of an RPS, time and cost savings, and safety advantages.

By employing PoE technology in an industrial setting, users have the ability to supply redundant power to many sensors and actuators without having to provide a local outlet or use the industrial 125Vdc UPS supply bus. Without PoE, the sensors are passive and data needs to travel long distances (up to 100meters) to the point of control or a local power source must be installed to drive the sensor. With PoE, a redundant power source can be used to power all the sensors and actuators through a single existing Ethernet cable without the expense and hassle of installing multiple power sources all around the factory floor.

There is also a significant safety benefit in using PoE in an industrial environment, particularly in a setting that is exposed to explosive gases or flammable liquids, where sparks or high voltage discharge are a concern. With PoE, all that power is a low voltage DC running through a single data cable, alleviating the safety issue inherent in electrical outlets and cabling. The POE standard requires limits turn on inrush currents for soft start without the need for additional components.

Single Point Backup

Power outages can mean costly work stoppage on a plant floor. When the power goes out, with a single UPS or redundant AB feeds, devices powered via PoE will continue to

work. This guarantee of 100 percent up time is particularly beneficial to industrial networks. By installing an n+1 product designed to operate from different power sources, users gain a power solution that can provide single point backup for distributed PoE-powered devices or network infrastructure without multiple UPSs.

Eliminates Wall Outlets
As operations grow and expand so does the need for more personnel, plant floor space and factory equipment. That can result in costly appointments with electricians to add and move wall outlets as work stations and personnel are reassigned or moved. With PoE, equipment can be easily moved and added since they are working off existing data cables, saving time, hassle and money.

Other benefits provided by Phihong's PoE solutions include:

- *Ease of Installation*

Unlike most solutions on the market, Phihong's PoE technology allows for plug-and-play implementation. Other products require power management, so at the time of set-up the installer is required to configure the PoE device for port priority to receive power as competitors' solutions rarely support full power. Phihong's PoE products are plug-and-play, with every port delivering full power out of the box.

- *Cost Savings*

In addition to the savings inherent when electricians and rewiring are not needed to add and move phones, Phihong makes PoE even more affordable because its full line of PoE solutions requires a much lower initial outlay than other products on the market. Unlike other suppliers, Phihong designs, manufactures and sells its own products, so pricing isn't driven up to cover the expenses of several companies involved throughout the design and manufacture process.

When PoE is implemented correctly, it can also detect valid loads and protect legacy RJ-45 devices; protect existing cabling infrastructure; support 10/100/1000 BaseT; meet communication and safety standards; protect against overloads and shorted circuits; and provide remote management and monitoring. Ethernet is the most widely used LAN technology; couple that with the ease of installing PoE and it quickly becomes the most obvious solution for many industrial networking needs.

Basics of PoE Implementation

PoE technology can be employed using a few different kinds of solutions:

- Midspan injectors from 1 to 24 ports that provide full power per port with no power management required, adding power between an existing switch and the device to be powered.
- Low-cost splitters designed for use with any non-enabled device. The splitter takes the power from data cable and provides required PoE detection and data separation.

- Power supplies with injection or PoE-compliant output voltages for switch and blade power solutions from 8 to 48 ports.

There are two fundamental implementations: midspans and switch or “blade.” A midspan is used to implement PoE into an existing network where power can be inserted on the spare pair. In a switch or “blade” implementation, the PoE is injected onto the data (spare optional) lines.

PoE delivers –44 to –57Vdc/350mA over two Cat 5 pairs – unused pairs 4+5 and 7+8, and/or used pairs 1+2 and 3+6. A single power source can support 1/6/12/24 or 48 terminals, and a power source with a UPS provides back up to a cluster of Ethernet devices. Power is automatically activated only when a PoE-enabled terminal is connected and detected.

Working from either midspan or switch, a PoE device accepts power from a primary data transformer or spare pairs, and includes a detection resistor. A switch disconnects the powered device until detection has occurred and 48V is applied. Numerous discrete circuits or integrated controllers are available for easy and inexpensive implementation.

Basic detection involves applying current-limited voltages that result in less than 10V to the cable. Per the original IEEE specification, the impedance of the powered device must conform to the allowable resistance and capacitance within specific levels before power can be applied. If it is not within specification, the switch remains open and no 48V power is supplied. Some “dumb injector” technologies have been known to significantly damage powered devices because they do not conform to these basic detection requirements of the specification.

The PoE standard also includes a classification option. Upon detection of a legal device, classification allows communication of the maximum power that will be consumed by a PoE device back to the power injector. It is used to determine power budgets and allows smaller power supplies to be used in the injector. For classification, 20V are applied upon detection of the legal device, followed by measurement of the current and class determination.

Once power is connected to the powered device, it is constantly monitored to verify connection. Within the standard, there are two detection schemes allowed for determining whether the device has been removed: DC and AC disconnect. DC disconnect uses Ohm’s Law to determine if the current has fallen below a set level. If this is detected, the power is removed. AC disconnect is accomplished by applying a low frequency AC current to the output and then measuring the voltage. Under load, this is not noticeable. If the load is disconnected, the AC voltage is relatively large. This is detected and the power is disconnected after a specific period of time.

Regardless of the disconnect scheme employed, when power is applied to a PoE device, the load is constantly monitored to ensure it is within an allowable envelope of current,

voltage and specified times. Should an “out of envelope” level be detected, the power is disconnected.

High Power Requirements and PoE Plus

The new IEEE 802.3 task force was formed to create an improved PoE standard. Building on the original IEEE 802.3af standard, the new IEEE 802.3at initiative, designated PoEPlus, will more than double the wattage available to powered devices which could greatly affect industrial networking applications.

For some industrial applications, 12.9W maximum of ‘af’ just isn’t enough power. PoEPlus will allow increased power to many more devices—at least 30W of power and potentially up to 60W. Some manufacturers, including Phihong, have already developed many products that deliver high-power PoE, but most customers would prefer a common industry standard for all devices on the market.

Currently, there are several ways to increase the power in a PoE application. The first is to increase the current. The original PoE specification limited the user to 350mA due to cable and patch panel limitations of Category 5 wiring systems. Since then, Category 5e & 6 cabling systems have become more common. The increased performance of these systems necessitated a lower impedance. Many manufacturers will rate these cables and connectors for 500mA.

The second method increases the sourcing voltage. The current standard allows PSEs (Power Sourcing Equipment) to have an output voltage of 44-57V. This is a very wide range where in practice the source is generally a well-regulated voltage that could be set anywhere within this range. By planning for this in the system it is possible to take advantage and gain extra power at the user device. This can be done so that the product is still in compliance to the existing standard with the same detection and protection schemes. The PD (powered device) can detect and utilize the higher voltage, making it possible to get 42 percent more power at the device. Some manufacturers are delivering such a device, such as a single port high power device delivering 30W.

Installing PoE in Industrial Networks

In selecting PoE for high power applications, it is important to choose suppliers that use the same principles of protecting equipment as the current IEEE802.3af standard. Some products on the market claim to offer PoE compatibility but are simply dumb injectors that can damage an overall system. Designers need a solution that offers fully compliant detection and disconnect to avoid those problems.

The current standard has classifications of power level loads, 1 through 4. When a device is detected, the classification allows communication of the maximum power that will be consumed by the device to the power injector. Classes 1,2 and 3 are defined, with Class 4 reserved for future determination. It is likely that the new specification will use this

classification method to detect higher power devices. This adds a few components to each PD and some additional complexity to the PSE detection circuit.

Using Both Data and Spare Pairs
The current standard allows for the power to be applied to either the spare or data pairs from an Ethernet switch. If a midspan power injector is utilized to implement PoE into an existing network, the standard requires power must be applied on the spare pair.

If you use both spare and data pairs it is possible to theoretically double the power, but it does present two significant challenges:
a) The first is that the impedance from the data and spare is different because of the data transformers. This requires that the powered device has input current sharing or individual current limiting on each source to ensure an overload condition does not occur, causing the sourcing equipment to shut down.
b) The second problem is that commercially available power source control ICs do sequential detection and connection. This means that each pair would be detected and then connected. The PD needs to draw enough current to maintain connection but hold off drawing high power until both pairs are connected.

In the industrial market the same double pair feeding can be used to provide redundant power to a device from two different sources.

Other Considerations

Given many of the applications for PoE, particularly for control and data connectivity, the reliability of PoE devices can be critical. A reliable PoE midspan must survive normal, everyday abuses such as electrostatic discharge and lightning strike surges, as well as not cause any degradation in the data transferred via the Ethernet cable. When used in an industrial environment, the PoE device must be even more rugged to withstand the daily demands of the plant floor. While these are simple concepts, it can be very difficult to develop detection and switch devices robust enough for these real-world reliability threats.

To help confirm reliability, a PoE Injector should be tested and evaluated by a valid third party, such as the University of New Hampshire Interoperability Lab. This facility tests compliance to the standards and interoperability between devices, as well as verifies that data is not corrupted. Major manufacturers should be able to supply a report.

The Future of PoEPlus for Industrial Networking

Recently, the IEEE 802.3 task force has turned its attention to choosing between a 2-pair or 4-pair solution for providing enough power for high-power applications such as multi-band access points and controllable security cameras. The driving factor in the decision is avoiding very high temperatures in the cabling which can cause eventual data degradation.

The group has approved a proposal stating that its objectives can most likely be met with a 2-pair solution, so members will be focusing efforts on developing this equipment that is lower in cost and easier to implement when compared to the alternative. The current proposal is to use a source voltage from the power sourcing equipment (PSE) of 51-57V with 650mA on Category 5 or better wire. The drop per pair total in the worst-case scenario of 100m cable and connectors is 12.5ohms. This will provide at least 30W at the power device with a voltage range of 40-57.

With the new specifications, Power-over-Ethernet will be the most obvious solution for powering industrial networks. The efficiency, safety and flexibility of PoE greatly benefit control applications on the factory floor through cost savings, ease of implementation and versatility of plant design.