Power over Ethernet in Military Environments

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Introduction

Although Power over Ethernet (PoE) may seem like new technology for some, especially for military and aerospace applications, PoE has actually been around for almost two decades now. PoE-compatible devices can transmit and receive Ethernet data as well as electric power up to 100 meters over the same copper network cable; however, there are several variants of PoE and how it can be implemented. This white paper will discuss PoE standards and explain why PoE can help you reduce complexity and save money.

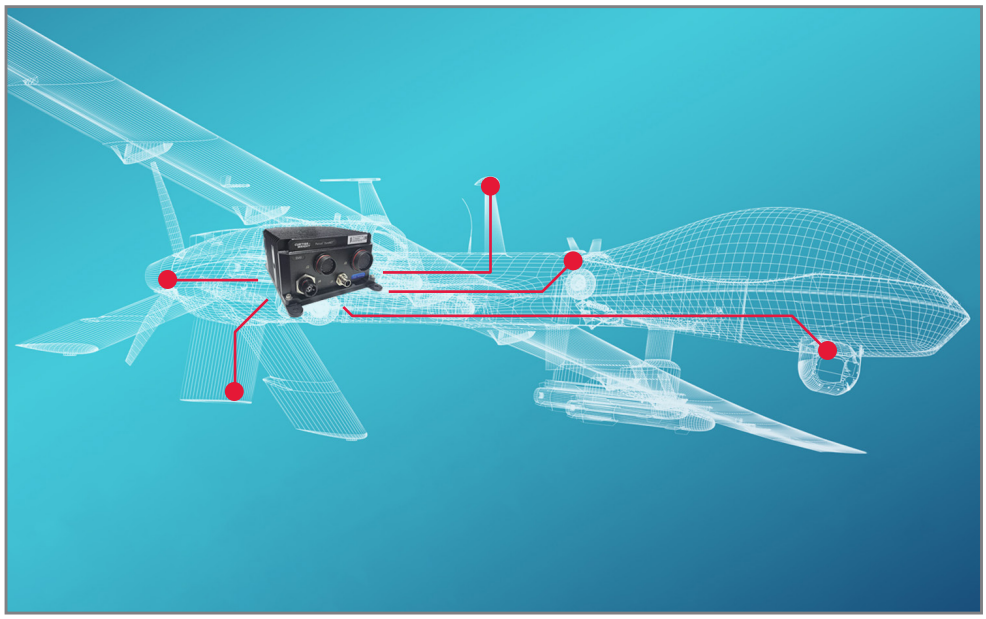

Figure 1: Sensors and cameras connected to a PoE network

A Brief History of PoE

PoE was originally referred to as “power injection.” Power injection meant that power sourcing equipment (PSE), such as a network switch, can provide DC current to a powered device (PD), using the unused twisted pairs in traditional CAT 5 copper Ethernet cabling not utilized for 10BASE-T or 100BASE-TX operation. Sounds simple enough, but in the beginning there were few standards or safety considerations, which meant that you could unintentionally damage a device, especially one that was not designed to accept power. That is why the IEEE 802.3 Working Group, the body that defines standards for Ethernet technology, got involved in 1999.

By 2003, the IEEE 802.3 Working Group had ratified the first standard, called IEEE 802.3af for "Type 1" PoE devices. Under this standard, power is transported on the same wire pairs, or spare wire pairs, as is the data for 10 and 100 Mbit/s Ethernet variants. For Gigabit Ethernet and faster, all four twisted pairs of the Ethernet cable are used for data, but just two pairs for power transmission. Power is transmitted on the data conductors by applying a common voltage to each pair. Because twisted-pair Ethernet uses differential signaling, this does not interfere with data transmission.

The original PoE standard allowed for PSE to source up to 15.4W and deliver up to 12.95W per port to PDs. It also dubbed PoE switches or routers that provide power over the Ethernet cable as "endspan" or "endpoint" devices, while external power injectors were referred to as "mid-span injectors" to be used in combination with a non-PoE switch. Endspans are normally used in new installations or when the switch has to be replaced for other reasons (such as moving from 10/100 Mbit/s to 1 or 10 Gbit/s), which makes it convenient to add the PoE capability. Midspans are used when there is no desire to replace and configure a new Ethernet switch, and only PoE needs to be added to the network.

Having PSE deliver 12.95W of power may not sound like a lot, but it's enough for many popular PDs, including Voice over IP (VoIP) phones, stationary cameras, and door access control units. Each PSE comes with a maximum power budget that it can supply to PDs, which is typically less than the maximum aggregate power for all PoE-capable ports. While this power budget was enough for most applications, before long some industries looked for an updated standard to handle more power per port.

The IEEE 802.3 Working Group listened and in 2009 adopted a new standard, which nearly doubled the available power output. The IEEE 802.3at standard for "Type 2" devices is called PoE-Plus or PoE+, and it allows PDs to source up to 30W. Like the original PoE standard, PoE+ utilizes just two pairs of wires for transmitting power and accomodates for power loss over long cable runs, promising delivery of at least 25.5W per port, twice that of PoE. This allowed for expanded device usage with wireless access points (WAPs) and motorized security cameras with pan-tilt-zoom (PTZ) capabilities.

Table 1

IEEE 802.3 STANDARD	IEEE 802.3af	IEEE 802.3at	IEEE 802.3bt
Approval year	2003	2009	2018
PoE type	Type 1	Type 2	Type 3, Type 4
Power sourced	15.4W	30.8W	60W, 90W
Common PDs	VoIP phones, stationary cameras, networked audio	Wireless access points, security cameras	Industrial lighting, door access systems, video phones, computers
Twisted pairs used	2 pair	2 pair	4 pair

Table 1: The three current standards for IEEE 802.3 PoE

Of course, it was not long before even more PoE power was desired to open the door to more applications. Various proprietary higher power PoE implementations began to penetrate the market, including Cisco's Universal Power over Ethernet (UPOE), Linear Tech's LTPoE++, among others. It took a decade, but in 2018, the new IEEE 802.3bt standard rolled out to support Type 3 (60W sourced) and Type 4 (90W sourced) devices for applications including industrial lighting, door access systems, video phones, smart building infrastructure, and thin client computers. Known as "4PPoE" or "4-Pair Power Over Ethernet", this standard uses all four twisted pairs of an Ethernet cable to transmit power for Gigabit Ethernet or faster. Each twisted pair needs to handle a current of up to 600 mA (Type 3) or 960 mA (Type 4). Additionally, support for 2.5GBASE-T, 5GBASE-T and 10GBASE-T was included. Foreseeably, this may open new opportunities for devices that require 100W for digital signage displays, point-of-sale systems, LCD TVs, smart homes or other applications.

PoE, PoE+, and 4PPoE powered devices are assigned a class from 0-8 based on how much power they require. When a PD is connected to a PSE, it provides its class to the PSE so that the PSE can supply the correct amount of power to it. Class 1, Class 2, and Class 3 devices require very low power, low power, and medium power, respectively. Class 4 (PoE+) devices require a high amount of power and are only compatible with PoE+ PSEs.

The Benefits of PoE

It's not hard to imagine the benefits of using PoE in industrial settings. Being able to use the same cable for both power and data means that power can be delivered to devices without having to wire new circuits or requiring a separate transformer that converts AC power to DC. PoE's "inline power" can significantly reduce the number of wires needed to install a network and also deliver greater flexibility for the location of installed equipment, less downtime and lower wiring and power costs.

Another benefit of PoE is that power transfers over much longer cables than what USB can handle. Advocates of PoE expect PoE to become a long-term DC power cabling standard to replace a multiplicity of individual AC adapters, which cannot be easily centrally managed.

In military environments, the benefits are even more pronounced. On military vehicles, for example, whether ground vehicles or airborne platforms, a common denominator is that size, weight, and power (SWaP) is always at a premium. Smaller and lighter equipment means more electronics payloads can be integrated and/or those platforms can be more energy efficient to go farther and/or faster. While this is true for virtually all vehicles, it's especially true for unmanned air, surface, ground, and undersea drones. Minimizing SWaP means mission endurance can be extended, fuel/battery costs can be lower, as well as operational costs.

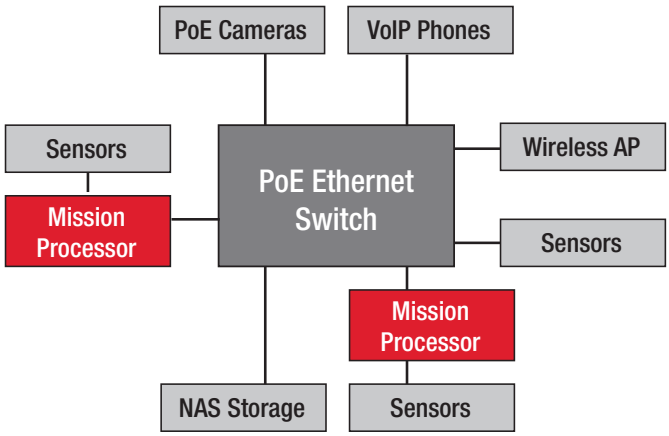

Figure 2: C4ISR Ethernet LAN Backbone with PoE

In vehicles or aircraft such as these, Ethernet has become the backbone for situational awareness and network-centric operations, connecting sensors, communications, and computing devices. With PoE, IP phones, PoE cameras and other devices are not only networked, but the cabling and power architecture on the platform can be simplified to help reduce SWaP, as no separate power supplies and cabling are required to each end-device. PoE can also offer device management capabilities since device power can be remotely monitored and controlled over the network. You can also save money with wiring, since it leverages the same traditional CAT5/5E/6 cabling that may already be installed for your network to now power your IP endpoint devices, reducing the cost of infrastructure or installation labor. PoE devices can also be mixed in a network with non-PoE devices, but non-PoE devices cannot provide power for PDs or be powered by PSEs. Non-PoE devices must have a separate source of power.

The Parvus DuraNET 3300 Network Switch

Despite all the advantages of PoE in military applications, to-date, system designers and integrators have not had many truly rugged PoE product options to choose from. That is until Curtiss-Wright designed the rugged COTS Parvus® DuraNET® 3300 small form factor (SFF) PoE/PoE+ switch. It is a MIL-rugged Cisco IOS®-managed L2/L3 embedded Ethernet switch that simplifies cabling and power management for IP cameras, phones, sensors, and more, supporting PoE injection for up to 24 devices (with max power budget of ~125W). This 10Gigabit (G) / 1G (24 x 1000BASE-T + 2 x 10GBASE-SR) switch provides up to 44 Gbps of line-rate multi-layer forwarding and advanced network security, data, video and voice services.

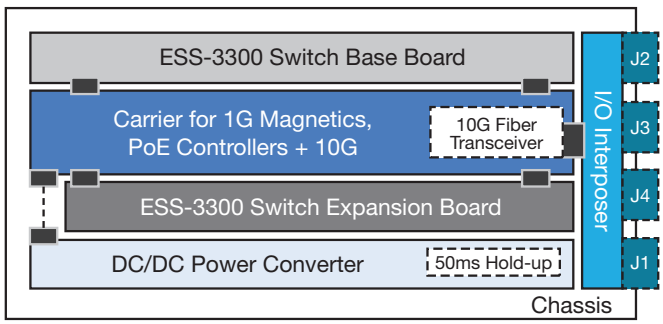

Figure 3: DuraNET 3300 architecture block diagram

The DuraNET 3300 delivers the best in class capabilities of Cisco IOS-XE software thanks to embedded Cisco technology (Cisco ESS-3300). It also has the rugged mechanical design (fanless, extended temp, circular connectors) expected of a Curtiss-Wright solution for harsh environmental and EMI requirements per MIL-STDs and DO-160 standards. This line replaceable unit (LRU) integrates Cisco's ESS-3300 cards onto a rugged Curtiss-Wright carrier board with PoE controllers, 1GBASE-T magnetics, and 10GBASE-SR optical transceivers. The switch and carrier are combined with a MIL-STD-704/1275/DO-160 DC/DC power converter card to meet military ground vehicle and aircraft power requirements, while supporting both PoE Type 1 and PoE Type 2 devices. The DuraNET 3300 has also been designed to allow for Cisco IOS visibility to manage the PoE ports through Cisco's UI to monitor, and control the PoE usage on each port, including which ports supply power and the number of watts per port within the total available power budget.

The DuraNET 3300 serves as an ideal Ethernet connectivity solution for size, weight, power, and cost (SWaP-C) sensitive unmanned air/ground vehicles (UAVs, UGVs, UUVs), helicopters, and other tactical/combat platforms exposed to harsh environmental conditions (e.g. high altitude, extreme shock and vibration, extended temperatures, humidity, dust and water exposure, noisy EMI, dirty power). Housed in a rugged, sealed (IP67 dust and waterproof) enclosure, the DuraNET 3300 combines rugged mechanical design with high-performance networking, delivering new capabilities for Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) applications. Built with industrial-temperature components, this compact system supports a wide operating temperature range of -40 to +71°C (-40 to +160°F) without fans or a cold plate.

Figure 4: Parvus DuraNET 3300 network switch

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Conclusion

PoE technology continues its upward spiral in performance and capabilities, transferring Ethernet data at faster speeds and DC power at higher levels—all in a single eight-wire cable. With Ethernet as the backbone for situational awareness applications and network-centric operations in the military and aerospace sectors, PoE is poised to further enhance system capabilities onboard air, land, and maritime platforms. Reliable MIL-STD qualified embedded PoE switch solutions are now available from Curtiss-Wright to help system integrators reduce platform SWaP-C, while simplifying cabling, power, and device management for modern networked electronic payloads.

Learn More

Products

- Parvus DuraNET 3300 Network Switch

Blog

- Curtiss-Wright demonstrates two low-SWaP rugged Ethernet solutions at AUSA 2019

Press Release

- Curtiss-Wright Debuts MIL-Rugged Cisco®-based 10GbE Managed Switch

White Paper

- Copper or Fiber for Military & Aerospace Networks?