Power-over-Ethernet goes green

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PoE systems (**Figure 1**) with new capabilities are being deployed against the backdrop of more stringent power requirements of the Energy Efficient Ethernet standard and other green initiatives. A number of key PoE technologies address this challenge to improve energy efficiency across the enterprise.

Here's how the efficiency of PoE systems compares to traditional wall adapters in various applications, and how new techniques and technologies, including dynamic power management and emergency power management, promise to make new PoE solutions more power- and cost-efficient.

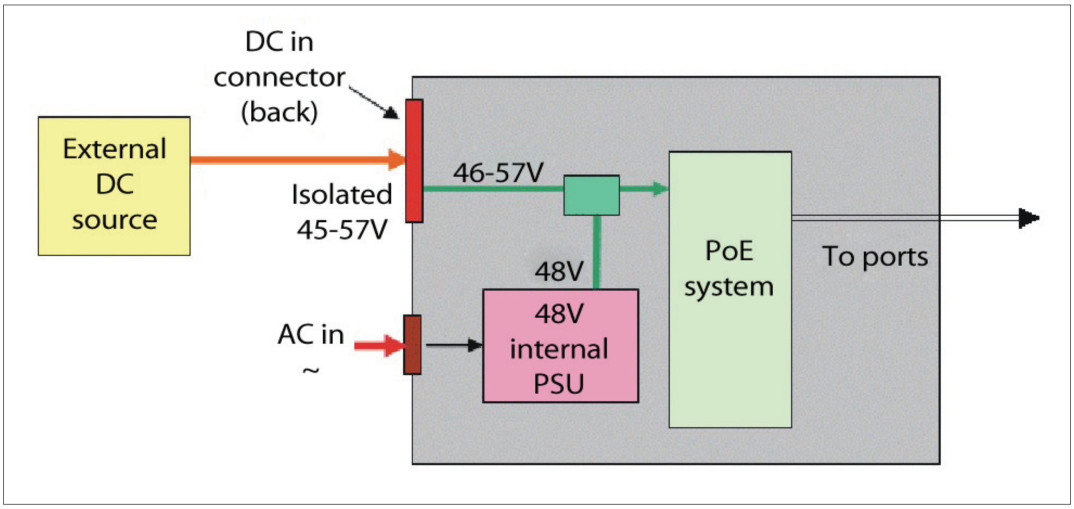

Figure 1: PoE systems are being deployed against the backdrop of more stringent power requirements of the EEE standard and other "green" initiatives.

Origin

Power and data have been bundled together on the same electrical cable since the late 1800s. However, the original Ethernet (IEEE 802.3) systems developed in the 1970s did not have provision for power. In the 1990s, during the arrival of data packet technology, alongside growing transmission rates and evolving VoIP, it became clear that Ethernet had to adapt to enable VoIP to be simple and reliable as traditional and digital telephony.

At the same time, WLAN protocols became sophisticated enough, with sufficient bandwidth, to replace wired Ethernet in some applications. Thus, strategic placement of WLAN access points, where AC power is not necessarily available, became a requirement. VoIP and WLAN technologies paved way for the IEEE 802.3 working group and the IEEE 802.3af task force, which developed specs to enable the transmission of data and packets on the same CAT class of Ethernet cable.

PoE applications

In 2003, the IEEE 802.3af task force created the first PoE standard, which specified 12.95W to powered devices. This was enough power for most applications, including VoIP phones, WLAN access point and network cameras, embedded thin clients, barcode RFID readers, and access control applications.

The low power capability, however, limits PoE from powering several devices with higher-end features. These include video phones, multichannel access points, outdoor applications such as fiber-to-the-home, optical network terminators, IEEE 802.16 subscriber stations and notebooks. The IEEE 802.3 working group addressed these issues in 2004 by creating the PoEPlus study group. In 2005, it became IEEE 802.3at task force, which aimed to provide at least 30W for devices powered over Ethernet cables.

At present, PoE is focused on transforming the RJ45 connector into the universal power socket. But is this energy-efficient?

PoE vs. AC adapter

PoE replaces a local power supply. Power is converted from 100-240Vac to 44-57Vdc at the output of the PoE power sourcing equipment (PSE), then delivered over a cable up to 300ft long. The cable delivers 37-57Vdc to the powered system (usually converted to 5, 3.3, 2.5, 1.2 and 0.9V for a system's various circuitry.

The overall efficiency of a PoE system is ηPoE = PSE power supply efficiency * PSE circuit efficiency * power device (PD) circuit efficiency * cable efficiency (cable, patch panel and connectors) * powered-device DC/DC efficiency.

At first glance, such a general system seems to have various losses that are unavoidable. But there is a major difference between the PSE and the powered device. The designer of the powered device must assume a worst-case power conversion of 57Vdc down to its lowest voltage, like 3.3V, for power dissipation purposes. Meanwhile, the PSE designer has the freedom to determine the output voltage (**Figure 2**).

For example, an IEEE 802.3at powered device requires 29.52W to operate and it is placed at the end of a 300ft CAT5 channel; resistance is 12.5Ω. The PSE circuit resistance is 0.65Ω, the powered device circuit resistance is 0.58Ω plus a diode bridge drop, and the source is 110Vac. The PSE designer has two options: either to use a power supply with a minimum voltage of 56V or a power supply with an output voltage of 51V. In the 56V system, the current will be 616mA at maximum load. In the 51V system, the current will be 720mA.

Now, let's determine the corresponding system efficiencies. For the 56V system, the core efficiency, neglecting the PSE power supply efficiency and powered-

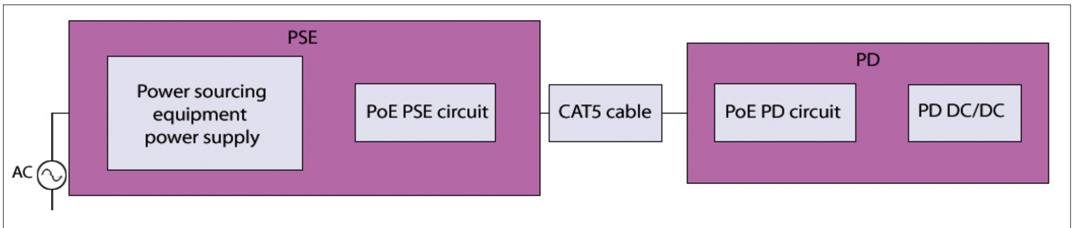

Figure 2: The designer of the powered device must assume a worst-case power conversion for power dissipation while the PSE designer can freely determine the output voltage.

device DC/DC efficiency in the equation, is 0.993 * 0.861 * 0.972 = 83.1 percent. For the 51V system, it is equal to 0.991 * 0.82 * 0.965 = 78.4 percent. Thus, the 56V system has 5 percent higher efficiency than the 51V system.

The overall efficiency of the 56V system, assuming an efficiency of 90 percent for both the DC/DC stage in the powered device and the AC/DC stage in the PSE power supply, is 0.9 * 0.9 * 0.831 = 67.3 percent. In contrast, typical standalone AC adapters such as those used in laptops are normally 50-70 percent efficient at maximum load.

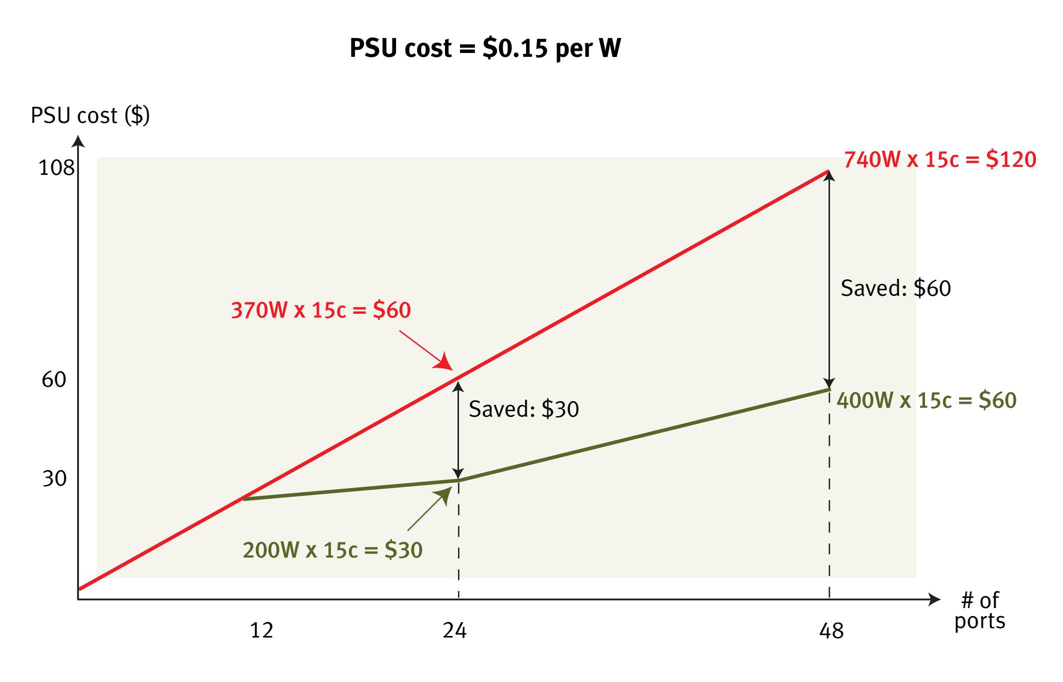

Figure 3: The cost of a PSE power supply is directly proportional to the difference between the input and output voltages.

Typical case

Another aspect of efficiency has to do with the power dissipated by huge PoE power supplies when they aren't being used. If an IT manager, for example, buys a 48-port switch with full power per port (total 800W), but uses it to power just 20 ports, the power supply may be operating very far from its optimal efficiency. Below the maximum power load, the supply's quiescent power is typically 10 percent that of the power supply rating. In this example, quiescent power is about 80W.

If you can accurately measure power consumption and install a sturdy algorithm to allocate dynamic power to the ports, you will maximize the amount of available power. That's not all. Smaller power supplies are also less expensive. And if you don't want full power to a port, the switch vendor can offer a means to provide power via an external power supply. This requires smart management of the power supplies available on the system.

Cost implications

We've established that having the maximum possible voltage at the PSE power supply is the most efficient solution. How about cost? Typically, the cost of a PSE power supply is directly proportional to the difference between the input and output voltages (**Figure 3**). Thus, a PSE power supply supporting 1,10V-to-56V conversion will cost less than a power supply providing 110V-to-51V conversion.

On the powered device side, the power supply needs to be designed for "worst-case" conditions, that is 57V. Thus, there is no cost penalty. And with the higher efficiency of a higher-voltage supply, you can drive a powered device load with a smaller power supply. Heat dissipation will be less and so, you can get by with a supply fan that is smaller or operated at reduced speed.