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More Green for PoE

By Daniel Feldman, Microsemi

Power-over-Ethernet (PoE) systems, with new wide ranging capabilities, are being deployed against the backdrop of ever-more-stringent power requirements of the Energy Efficient Ethernet (EEE) 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 "smart" PoE solutions even more power- and cost-efficient.

Origins

Power and data have been bundled together on the same electrical cable since the late 1800s and Bell's telephone. Curiously enough, however, the original Ethernet (IEEE802.3) systems developed in the 1970s did not have provision for power. In the 1990s, with transmission rates growing and the the arrival of data packet technology, as well as evolving voice-over-Internet protocols (VoIP), it became clear that Ethernet had to adapt to enable VoIP to be as simple to use and reliable as traditional and digital telephony.

At the same time, wireless LAN (WLAN) protocols became sophisticated enough (again, 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 triggered the IEEE802.3 work group and ultimately the IEEE802.3af task force (1999), which developed specs to enable the transmission of data and packets on the same CAT class of Ethernet cable.

IEEE802.3af applications

After four years, the IEEE802.3af task force created the first PoE standard, which specified 12.95 watts to powered devices (PDs). 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.

But the low power capability limits PoE from powering several devices with higher-end features. These include video phones, multi-channel access points, outdoor applications such as fiber-to-the-home, optical network terminators, IEEE802.16 subscriber stations and even notebooks. The IEEE802.3 working group addressed these issues in 2004 by creating the PoEPlus study group. In 2005, it became IEEE802.3at, with the goal of providing at least 30 watts for devices powered over Ethernet cables.

The challenge

Power over Ethernet is now focused on transforming the RJ45 connector into the universal power socket. But is this energy-efficient?

Efficiency: PoE vs. AC adapter

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

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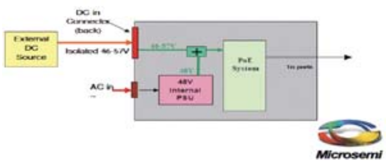

Figure 1: Basic PoE configuration

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

At first glance such a general system seems to be one in which various losses are unavoidable. But there is a major difference between the PSE and the PD. The designer of the PD must assume a worst-case power conversion of 57 VDC down to its lowest voltage (e.g., 3.3 volts) for power dissipation purposes. The PSE designer, on the other hand, has the freedom to determine the output voltage.

Say, for example, an IEEE802.3at powered device requires exactly 29.52 watts to operate and it is placed at the end of a 300-foot CAT5 channel (resistance is 12.5 ohms). The PSE circuit resistance is 0.65 ohm, the PD circuit resistance is 0.58 ohm plus a diode bridge drop, and the source is 110 VAC. The PSE designer has two options: Either use a power supply with a minimum voltage of 56 volts or a power supply with an output voltage of 51 volts. In the 56-volt system, the current will be 616 mA at maximum load. In the 51-volt system, the current will be 720 mA.

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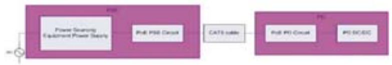

Figure 2: Power efficiency considerations

Now let's determine the corresponding system efficiencies. For the 56-volt system, the core efficiency (neglecting the first and fifth terms in the above equation) is: 0.993 x 0.861 x 0.972 = 83.1 percent. For the 51-volt system, it's equal to 0.991 x 0.82 x 0.965 = 78.4 percent. Thus the 56-volt system has 5 percent higher efficiency than the 51-volt system.

The overall efficiency of the 56-volt system, assuming an efficiency of 90 percent for both the DC/DC stage in the PD and the AC/DC stage in the PSE power supply, is 0.9 x 0.9 x 0.831 = 67.3 percent. In contrast, typical stand alone AC adapters such as the ones used in laptops are normally 50 to 70 percent efficient at maximum load.

A 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 800 watts), but uses it to power just 20 ports, the power supply may be operating very far from its optimal efficiency. Indeed, below the maximum power load, the supply's quiescent power is typically 10 percent of the power supply rating (in this example, quiescent power would be about 80 watts).

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 (e.g., Microsemi's Emergency Power Management system).

Cost implications
We've established that having a voltage as high as possible at the PSE power supply is the most efficient solution. How about cost? The cost of a PSE power supply is typically directly proportional to the difference between the input and output voltages. Thus a PSE power supply supporting 110-to-56 volt conversion will cost less than a power supply providing 110-to-51 volt conversion.

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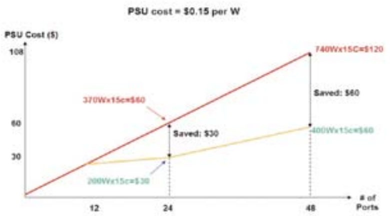

Figure 3: Cost calculations

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

About the author
Daniel Feldman serves as a senior product line manager in the Analog and Mixed Signal Group. He's in charge of all products in the PoE, xDSL remote power, and Telephony Ring Generation markets, including ICs and modules. He is an active member of the IEEE 802.3at Task Force and chairs the Ethernet Alliance PoE/PoEPlus Technical Committee. Previously, Mr. Feldman worked for PowerDsine as a senior product manager responsible for Outbound Marketing activities in the Americas; at IC4IC as the system architecture group manager responsible for the specification of a wireless access VLSI product line for 3G infrastructure equipment vendors; as a VHDL engineer at NICE Systems; and as VLSI engineer at RAFAEL. Mr. Feldman holds a B.Sc. in computer engineering from the Technion Institute of Technology in Haifa, Israel, and is an MBA candidate at UC Berkeley's Haas School of Business.