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PoE with integrated digital isolation saves energy and money

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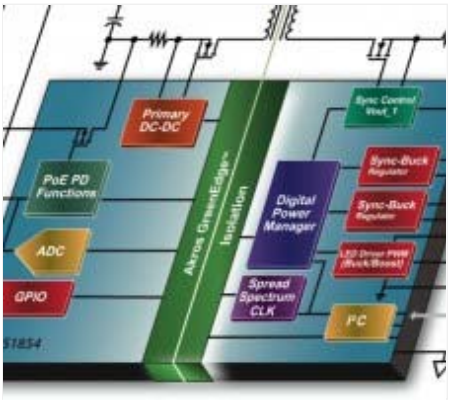

Employing on-chip electrical isolation between primary and secondary power in PoE devices provides real-time power management, parts count reduction, and substantial energy savings for large enterprises and Industrial Ethernet users.

Today, network power can be consolidated at Power Sourcing Equipment (PSE) in the data center, thanks to the latest Power over Ethernet (PoE) standards that enable power to be delivered to network devices along the same Ethernet cable used for data. This approach removes the necessity for a “wall wart” power cube to power every device and translates into tremendous benefits for data centers in the form of lowered cost, simplified infrastructure, and backup power management.

However, overall power management has only been crudely addressed in previous-generation PoE clients via power classification. This leads to overdesign and over budgeting of power systems in the data center or large Industrial Ethernet installations, resulting in wasted capacity and heat generation.

Possible PoE savings

To reduce energy consumption in the enterprise, it is critical to focus on all aspects of energy, including usage, allocation, and management. New PoE System-on-Chip (SoC) technology with integrated digital isolation was developed to increase the power-conversion efficiency of individual Power Devices (PDs) in a simple and cost-effective way. Using high-speed digital isolation integrated into a PoE SoC, it is possible to provide the data required for network software to reduce enterprise energy consumption with better power allocation and management.

Using such a device can offer considerable benefits in an enterprise setting where thousands of IP phones, wireless access points, thin-client PCs, security cameras, and other Ethernet devices all draw power from the network. The cumulative effect of efficiency improvements at each of the PD nodes can be quite substantial. For example, if a PoE Class 2 IP phone draws an average power of 5.2 W from the PSE, improving the PD power conversion efficiency by

5 percent (from something like 86 to 91 percent) will provide more than 500 mW of savings at the PD, as well as approximately 700 mW of savings referred back to the PSE input. Similarly, a 20 W IP camera can save 1.3 W at the PD and in excess of 1.6 W referred to PSE input.

Table 1 shows savings for different types of appliances, assuming average power consumption based on the device PoE Class. Consider a simple model based on a 1,000-employee enterprise that consists of 1,100 IP phones, 60 wireless access point nodes, and 40 IP cameras. Power savings at each PD node due to efficiency improvements can lead to more than 860 W of power savings and in excess of 16.6 kWh of energy savings per year when reflected to the PSE input, including savings from less heat dissipation in the data center.

PD efficiency improvement (91% vs. 86%)	Used power (W)	Savings at PD (W)	Savings at PSE A/C main (W)
IP phone (average usage)	5.2	0.54	0.69
WAP (13 W)	10.7	0.68	0.88
IP camera/IP PTZ camera (13 W/25 W)	10.7/20.0	0.68/1.28	0.88/1.64

Table 1: Average power savings per PD node

(click graphic to zoom by 1.6x)

Intelligent power allocation

Allocation of PSE power in a traditional PoE environment consists of setting aside the maximum power that each port will be expected to deliver to a PD at any phase of its operation. In addition, maximum cable power losses must also be set aside. A significant margin typically exists between the maximum advertised power and the actual power consumed. These maximums force significant overdesign of PSE power supplies. In addition, power supplies are much more efficient when used near their peak capacity, rather than under light loading.

For example, a traditional PSE will budget 7.7 W of power for a Class 2 IP phone (6.95 W for PD, 0.71 W for 100 m cable loss) and 30 W of power for a Class 4 IP camera (25.5 W for PD, 4.5 W for cable loss). If the PSE could determine a PD's dynamic power consumption and the cable distance between the PSE and PD, the PSE could substantially optimize its power allocation and thus reduce total required power at the PSE. Assuming average power drawn by the PDs, as in Table 1, as well as average Ethernet cable length of 50 m between the PSE and PD, intelligent allocation can reduce the power budget at the PSE by more than 35 percent (7.3 kW versus 11.2 kW for static allocation) in the 1,000-employee enterprise model.

This not only reduces the power supply size needed at the PSE, delivering direct cost savings, but it also allows the PSE power supplies to operate at near full-load conditions for higher efficiency, reducing power wastage and conversion to heat in the data center. Energy savings from better power allocation for the 1,000-employee enterprise example can be greater than 11.8 kWh, including the savings from reduced cooling requirements.

Translating energy to dollars

Using the 1,000-employee model, if each PD saved an average of 0.5 to 1.3 W, the total savings for the enterprise would be nearly 16.6 kWh or $5,300 annually, assuming average commercial energy rates. With rising energy costs, this factors into a five-year savings of more than $30,000. The total savings approaches $52,000 over five years (Table 2), after adding in the savings effect of intelligent power allocation between the PSE and PDs.

Energy savings from PD node efficiency, including cooling	16,626 kWh
Yearly savings from PD node efficiency	$5,300
Energy savings from real-time power monitoring	11,836 kWh
Yearly savings from real-time power monitoring	$3,800
Total yearly savings (PD efficiency, real-time power monitoring)	**$9,100**
Total lifetime savings (5 years)	**$52,000 ($44 per node)**

Table 2: 1,000-employee enterprise model energy-saving benefits
(click graphic to zoom by 1.2x)

Considering a PD's five-year average lifespan, this energy savings translates to nearly $44 in recurring cost savings per PD node, a substantial direct monetary benefit. It also helps enterprises achieve their energy-efficiency objectives.

PoE device with integrated digital isolation

New device technology integrates 2 kV digital isolation technology with next-generation PoE PD and power-conversion technology, a combination that delivers groundbreaking power integration and enables a new range of digital power PoE PD capabilities and solutions.

A few devices that have recently emerged in the market integrate an IEEE 802.3af/at-compliant PD with high-voltage isolation and multiple flexible digital power DC-DC converters, creating a complete PoE and power management solution in a single device with minimal external components. This approach simplifies PoE PD system design and delivers the benefits of power system efficiency and intelligent management (see Figure 1).

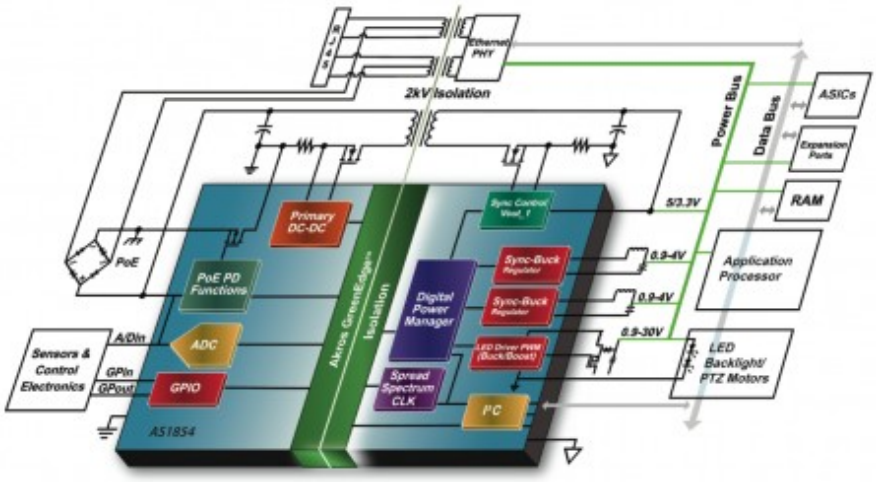

Figure 1: Highly integrated power SoC for a PoE powered device
(click image to zoom by 1.9x)

Integrated digital isolation offers a breakthrough for improving power system efficiency and cost savings. Using a built-in isolated synchronous driver for secondary-side rectification, an integrated PoE not only eliminates the need for external pulse transformers to create the sync drive, it also allows the device to intelligently manage timing of the primary and secondary drives. This optimizes sync delay and overlap delay parameters, practically eliminating PWM timing-related energy losses (Figure 2).

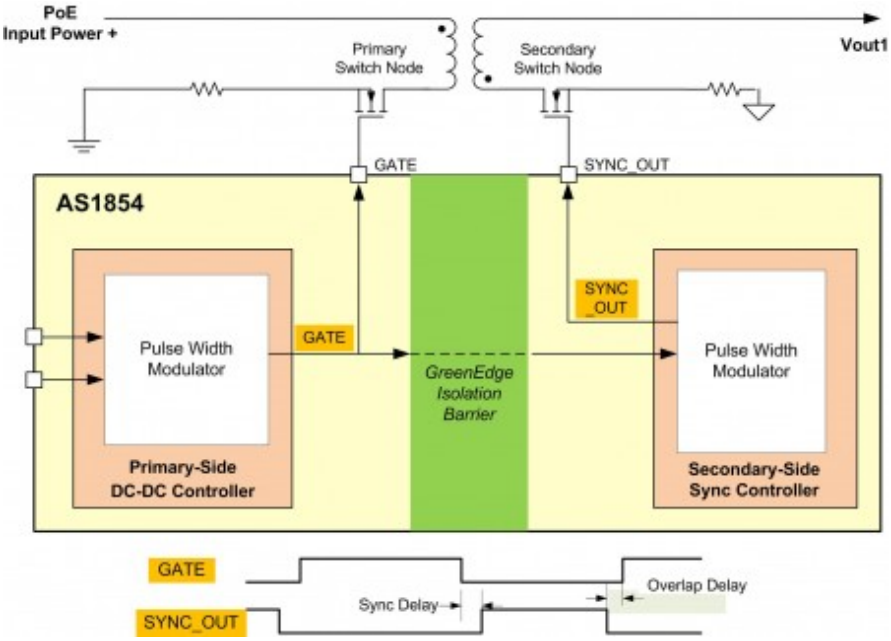

Figure 2: Primary and secondary PWM timing management across integrated isolation

(click image to zoom by 1.9x)

Figure 3 shows improvements in PoE power system efficiency attained by using a PoE PD. In addition to improving both light- and full-load efficiency compared to traditional designs, integrated isolation delivers efficiency improvements of more than 8 percent in the PoE Class 2 range (the one most commonly used for VoIP phones) over typical traditional designs.

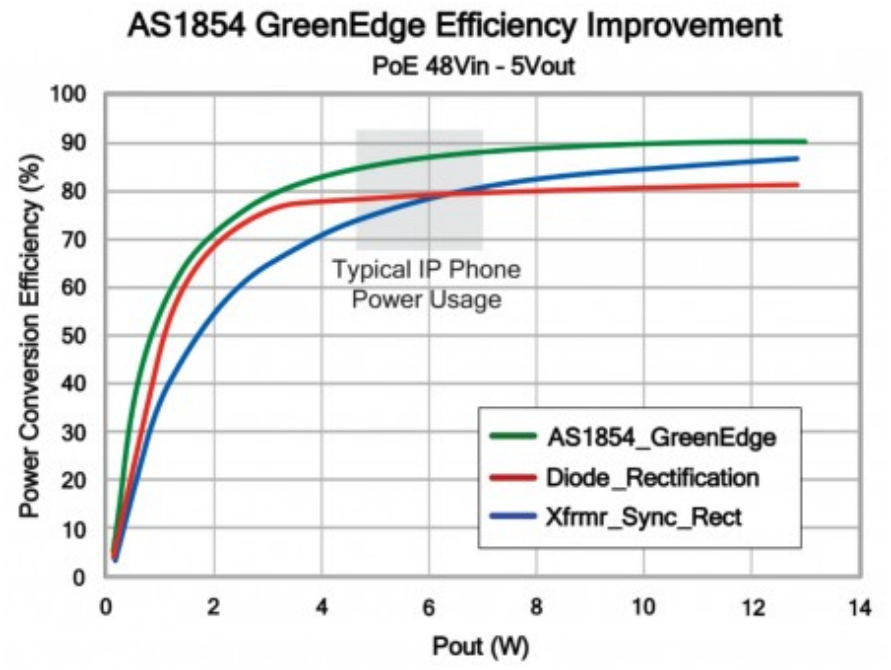

Figure 3: Power efficiency improvement

(click image to zoom by 1.9x)

Additionally, integrated isolation technology enables direct digital management of both isolated primary power and secondary system power. Primary-side isolated ADC in a PoE PD allows for direct power usage monitoring by the PD's microcontroller across the isolation barrier. Real-time power monitoring collects instantaneous power usage to pass to the PSE's network management software via standards-based Link Layer Discovery Protocol messaging. This enables the PSEs to deduce cable power loss and true PSE power allocation needed per PD port, eliminating

blind allocation of maximum power to each PD.

This approach enables PSEs to serve the same number of PDs with a much lower-power and efficient power supply. In addition, savings can be augmented upstream using a live monitoring capability, which allows for better power allocation and higher-efficiency PSE power supply utilization. Although isolated communication channels can be accomplished using discrete components such as opto-couplers, this approach tends to be slow, bulky, and expensive, making the design more costly, much larger, and sometimes even impractical.

Integration for savings

PD efficiency improvements and intelligent allocation capabilities can deliver significant monetary benefits to the enterprise with lower energy usage and lower cost of power supplies in the data center.

This new approach to integrated high-voltage power management provides a unique opportunity for cost-effective, end-to-end “green power” applications. By employing an integrated PoE SoC, such as Akros Silicon’s AS1854 family, designers can create value-added and differentiated feature sets in a cost-effective manner, passing on recurring energy-saving benefits to their end customers.

Amit Gattani is the business unit director for network power at Akros Silicon, based in Folsom, California. Amit has more than 17 years of semiconductor industry experience across engineering, marketing, and management disciplines in various start-ups and large public companies. He holds MBA and MSEE degrees from the University of California and has authored numerous patents, papers, and technical articles.

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