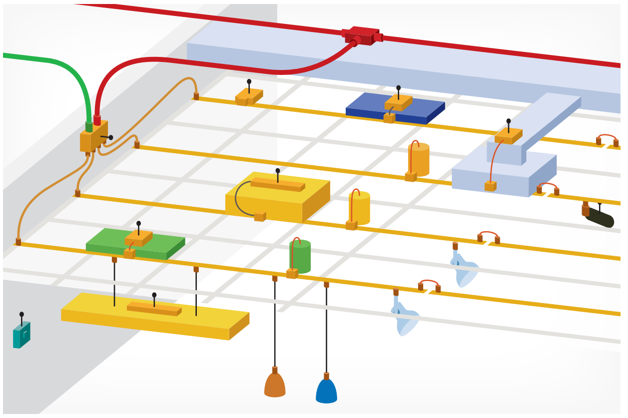
DC power distribution favors LED lighting

A low-voltage DC power standard could accelerate the conversion to LED lighting and create an enabling infrastructure for the workplace, write **BRIAN PATTERSON** and **PAULA ZIEGENBEIN**.



Schematic of a typical ceiling-based plug-and-play DC system. Picture courtesy of Armstrong World Industries and the EMerge Alliance Corp.

Many opportunities to save energy exist in the commercial building environment. Besides the offer of high efficacy, extended operating life and reduced maintenance, significantly reduced power consumption favors the eventual conversion of most lighting uses to solid-state sources, most particularly LEDs. To underscore this contention, after three years of relatively slow growth, the market use of LEDs has virtually exploded into double-digit growth in the past two years, particularly in fixed position applications like architectural lighting. The U.S. Department of Energy estimates that if LEDs become standard technology in indoor white-light niche market applications, 108 TWh of electricity could be saved per year, which is equivalent to 1.1% of total annual primary energy consumption and 13% of electrical energy consumption for lighting in the U.S. in 2007 [1].

However, one of the subtle obstacles facing LEDs, despite their otherwise compelling benefits, is that driver circuits for these devices must include power conversion capability to transform alternating-current (AC) branch distribution voltages (typically 277 V AC) to low-voltage direct-current (DC) power. While this process is fairly simple, it adds cost and can reduce the otherwise extraordinary power conversion efficiency of the LEDs themselves. It is like putting a brick wall in front of each device or light engine. Given today's typical building AC power distribution infrastructure, there is not much choice.

Of course, LEDs are not the first devices to run into this brick wall; all digital devices used in commercial buildings have the same issue – they are DC devices trying to exist in an AC environment. This problem includes computers, printers, cell phone chargers and assorted other personal use devices, as well as basic building controls, sensors, HVAC actuators, security systems and A/V systems. It is the latter part of this list that increasingly has become a larger portion of the fixed building infrastructure's use of power. Even state-of-the-art high efficiency fluorescent lighting systems take an efficiency hit because all electronic ballasts have a front end that converts AC input voltage to DC voltage. Electronic ballasts require DC voltage to efficiently drive fluorescent lamps at high frequency as well as to facilitate dimming, programmed starts and assorted other digitally managed tasks. Typical AC to DC conversion efficiencies range between 85% and 92%.

Power generation dilemma

The situation is not much different on the power generation side when site-based photovoltaic (solar), wind or other alternative generation is put into play. The native DC power generated by these increasingly efficient sources must be converted and synchronized with the utility-based AC power – meaning it typically is converted to 60Hz AC power. This comes at a higher initial investment cost for inverters, isolation, controls and noise filters, and a significant operating efficiency loss.

Making matters worse is the sometimes necessary use of a UPS battery-based backup system, which nearly doubles the initial loss, as DC power is converted to AC two times before making contact with the devices. To put this in perspective, because of accumulated conversion losses, a typical device in a building data center will only see half the power that was first measured and paid for at the utility power meter. This statistic does not even take into account any power used in cooling to compensate for any waste heat that can escape back into the occupied environment.

Society has been headed for a digital, DC-powered world at break-neck speed, while powered by an analog, AC-powered infrastructure that has not changed much in more than 100 years. And if you're not yet convinced, look at the statistics concerning the use of external power supplies [2].

In 2008 alone, 3.2 billion external power supplies will be manufactured worldwide. Also in 2008, 737 million external power supplies will be shipped to the U.S. and 434 million external power supplies will be retired in the U.S. alone. Only 12.6% of them will be recycled, resulting in 379 million external power supplies going into landfills.

BRIAN PATTERSON *is chairman of the EMerge Alliance (www.emergealliance.org) and GM, Business Development, Armstrong World Industries.* PAULA ZIEGENBEIN *is an application marketing manager with Osram Sylvania.*

These statistics do not include transformers inside ballasts and other internal power conversion devices. A conservative estimate would easily double the numbers if it counted all the AC to DC power conversions made each year, and added a double-digit compound average annual growth rate on top of that figure.

Adding a hybrid distribution layer

One solution to this dilemma, however, particularly favors the use of solid-state devices like LED light engines and lighting fixtures. Taking the form of a hybrid distribution layer of low-voltage (typically 24 V DC) power, it does not replace AC in a building, but complements it. After all, there are still some high-current loads that favor the use of AC power. The goal is to efficiently aggregate or eliminate multiple AC to DC conversions, thereby making devices simpler, safer and more flexible in use.

Why add DC? Two reasons:

Efficiency: Both alternative power generation and device consumption becomes more efficient with the consolidation or elimination of poor and highly fractionated power conversion.

Cost: More and more devices, like LEDs, are native users of DC power, and therefore can be easier to build and smaller when directly connected to DC power.

Why low-voltage? Two reasons:

Safety: Low-voltage power allows use of greatly simplified and less expensive class-2 wiring [3] and device protection, greatly reduces spark and fire hazards and eliminates shock/startle hazards.

Flexibility: Low-voltage power allows for 'hot-swap' plug-and-play connectivity that essentially can be embedded into existing building structure and elements, i.e. suspended ceiling grid, modular furniture, etc.

A typical ceiling-based plug-and-play DC system might look like the figure on p. 43.

Safety, flexibility, efficiency, and cost

Couple these basic benefits with the enormous capability offered by either digital RF or power line carrier (PLC) device controls, and the result is a system with the promise to deliver near-wireless capability all around (power and signal), eliminating the need for battery-powered switches, sensors and controls.

By providing convenient direct access to safe power (low-voltage, DC), such a system could:

1. Make it easier and less expensive to install lighting fixtures, sensors and other devices and simpler to repurpose and reconfigure future renovations without building or device re-wiring so buildings can resume operation sooner.
2. Help dramatically reduce technology upgrade costs for new technologies such as LED lighting, while reducing energy consumption via state-of-the-art device control and digitally integrated load and source management that can enable higher resolution control, metering and demand response
3. Promote sustainability with simpler system devices that have fewer materials without AC to DC conversion components and through use and reuse of system devices with interoperable plug-and-play mobility and simplicity.
4. Facilitate the direct connection and efficient use of energy from solar, wind, or other native DC alternative energy sources.
5. Allow facility technicians to quickly and safely move or re-install lighting fixtures and other low-voltage devices without the need to shut down branch power lines or otherwise significantly interrupt area occupants.

New commercial DC power standard

In a move aimed at addressing existing problems and increasing the flexibility, efficiency and sustainability of commercial buildings, a group of visionary companies recently announced in November 2008 the creation of an organization called the EMerge Alliance™. The Alliance is leading the creation and deployment of a new power, control and device-level technology standard for commercial interiors, developed around the use of safe, low-voltage DC power.

Founding members of the Alliance at the Governing level include Armstrong World Industries, Johnson Controls, Nextek Power Systems, Osram Sylvania and Wave. Having worked behind the scenes on this concept for the last several years, the alliance officially launched in November 2008 and currently has council and membership representing over 25 well-known companies, agencies and industry experts in the following fields: architecture/design; electrical and mechanical engineering; sustainability consultants; energy providers; building owners/developers; government; code and industry groups; product manufacturers in lighting, power supplies, electrical systems, cabling, HVAC sensors and controls; and A/V and security, building automation, and interior systems (ceilings, walls, and furniture).

Membership in the alliance is open, with tiered rights and privileges. Representation is given at the organization level with one vote per organization, depending upon membership type. The alliance hopes to draw from a broad and deep pool of industry leaders involved in the design, construction and management of commercial buildings to create an enabling infrastructure that prepares the workplace for the future of DC power.

A step in the right direction

The central features of the proposed EMerge standard include the selective and scaleable distribution of low-voltage DC power within common infrastructures already present in commercial interiors, as well as improvements in the optional use of on-site alternative energy through providing a means of direct and more efficient connection between these new energy sources and interior electrical loads, such as lighting and controls.

The belief is that this new commercial technology standard will also provide a platform for innovation to create even more energy efficient and individually controllable devices for the future, including new forms of LED or other solid-state general lighting devices. In essence, the alliance is focused on the nexus of today's top priorities for building owners – energy savings and adaptability. Sustainability-minded building owners are looking for leading-edge technologies that can provide a faster return on their investment in clean energy. This new standard is a deliberate and empowering step in that direction.

References

1. "Energy Saving Estimates of LEDs in Niche Applications" US DOE, October 2008: www.netl.doe.gov/ssl
2. Green Plug, Inc: www.greenplug.us/impact.php
3. NFPA 70- National Electrical Code (NEC): http://en.wikipedia.org/wiki/National_Electrical_Code