Interconnecting Solid State Lighting System Elements

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Advances in light emitting diode (LED) performance and cost, combined with the push for greater lighting efficiency have created an unprecedented opportunity for Solid State Lighting (SSL). However, the manufacture of solid state lighting fixtures is far more complex than producers of traditional lighting are accustomed. One of the critical areas involves connectors and wiring. SSL systems require the interconnection of driver/control devices and circuitry with one or more LEDs. What was once a pair of pigtail wires connecting the fixture to an AC power source has been replaced with high and low voltage interconnects requiring careful consideration of system rating, grounding, electrostatic discharge, polarity and more.

For a smooth transition to solid state lighting, the connections must be robust, reliable and easily adapted to high volume manufacturing processes. Connectors also can play an important role in testing prior to manufacturing to obtain the necessary government and safety agency certifications. Tyco Electronics has addressed these issues in the connectors and wiring designed for its recently introduced NEVALO lighting systems.

Interconnects in the SSL System

For the most part, interconnects (cables and connectors) have been a critical but unaddressed challenge for solid state lighting products. The wiring and connectors have a significant impact on the cost, manufacturability, operation and overall reliability of the system. Early versions of solid state lighting use solder connections but they cause several problems including limiting the flexibility of the design for future upgradability. Interconnects have system design implications and complexity well beyond the traditional lamp holder and lighting socket.

Unlike traditional lighting systems that are basically non-polarized AC electrical products, a solid state luminaire is an electronic system. Some of the common problems that system-level connectors can avoid are the misconnection of components as well as grounding, electrostatic discharge (ESD) and polarity issues. For example, a first-make/last-break for the ground connection is necessary to achieve a continuous path for static discharge to protect static-sensitive semiconductor junctions. In addition, a properly designed interconnect system can avoid ESD problems and bring together all the protection aspects of the system as well.

Even though several subassemblies need to be interconnected in an SSL fixture, solid state lighting does not have standards for wiring or connectors — yet. However, in 2009, NEMA published Solid State Lighting: The Need for a New Generation of Sockets and Interconnects. A standardized approach to connectors

and wiring not only provides a cost-effective solution, it can prevent assembly problems of inadequately mated connectors, and readily identify/avoid mistakes through color coding and keyed design features. (Figure 1).

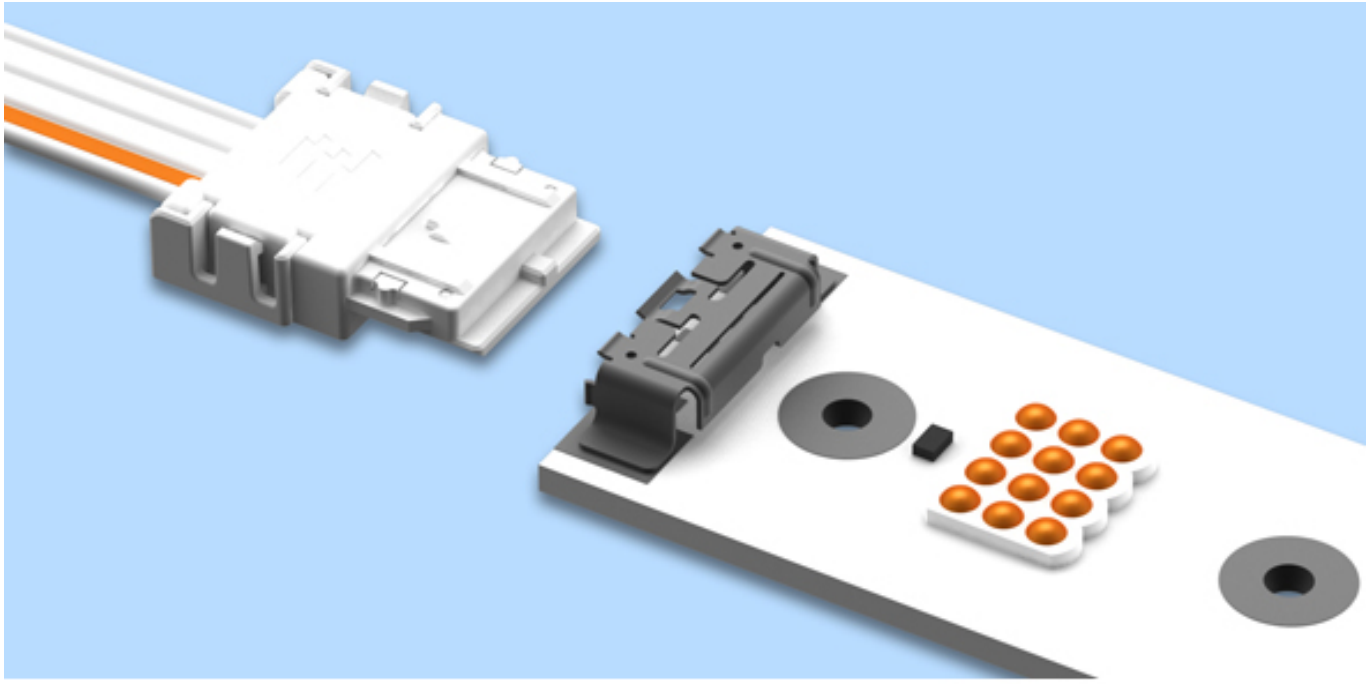

Figure 1. Connector designs for SSL must address inadequately mated connectors with a snap design or detent latch and have keyed design features to avoid connecting incompatible subassemblies. Color-coded wiring provides a visual means of verifying the compatible rating of interconnected components. Source: Tyco Electronics NEVALO system.

As noted in the 2009 NEMA article, new generation interconnects must provide:
– Improved efficacy over traditional bases
– Replacement capability
– Upgrade path in performance
– Optimized performance
– New lighting options
– Prevent substitution of low efficacy lamp sources
– Communications and network potential for integrated energy systems

Reducing cost is also a major challenge for solid state lighting in all areas. The connectors can do their part by avoiding costly assembly procedures that require special tooling and stripping and cutting assembly techniques. Insulation displacement connectors (IDC) are a proven technique for quality low-cost reliable connections in many applications. (Figure 2 (a).)

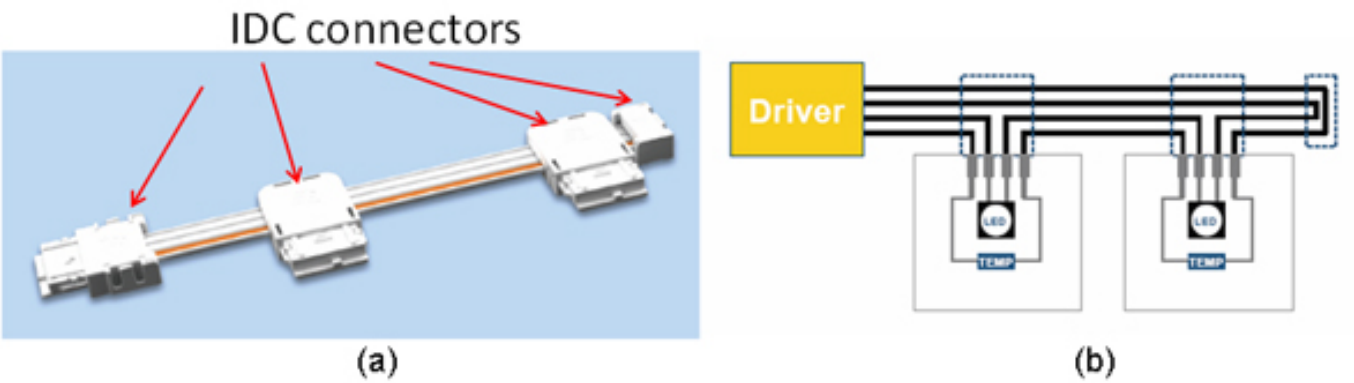

Figure 2. (a) IDCs avoid solder connections and provide many of the requirements proposed by NEMA in 2009 such as replacement capability, upgrade path in performance and communication and network potential for integrated systems as well as a low-cost, reliable connection. (b) IDC technology easily allows the insertion of a thermistor and termination of the ribbon cable in the SSL wiring.

Meeting Agencies' Requirements

The new ENERGY STAR standards differentiate between fixtures where the source and the systems are separable or integral. There are different levels of performance associated with each. Integral designs cannot be upgraded or replaced. As a result, integral designs have to perform 20 to 30 percent better than other systems. Avoiding solder interfaces in the connectors is one means of achieving interchangeability, increased reliability and future upgradeability.

Moreover, reliable connections are essential to assure that the interconnect system is as robust as the solid state lighting sources. A properly made interconnect system allows the LED light module (LLM) to be easily installed, exchanged, upgraded and replaced if necessary.

SSL connectors add a design challenge that is common in portable consumer electronic products – the connectors must be small and unobtrusive. However, the connectors and wiring are in close proximity to heat-generating LEDs so their operating temperature environment more closely resembles industrial applications. Interconnects must solve the mechanical, electrical, thermal and optical issues that arise in an SSL system. Figure 2 (b) shows how a temperature sensor can be integrated into the cable and interconnect system.

Prior to manufacturing any new SSL fixture, compliance must be established to several safety as well as government agency requirements. This requires testing that can be extensive and complex. In an SSL system approach, the testing is simplified and facilitated through a thermal evaluation tool that uses a special connector for conveying collected data in the luminaire environment to a graphical user interface. Figure 3 provides an example of a thermal test board with a special test connector.

Figure 3. In the NEVALO system, every LED Light Board has a counterpart to simplify testing. The special connector on the right side of the test board provides connectivity to a PC through the USB port.

To obtain the efficiency as well as networking and customization benefits afforded by solid state lighting, luminaire manufacturers must cope with many changes. A systems approach, such as Tyco Electronics' NEVALO design methodology that addresses every aspect — including the interconnects — greatly simplifies the transition from traditional incandescent or fluorescent lighting.

This article is excerpted from the white paper, "A Systems Approach to the Design and Manufacture of Solid State Lighting Fixtures." The complete white paper is available for download from www.nevalo.com [1].

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