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White Paper

Standardizing interfaces, enabling interoperability

By standardizing interfaces for interoperable components of LED luminaires, Zhaga is facilitating luminaire design and in-the-field serviceability

Lighting must become connected and serviceable – and that requires standardized interfaces that support interoperable components. However, such components will have a major impact on the business models of many companies along the entire lighting industry value chain. That's why Zhaga, the global lighting-industry organization that aims to standardize the interfaces of LED luminaire components, is working with industry stakeholders to define the best solutions.

Zhaga puts the spotlight on interoperability. Its mission is to specify electrical, mechanical, optical, thermal and communication interfaces for interoperable components used in LED luminaires. This will ensure that when a new luminaire is designed, it has many interoperable components – based on standardized interfaces – to work with. This in turn will give the new design value-added differentiation and remove non-value-added complexity. Furthermore, these interoperable components allow LED luminaires to be upgraded and serviced (depending on the luminaire manufacturer's design choices).

This white paper explains what interoperability means for lighting technology, discusses the technical and non-technical challenges to reach interoperability, and shows what Zhaga is doing to address these challenges. The paper concludes by highlighting Zhaga's initial accomplishments and providing an overview of what is to come.

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Interoperability and plug-and-play interoperability

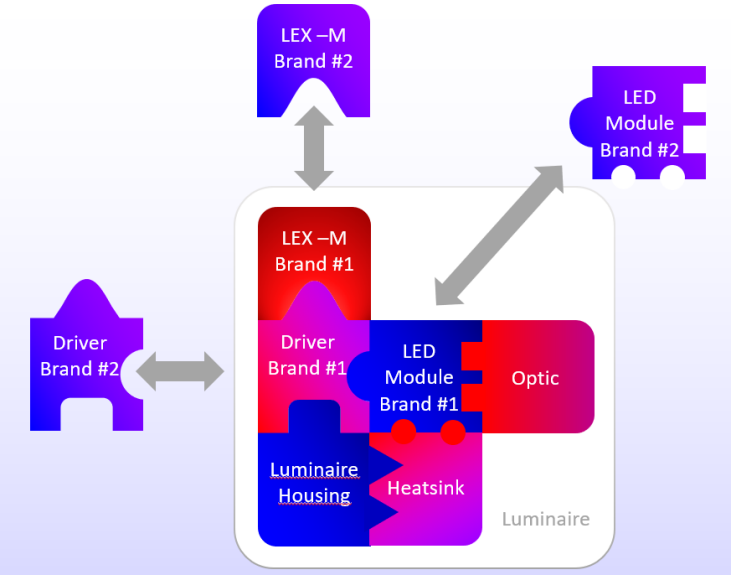

Fig.1. Illustration of the interoperability of a driver, connectivity module and LED module with luminaire components.

A luminaire component is considered interoperable when it can be combined with (an)other interoperable component(s) and functions as intended. Thus, interoperability requires that components match on all aspects of each relevant component interface, including mechanical, electrical, photometrical, thermal and communication interfaces. 'Functions as intended' means that the component is capable of functioning as specified in its datasheet. This also implies that when using such components, all safety and/or regulatory requirements are met.

Interoperability does not, however, mean that components used in combination always form a fully functioning system. Although putting together the components already forms a sub-assembly, further components might be needed to create a system that functions as intended. To illustrate, a Chip on Board (CoB) holder may be interoperable with a CoB, but an additional power supply is needed to produce light.

A typical use case where interoperability is important is the replacement of an LED module with a more efficient LED module. The new LED module is considered interoperable if it fits into the luminaire and can function according to its data sheet. However, installing the LED module may require the use of a special tool, and the current setting of the luminaire's LED driver might need to be readjusted. A special case of interoperability is when component offers plug-and-play interoperability, meaning components can be mounted without tools and the combination functions without any further action.

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Interoperability and interface specifications

So far, component interoperability was defined. However, Zhaga does not specify components, but interfaces of components. Therefore, the relation between interoperability and interface specifications must be considered.
An interface specification specifies the interfaces between (typically two) different luminaire component types. At the most basic level, a specification supports interoperability when all compliant components of a first type are interoperable with all compliant components of a second type. In more advanced cases, the specification defines several profiles and the interoperability of compliant components is limited to the defined profiles. In still other cases, the interface specifications only define a limited number of interface aspects; additional information beyond compliance is required to verify that components are interoperable and able to achieve the intended full functionality.
In all cases, the specification never interferes with safety and other regulatory requirements. However, fulfilment of these requirements will involve other aspects beyond the component interface. Therefore, a full assessment of safety and regulatory aspects is beyond the scope of an interface specification.

A focus on interoperability

Zhaga develops interface specifications that serve as the standard for the lighting industry. The interface standards enable ecosystems of interoperable components and the certification of these components gives confidence in their interoperability and capability of becoming a part of an existing eco-system.

There are numerous benefits to have components available that comply with and are certified according to such standards. (To learn more about these benefits, please visit https://www.zhagastandard.org/about-us/benefits/). Zhaga's focus on interoperability enhances these benefits for luminaire OEMs, component manufacturers, specifiers and end-users alike. For example, a luminaire OEM's design of a new luminaire is facilitated by the availability of many components of different types, all of which are based on standardized interfaces. Having certified components of different types readily available alleviates the need to check whether components will function together. Additionally, the Zhaga certification mark makes it easy to source alternative compliant components from different vendors.

The use of interface specifications that support interoperable components also benefits component manufactures. The interface specification defines what is required for the components to work together. Products manufactured in accordance with such an interface specification therefore require less, or even no, co-development. It also eliminates the hassle of having to deal with companies providing complementary components.

No longer concerned about whether their products are interoperable, these companies can now focus on innovation and differentiating features. These products then become part of a richer eco-system of complementary products, which ultimately benefits the end customer.

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Another benefit of having interoperable components based on standardized interfaces is that it allows for the upgrading and servicing of LED luminaires – particularly if the interface supports plug-and-play interoperability. This advantage is especially appealing to end-users and specifiers.

The ability to upgrade and service an LED luminaire also plays an important role in the various stages of a luminaire's life cycle. For example, replacing a component in-the-field not only fixes the broken part, it could also serve as an opportunity to adjust, upgrade or even extend a luminaire. It also allows end-users to separate certain decisions (e.g., they can first decide on the luminaires and later about adding sensors for smart applications). This ease both project planning and execution.

Finally, during the end-of-life treatment of a luminaire, plug-and-play interoperability allows components to be 'unplugged' – a feature that supports the circular economy and facilitates sustainable recycling.

Zhaga's achievements

The interoperability of components used in LED luminaires is the focal point of Zhaga's vision and mission. To illustrate this focus, three examples of recent or upcoming Zhaga specifications are listed below.

Zhaga Book 18

Specifying the smart interface for outdoor luminaires, Book 18 is Zhaga's first achievement in the field of component interoperability. This Zhaga Book is an example of plug-and-play interoperability between luminaires with this interface and compliant sensing and/or communication modules. This means these sensing and/or communication modules, when mounted, can function as intended without any other action needed from the operator or end-user.

Zhaga Book 20

Paralleling our work on outdoor luminaires (Book 18), this specification offers a comparable smart interface intended for indoor luminaires and allows luminaires to be interoperable with sensing and communication modules in indoor applications. One difference between Book 18 and Book 20 is the use of a male-female connector (Book 20) versus a socket (Book 18). Another difference is that Book 20 only addresses single-module applications and that the provision of auxiliary power is not supported.

Zhaga Book 21

Although still in development, Book 21 will provide a new, cost-effective mechanical and electrical interface for socketable linear LED modules without an integrated driver. The accompanying LED modules are of rectangular shape (up to 4 ft in length) and are typically used in general lighting applications. Interoperability of LED modules with the luminaire system, guaranteeing the same luminous flux, is obtained by introducing LED module categories. These categories have been defined

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for each module length and for two different lumen per foot values (1100 and 2200 lm/ft). Individual lm/foot values will be proposed for CRI 90 products. The luminous flux of an LED module corresponds to the lumen per foot category and the rated current level (e.g. 1100 lm/ft at 350 mA).

Luminaire OEMs can design-in these modules at any current level between zero and the standardized rated current level, yielding the desired lumen output. The SELV linear products are foreseen to be installed and replaced by ordinary users rather than only by electrical specialists. When replacing the LED modules, the users will not need to (re)configure the current of the LED-driver. The ability to service or upgrade LED luminaires in-the-field is the main value proposition for customers.

A further, comparable book which is also already in development will specify relevant interfaces for similar nonSELV applications.

Challenges to interoperability

Before interface specifications can enable interoperable luminaire components, several technical challenges must be solved. For example, interoperable luminaire components require a technical alignment of all interface aspects, including electromagnetic compatibility.

Zhaga is addressing this challenge with the goal of demonstrating the technical feasibility of using reference luminaires for the EMC testing of LED modules and drivers. If the driver meets the EMC regulatory requirements in this worst-case reference luminaire, it lowers the design-in effort required for the luminaire and enables upgradeability and serviceability of LED modules and drivers. Reference luminaires have been defined in CISPR TR 30-1 and TR 30-2 for certain conventional lamp luminaires, but not yet for LED-based luminaires.

EMC testing on component level is an essential element in Zhaga's focus on interoperability. It is also a key enabler for the field-serviceability of LED modules and drivers and thereby for a circular economy. As a first step, Zhaga standards already cover linear indoor applications. In a later phase, other segments, like indoor spot modules and outdoor drivers, will be considered.

Another challenge is that the module driver interface makes it difficult to match a module to a driver (e.g. when exchanging modules in the field). In Book 21, Zhaga deals with this challenge by introducing two categories of modules related to their rated current and a corresponding luminaire classification.

This concept is future proof as it will allow LED modules with higher efficacies to be introduced into the luminaire system. As more efficient LED-modules require less power, the operating voltage is the parameter to be tuned as the current is fixed once during the luminaire's design. To ensure interoperability, Zhaga specifies the lumen output at rated current (I rated). Another approach is to specify the programming of drivers for both production and in-the-field (Book 24 and Book 25). This programming ensures that the driver and LED module combination functions as intended.
A key technical challenge is the specification of the thermal interface between LED modules and luminaires. One of the options being considered by Zhaga is to define a worst-case test luminaire and a

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worst-case test module. In this worst-case luminaire, a module's thermal behaviour is measured at rated current (I rated) without the use of a thermal interface material (TIM) and with the fixation means provided with the luminaire. The temperatures measured on the module in this worst-case luminaire should stay below the module's rated temperature.

In addition, when testing luminaires, the worst-case test module is operated in the luminaire. Its temperature is measured in this luminaire and should stay below the worst-case temperature at I rated. This worst-case temperature is defined by measuring the thermal behaviour of the worst-case test module in the worst-case test luminaire at I rated (see diagram). This approach is applied in Book 21.

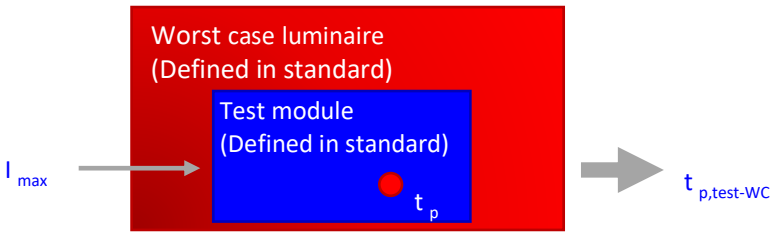

Fig. 2. Illustration of measuring thermal behaviour in the worst-case test luminaire

Providing specifications that ensure a minimum level of functionality necessary for interoperability whilst leaving room for performance differentiation is another challenge that must be addressed. Differentiation means that different suppliers provide products with different performance characteristics on top of the specified, minimum functionality. An example for this differentiation is the light distribution of LED modules for outdoor applications. Here, although very different road settings are served by very different light distributions, the LED modules always comply with the same specification.

Finally, legacy management must be considered so that a new generation of components is still interoperable with all other components in the luminaire. Zhaga supports this by developing standards that evolve with market and/or technology changes whilst remaining backwards compatible where relevant. An example of this can be seen by the introduction of a new CoB category in book 12 that enables dim-to-warm functionality, but still using the already existing mechanical luminaire interface specification.

Closing thoughts

To realize interface specifications that enable interoperable luminaire components, several technical and non-technical challenges must be solved. Zhaga typically addresses these challenges on a case-by-case basis, zooming in on a specific interface and considering the defined types of equipment and the requirements that come with the use cases that motivated the interface in the first place. A good example of this approach can be seen with Zhaga's Book 18.

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However, sometimes interface challenges must be considered more generally, such as being a pre-cursor to specific interface specifications. A good example showing that Zhaga takes this approach is its EMC Task Force.

Zhaga also must address non-technical challenges, such as aligning the industry's companies and further standardization organizations. The Zhaga consortium, which represents the lighting industry with its broad membership and having liaisons with standardization organizations like IEC and ANSI, is the right place to collaborate on this topic.

To handle regional differences in legislation properly, Zhaga specifies basic sets of requirements that allow regions to tailor requirements to their legislative needs.

Standardized interfaces that support interoperable components benefit business models and many companies along the lighting industry's entire value chain. Through the processes followed by Zhaga, the industry's experts come together to discuss, debate, and agree on best solutions. Zhaga is an open organization and invites all interested companies to join and participate in this important task.

About Zhaga
Zhaga is a global association of lighting companies that is standardizing interfaces of components of LED luminaires, including LED light engines, LED modules, LED arrays, holders, electronic control gear (LED drivers), connectors and sensor and/or wireless communication modules. This helps to streamline the LED lighting supply chain, and to simplify LED luminaire design and manufacturing. Zhaga continues to develop specifications based on the inter-related themes of interoperable components, smart and connected lighting, and serviceable luminaires. For more information, visit www.zhagastandard.org.