Criteria of the Photometric Interface of a Zhaga Compatible LED Light Engine

Horst Rudolph, from Trilux, explains criteria of the photometric interface of a Zhaga compatible LED Light Engine based on "Book 3 - Spot LED Light Engine with Separate Electronic Control Gear".

The Zhaga Specifications (called Zhaga Books) define LED Light Engines ("LLE") consisting of one or more LED modules and an electronic control gear. The LED module is to be mounted to or into a Luminaire by an OEM luminaire manufacturer. The luminaire may incorporate optical elements ("luminaire optics"), which shape the light output of the LED module to a specific light distribution which is required in the application for which the luminaire is designed for. In that case the light output of the LED module itself has a general distribution which is defined in the respective book.

The photometric interface of the Zhaga compatible LED light engine is specified in such a way that using suitable luminaire optics (reflectors, lenses, prisms, etc.), similar luminaire performance is to be expected using different LLEs with the same photometric interface. The specifications have been carefully evaluated to yield as much "similar" performance as possible without either restricting the inner structure of the LED module or the LED technology used inside. This has been done to leave as much room as possible for technical innovation in this field.

For spot light applications, for example, the definition of the photometric interface has been developed aiming at a maximum deviation in both beam angle and center beam intensity of luminaires with reflectors of +/- 12,5 % from sample average. Testing of the standard with reference parts has shown that these criteria could be met. However, it cannot be guaranteed for any combination of luminaire optics and LED light engines.

This article explains some criteria of the photometric interface of a Zhaga compatible LED light engine and its interaction with the luminaire optics.

Luminous Intensity Distribution ("light distribution")

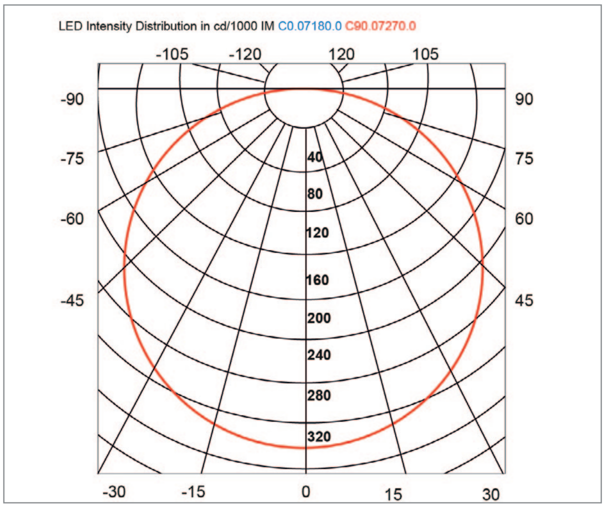
In the case that the LED module is co-operating with luminaire optics, the general light distribution of the LED module itself shall be Lambertian-like as shown in figure 1. A way to describe such a light distribution in more detail is to divide this curve into several parts and calculate the relative luminous flux that is emitted in each part. The CIE has developed such a principle, which is well known and broadly used to define the so called "CIE flux codes" of light sources.

Zhaga uses the same principle to describe Lambertian-like light distributions in more detail and restrict deviations from the ideal Lambertian-like light distribution (Figure 2). Deviations will occur because Zhaga LED light engines from different manufacturers will not be identical in any detail, even when they are designed to meet all specifications of the same Zhaga standard. For example, the height of some LED modules outlines are just defined as maximum values, resulting in different shielding angles between LEDs and module outline.

The luminous intensity distribution of the LED module is divided into 4 parts, where each of them covers the same solid angle of $\omega = \pi/2$. The relative luminous flux fractions of an ideal Lambertian-like light source are shown in table 1. Many tests and photometric calculations with different luminaire optics have shown that LED modules for spot light applications may deviate from the relative luminous flux fractions as also shown in table 1, and still lead to comparable photometric results in the application. There will be other minimum and maximum restrictions for other LED light engines, depending on the application they are designed for.

Figure 1 (left): Lambertian-like light distribution

Figure 2 (right): CIE zones to calculate flux fractions



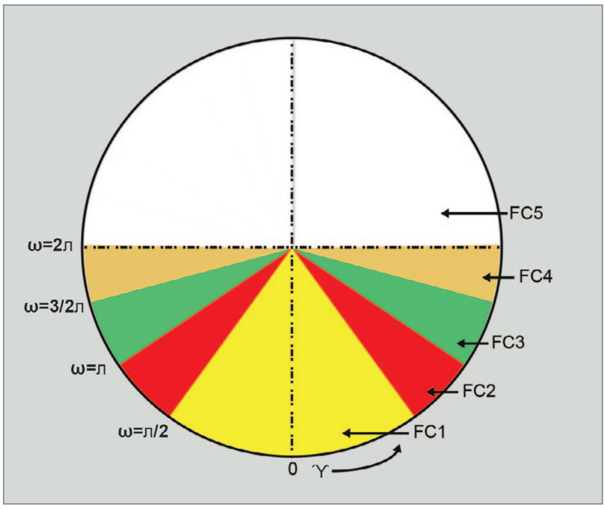


Table 1: Relative partial luminous flux

		Relative Partial Luminous Flux		
Flux zone	γ-angles (all C-planes)	Ideal Lambertian-like light source	Minimum value of spot light LLE	Maximum value of spot light LLE
FC1	0° - 41.4°	43%	39%	56%
FC2 – FC1	41.4° - 60°	32%	31%	37%
FC3 – FC2	60° - 75.5°	18%	11%	22%
FC4 – FC3	75.5° - 90°	7%	0%	7%

Luminance Properties

It is also very important to specify the near field light distribution in the Light Emitting Surface ("LES") to achieve similar light beams when luminaire optics are attached to the LED module. Otherwise, the illuminated task area may show bright spots or dark regions instead of the desired homogeneous appearance. Therefore, the light emitting surface is divided into several areas of the same size with which the luminance characteristics are calculated (Figure 3).

These areas allow the calculation of symmetry factors (horizontal, vertical or rotational symmetry) without counting the single LEDs which may be placed in an arbitrary variety inside the light emitting surface (Figure 4). It is also possible to calculate the center balance of the light emitting surface by taking the luminances of the inner and outer areas into account. For some Zhaga compatible LED light engines some or all luminance properties may be reported in the datasheet because they affect the light distribution of the appropriate luminaire via the luminaire optics.

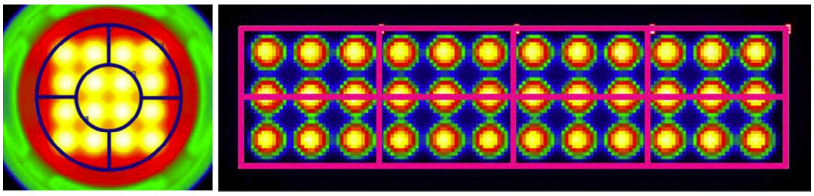


Figure 3: The light emitting surface of LED modules for spotlight applications is divided into 5 areas (left) and for streetlight applications it is divided in 8 areas (right) for luminance characterization

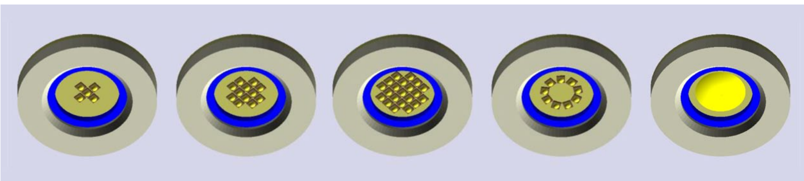


Figure 4: Arbitrary variety of LED arrangements inside a circular shaped Light Emitting Surface

For some LED modules additionally a more detailed evaluation of the uniformity parameter is also necessary to ensure a similar performance of the appropriate luminaire in the application. After testing different mathematical principles and comparing their results with visible effects on task areas which were illuminated with a huge variety of different LED modules attached to luminaire optics, the following principle was chosen to achieve the LES uniformity value:

Measure the luminance distribution of the light emitting surface with an imaging luminance measuring device. Calculate the average luminance L_{avg} and the RMS (Root Mean Square) of the luminances L_j of every pixel j inside the light emitting surface with RMS = $\sqrt{(\sum L_j^2 / N)}$. The number of pixels N shall not be less than 500. The uniformity parameter shall be calculated U = L_{avg} / RMS.

More specifications for all technical interfaces of LED light engines are defined in detail in the respective Zhaga Books to make electronic light sources interchangeable. ■