Taking the LED Challenge

Accurate LED measurements require proper procedure and understanding of detector-filter requirements.

LEDs are finding use in a variety of application areas as single lamps, clusters of lamps, or unpackaged chips. Users require reliable performance data; measurement standards are needed to achieve this goal. This cannot be a simple application of the photometric and radiometric test methods used for other conventional light sources, for several reasons. LEDs are point-like sources, with extra optics added to the chip, resulting in a complicated spatial light distribution pattern. Devices incorporate many different types of headers and lenses. Without the exception of white-light devices, most LEDs produce fairly narrow spectral power distribution.

Last but not least, LED light output is usually less than that of most conventional light sources.

The most frequently used quantities for LED characterization are luminous/radiant intensity, luminous/radiant flux, and chromaticity coordinates. All of these quantities need special consideration in case of LED measurements in order to avoid large discrepancies in results from different metrology laboratories. The International Commission on Illumination (CIE; Vienna, Austria) made the first attempts at standardization, which resulted in the 1997 definition of averaged LED intensity, which deviates from the original definition of luminous intensity; it requires specific geometrical measurement conditions that can be easily reproduced for any kind of LED lamp-types (see figure).  

In order to make accurate luminous intensity measurements without a spectroradiometer there is one other important criterion: The measuring detector has to have an aperture of exactly 1 cm² and the detector spectral response has to closely follow the V(λ) function, which describes the photopic relative luminous efficiency of the CIE 1931 standard observer. This usually requires a detector-filter combination. A match to the V(λ) function is described by the f₁' number, which is a number defined for qualifying photometric detectors. Basically it is obtained from an error function, normalized to an incandescent light source (CIE Type A (Planckian radiator)) and expressed as a percentage: an f₁' of less than 1.5% is considered an extremely good match.

These types of detectors should be calibrated in lumens/amps, which allows easy calculation of candela values. If a laboratory does not have a very well-matched photometric detector, accurate averaged LED intensity measurements still can be performed by using a standard LED with a known intensity value. If the standard LED has a spectral and spatial power distribution similar to or the same as the test LED, a simple comparison measurement can be performed by measuring only the detector's current output both for the standard and test LEDs.

To yield the required constant light output, the reference standard LED requires current and temperature stabilization (see figure inset). The housing for such a standard needs to be compatible with generally available mounts and/or fit into a specially designed tube for averaged LED intensity measurements.

Even for laboratory measurements using high-precision matched detectors with f₁' less than 1.5%, problems can arise. The definition of f₁' was developed primarily for incandescent lights, so it contains a weighting function to represent the spectral power distribution of a Type A light source. As a result, a small f₁' value ensures a good fit only in the middle of the visible spectral region. Relative errors can be quite large at the two ends of the region; measurements for blue and red LEDs, for example, can differ by 50% to 60% from actual values. The CIE technical committee TC-2-45 is working to develop a detector qualification number that would enable the user to determine whether a particular detector will be suitable for certain types of LED measurements.

At present, CIE TC2-45 is working on protocols for measuring the total flux of LEDs in integrating spheres, here the design of the integrating sphere and the geometrical positioning of the measured LED play critical roles. Finally, the same report will specify the exact conditions for spectral power distribution measurements using spectroradiometric techniques.

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References