The New CIE 127 Standard for LED Measurement

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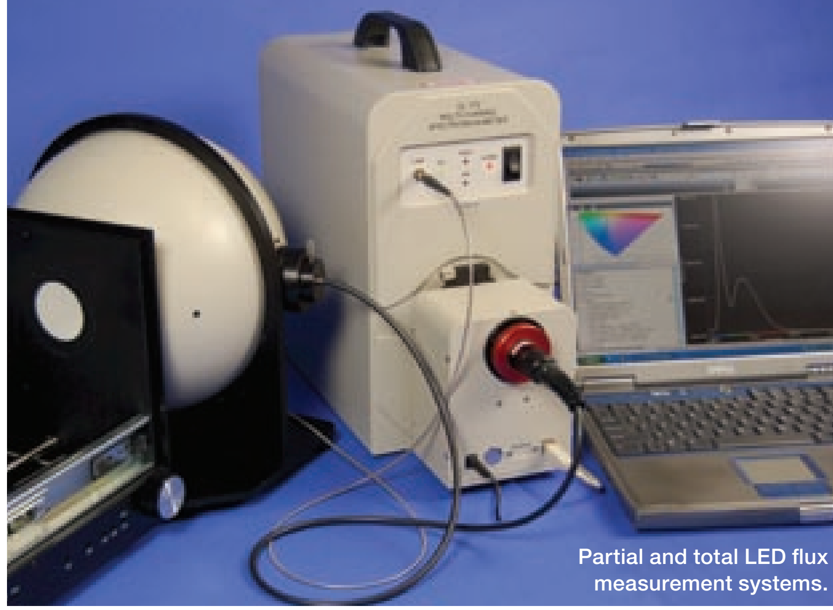


Partial and total LED flux measurement systems.

Optronic Laboratories

Recently, the CIE has published an updated version of its ubiquitous lighting standard, the CIE 127. Among other things, the new standard refines the technique for measuring total radiant flux and introduces a concept called partial LED flux.

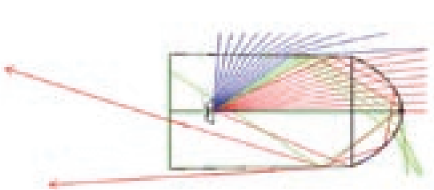
Anyone who works in the LED industry is familiar with the International Commission on Lighting's (CIE) document on LED measurements, called the CIE 127:1997. The document describes techniques for measuring various photometric and radiometric quantities that are important to manufacturers and users of LEDs. This industry standard allows different researchers—sometimes halfway across the world from one another—to compare measurements in a meaningful way.

However, the document is not perfect. For example, the original definition for total radiant flux left ample room for varying interpretations and inconsistent results. One of the issues with the technique was the placement of an LED within an integrating sphere. For the total radiant flux measurement, CIE 127:1997 recommended that an LED should be placed within a specifically designed and calibrated integrating sphere, such that all of the flux that the LED emitted would be captured and measured by a baffled detector. However, the exact location of the LED within the integrating sphere was vague and open to interpretation. Although this detail may seem trivial, it has considerable consequences when the LED under assessment emits light to the rearward direction. This is particularly true for lensed LEDs, because total internal reflection within the lens can reflect emitted light backward as shown in the left figure.

Also, for devices that do not emit in rearward directions, such as non-lensed surface-mount LEDs, measurement at the sidewall is equivalent to assessment at the center of the sphere. For this reason, the CIE revised its definition of total luminous flux to include mounting at the center of the sphere for devices with rearward emission, and mounting at the sphere sidewall for devices without rearward emission.

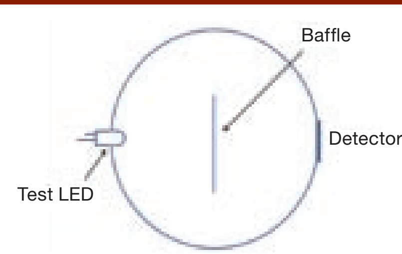
The CIE's recent standard—the CIE 127:2007—recognizes that, in addition to total luminous flux, a quantity that describes the luminous flux radiating

[Ray trace of lensed LED shows backward-reflected light]



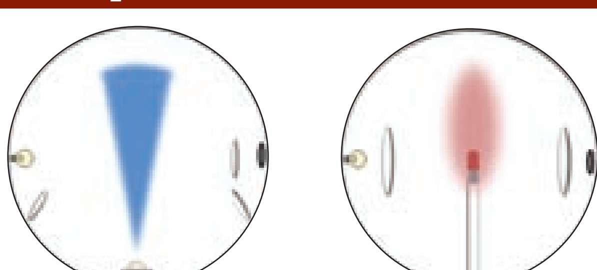
Courtesy of Dave Jenkins, Andrew Riser and William Cassarly of Optical Research Associates.

[Example of a total flux configuration from CIE 127:1997]



Note the placement of the LED is not in a definitive location.

[Recommended LED placement for total luminous flux measurements from CIE 127: 2007]



The left figure shows an LED without rearward emission; the right shows an LED with rearward emission. Note the correct baffling configurations of both.

into a given solid angle is of practical importance for specific LED applications. For example, a manufacturer of LEDs for automobile headlamps may be very interested in the amount of flux radiating into, say, a circular cone with a 60-degree vertex angle in the forward direction, yet have little use for flux radiating outside this solid angle. In a sense, this is a "useable" flux measurement. For this purpose, CIE 127:2007 has introduced the concept of "partial" LED flux.

In the partial flux measurement technique, the mechanical axis of the LED is centered on a precisely manufactured circular aperture of 50-mm diameter. The distance from the tip of the LED to the center of the aperture is set to define a specific solid angle. It follows that the distance from the tip of the LED to the center of the precision aperture is given by:

$$x = \frac{25 \text{ mm}}{\tan(\theta/2)} ,$$

where θ is the desired cone vertex angle. The CIE-recommended cone vertex angles include 180, 120, 90, 60 and 40 degrees.

The partial LED flux measurement should not be confused with averaged

We performed a partial flux measurement technique on three LED package styles (shown in their holders): Philips/Lumileds-Luxeon batwing LED (on top), Osram SMT TopLED (left), and generic T1-3/4 (right).

LED intensity or far-field partial flux. Partial LED flux is given in lumens and denoted by $\Phi_{LED\theta}$, where θ represents the cone vertex angle of the measurement.

As an example of the partial LED flux-measurement technique, we measured three LED package styles with an Optronics Laboratories OL 770 Multi-Channel Spectroradiometer and an OL 1272-LED partial- and total-flux integrating sphere. The three styles included a T1-¾ (5 mm) LED, a surface-mount technology (SMT) LED and a batwing side-emitter LED. These styles have very different spatial radiation patterns that enhance their differences in partial LED flux measurements.

The data for partial LED flux for each of the three package styles is shown in the bottom figure on the left; this plot includes a comparison to a theoretical Lambertian radiator for reference.

As expected, the SMT LED has similar partial LED flux characteristics to the theoretical Lambertian radiator. This is because there is no lens element on the SMT LED; therefore, its Lambertian qualities are not altered from those of the basic diode chip. The T1-¾ LED package radiates primarily into the forward hemisphere; this is shown by the fact that 60 percent of its maximum full hemisphere radiation is captured within a 40-degree cone vertex angle. The batwing LED, on the other hand, radiates very little light into the forward hemisphere. In fact, even in a generous 40-degree cone vertex angle, almost no radiation is captured.

The benefits of the partial LED flux technique are largely realized by manufacturers with high production rates. The technique allows for quick, accurate and repeatable "useable" flux measurements that will reveal much about a device's performance for a given application. Also, because the LED is measured from outside the integrating sphere, it eliminates the need for fixture changes. It does not require the test technician to determine a specific, tedious-to-align location for the device within the integrating sphere. Therefore, recalibrations are not required from device to device.

The CIE 127:2007 standards will allow for greater accuracy, repeatability and reproducibility in LED measurement. The new partial LED flux-measurement technique will provide LED users, designers and manufacturers a flux quantity that is more closely aligned with the application of the LED.

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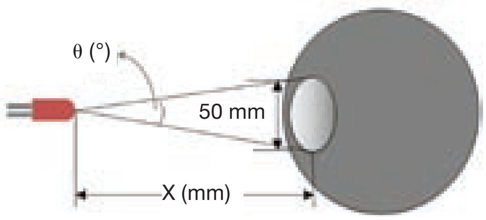
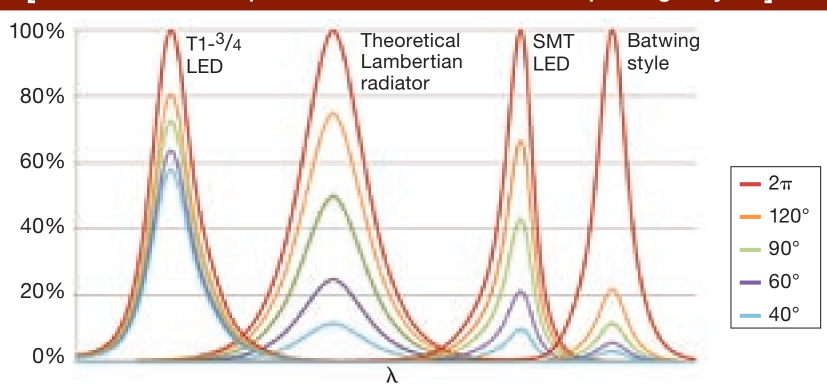
[Recommended configuration for partial LED flux]



[Partial flux technique: Results from various LED package styles]



[References and Resources]

>> CIE, Publication No. 127, *Measurement of LEDs*, Central Bureau of the CIE, Vienna, Austria, 2007.