Measuring the Electrical, Optical and Thermal Characteristics of LEDs

Proper measurement of the operational characteristics of LEDs is essential to their long-term successful use in commercial products. Evaluation of LEDs for possible incorporation in a given application requires a good understanding of their behaviour under realistic operating conditions. The three main parameter classes of interest for LEDs are their electrical, optical and thermal characteristics. Knowledge of electrical behaviour is essential for designing LEDs into suitable electronic circuits. Conservatively designed LED drive circuits ensure that the maximum permissible voltage and current ratings are not exceeded during any operating condition. A good understanding of thermal characteristics plays a similarly important role in ensuring the longevity of an LED-based product by ensuring that maximum allowed thermal limits are not crossed during system operation. Finally, proper appreciation of the optical characteristics of an LED is essential for obtaining maximum light output in a desirable optical configuration. While datasheets aim to provide all relevant information about LED parameters, LEDs, like all electronic components, differ individually from each other and show a statistical spread in parameter values. Described below are some simple measurements that can be carried out on LEDs in order to determine their operational characteristics.

Electrical measurements

Current-voltage characteristics are measured with a Semiconductor Parameter Analyzer (SPA). However, a power supply and two multimeters can also be used to obtain these characteristics in a more laborious fashion. Drive the LED from the power supply with one multimeter connected in series to measure current whereas the other multimeter should be connected in parallel across the LED to measure the voltage drop across it. Start increasing the current flow through the LED in steps of 1 mA (low-power LEDs) or 10 mA (power LEDs). Record the drive currents and corresponding LED voltage drops. Be careful not to exceed the maximum current limit as stated on the datasheet. Plotting the drive current against the voltage drop then produces the LED current-voltage characteristic. From the current-voltage data it is also possible to plot the derivative (dV/dI) against voltage drop to obtain the dynamic resistance characteristic of the LED.

Optical measurements

The optical output power of LEDs can be measured with an optical power meter using a suitable integrating sphere. The latter ensures that all the light emitted by the LED is collected for power measurement. A simpler measurement can be carried out by using a hemispherical LED reflector immediately followed by a light intensity meter. LED reflectors to collect and collimate light from LEDs are now widely available and a suitable reflector can be used to collect most of the LED light and direct it to a measuring device.

The angular emission pattern of an LED can be measured in a simple manner by mounting the LED on a cylinder and rotating it underneath a light intensity meter. As this is a relative measurement so it does not require an integrating sphere.

LED spectra can be measured using any optical spectrometer that covers the optical range. A number of companies make inexpensive spectrometers that can be connected to a PC over a USB link. When making a spectral measurement keep in mind that the

spectrum will depend on the LED drive current. It is best to take a set of spectra at different drive currents to fully characterize the spectral performance of an LED.

For measurement of chromaticity coordinates a radiometric detector is needed. Such a detector is capable of measuring the power contained in narrow spectral intervals. Several optical spectrometers are capable of chromaticity measurements and it is a good idea to obtain one with this capability if color coordinate measurement is an important consideration.

Thermal measurement

The heating behaviour of LEDs can be assessed by measuring its stable package temperature at different drive currents. Such a measurement is usually only made for power LEDs. The LED is first mounted on a suitable heat sink. For this purpose the usual practice is to solder the LED to an aluminum core PCB (also called a metal core PCB – MCPCB) and then to mount it on a suitable metal heat sink. The LED is then driven at different current levels and its temperature measured with either a thermocouple placed in contact with the LED package or with an infrared thermometer. If the latter is used then care must be taken not to aim the thermoscope at the light emitting surface of the LED. Furthermore, each temperature reading should be taken after the LED has operated at a given current drive for some time so that its temperature has stabilized. Such a measurement is specific to the particular thermal configuration utilized with the LED.