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PHOTOMETRIC AND ELECTRICAL MEASUREMENTS OF LED LIGHT ENGINES

M.Sc. Martti Paakkinen, D.Sc. Eino Tetri and Prof. Liisa Halonen

Lighting Unit, Helsinki University of Technology, Finland

Introduction

The benefits of LEDs are a long lifespan up to 100 000 h, no infrared radiation, design flexibility and bright light due to its small size, easy control and dimming, safety due to low-voltage operation, ruggedness, and high efficacy. LEDs need to be equipped with special electronics and optics rather different from conventional metal fabrication and therefore this will lead to the formation of a whole new industry for LED luminaires. Luminous flux from one LED unit is still rather small compared to e.g. discharge lamps or fluorescent lamps and therefore it is a natural choice to mount several LEDs on one circuit board attached to one heat sink. Our goal was to design a LED module which gives more than 1000 lm with good efficacy. This kind of LED module or light engine can then be used to build luminaires for outdoor lighting and general lighting indoors. This paper gives description of the light engine and the testing procedure of the light engine.

Light engine

A LED light engine included 16 high-power white LEDs on printed circuit board (PCB), a heatsink, four drivers (buck converters) each driving four LEDs and an external lens. In this research we had 20 different light engines. They varied from each other by type of PCB or by LEDs placed on PCB. We used five different high-power LED brands from three different manufacturers. Size of the PCB was 75x85 mm² and the area where LEDs were placed was 50x 50 mm².

Measurements

Luminous flux was measured in an integrating sphere. The equipment measures the spectral power distribution from which the luminous flux, correlated colour temperature, colour rendering index and colour coordinates were calculated. Measurements were made after the thermal equilibrium was reached, in our case after one hour.

Luminous intensity distribution was measured with goniometer. These measurements were made both with and without external lens. Lens was optimized for one chip brand, but we tested it with also four other chip brands. Differences what the change of LED brand did to distribution were calculated. Correlated colour temperatures as a function of angle was also measured from light engines. Measurements were made with and without lens. The CCT is not constant because the spectrum of one LED varies spatially and also the lens can cause light diffraction.

IV-characteristics were also measured as a function of ambient temperatures from 25 °C to 85°. Light engine was in heating chamber and the supply current was pulsed. The duration of one pulse was only 5 ms. The assumption was that the junction temperature is the same as the chamber temperature. The pulse was so short that it did not heat the LED significantly. Therefore we were able to evaluate the relation between current, voltage and LED junction temperature. Influences of different current levels and current related operating temperature of the engine to luminous flux were calculated.

Results

Luminous flux that was measured from light engines with external lens, varied from 783 lm to 2452 lm at 700 mA. Calculated luminous efficacy varied from 15.6 lm/W to 61.8 lm/W. There were two main reasons for poor efficacy in some engines. One is the binning of the LEDs and the other is quite big resistance in PCB type, which caused power losses and extra heat on the circuit board.

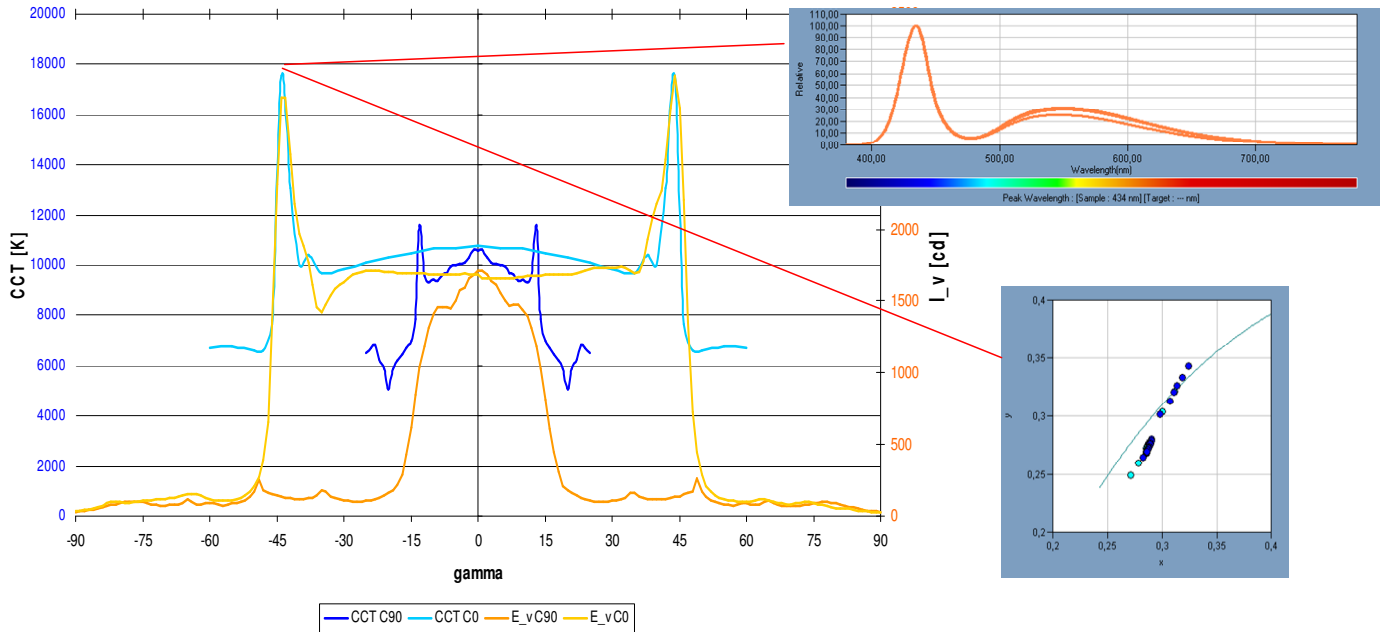


Figure 1. Example of CCT variations when measured from zero to 90 degrees. External lens attached on light engine.

Conclusions

LEDs are quite temperature dependent light sources and the dependence is also related to the LED type, binning and manufacturer. It is difficult to design a light engine whose characteristics are not dependent on the LEDs that finally will be mounted on circuit board. Paper gives an overview of characteristics what should be taken into account in the design phase and gives also an overview of the measurements methods and results which were achieved with one light engine. Final conclusions will show how these light engines can be used to make a luminaire for outdoor use.