Dawn of neutral white LEDs in street lighting

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LED-based streetlights first appeared on streets about four years ago, mainly as design concepts or test lamps at universities. Yellow phosphor was one of the only available and stable phosphor at that time with the ability to create white light in conjunction with a blue chip. Most of the street lights were built using cool white LEDs with a correlated color temperature of 6,000K or even cooler.

Though some street signs showed very good readability under the LEDs’ cool white light—for example blue and white parking signs— people did not like the coloring of cars and buildings illuminated by cool white light. Moreover, skin tones appeared pale under cool white street lights.

To address this, LED and phosphor manufacturers developed new high-light-output LEDs for street lighting with a neutral, natural white color (4,000K). The Avago Technologies’ ASMT-JN32-NWX01, for instance, delivers a minimum brightness of 114 lm at 350 mA or 192 lm at 700 mA, at a typical color temperature of 4,000K correlated color temperature (CCT).

Advancements have also been made in minimum lifetime expectancies. The LM-80 LED lifetime testing recommendation requires LED light sources to have a minimum lifetime expectancy of 35,000 hours; the latest high-power LEDs have a predicted lifetime of up to 60,000 hours (L70, B10) at a high junction temperature. Operating twelve hours per day on average (~4,400 hours per year), a street light with the latest LED technology could easily operate for ten years without replacing the light source.

From a package point of view, modern LED packages have a low thermal resistance of 6 9° C/W (K/W). This helps transfer as much heat as possible from the junction to the heat sink. Additionally, the light-output over junction temperature is very stable with less than a 20% drop across a 25 to 110° C junction temperature range (see Figure 1).

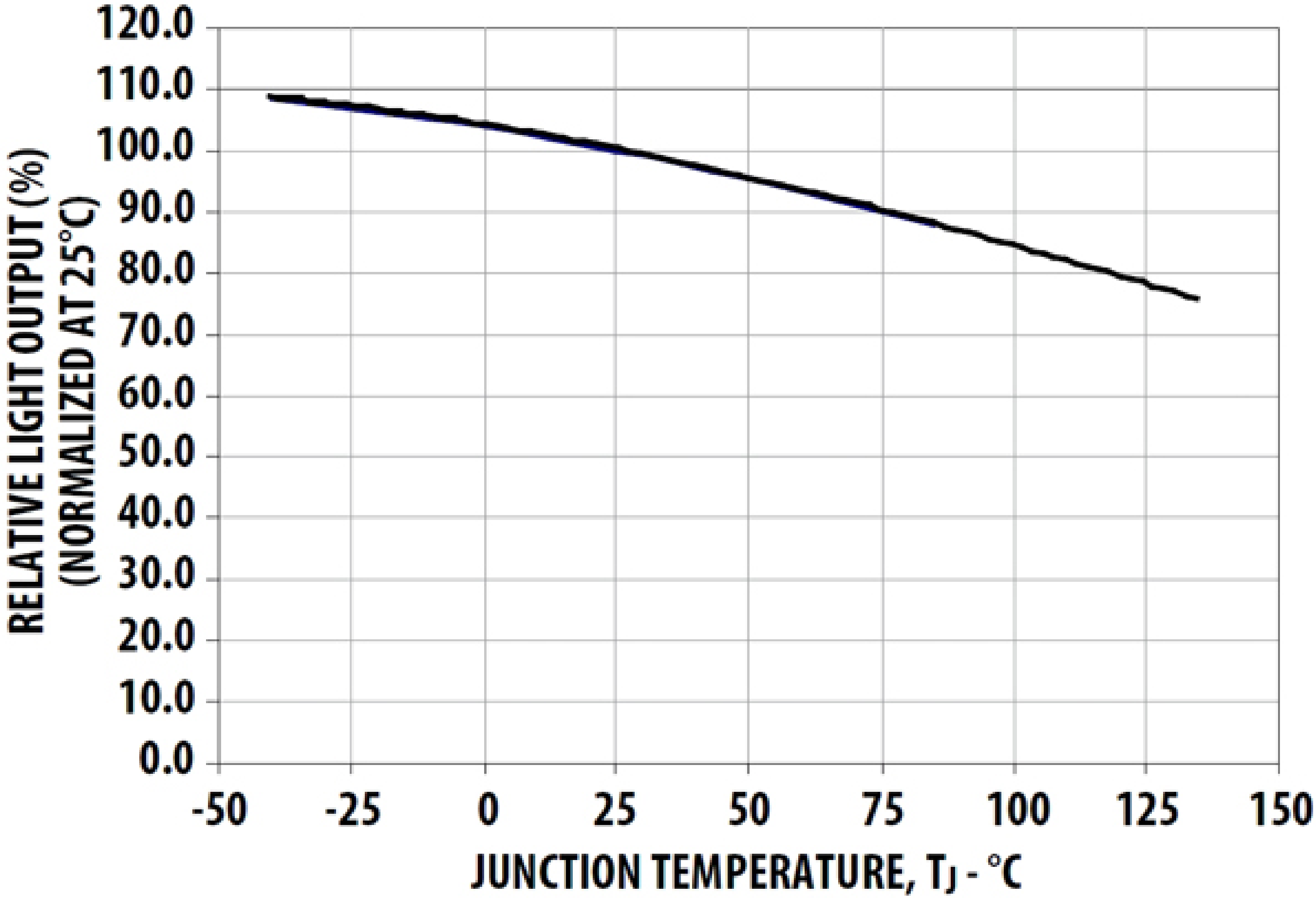


Figure 1. Flux Output Neutral White versus Junction Temperature

Another advantage of neutral white high power LEDs is their spectral distribution made possible by advanced phosphor technology. Compared to cool white LEDs, neutral white LEDs emit more light with yellow and red wavelength (see Figure 2). This spectral distribution helps, for example, to distinguish different liquids on asphalt surfaces. Cool white LEDs make it very difficult, if not impossible, to differentiate between oil, water or cherry juice on the street. Neutral white light sources, on the other hand, make it easy to recognize the brownish color of oil or red color of cherry juice. Additionally, skin tones appear more natural under neutral white LED light.

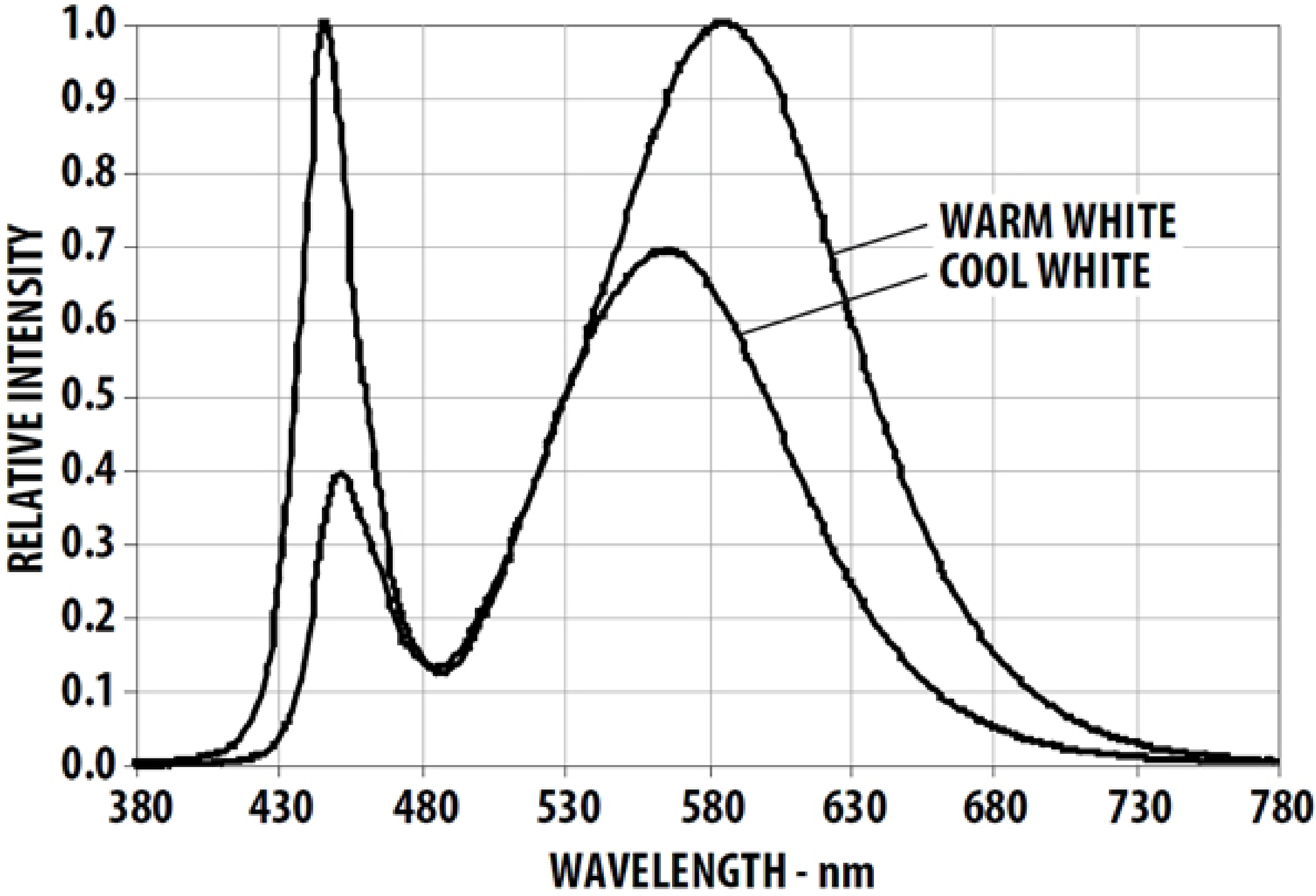


Figure 2. Comparison of Spectral Distribution Neutral White & Cool White

Thermal design

The thermal characteristics of lighting modules are extremely important for effective designs. A good rule of the thumb is that a metal-core (MC) PCB of about one square inch to dissipate 1 W of heat from an LED. A 3 W light source would than require about 3 in² or 1,935 mm² of MC-PCB to allow an ambient operating temperature of up to 85° C.

If a design does not allow for large MC-PCB’s for each LED, additional heat sinks can be utilized to dissipate the heat. There are mainly two different types of passive heat sinks available: one uses extruded metal, for example aluminum, and the other uses fine metal fins.

Another approach to dissipate LED heat is an active cooling system. Conventional active cooling systems are based on liquids – such as water or oil – or forced air. Forced air cooling is usually done with fans and is probably the most suitable LED cooling solution.
New approaches include membrane-based coolers which claim to be able to achieve similar lifetime expectancies as the LEDs (60,000 hours or more).

Whether the cooling is active or passive, thermal interface materials (TIM) must be used to connect the PCB to the heat sink. Microscopic irregularities on the surface create slight air gaps that increase thermal resistance.

Optical design

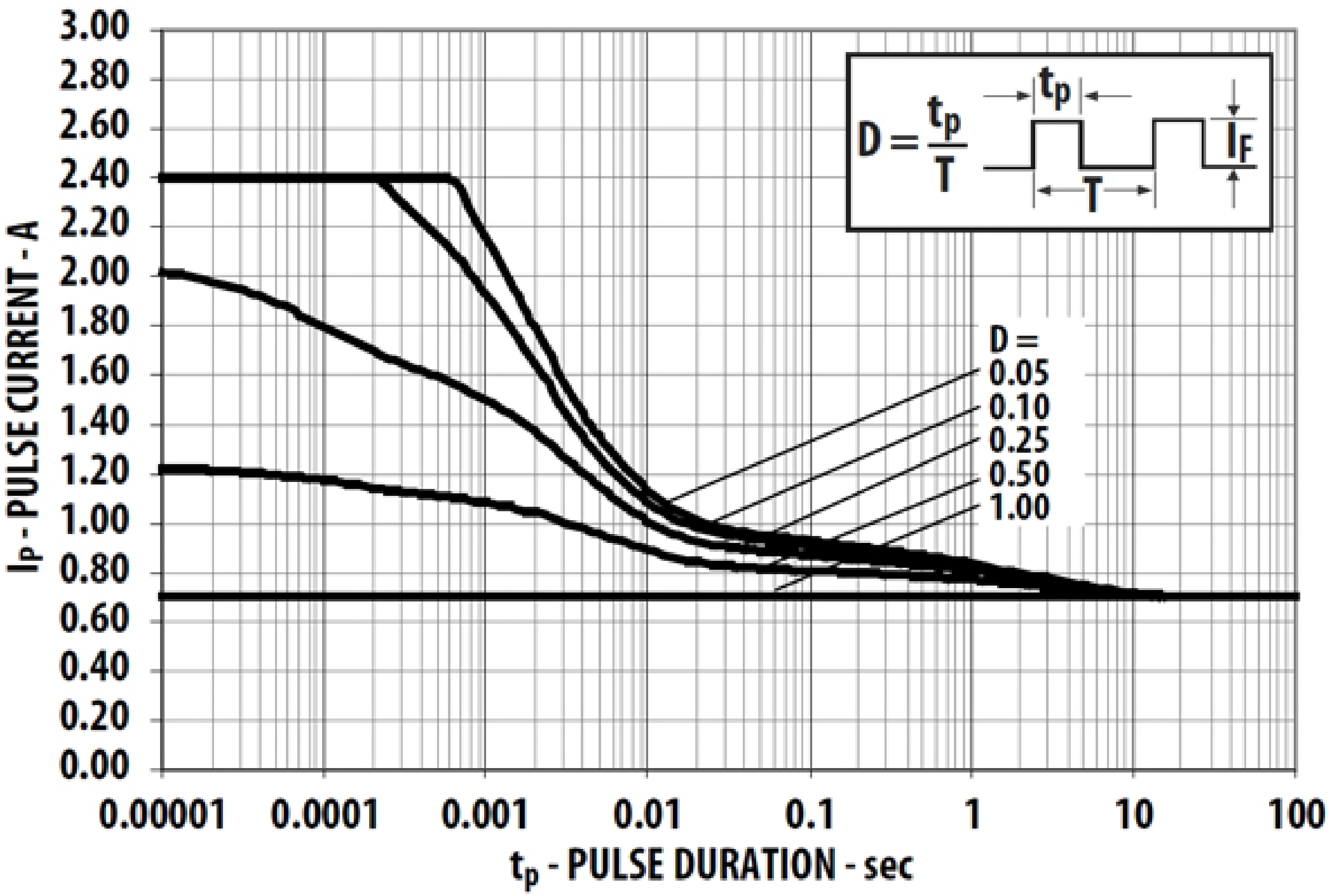
For different forms of street lighting, acceptable luminance and uniformity depends on how the LEDs are used. It is important to be able to illuminate highly travelled streets and junctions with a high amount of light very uniformly. For safety, glare that distracts drivers must also be avoided.

All these factors can be easily adjusted with secondary optics; manufacturers of secondary optics supply off-the-shelf solutions for most available LED packages or have the ability to customize optics.

Some street sections, like pedestrian crosswalks, roundabouts or dangerous junctions, require special illumination by law. In the past, this was done using yellowish sodium high-pressure lamps. Now these lamps can be designed using mono-chromatic amber (or yellow) LEDs.

Electrical design
An LED driver should be able to adjust the current based on an input signal in order to be able to adjust LED brightness over time. This is necessary to enable smart street lighting, which adapts the illumination to real-time street use to minimize power consumption and further reduce electricity bills.

The LED driver should also adjust the output voltage at a fixed output current. For example, the current applied to Avago’s ASMT-JN32-NWX01 can be up to 700 mA direct current (DC) or up to 2,400 mA pulsing current, depending on the frequency and duty cycle (Figure 3).



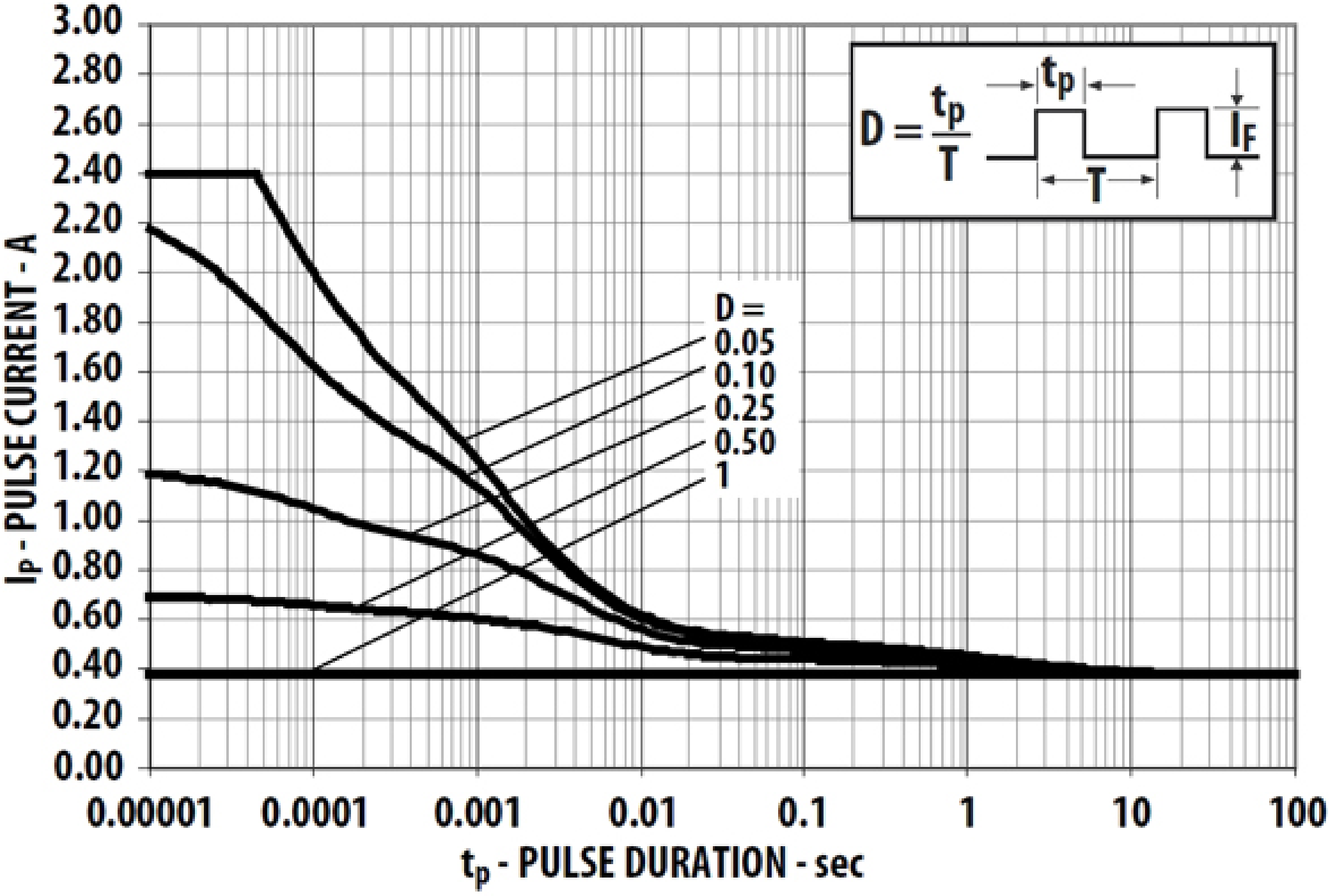


Figure 3.1. Maximum Pulse Current vs. Ambient Temperature of 25°C;
Figure 3.2. Maximum Pulse Current vs. Ambient Temperature of 85°C

Compared to conventional street lighting, the LED street lighting energy savings can be in the range of 25-50% per year depending on the technology and age of the previous installation. For example, with a worst-case scenario of 15% energy savings per year, LED based lamp installations will be amortized in less than seven years. Electrical savings can be even higher with smart street lighting. And, compared to fluorescent or HID lamps, LEDs don’t require any warm-up time, emitting the full amount of light almost instantly.

Additionally, LED street lights can be considered “maintenance free” as the LEDs age slowly over time and can easily run for up to 60,000 hours while still delivering, on average, more than 70% of their initial light output. This helps reduce the maintenance budgets in local communities.

Conclusion

Changing to new energy-efficient light sources will become a hot topic in many communities and municipalities shortly, and neutral white high-power LEDs can be easily used in residential street lighting installations today.

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