Dimming LEDs with respect to grouping current
Application Note

Introduction

In the design of a driving circuit for LEDs, the dimming behaviour is an important topic to fulfil the end customer requirements. The intend of this application note is to describe the behaviour of LEDs in respect to brightness by varying the current and to suggest solutions for avoiding negative influence for the application.

Following items point out some topics where it is necessary to adjust the brightness of LEDs, if the customer specification is tight:

- LED brightness at the grouping current doesn't fit to the specified brightness in the application, hence the LED grouping current doesn't correlate to the application current,
- different brightness groups of the used LEDs,
- dimming of brightness in the application,
- different switches or displays to backlight.

Behaviour of LED brightness curve

Each LED curve has a specific progression of luminous intensity versus current. Depending on the chip technology, variation is more or less distinctive. Figure 1 shows the brightness versus current for two LED emitters, both of the same chip technology and with the same brightness at 20mA. By changing the current the brightness of both emitters change differently. This effect is based on slight differences in the semiconductor, caused by production tolerances at the epitaxial growth. By moving away from the grouping current, the brightness differences of the LEDs get higher.

Figure 2 shows the maximum ratio of I_{vmax} / I_{vmin} in dependency of the current for two LED emitters of the same chip technology, both LEDs have the same brightness at the grouping current (here: 20mA). This diagram is valid for the main production distribution.

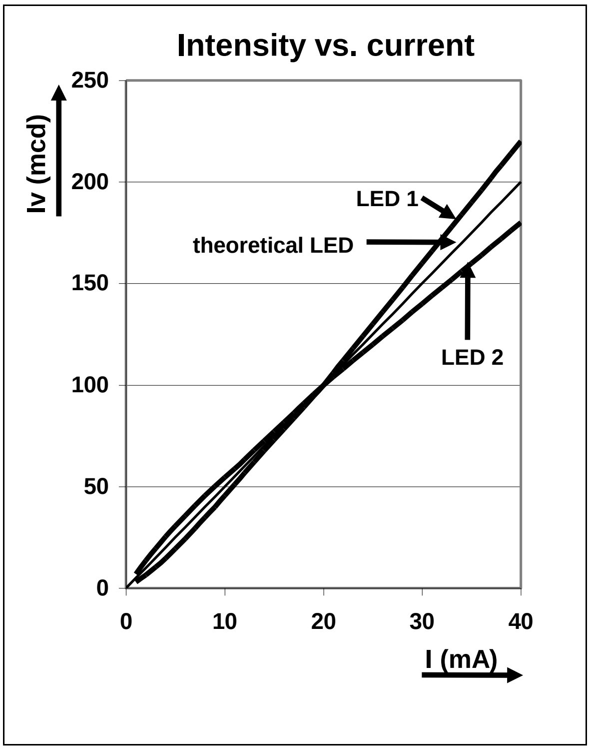

Figure 1 - LED I/Iv curve

Based on worst case calculations, we have seen that this I_{vmax} / I_{vmin} ratio should be lower than 1.6. For application currents far away from the grouping current this ratio can increase extremely. The drawn through and the doted line in Figure 2 and Figure 3 are corresponding. The thinner lines in Figure 3 are the max. and min. dimming curves, based on the main production distribution.

Each chip type has a specific semiconductor design and epitaxial growth, which leads to

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different behaviour of the described effect. For the specific LED, which is intend to be used, please look up the datasheet of the LED at the website: **www.osram-os.com**.

The datasheet comprised the diagram shown in Figure 3 for the specific LED. In the datasheet just the typical curve is plotted.

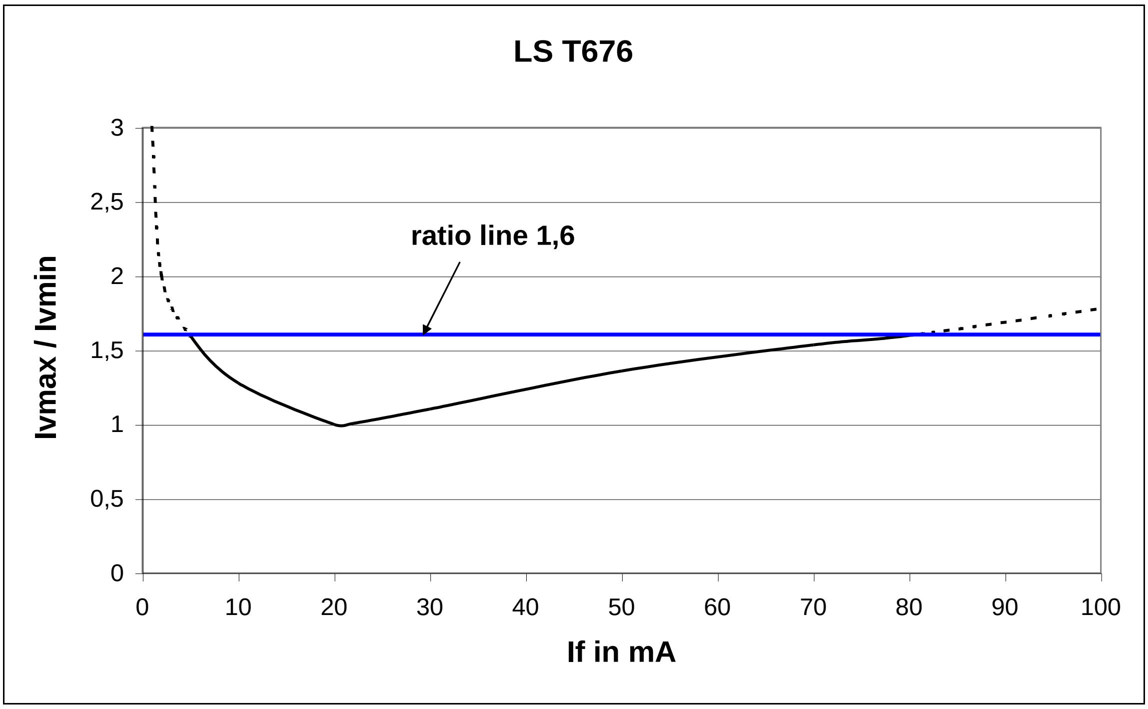

Figure 2 – Brightness ratio

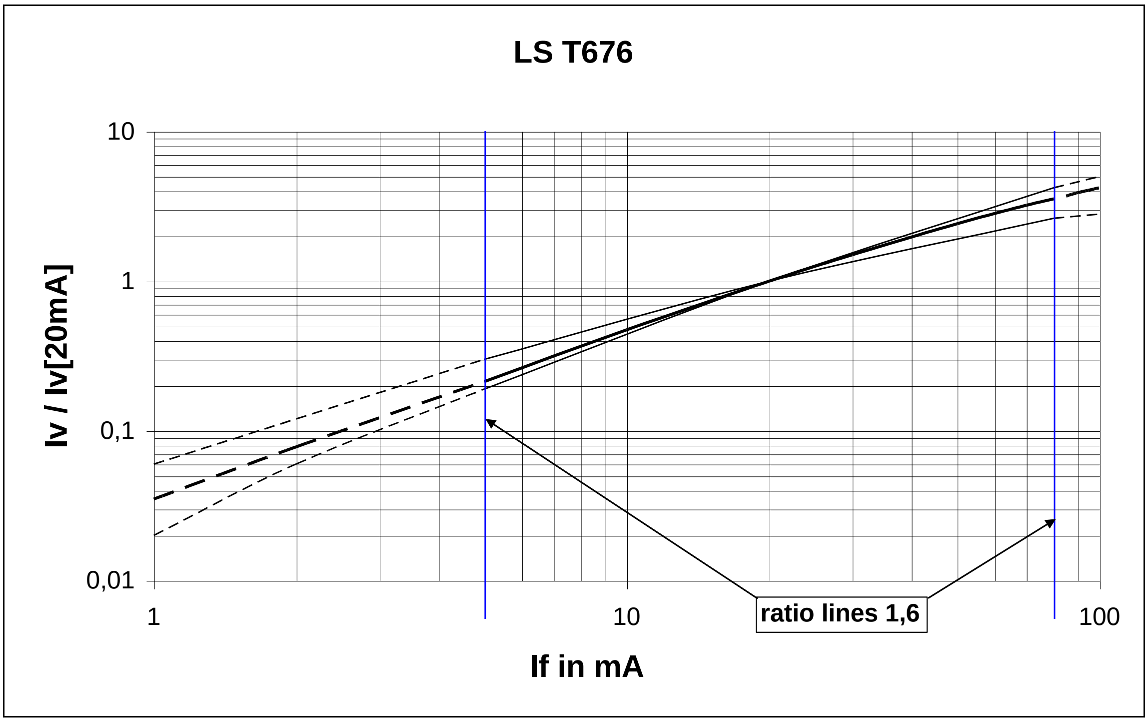

Figure 3 – Relative Luminous Intensity

Variations in the brightness grouping and measurement tolerances need to be added to get the LED brightness variation in the application.

As result of this behaviour it is risky to design in a LED at a current far away from the grouping current. But this is strongly dependent on the brightness tolerance specification in the application.

Intensity of the described manner is also dependent on the technology and status of those technologies. Generally this effect decreases with advanced technologies, caused by precise semiconductor processes and equipment. Further behaviours for InGaN chip technology needs to be considered, please observe Osram Opto Semiconductors application brief “Dimming InGaN LEDs”

Design Assistance

If the application requires best achievable homogeneity, two different option may be taken as a solution.

Generally the favourable solution is to design in the LED close to the grouping current. However, if the LED need to be dimmed or it is not possible to set the current close to the grouping current by brightness specifications then the alternative solution will be to use PWM (pulse width modulation).
PWM works in the following way: The forward current I_F is kept at a constant value (close to the grouping current) and only the duty cycle D is changed. The duty cycle is given by $D = t_p / T$ and expresses the ratio between pulse duration and signal period.
That means the LED is rapidly switched on and off so that the light flickers. Recommended frequency is 1kHz, at such high frequency, under no circumstances the human eye cannot perceive the individual light pulses. The eye integrates the light pulses and interprets them in terms of brightness that can be changed by varying the duty cycle.
Using PWM for dimming has the advantage, that for lower currents than the grouping current, the duty cycle determines the brightness, but the LED on current could stay with the grouping current to keep the variance of brightness to a minimum level.

Appendix

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ABOUT OSRAM OPTO SEMICONDUCTORS

OSRAM, Munich, Germany is one of the two leading light manufacturers in the world. Its subsidiary, OSRAM Opto Semiconductors GmbH in Regensburg (Germany), offers its customers solutions based on semiconductor technology for lighting, sensor and visualization applications. Osram Opto Semiconductors has production sites in Regensburg (Germany), Penang (Malaysia) and Wuxi (China). Its headquarters for North America is in Sunnyvale (USA), and for Asia in Hong Kong. Osram Opto Semiconductors also has sales offices throughout the world.
For more information go to www.osram-os.com.