Product Document

Published by
ams OSRAM Group

ams OSRAM

OSRAM
Opto Semiconductors

DURIS® L38 — Details on properties, handling and processing

Application Note

Valid for:
DURIS® L38
GW T3LMF1.EM
GW T3LRF1.EM
GW T3LSF1.EM
GW T3LSF2.EM
GW T3LSF3.EM

Abstract

This application note provides information about the properties, handling and processing of DURIS® L38 LED from OSRAM Opto Semiconductors.

A basic overview of construction, optical, thermal and electrical characteristics of the LED are presented. In addition, details on handling and processing are provided.

DURIS® L38 can generally be used in all types of omni-directional bulbs range from modern to classical. Users can utilize the conventional bulb assembly equipment and assembly lines.

For optimal filament bulb performance and reliability, it's best to fill the filament bulb with inert gas.

Author: Ch'ng Kar Siew / Vagra Horst

Table of contents

A. DURIS® L38

The DURIS® L38 (GW T3LxFx) is a filament LED with a beam angle of 360 ° for indoor retrofit lighting applications. It combines the advantages of the modern LED technology with the aesthetics of traditional light bulbs.

The DURIS® L38 provides excellent color over temperature behavior, hot cold factor and an exceptional lumen maintenance. The LED is binned with forward voltage (V_f) binning in order to improve the lifetime on system application level.

Figure 1: DURIS®L38

With its optimized features — high lumen efficacy (> 150 lm/W @ 15 mA) and 360 ^{o} radiation angle, the LED is mainly targeted for the below application:

- Omni-directional retrofits
- Candle lamps
- Indoor consumer

B. Features and construction

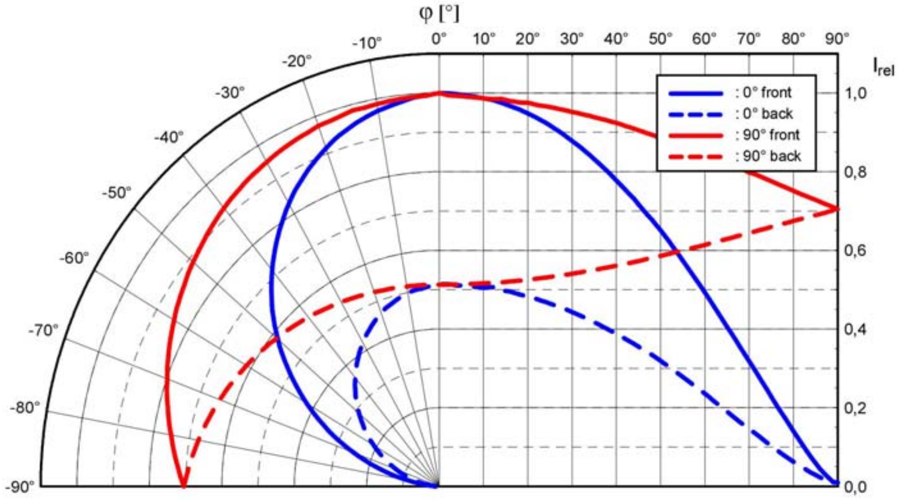
The construction of the DURIS® L38 consists of a ceramic-based frame with two alloy connectors at both ends. A number of highly efficient LED chips (depending on the lumen package) are mounted on the ceramic-based frame and they are electrically connected through wire bonding, covered by a colored diffused silicone resin.

Figure 2: Design for DURIS® L38

The DURIS® L38 LED chips can withstand up to 2 kv of ESD voltage. This device is categorized as HBM Class 2, according to ANSI/ESDA/JEDEC JS-001.

Beyond that, the DURIS® L38 fulfills the current RoHS guidelines (European Union and China), and therefore contains no lead or other hazardous substances.

Figure 3: Radiation characteristic of DURIS®L38



C. Handling, cleaning & packing

Handling

Following general guidelines for the handling of DURIS® L38, additional care should be taken to minimized mechanical stress on the silicone surface.

In general, all types of sharp objects (e.g. forceps, fingernails, etc.) should be avoided to prevent damages to the surface, which could lead to spontaneous failure of the DURIS® L38.

Please keep in mind that the DURIS® L38 is an ESD HBM Class 2 device. Handling and processing must be ESD-conform.

Cleaning

A simple cleaning by means of purified compressed air (e.g. central supply or spray can) is recommended.

Packing

The DURIS® L38 is supplied in tray format. Please check the product data sheet for details.

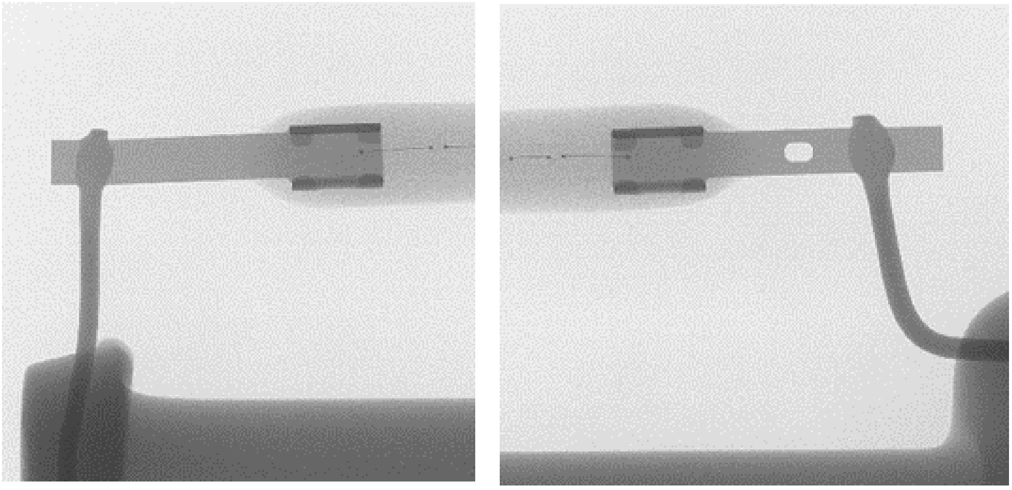
D. Processing

Spot welding process

A spot welding process is required to attach the filament LED to the lamp wick. When welding the filament, all types of sharp objects should be avoided in order to prevent damaging of the silicone resin which may lead to optical degradation or complete failure. During handling in the spot welding process, an ESD tweezer is recommended.

For optimal spot welding, a voltage in the range of 120 V_{ac} to 140 V_{ac} is recommended. Welding rework may be done not more than once.

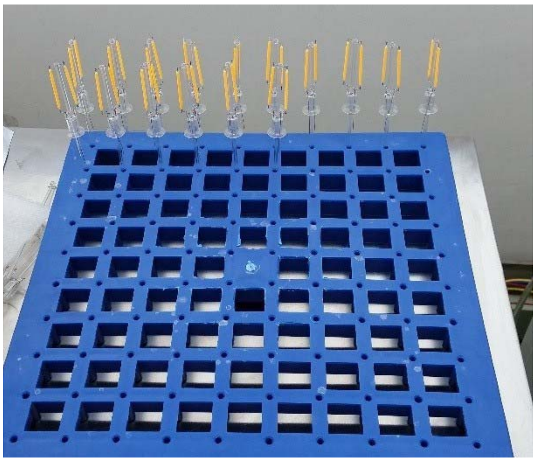
Figure 4: X-ray image of manual spot welding



Post spot welding storage

After the spot welding process, the lamp wicks with filament LEDs are recommended to be placed on dedicated carriers. The wicks should not be stacked in a way that force is applied to the filament LED.

Figure 5: Post Spot welding storage for DURIS® L38



E. Application

Optical

The DURIS® L38 is an omni-directional emitting LED at the x-axis direction. The flux distribution over angle in forward and backward direction is different. The intensity of Phi = 0 ° is ~ 2 times higher than the intensity of Phi = 180 °. 60 % of the power is emitted in forward direction and 40 % is emitted backwards.

Figure 6: DURIS® L38 forward and backward direction (schematics)

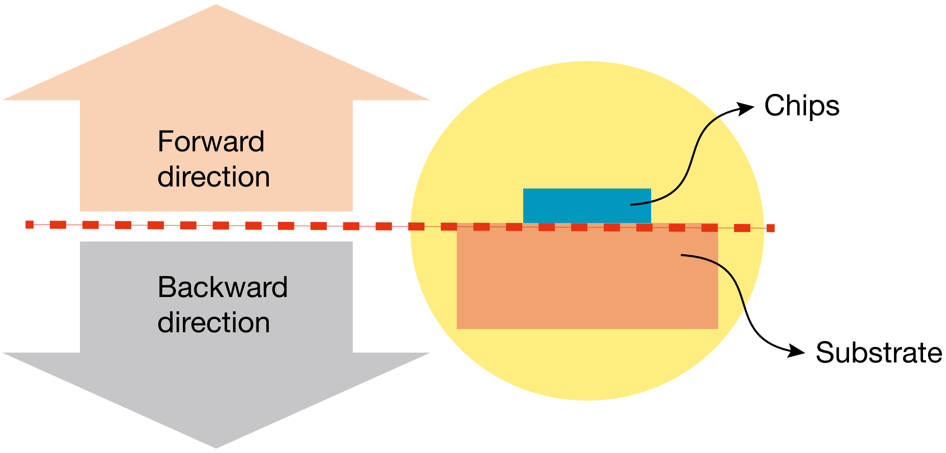


Figure 7: DURIS® L38 forward (Phi = 0 °) and backward (Phi = 180 °) direction

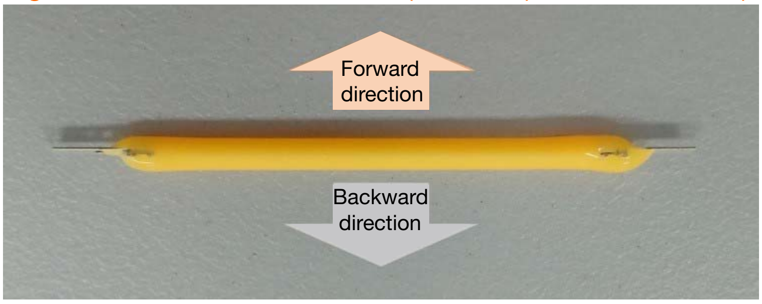
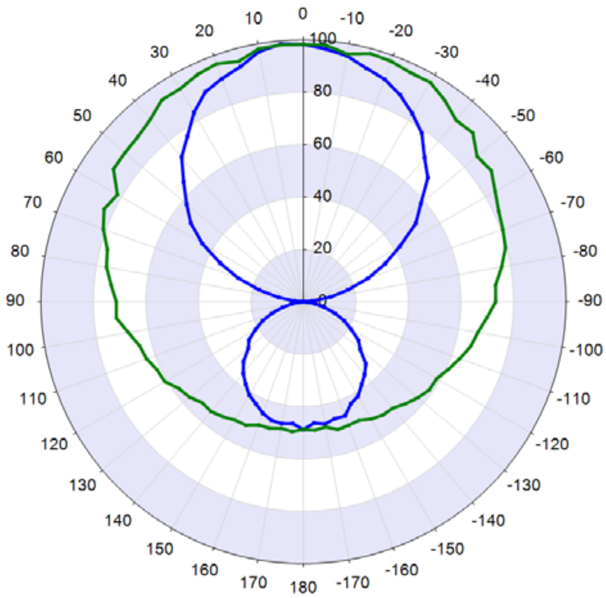


Figure 8: DURIS® L38 radiation characteristic



As the flux is asymmetric distributed over all angles, an optimal arrangement is necessary in order to achieve a homogeneous bulb emission. An optimized arrangement is shown in Figure 9 and Figure 10 as an example.

Figure 9: DURIS® L38 in A60 bulb from side view

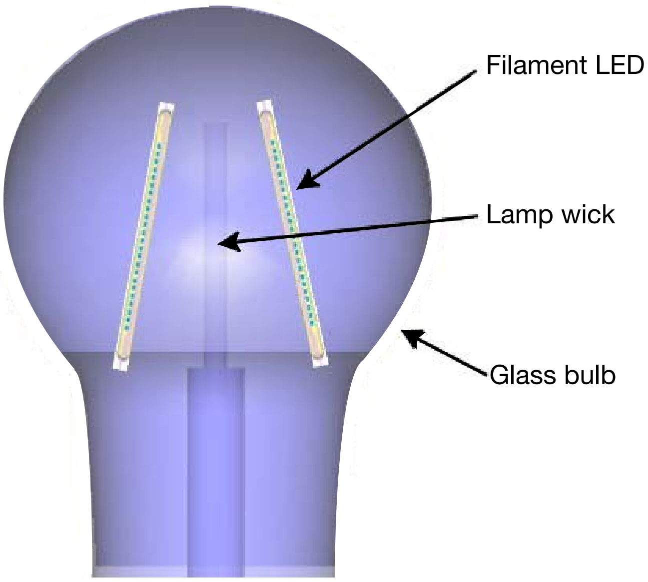
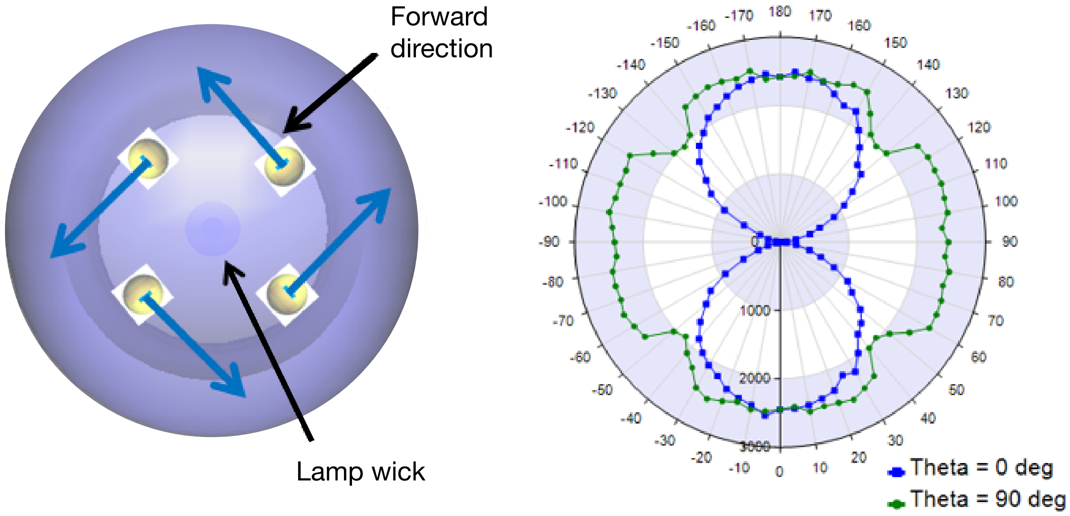


Figure 10: DURIS® L38 in A60 bulb from top view



Thermal management

The temperature of the filament LED depends on the 4 basic factors:

- Biasing current
- Ambient temperature
- LED configuration in the bulb
- Bulb size

The bulb is recommended to be filled up with an inert and thermally conductive gas (e.g. helium) in order to effectively dissipate the heat generated by the LED and in order to achieve the target product lifetime. The junction temperature of the filament LED in air is ~1.7 times higher than in helium.

The R_{th} and junction temperature of the filament LED will vary depending on the bulb type and the number of filament LEDs in bulb. For further support, please contact your regional application engineers.

For reference purpose, Table 1 shows the filament LEDs electrical thermal resistance of junction to ambient ($R_{th\ ja}$) in G40, A60 and B35 bulbs (see Figure 11) with the boundary conditions as stated below:

- The $R_{th\ ja}$ is based on the T_j Average (T_j Ave) with an ambient temperature (T_a) outside the bulb of 25 °C.
- The filaments are running with typical current as stated in data sheet.

In principle, the $R_{th\ ja}$ will increase with a smaller area or volume of the bulb. The surface area and the volume for G40, A60 and B35 bulbs are listed below:

- G40: 53,000 mm^2 or 1,110,000 mm^3
- A60: 13,000 mm^2 or 130,000 mm^3
- B35: 6,800 mm^2 or 45,700 mm^3

Table 1: Thermal resistance ($R_{th\ ja}$) of the DURIS® L38 in different type of bulbs for GW T3LxF1.EM

Bulb type	**G40**		**A60**		**B35**	
LED configuration	**T_j Ave °C**	**R_{thja} K/W**	**T_j Ave °C**	**R_{thja} K/W**	**T_j Ave °C**	**R_{thja} K/W**
2F	82	32	98	41	107	45
4F	89	18	119	26	NR	NR
6F	111	16	NR	NR	NR	NR

NR — Not recommended as T_j Ave will exceed the allowable maximum limitation stated in the data sheet

Table 2: Thermal resistance ($R_{th\ ja}$) of the DURIS® L38 in different type of bulbs for GW T3LxF2/F3.EM

Bulb type	G40		A60		B35	
LED configuration	**T_j Ave °C**	**R_{thja} K/W**	**T_j Ave °C**	**R_{thja} K/W**	**T_j Ave °C**	**R_{thja} K/W**
2F	75	23	88	29	98	34
4F	81	13	103	18	NR	NR
6F	90	10	122	15	NR	NR

NR — Not recommended as T_j Ave will exceed the allowable maximum limitation stated in the data sheet

Table 3: Thermal resistance ($R_{th\ ja}$) of the DURIS® L38 in different type of bulbs for GW T3LTF1.EM

Bulb type	G40		A60		B35	
LED configuration	**T_j Ave °C**	**R_{thja} K/W**	**T_j Ave °C**	**R_{thja} K/W**	**T_j Ave °C**	**R_{thja} K/W**
2F	73	23	86	29	97	34
4F	80	13	101	18	122	23
6F	88	10	120	15	NR	NR

NR — Not recommended as T_j Ave will exceed the allowable maximum limitions stated in the data sheet

Table 4: Thermal resistance ($R_{th\ ja}$) of the DURIS® L38 in different type of bulbs for GW T3LWF1.EM

Bulb type	G40		A60		B35	
LED configuration	**T_j Ave °C**	**R_{thja} K/W**	**T_j Ave °C**	**R_{thja} K/W**	**T_j Ave °C**	**R_{thja} K/W**
2F	74	17	92	22	101	25
4F	83	10	111	14	NR	NR
6F	93	8	NR	NR	NR	NR

NR — Not recommended as T_j Ave will exceed the allowable maximum limitations stated in the data sheet

Calculation of the junction temperature, T_j . The thermal resistance $R_{th\ ja}$ between the junction and the ambient temperature for the DURIS® L38 can be obtained from the Tables 1-4. With this information, the junction temperature T_j can be calculated according to the following equation:

$T_j = T_a + I_f * V_f * R_{th\ ja}$

, where T_j is the junction temperature of the LED (°C), T_a is the ambient temperature around the LED (°C), I_f is the forward current of the system (A), V_f is the forward voltage of the system (V) and $R_{th\ ja}$ is the thermal resistance of the LED, junction to ambient temperature (K/W).

To determine the junction temperature T_j experimentally, the LED assembly must be switched on at the necessary forward current until it reaches a stable temperature.

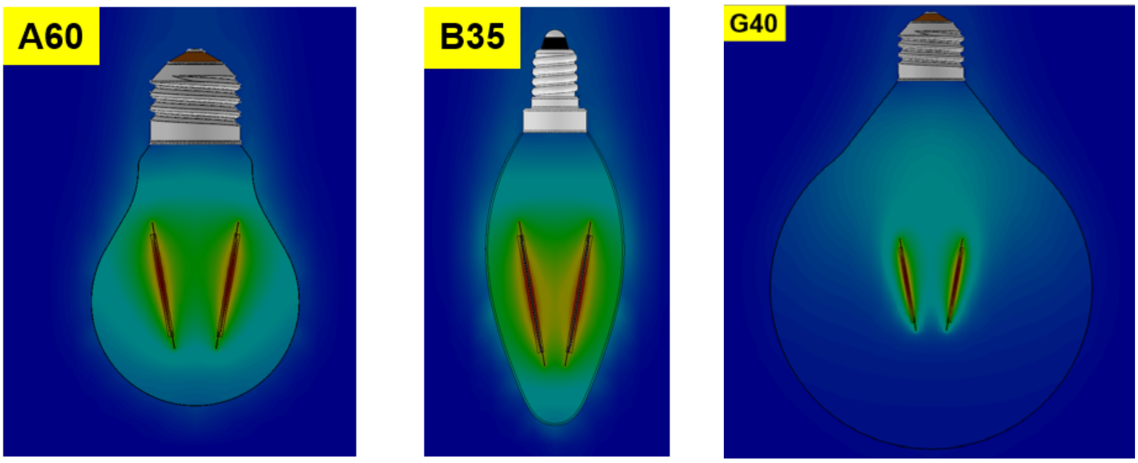
Example:

The thermal resistance $R_{th\ ja}$ between junction and ambient temperature is approximately 40.5 K/W in an A60 bulb with 2 filaments.

The T_j can be calculated as below:

$T_j = T_a + (2 * I_f * V_f) * 40.5$ K/W

Figure 11: Simulation results of the junction temperature of 2 DURIS® L38 filaments in different types of bulbs



Electrical

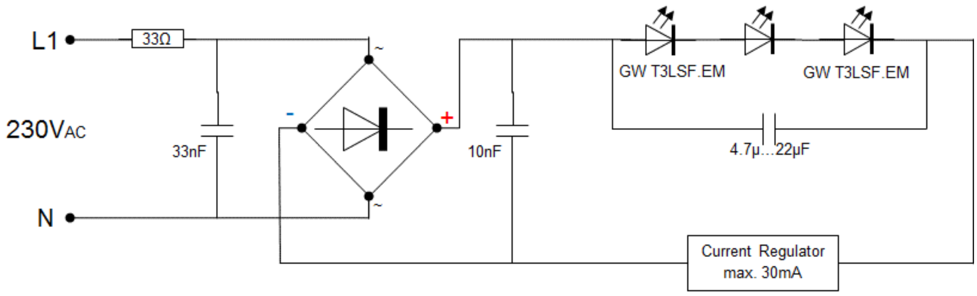
Below the requirements to meet the Energy Star standards are listed:

- PF > 0.7
- THD < 20 %
- Flicker percentage < 20 %
- Electrical efficiency > 80 %

Schematic proposal. By having the capacitor clamped directly to the LED string, the CCR (constant charge regulation) topology offers flexibility in controlling the flicker, optimizing the PF, and improving the lifetime of the electrolytic capacitor.

In terms of efficiency, an LED voltage around 27 V +/- 10 V should be targeted at 25 ^{o}C. The combination of 3 to 4 filaments for 230 V AC applications are suitable.

Figure 12: Schematic proposal for 3 x GW T3LSF1.EM



Simulation results.

- Junction temperature filament: $T_{junction}$ = 120 ^{o}C
- Operating voltage: V_{RMS} = 230 V AC 50 Hz
- Apparent power: S = V_{RMS} * I_{RMS} = 230 V * 19.0 mA = 4.4 VA
- Real power: $P_{measured\ by\ LTSPICE}$ - 3.6 W
- Reactive Power:

$$Q = \sqrt{S^2 - P^2} = \sqrt{(4,4\,VA)^2 - (3,6\,W)^2} = 2,5\,var$$

- LED power: P_{LED} = $V_{LED(DC)}$ * I_{LED} = 277.7 V * 11.8 mA = 3.3 W; $P_{LED(measured\ by\ LTSPICE)}$ = 3.1 W
- Power fact:

$$PF = \frac{P}{S} = \frac{3,6\,W}{4,4\,VA} = 0,82$$

- Total harmonic distortion: THD = 64%
- Efficiency

$$\eta = \frac{PLED}{P} = \frac{3,1\,W}{3,6\,W} = 0,86$$

- Flicker Percentage

$$Flicker = \frac{Area1}{Area2} = 0,07 \quad \text{for } C_{LED} = 10\ \mu F$$

Figure 13: LED driving current

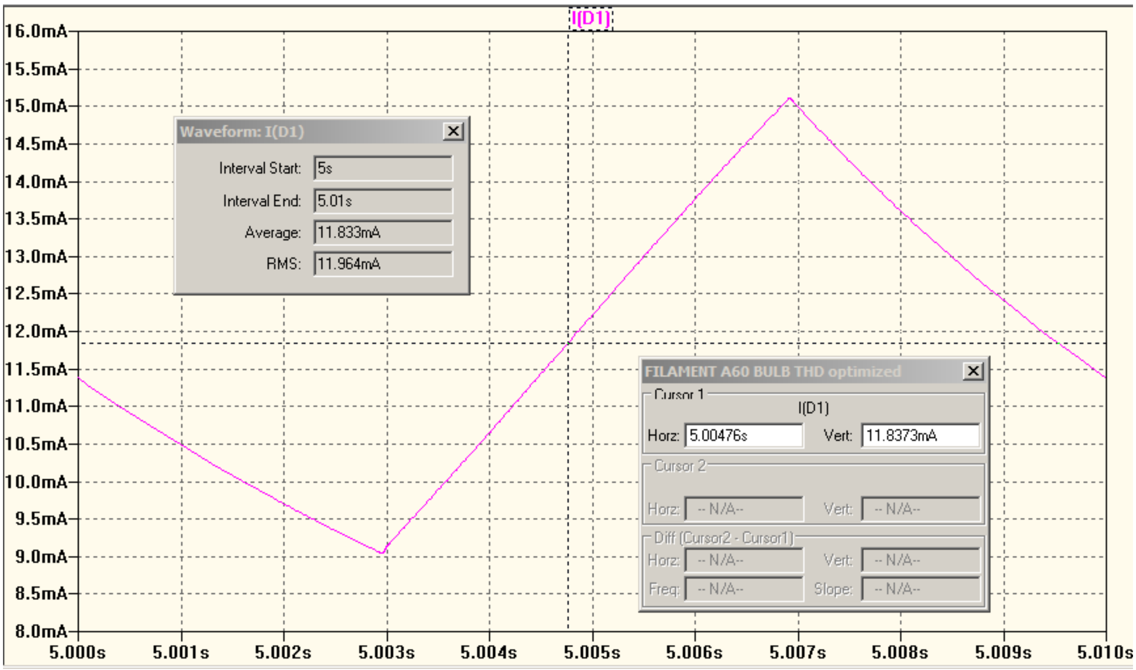


Figure 14: V_{source}/ I_{source} / I_{LED}

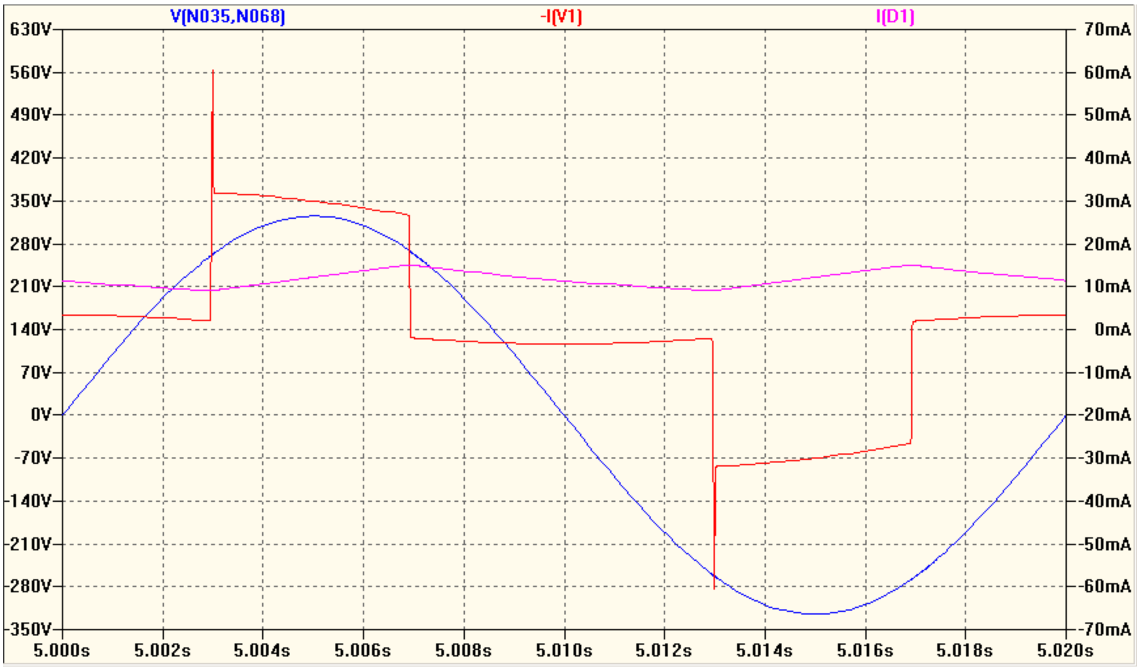


Figure 15: Explanation to calculate the flicker behavior

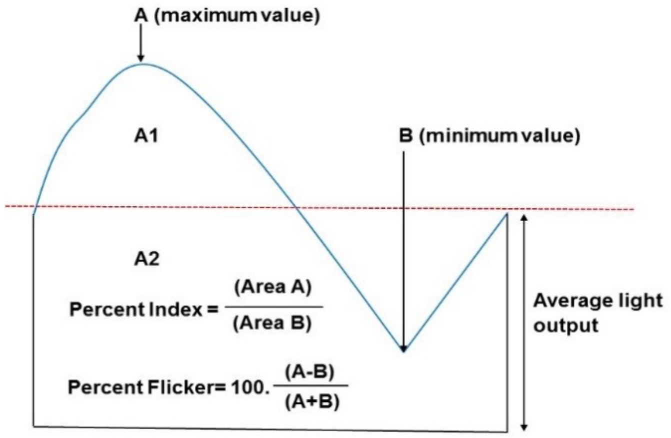
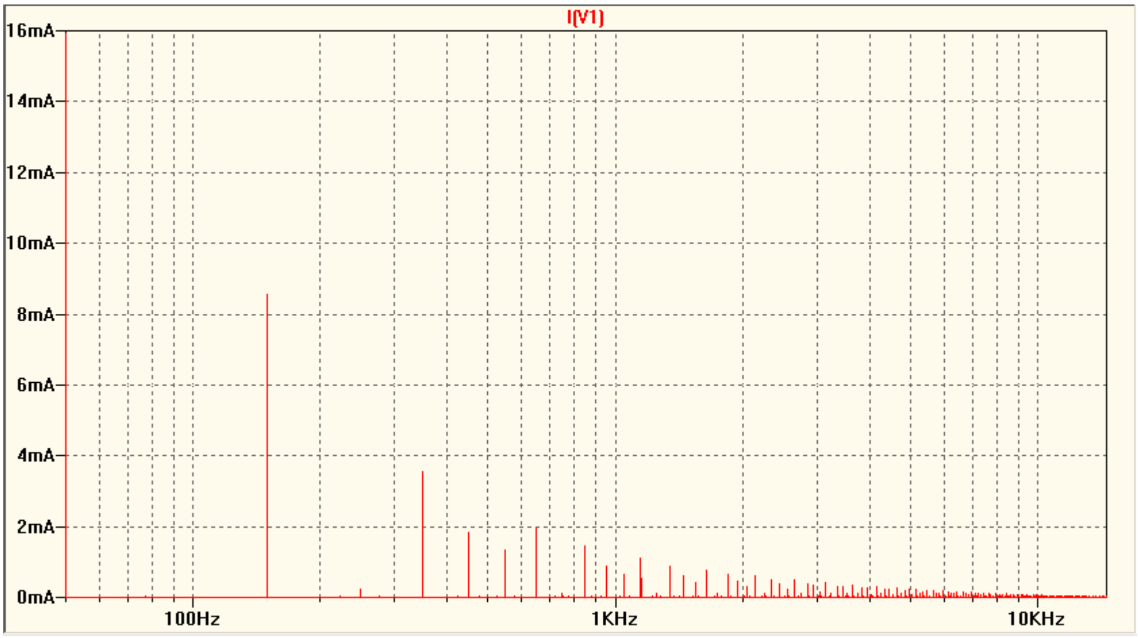


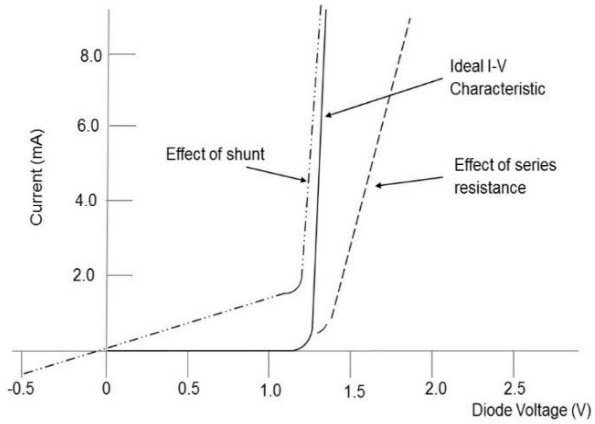
Figure 16: Total harmonic distortion (THD) consideration --> FFT (I_{source})



The simulation was done for an average temperature 120 °C filament LED. By changing the LED capacitor, the flicker, PF and the efficiency can be influenced. Additionally, the linear regulator level has to be set below the maximum filament current. For the regulator, any standard components from various manufacturers can be used or one can use a discreet approach by choosing the right transistor. It is hard to find a trade-off between PF and THD. By increasing the reactive power using higher capacitance before the rectifier, THD can be improved but this will definitely decrease the PF. Thus, improving THD and decreasing PF is not recommended because there is no THD requirement below 5 W power consumption where THD will not be considered.

Worst case simulation of parallel connected filaments. There are basically two parameters which are mainly influencing the forward voltage of an LED. The serial resistance R_S which is the most realistic parameter and the band gap energy which is defined by the peak wavelength of the blue chip. By changing the band gap energy, the nonlinearity will remain and it will lead to a worst case estimation describing the forward voltage by mainly shifting the V_f (I_f). From the worst case simulation of GW T3LSF1.EM with 1 V binning, a maximum current deviation of about 10 % can be observed which is statistically very rare.

Figure 17: I-V characteristic of diode



F. Application support and services

Premium application support services

The Premium Application Support Services (PASS) offers commercial businesses access to OSRAM Opto Semiconductors' application engineering expertise, resources and lab services, supported by an á la carte program that you can mold to your own product or system needs.

PASS can be accessed through a dedicated web page, where you can request services through a dynamic menu featuring simulation, prototype, LED data and system metrology services. You give us your specifications, and we'll measure, simulate, prototype and evaluate your project and identify issues and solutions before you go to final implementation.

Make it good, make it fast, make it easy — with PASS.

For further information, please visit http://ledlight.osram-os.com//pass

pass Premium Application Support Services

Don't forget: LED Light for you is your place to be whenever you are looking for information or worldwide partners for your LED Lighting project.

www.ledlightforyou.com

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.

DISCLAIMER

PLEASE CAREFULLY READ THE BELOW TERMS AND CONDITIONS BEFORE USING THE INFORMATION SHOWN HEREIN. IF YOU DO NOT AGREE WITH ANY OF THESE TERMS AND CONDITIONS, DO NOT USE THE INFORMATION.

The information provided in this general information document was formulated using the utmost care; however, it is provided by OSRAM Opto Semiconductors GmbH on an “as is” basis. Thus, OSRAM Opto Semiconductors GmbH does not expressly or implicitly assume any warranty or liability whatsoever in relation to this information, including – but not limited to – warranties for correctness, completeness, marketability, fitness for any specific purpose, title, or non-infringement of rights. In no event shall OSRAM Opto Semiconductors GmbH be liable – regardless of the legal theory – for any direct, indirect, special, incidental, exemplary, consequential, or punitive damages arising from the use of this information. This limitation shall apply even if OSRAM Opto Semiconductors GmbH has been advised of possible damages. As some jurisdictions do not allow the exclusion of certain warranties or limitations of liabilities, the above limitations and exclusions might not apply. In such cases, the liability of OSRAM Opto Semiconductors GmbH is limited to the greatest extent permitted in law.

OSRAM Opto Semiconductors GmbH may change the provided information at any time without giving notice to users and is not obliged to provide any maintenance or support related to the provided information. The provided information is based on special conditions, which means that the possibility of changes cannot be precluded.

Any rights not expressly granted herein are reserved. Other than the right to use the information provided in this document, no other rights are granted nor shall any obligations requiring the granting of further rights be inferred. Any and all rights and licenses regarding patents and patent applications are expressly excluded.

It is prohibited to reproduce, transfer, distribute, or store all or part of the content of this document in any form without the prior written permission of OSRAM Opto Semiconductors GmbH unless required to do so in accordance with applicable law.

OSRAM Opto Semiconductors GmbH

Head office:

Leibnizstr. 4
93055 Regensburg
Germany
www.osram-os.com