Equalizing Brightness of Standard LEDs

Doc. Version 2016-11-14-1

Author: Mario Blunk

Abstract: *Guideline to compare optical and electrical parameters of standard light emitting diodes made by Würth Elektronik eiSos GmbH & Co. KG / Germany. LEDs of different light color need to be operated so that the emitted light intensity appears homogeneous to the human eye independent of the wavelength radiated. Individual forward current setting is required by a series resistors.*

Keywords: *maximum intensity, luminous intensity, millicandela, mcd, standard LED, radiation, emitted, emission, wavelength, output power, color, resistor, forward current, forward voltage, table, datasheet, equalization, damping, red, green, blue, yellow*

Table of Contents

1 LED Types Used

The calculations conducted in this document apply to a certain set of standard LEDs only. According to the datasheets published by the manufacturer, relevant information has been extracted and pasted in the following.

The manufacturer gives the individual luminous intensity radiated at a forward current of 20mA (marked red in the following tables). By comparing these values it becomes obvious, that equalization is required. Due to the mixture of light colors emitted, the weakest LED, in this case the green one, dictates which of the remaining LEDs need to be damped down.

The maximum intensity allowed for all LEDs is defined by the maximum output of the green LED (40 mcd). See table Table 2. For debugging issues and status indication on a board, intensities of 10, 20 and 40mcd should be sufficient. See tables in 3 Summary page 8 ff.

2 How to read the diagrams ?

In the diagrams below, as an example, green pointers indicate the point of operation at **40 mcd** output intensity for all LEDs.

Start with the red LED, Diagram 2. The pointer is set at the 40mcd notch which yields a forward current of 4mA. Go to Diagram 1. There the pointer is set at 4mA which in turn gives a forward voltage of about 1.8V. So we have these input values for further calculations:

$$I_f = 4\text{mA}$$

$$V_f = 1.8\text{V}$$

On a power supply voltage V_{cc} the required series resistor equals

$$R_s = \frac{(V_{cc} - V_f)}{I_f}$$

For a given V_{cc} of 3.3V the calculation yields:

$$R_s = \frac{(3.3\text{V} - 1.8\text{V})}{4\text{mA}}$$

$$R_s = 375\,Ohms$$

The nearest selection according to the E-24 series (3) would be 390 Ohms (See Table 7).

Repeat these steps for given parameter of 40mcd and V_{cc} with the remaining LEDs and you get the results as listed in Table 7. Table 5 and Table 6 have been calculated for luminous intensities of 10 and 20mcd respectively.

2.1 Type 150080RS75000 (red)

Datasheet URL: http://katalog.we-online.de/led/datasheet/150080RS75000.pdf

D Electrical & Optical Properties:

Properties	Test conditions		Value			Unit
			min.	typ.	max.	
Peak Wavelength	20 mA	λ_{Peak}		630		nm
Dominant wavelength	20 mA	λ_{Dom}		625		nm
Luminous Intensity	20 mA	I_V	120	150		mcd
Forward Voltage	20 mA	V_F		2.0	2.4	V
Spectral Bandwidth	20 mA	$\Delta\lambda$		15		nm
Reverse Current	5 V	I_{Rev}			10	µA
Viewing Angle	20 mA	$2\theta_{50\%}$		140		°

Table 1

F3 Forward Current vs. Forward Voltage:

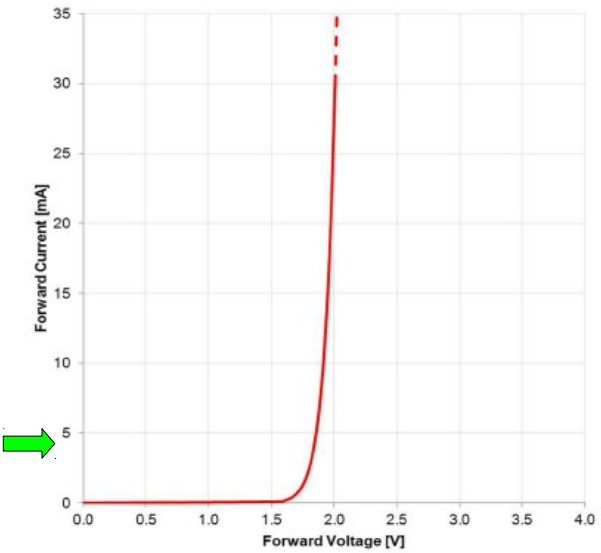

Diagram 1 Current vs. Voltage

F4 Luminous Intensity vs. Forward Current:

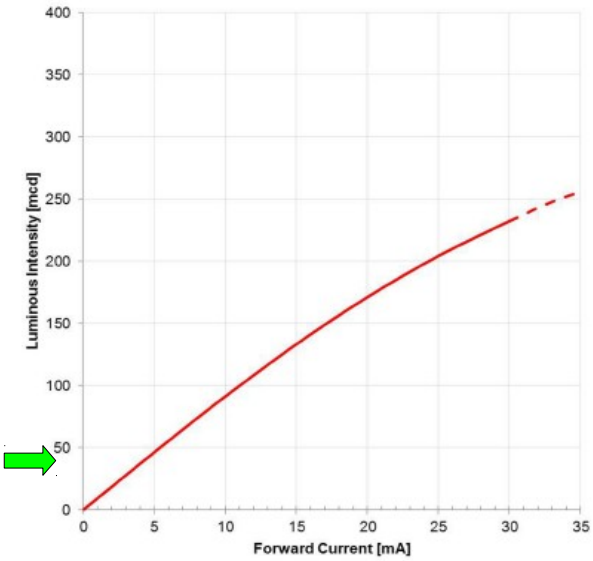

Diagram 2 Intensity vs. Current

2.2 Type 150080VS75000 (Green)

Datasheet URL: http://katalog.we-online.de/led/datasheet/150080VS75000.pdf

D Electrical & Optical Properties:

Properties	Test conditions		Value			Unit
			min.	typ.	max.	
Peak Wavelength	20 mA	λ_{Peak}		572		nm
Dominant wavelength	20 mA	λ_{Dom}		570		nm
Luminous Intensity	20 mA	I_V	12	40		mcd
Forward Voltage	20 mA	V_F		2.0	2.4	V
Spectral Bandwidth	20 mA	$\Delta\lambda$		15		nm
Reverse Current	5 V	I_{Rev}			10	µA
Viewing Angle	20 mA	$2\theta_{50\%}$		140		°

Table 2

F3 Forward Current vs. Forward Voltage:

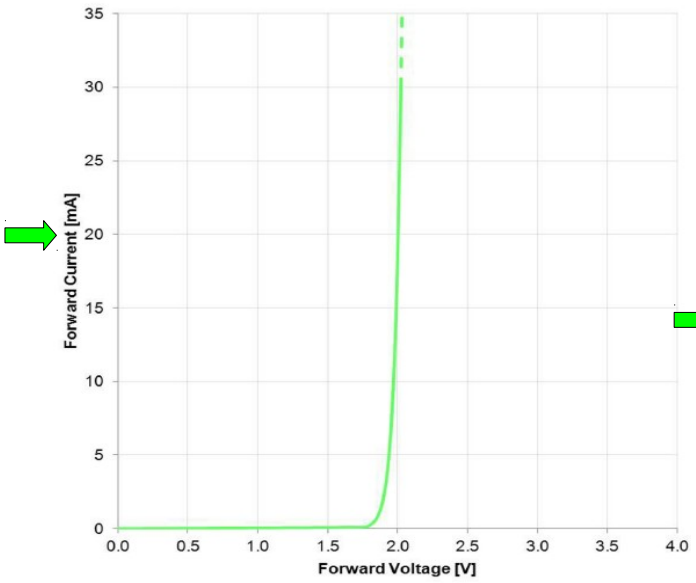

Diagram 3 Current vs. Voltage

F4 Luminous Intensity vs. Forward Current:

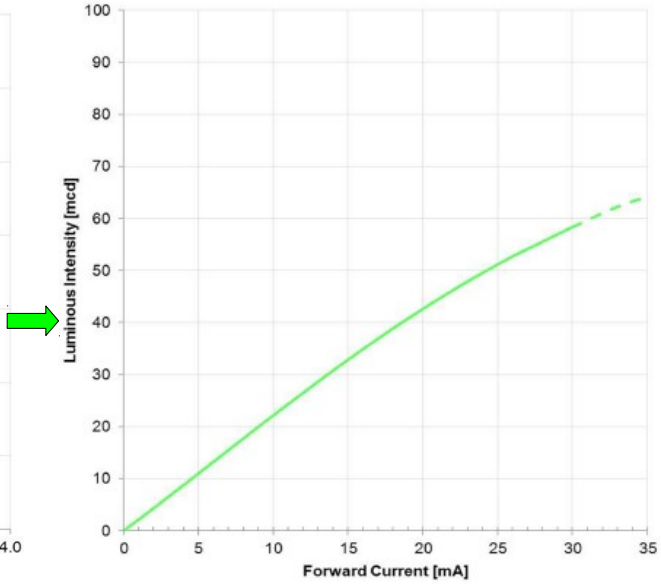

Diagram 4 Intensity vs. Current

2.3 Type 150080BS75000 (blue)

Datasheet URL: http://katalog.we-online.de/led/datasheet/150080BS75000.pdf

D Electrical & Optical Properties:

Properties	Test conditions		Value			Unit
			min.	typ.	max.	
Peak Wavelength	20 mA	λ_{Peak}		465		nm
Dominant wavelength	20 mA	λ_{Dom}		470		nm
Luminous Intensity	20 mA	I_V	90	145		mcd
Forward voltage	20 mA	V_F		3.2	3.5	V
Spectral Bandwidth	20 mA	$\Delta\lambda$		25		nm
Reverse Current	5 V	I_{Rev}			10	µA
Viewing angle	20 mA	$2\theta_{50\%}$		140		°

Table 3

F Forward Current vs. Forward Voltage:

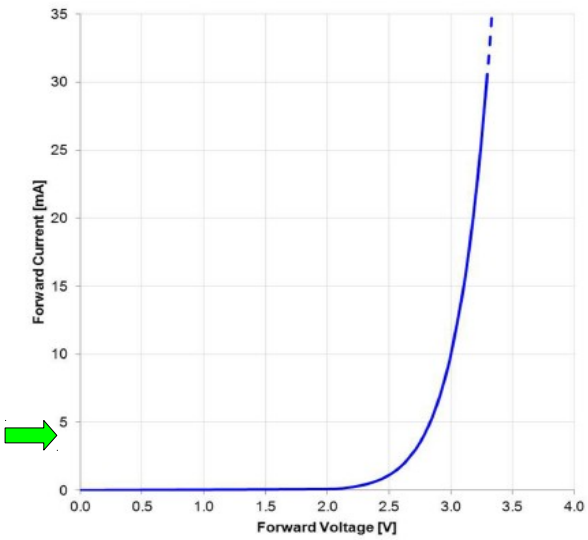

Diagram 6 Current vs. Voltage

F Luminous Intensity vs. Forward Current:

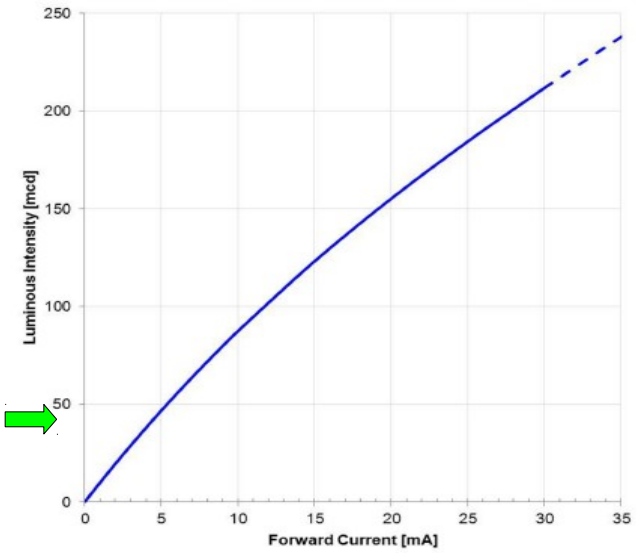

Diagram 5 Intensity vs. Current

2.4 Type 150080YS75000 (yellow)

Datasheet URL: http://katalog.we-online.de/led/datasheet/150080YS75000.pdf

D Electrical & Optical Properties:

Properties	Test conditions		Value			Unit
			min.	typ.	max.	
Peak Wavelength	20 mA	λ_{Peak}		595		nm
Dominant wavelength	20 mA	λ_{Dom}		590		nm
Luminous Intensity	20 mA	I_V	90	120		mcd
Forward Voltage	20 mA	V_F		2.0	2.4	V
Spectral Bandwidth	20 mA	$\Delta\lambda$		15		nm
Reverse Current	5 V	I_{Rev}			20	µA
Viewing Angle	20 mA	$2\theta_{50\%}$		140		°

Table 4

F3 Forward Current vs. Forward Voltage:

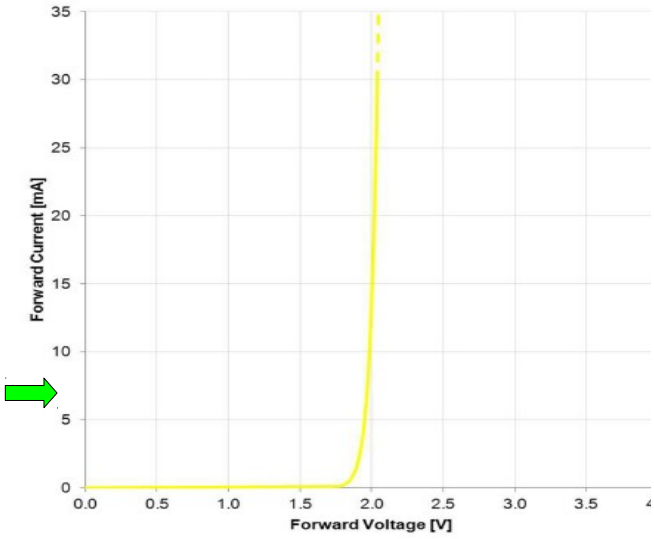

Diagram 8 Current vs. Voltage

F4 Luminous Intensity vs. Forward Current:

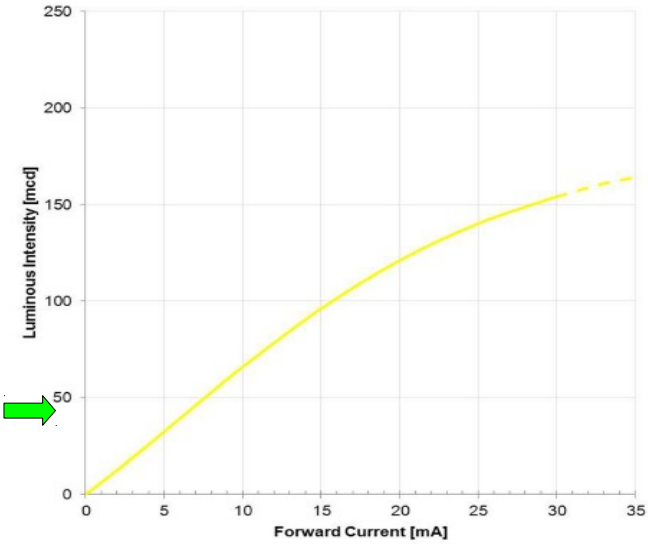

Diagram 7 Intensity vs. Current

3 Summary

In order to keep things easy, a simple example of an LED and its series resistor is shown on the right. The LED might be driven by an IC or a transistor as well.

Table 5 through Table 7 give the value of the series resistor required to obtain a luminous intensity of around 10, 20 or 40 mcd for every light color radiated at a given operating voltage. Of course, these tables apply only to the LED types specified above.

Note: Mind the thermal load of the series resistor in certain cases !

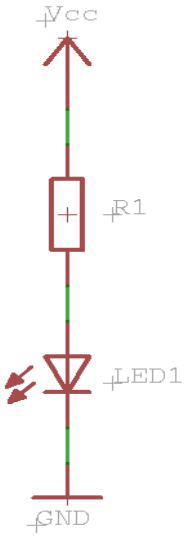

Figure 1

Light Color	R @ 3.3V [kOhms]	R @ 5V [kOhms]	R @ 12V [kOhms]	R @ 24V [kOhms]	Remarks
red	1.5	3.3	10	22	
green	0.33	0.75	2.4	5.6	
blue	0.82	2.5	10	22	
yellow	0.91	2.2	6.8	15	

Table 5: Series Resistor Values for a homogeneous Intensity of approx. 10mcd

Light Color	R @ 3.3V [kOhms]	R @ 5V [kOhms]	R @ 12V [kOhms]	R @ 24V [kOhms]	Remarks
red	0.68	1.8	5.6	12	
green	0.14	0.33	1.1	2.4	consider P
blue	0.33	1.2	4.7	10	
yellow	0.47	1	3.3	7.4	

Table 6: Series Resistor Values for a homogeneous Intensity of approx. 20mcd

Light Color	R @ 3.3V [kOhms]	R @ 5V [kOhms]	R @ 12V [kOhms]	R @ 24V [kOhms]	Remarks
red	0.39	0.82	2.4	5.6	
green	0.075	0.16	0.56	1.1	consider P
blue	0.14	0.56	2.2	5.1	
yellow	0.22	0.47	1.5	3.3	

Table 7: Series Resistor Values for a homogeneous Intensity of approx. 40mcd

4 References

(1) Winfried Müller, "*Optoelektronische Sender, Empfänger und Koppler*" ; German; Militärverlag der DDR (VEB) Berlin, 1986

(2) Würth Elektronik eiSos GmbH & Co. KG / Germany, Datasheets of LEDs

Datasheet URL: http://katalog.we-online.de/led/datasheet/150080RS75000.pdf
Datasheet URL: http://katalog.we-online.de/led/datasheet/150080VS75000.pdf
Datasheet URL: http://katalog.we-online.de/led/datasheet/150080BS75000.pdf
Datasheet URL: http://katalog.we-online.de/led/datasheet/150080YS75000.pdf

(3) The E-series at http://www.logwell.com/tech/components/resistor_values.html

5 Links

- find updates of this document at www.blunk-electronic.de
- Simplify manufacturing fault detection, hardware bring-up, debugging and system tests with *System M-1* the Boundary-Scan Test System at

  http://www.blunk-electronic.de/products.html

6 Disclaimer

This document is believed to be accurate and reliable. I do not assume responsibility for any errors which may appear in this document. I reserve the right to change it at any time without notice, and do not make any commitment to update the information contained herein.

Blunk electronic / Owner : Dipl. Ing. Mario Blunk / Buchfinkenweg 3 / 99097 Erfurt / Germany / Phone +49 361 6022 5184