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OSRAM RGB-LED for Automotive Interior Application

Chen Xiaoli | 2018-11-15 | Kunshan—2018 Automotive Smart Interior Ambient Light Summit Forum

Light is OSRAM

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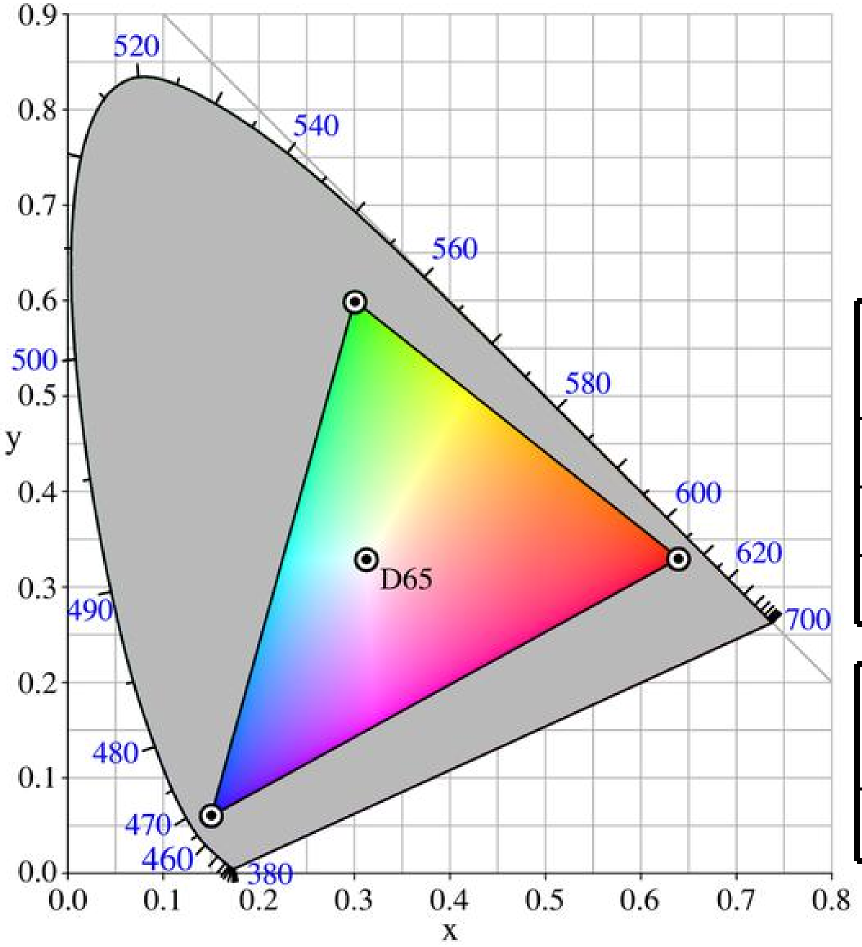
Agenda

1. RGB color mixing concept and LED characteristics
2. Normal RGB LED solution
3. Intelligent RGB LED solution

RGB color mixing concept



1. A set of primary colors, define a color triangle; only colors within this triangle(color Gamut) can be reproduced by mixing the primary colors.
2. The color of mixed light depends on the respective brightness proportion of Red's, Green's, and Blue's.
3. The Brightness of mixed light is the total brightness of Red's, Green's and Blue's.

Primary color	Cx	Cy	Brightness [mlm or mcd]	Duty Cycle
Red	x_1	y_1	Y_1	D_1
Green	x_2	y_2	Y_2	D_2
Blue	x_3	y_3	Y_3	D_3

Mixed color	Cx	Cy	Brightness [mlm or mcd]
Any	x_m	y_m	Y_m

$$x_m = \frac{\frac{Y_1 D_1}{y_1} x_1 + \frac{Y_2 D_2}{y_2} x_2 + \frac{Y_3 D_3}{y_3} x_3}{\frac{Y_1 D_1}{y_1} + \frac{Y_2 D_2}{y_2} + \frac{Y_3 D_3}{y_3}}$$

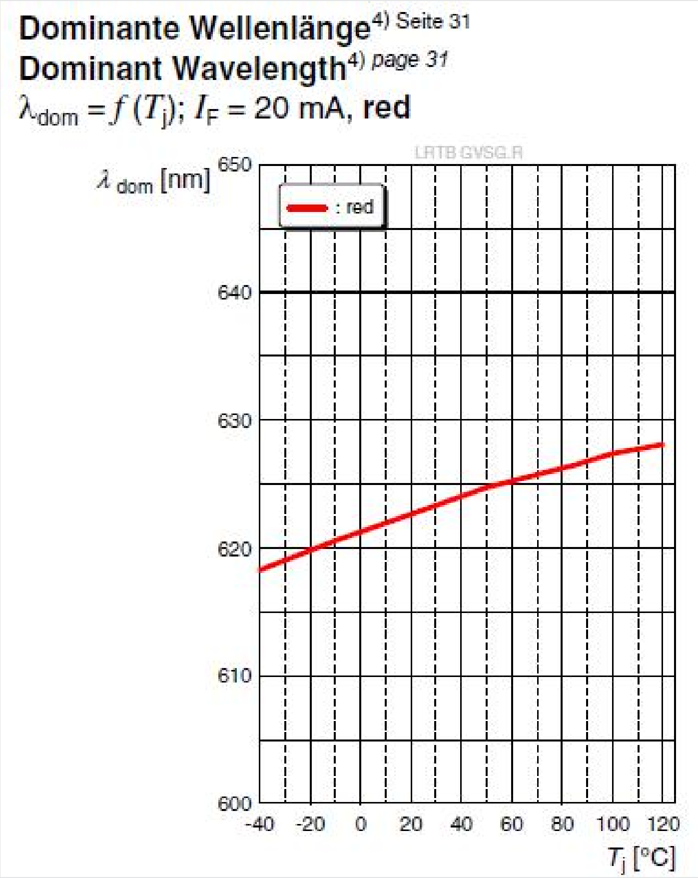
$$y_m = \frac{\frac{Y_1 D_1}{y_1} y_1 + \frac{Y_2 D_2}{y_2} y_2 + \frac{Y_3 D_3}{y_3} y_3}{\frac{Y_1 D_1}{y_1} + \frac{Y_2 D_2}{y_2} + \frac{Y_3 D_3}{y_3}}$$

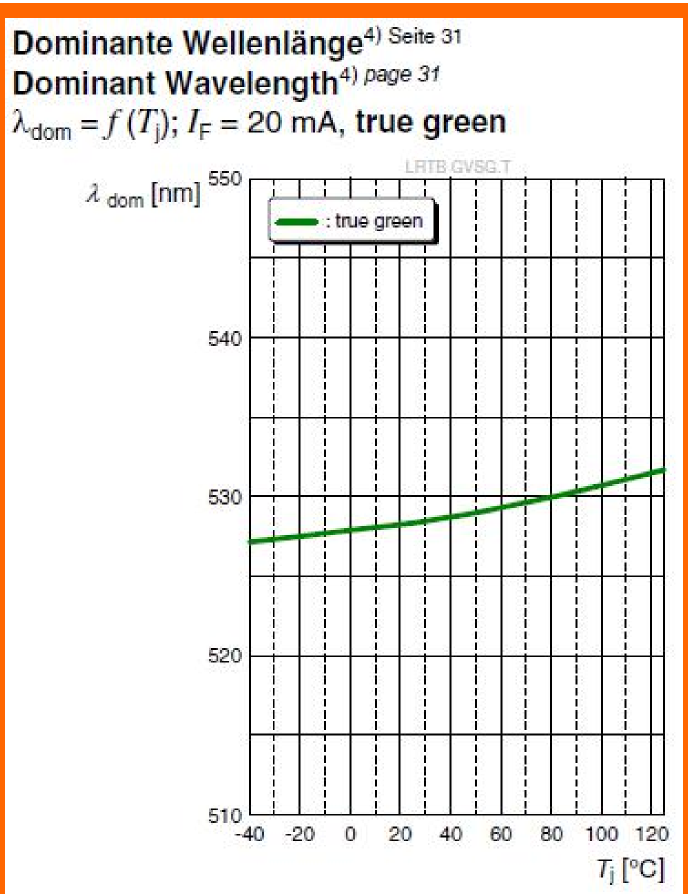
$$Y_m = Y_1 D_1 + Y_2 D_2 + Y_3 D_3$$

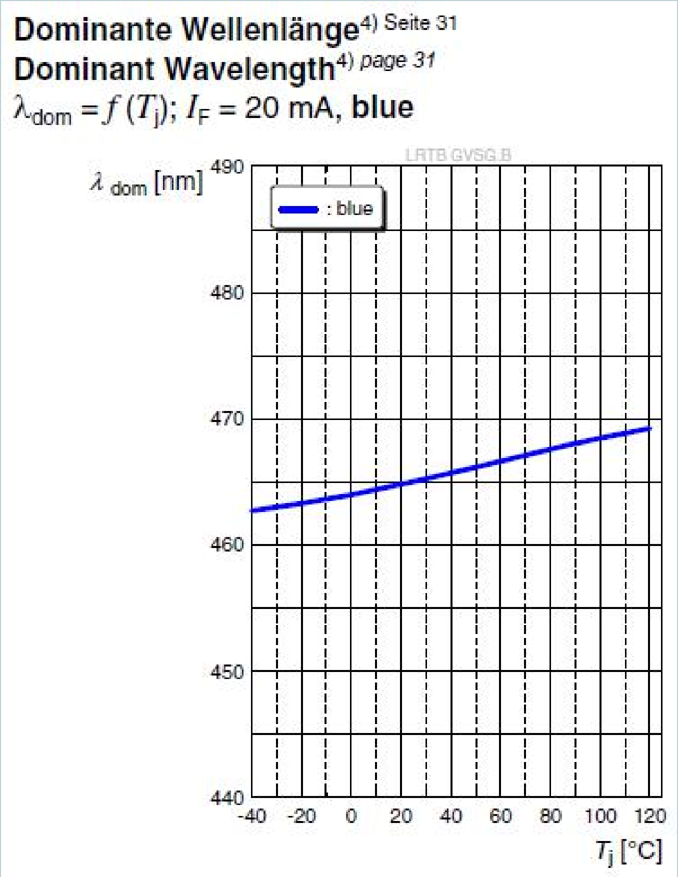
LED Characteristics

Temperature Dependency of λ_{dom}

Red	True Green	Blue



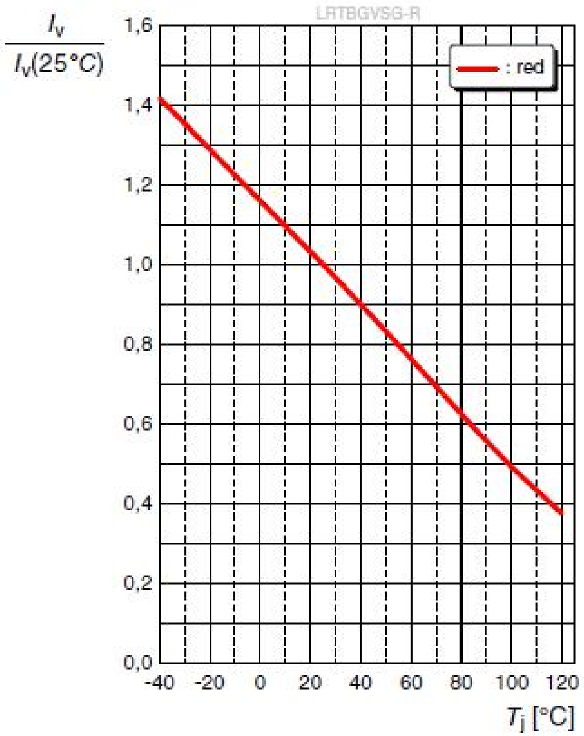




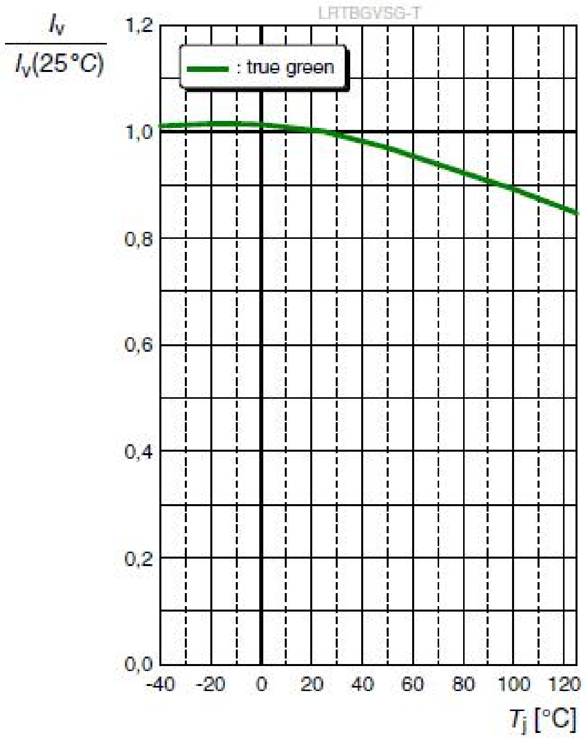
LED Characteristics
Temperature Dependency of Forward Voltage V_f

Red	True Green	Blue

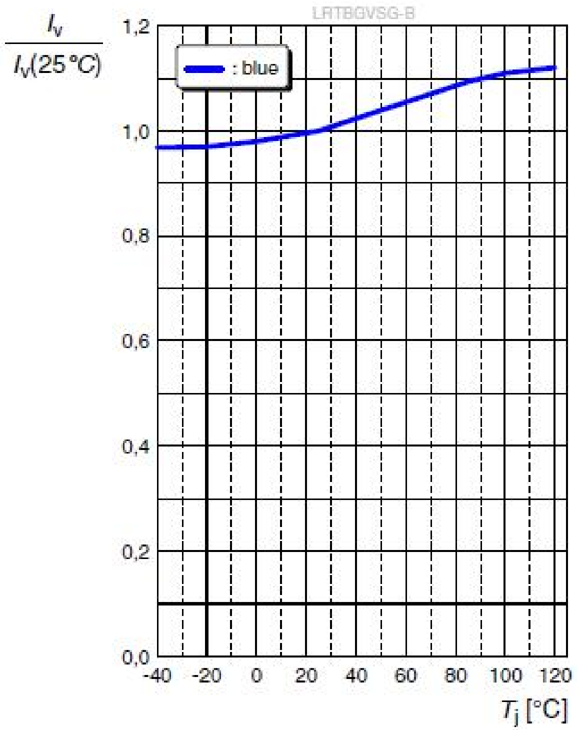
Relative Lichtstärke[4] Seite 31
Relative Luminous Intensity[4] *page 31*
$I_V/I_V(25\ ^\circ C) = f(T_j)$; I_F = 20 mA; **red**



Relative Lichtstärke[4] Seite 31
Relative Luminous Intensity[4] *page 31*
$I_V/I_V(25\ ^\circ C) = f(T_j)$; I_F = 20 mA; **true green;**

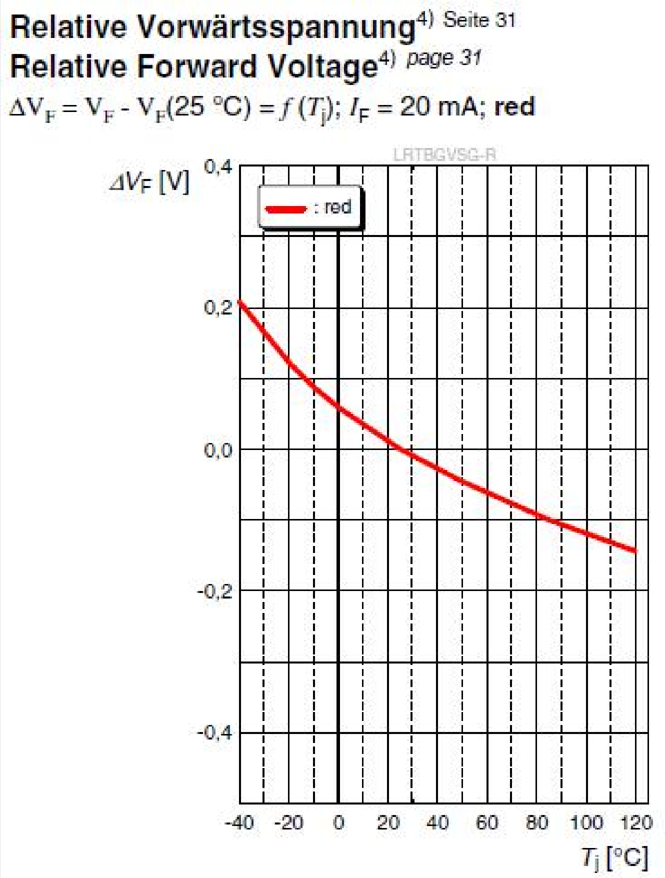


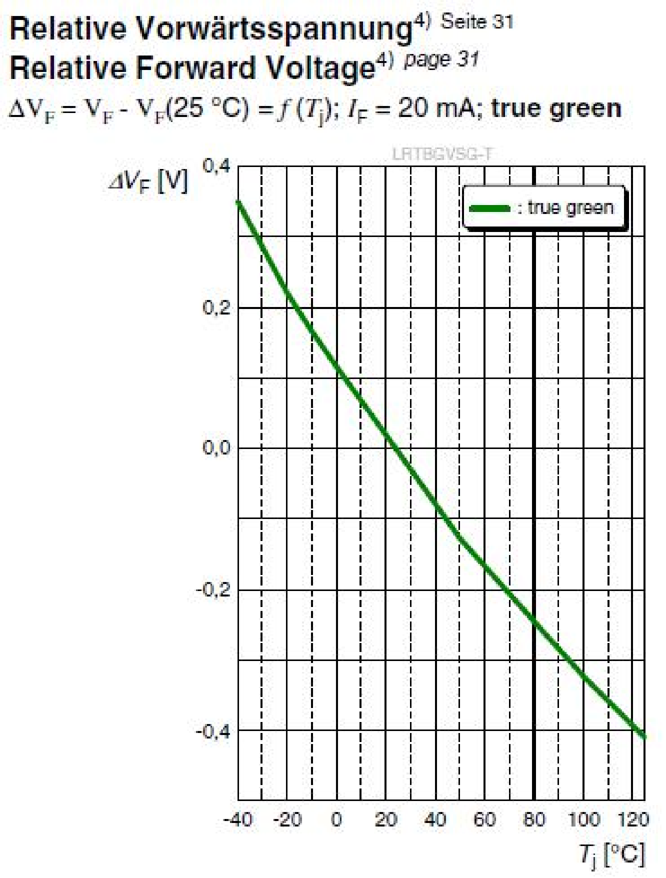
Relative Lichtstärke[4] Seite 31
Relative Luminous Intensity[4] *page 31*
$I_V/I_V(25\ ^\circ C) = f(T_j)$; I_F = 20 mA; **blue**

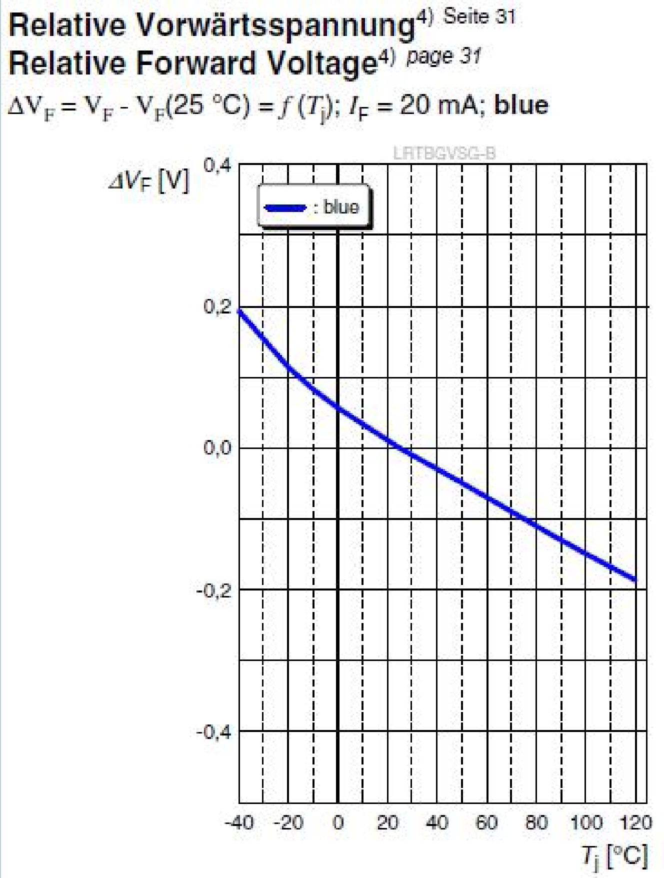


LED Characteristics
Brightness Degradation with Temperature

Red	True Green	Blue



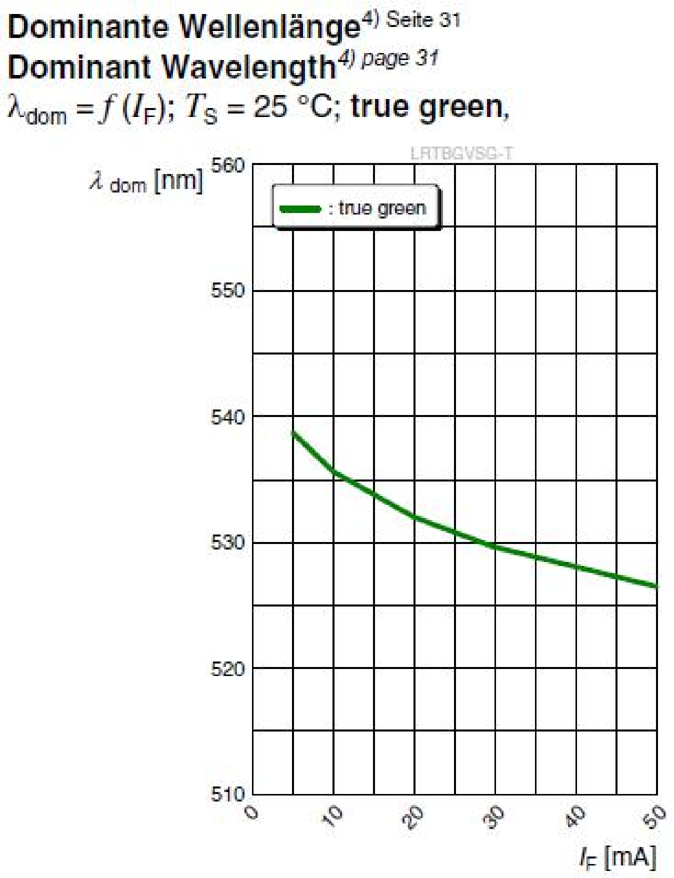


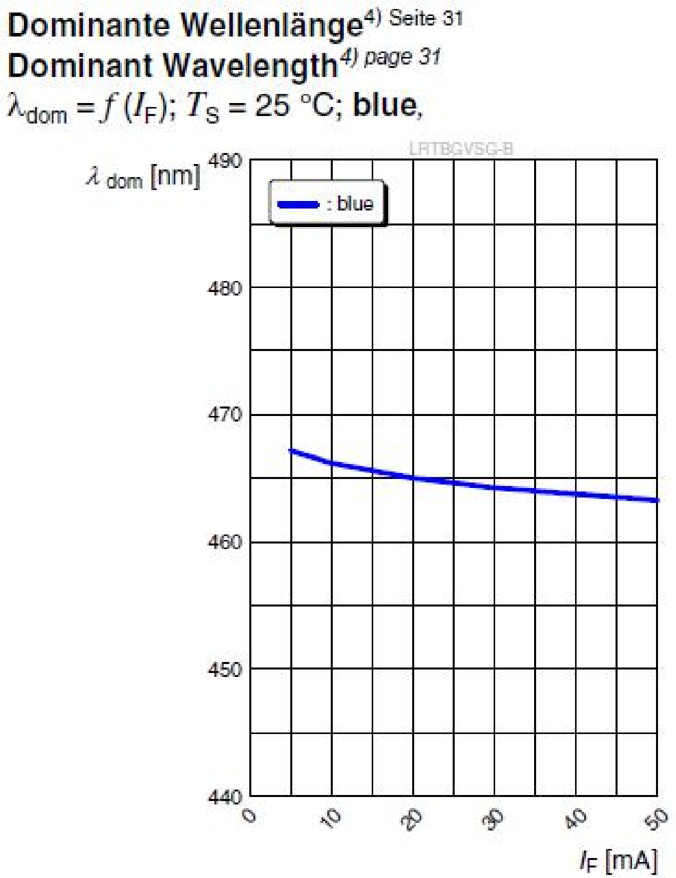


LED Characteristics

Forward Current Dependency of λ_{dom}

True Green	Blue





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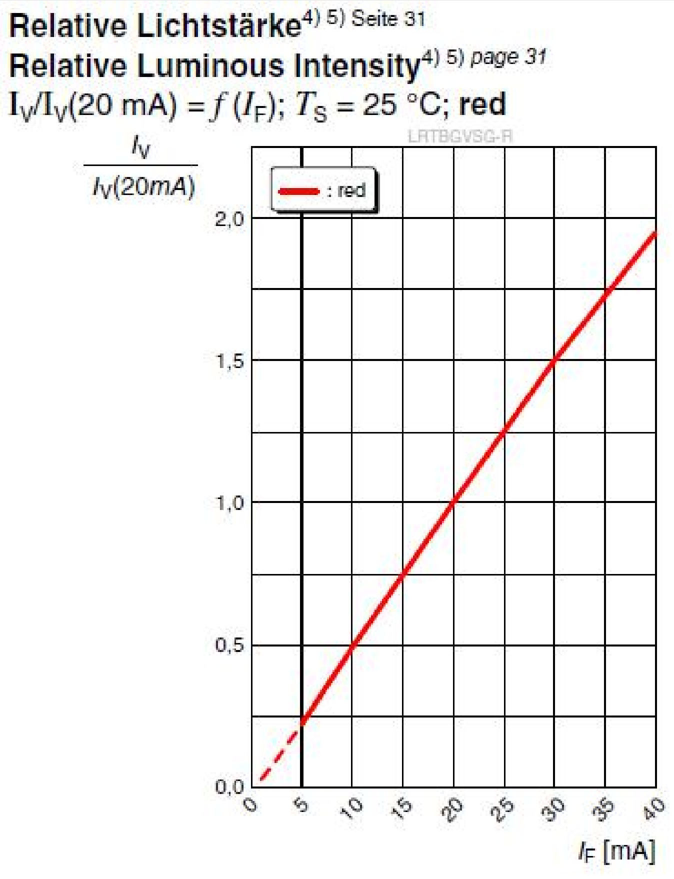
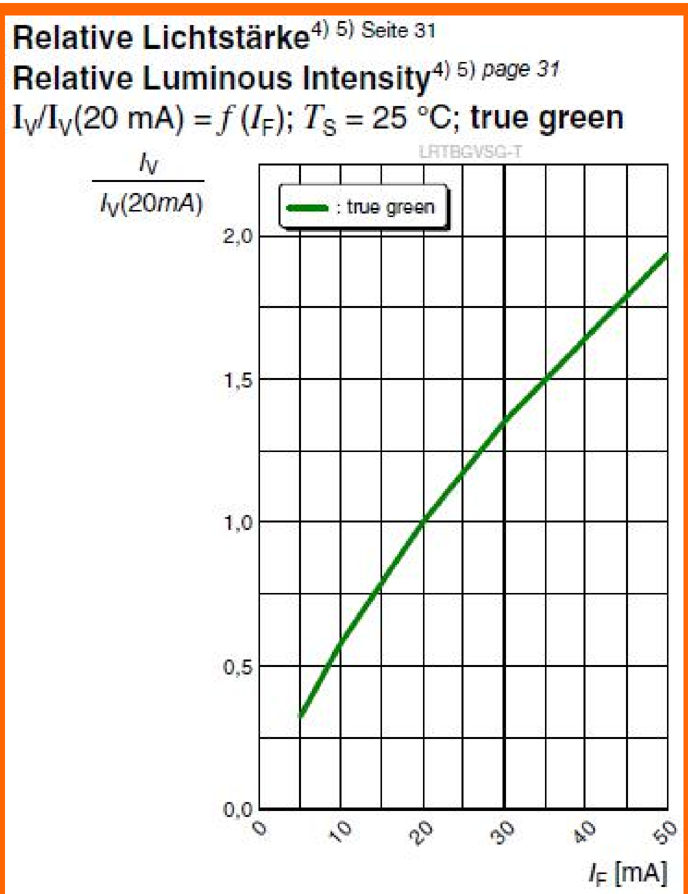
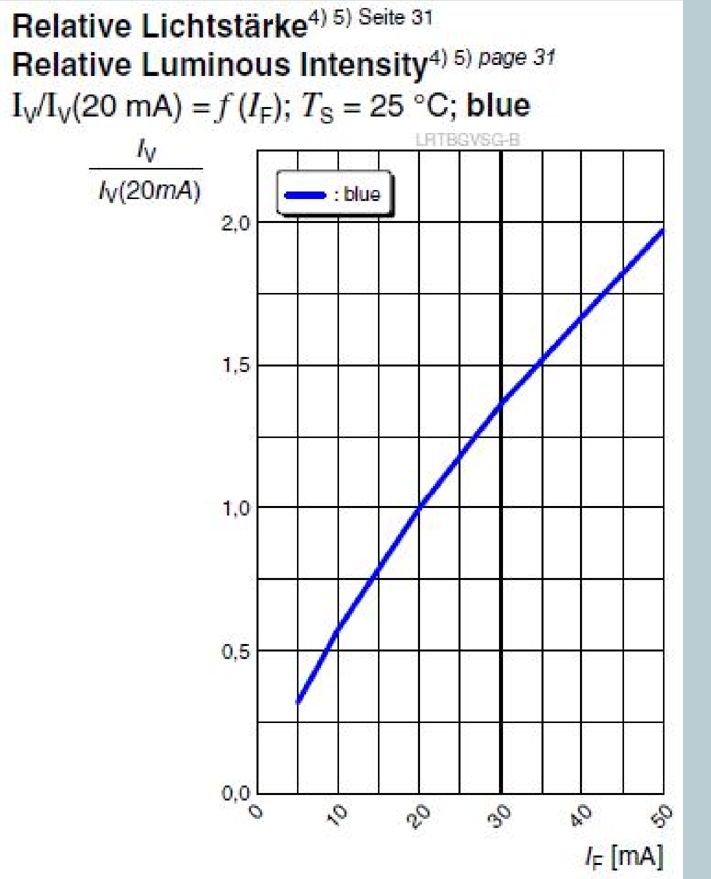
LED Characteristics
Forward Current Dependency of Brightness

Red	True Green	Blue

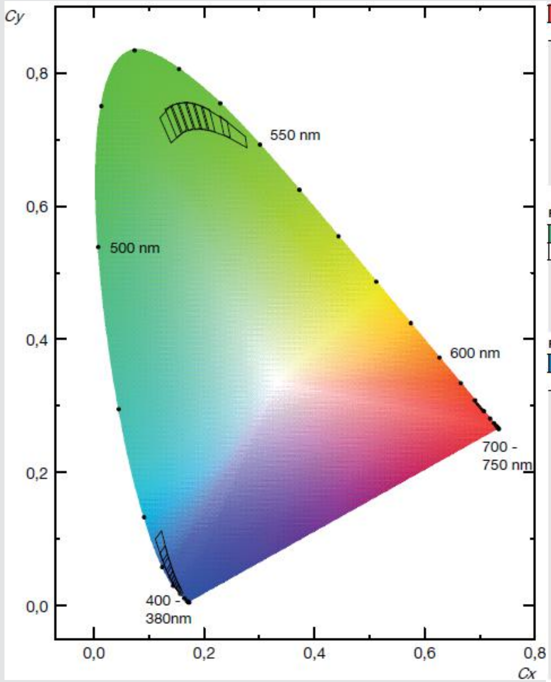






LED Characteristics
Bin groups and Color Gamut

Color and brightness bin groups



red
UE = 500 ... 630 [mcd]
UF = 529 ... 669 [mcd]
UG = 560 ... 710 [mcd]
UH = 594 ... 754 [mcd]
UI = 630 ... 800 [mcd]
UJ = 669 ... 849 [mcd]
VC = 710 ... 900[mcd]
VD = 754 ... 949 [mcd]
VE = 800 ... 1000 [mcd]

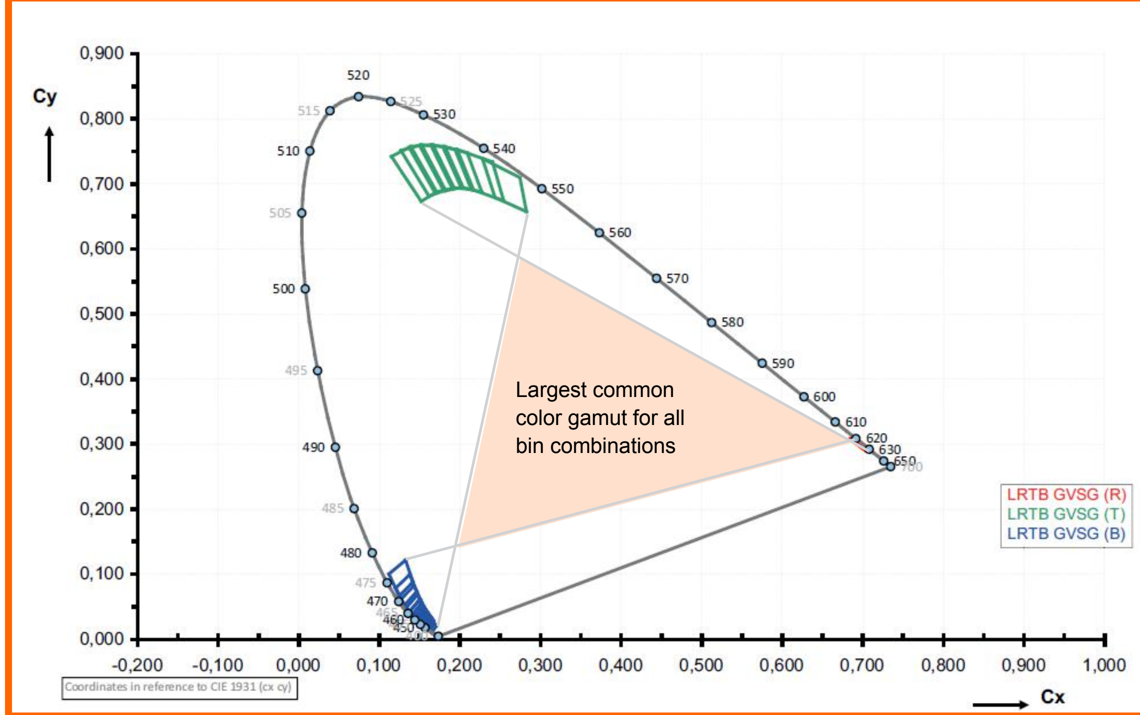
Floating Bins

true green
AM = 1250 ... 1590 [mcd]
AN = 1323 ... 1692 [mcd]
AO = 1400 ... 1800 [mcd]
AP = 1492 ...1902 [mcd]
AQ = 1590 ...2010 [mcd]

Floating Bins

blue
SC = 180 ... 224 [mcd]
SD = 190 ... 237 [mcd]
SE = 201 ... 250 [mcd]
SF = 212 ... 265 [mcd]
SG = 224 ... 280 [mcd]
SH = 237 ... 297 [mcd]
SI = 250 ... 315 [mcd]
SJ = 265 ... 334 [mcd]
TC = 280 ... 355 [mcd]
TD = 297... 377 [mcd]
TE = 315 ... 400 [mcd]
TF = 334 ... 424 [mcd]
TG = 355... 450 [mcd]
TH = 377 ... 474 [mcd]
TI = 400 ... 500 [mcd]
TJ = 424 ... 529 [mcd]
UC = 450 ... 560 [mcd]

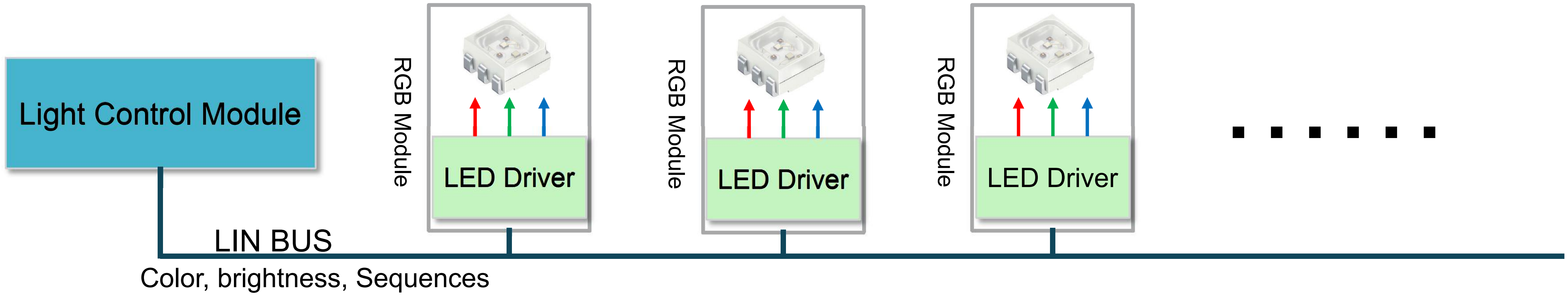
Color Gamut



RGB Ambient Lighting
Agenda

1. RGB color mixing concept and LED characteristics
2. Normal RGB LED solution
3. Intelligent RGB LED solution

Normal RGB LED solutions



Color stability requirements result in the following driving schemes

- Temperature compensation is necessary
- Use PWM for adjusting color and brightness (eliminate forward current dependencies)
- Module calibration is necessary
  - ✓ To compensate for differences within the same bin
  - ✓ To compensate between different bins (largest common color gamut for all bin combinations)

LRTB GVSG

Part No.	LRTB GVSG		
Dimension [mm³]	3.4×3.3×1.8		
Chip Color	Red	True Green	Blue
IF (typ.) [mA]	20	20	20
VF (typ.) [V]	2.05	3.2	2.85
Iv (typ.) [mcd]	500~1000	1250~2010	180~560
ESD [kV]	2	2	2
Viewing angle at 50% Iv	120°	120°	120°
λ_{dom}(typ.)[nm]	625	528	460

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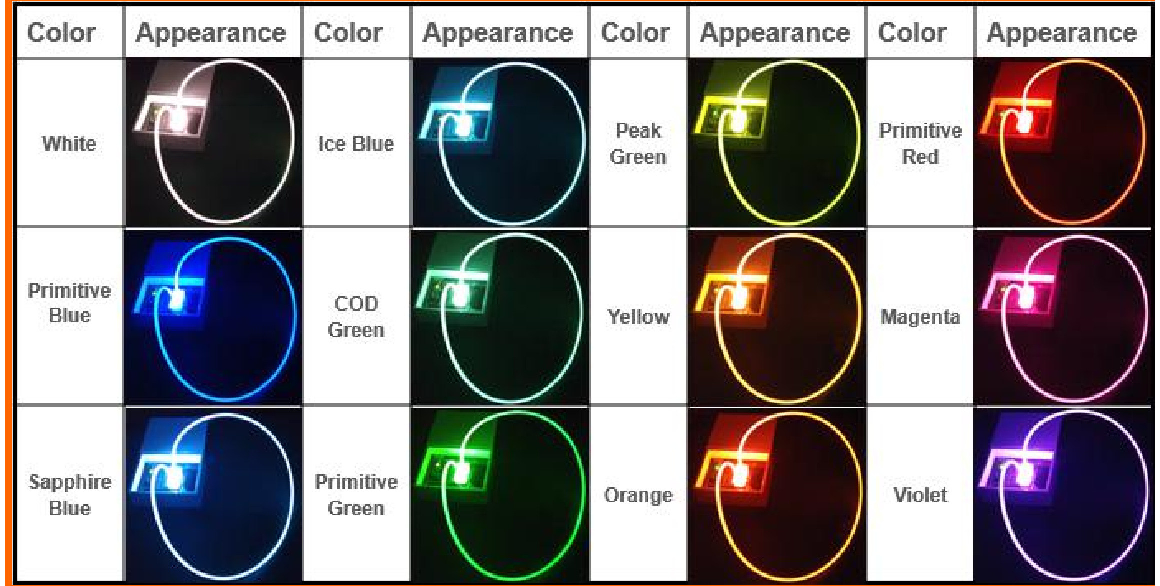
Example
Demo with LRTB GVSG

Target and Measurement

No	Color	LED Target Data			Lightguide surface Test Data		
		Cx	Cy	Iv [mcd]	Cx	Cy	Luminance [cd/m^2]
1	White	0.318	0.318	2295	0.3176	0.3176	27.2
2	Primitive Blue	0.1434	0.0526	379	0.1399	0.0476	4.2
3	Sapphire Blue	0.19	0.19	1814	0.1888	0.1897	22.2
4	Ice Blue	0.2	0.3	1813	0.1998	0.2991	21.5
5	COD Green	0.23	0.42	1715	0.2308	0.4188	20.5
6	Primitive Green	0.2053	0.7214	1508	0.2086	0.7232	13.1
7	Peak Green	0.35	0.6	1774	0.3506	0.601	21.3
8	Yellow	0.55	0.43	1801	0.5471	0.4316	20
9	Orange	0.62	0.37	1288	0.618	0.3706	14.2
10	Primitive Red	0.6924	0.3041	900	0.694	0.3053	9.9
11	Magenta	0.45	0.2	1062	0.4453	0.1966	11.6
12	Violet	0.25	0.1	906	0.2474	0.0977	10.7

Lit appearance



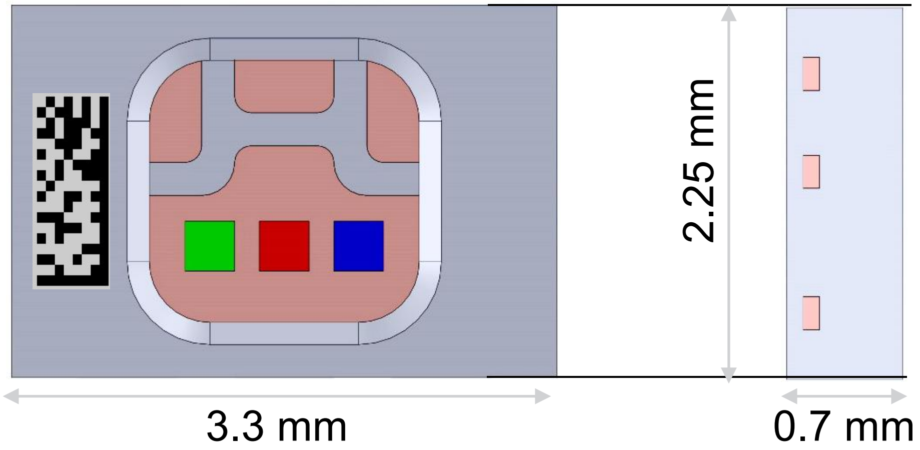
Due to chromatic aberration of camera, maybe the colors are not what human eyes see.

RGB-Package with Data Matrix Code (DMC) carrying Device ID

- Superior corrosion robustness
- ESD stable HM 2kV, MM500V
- Target driving current up to 50mA
- Common anode
- Same light emitting area as intelligent RGB(in following slides)
- DMC on Package carrying device ID
- Logfile: Look-up Table linking device ID & Test Data
- Traceability via device ID

Target Brightness Values

Red	green	blue
1600 mcd	3000 mcd	1000 mcd
		> 4300 mcd at D65



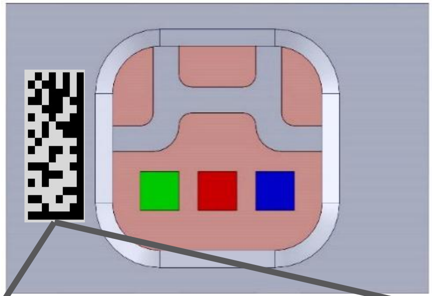
Calibration data based on device ID

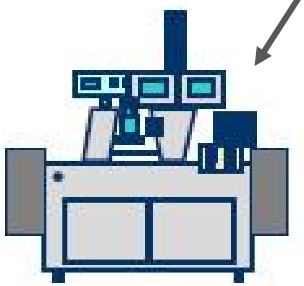
- DMC carrying device ID

→ Access to look-up file provided by OS

→ Device ID linked to electro optical test data

→ White point calibration based on test data possible

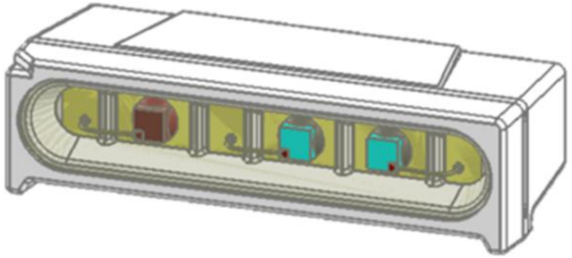


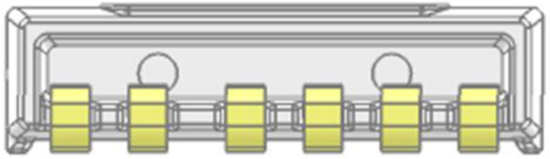


Device ID (DMC)	Test data (look-up file)
#1	LED binning data
#2	LED binning data
#3	LED binning data
…	…

Sidelooker RGB

Package & Design	Highlights & Benefits
• Premold SMT Package • Optimized lead design • Top emitting chips • 6 leads	• Good self alignment at soldering • Stable upright positon • Fully individually addressable





Part No.	KRTB AELPS1.32		
Dimension [mm^3]	5.5×1.5×1.8		
Chip Color	Red	True Green	Blue
IF (typ.) [mA]	20	20	20
VF (typ.) [V]	2.05	3.2	2.85
Iv (typ.) [mcd]	500~1000	1250~2010	180~560
ESD [kV]	2	2	2
Viewing angle at 50% Iv	120°	120°	120°
λ_{dom}(typ.)[nm]	625	528	460

RGB Ambient Lighting
Agenda

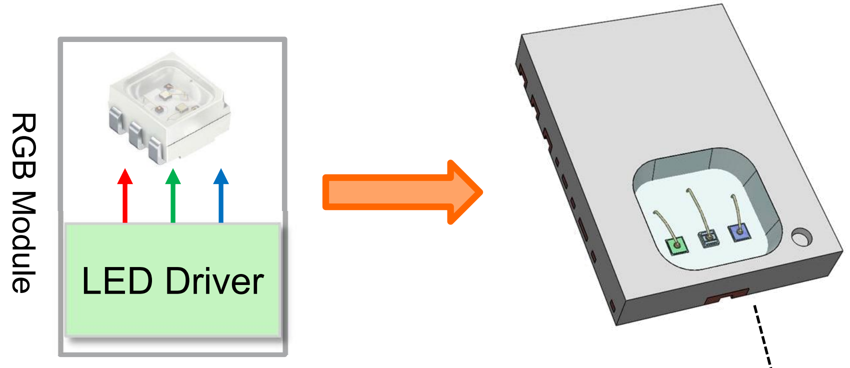
Concept of Intelligent RGB (RGBi)

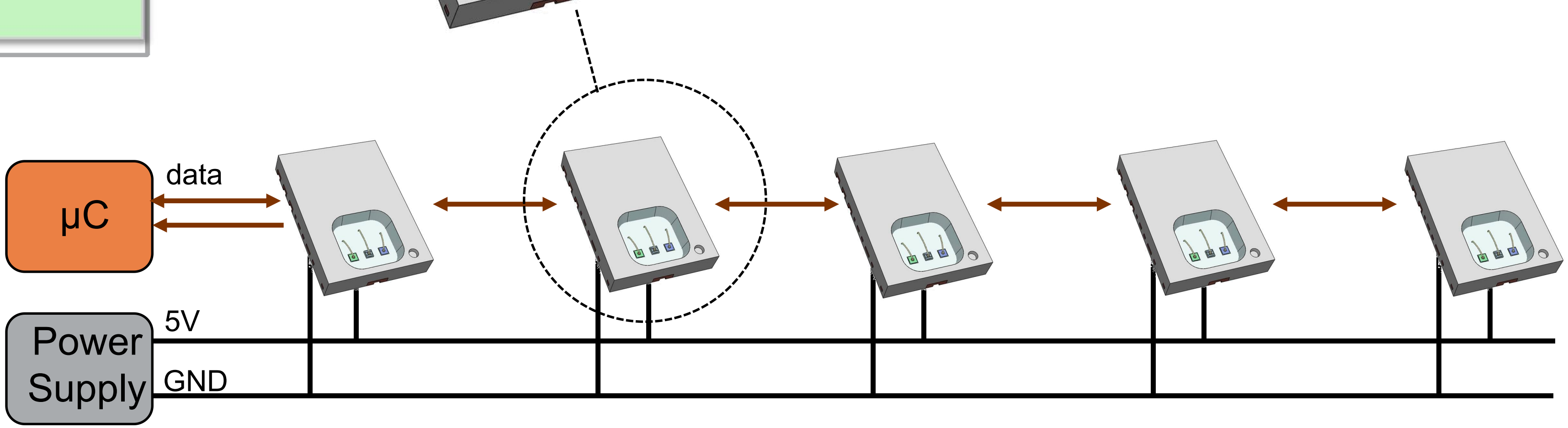
ISELED standard: >1200mcd at D65 (6500K)*
5V DC supply*
Application: Automotive Interior
Target dimensions: 3.3 x 4.6 x 0.7mm³

***** Performance data of first product generation***

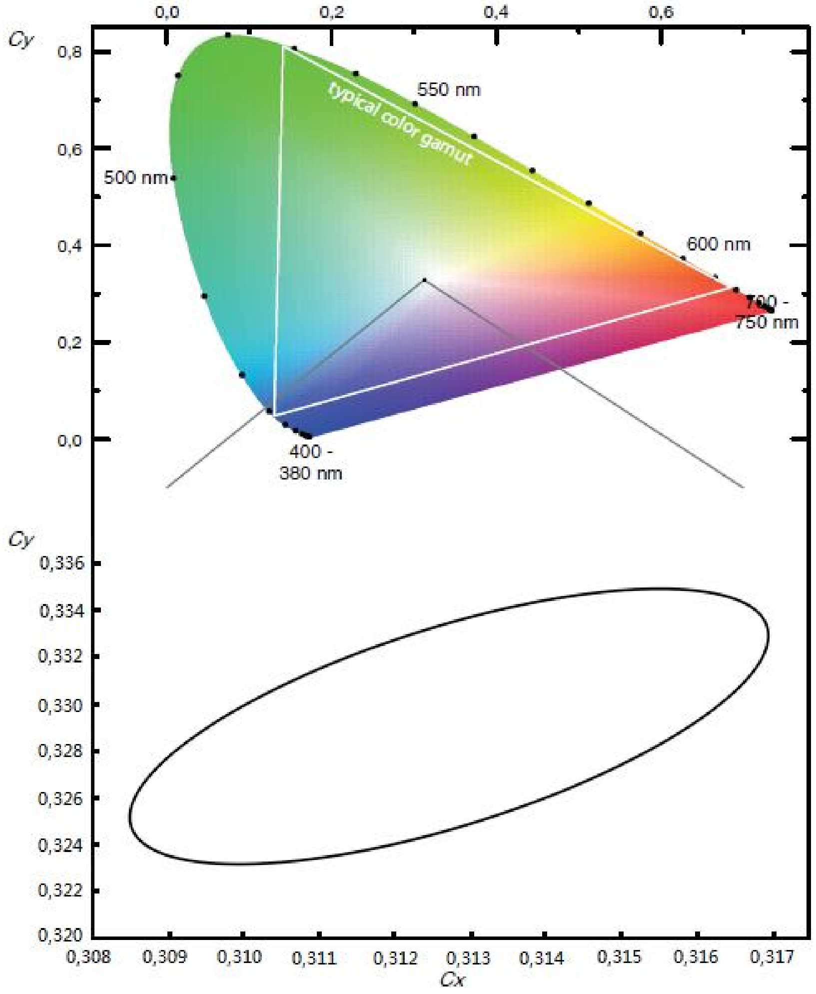
Integrated Inova Micro Driver:

- ID for every package in a daisy chain by autoadressing(Max 4096 node)
- LEDs are accessed via micro driver and its ID
- LED update rate of 100 LEDs < 10ms
- Temperature compensation for RED-chip based on pulse width of PWM signal
- ASIC initialization based on test data: Brightness „calibration“ via puls width of PWM signal





RGBi Color Group



Typical parameters

Color	Ldom/nm	Brightness mcd	IF_average mA	IF_peak mA
R	619	366	6	25
G	527	790	10	20
B	466	74	4	20

White Point Group

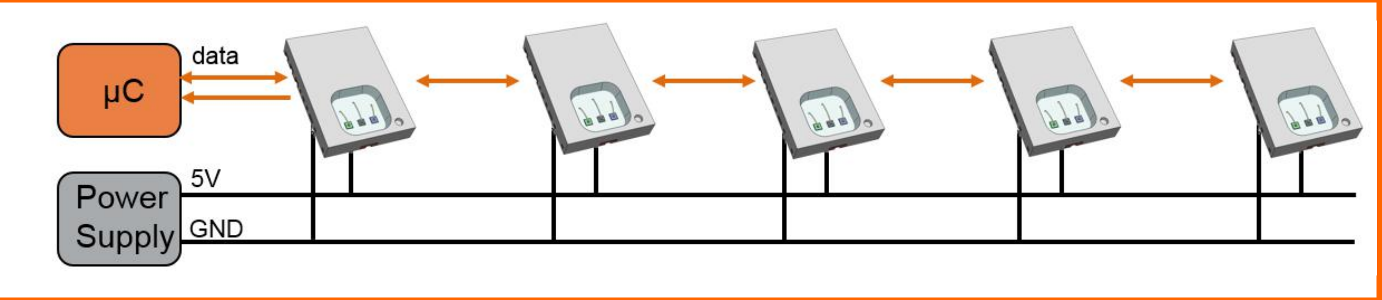
Group	Ellipse	Cx	Cy	a	b	Θ°
D65	3 Step	0.31271	0.32902	0.00669	0.00285	58.57

Brightness Group

Group	Luminous Intensity Colorsetpoint: RGB = 255/255/255	Unit
IC12	1200 ± 2%	mcd

Technical Advantages of Intelligent RGB (RGBi)

Solution based on Chain of RGBi



- PWM Engine: 12 bit per Color
- PWM frequency: 488Hz - 122Hz
- Driving scheme: 8 bit per Color (256 levels)
- Introduction of DIM value

  1 / 1:2 / 1:4 / 1:8 (rescale of 8bit)

✓ Calibration of LED µ-driver during package production test.
  - ➔ Compensation of light output variations is processed by IC in package.
  - ➔ Traceability of optical test data for each package is not needed for calibration.

✓ EMC-friendly technology.

✓ IC enables diagnostics (i.e. temperature)

✓ Included LED drivers and physical layer for communication in each package, allows a small and easy PCB design.

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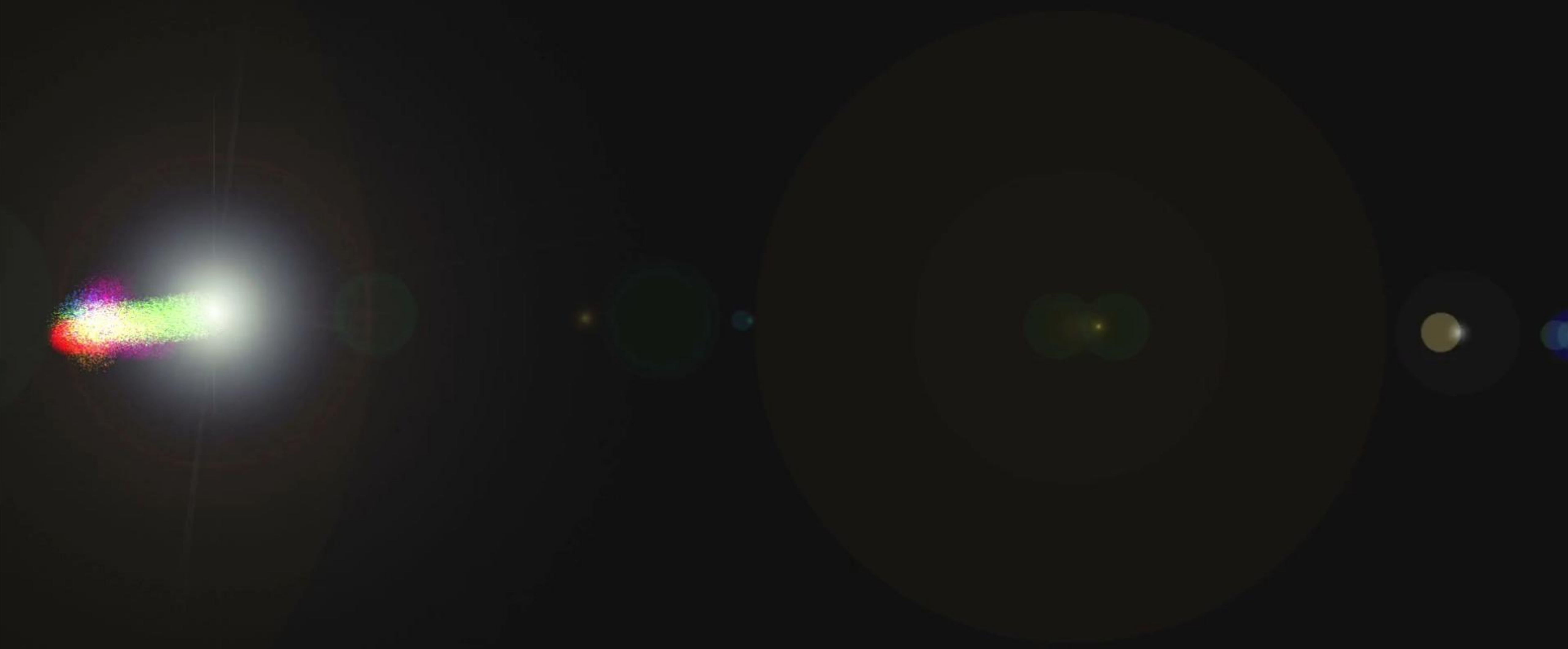

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