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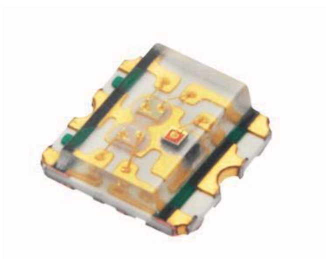
Surface Mount LED package



Application Note - General electric design characteristics and design guide to avoid uniformity issue

AN No.500303, Ver: 1.0

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Abstract

Liteon' s Surface Mount Type LED has been used anywhere in the worldwide with variety kinds of application. Historically, through-hole LED / Dot Matrix had dominated visible optical device applications by using Copper/ Aluminum / Iron leads as a standoff on the PCB in the past few decades. The Surface Mount Type LED provides a revolutionary way to mount on the PCB using the reflow process rather than auto insertion during PCB assembly.

This application clearly states how to appropriately make a spec selection among the various different specs under the same package to avoid the uniformity issue that is happened frequently in design in stage, based on different circuit design application

The description in the following chapter will focus on the low power visible LED (If<100mA), invisible devices(IR/Sensor/Photo-coupler) may not be appropriate to be applied to these instructions.

The low power LED of the Liteon SMD product line are listed as below, package type have chipLED(PCB based) and PLCC lead frame based.

A. Monochrome non-white.
B. Dual Color LED
C. White
D. RGB LED
E. IC Embedded LED

Note: Backlight and lighting (High power) white LED has more complicated rules for spec selections, please contact sales for technical assistance.

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A. Optical/Electrical Rating & Characteristics

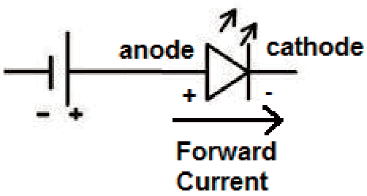
i. Maximum Power Dissipation

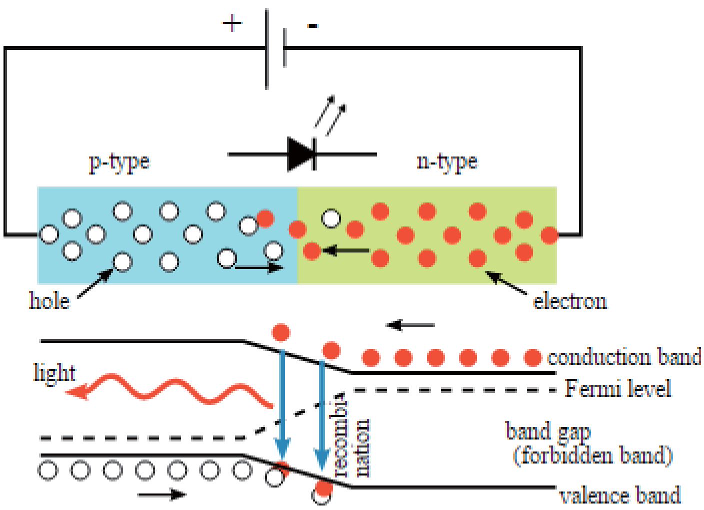
$$Pd = I_{f(Dice\ 1)} * V_{f(Dice1)} + I_{fMAX(Dice\ 2)} * V_{fMAX(Dice2)} + I_{fMAX(Dice\ 3)} * V_{fMAX(Dice3)}$$

Power dissipation is the maximum power under its thermal dissipation and LED dice capability that LED can be tolerate. Generally Liteon estimate this value by simulated with the maximum junction temperature in the core of the package.

ii. Peak/DC Forward Current

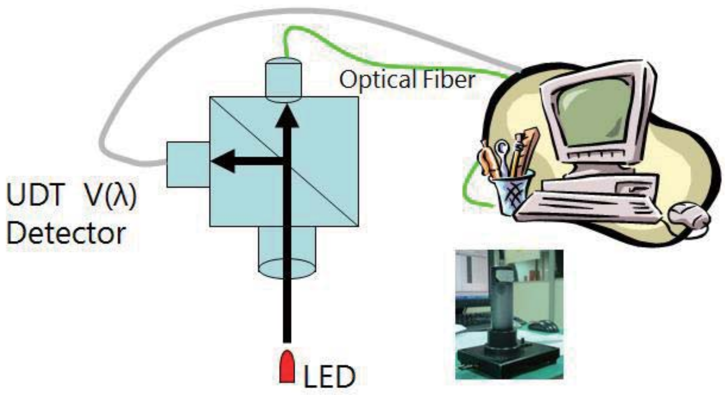
Forward current is a current flow across from LED's anode to cathode, to stimulate the combination electron and hole into light emission. The capability of the continuous(DC) forward current is usually defined by LED chip size, generally <10mil size LED chip is strongly recommended to apply under 20mA, while 10~15mil can be applied to 30~50mA, to avoid these chips operates over its max junction temperature and decrease its lifetime. A peak current should also be aware during design, which is different to continuous(DC) forward current. Please do not apply more current to LED than these specifications.





iii. Luminous intensity (Iv)

Liteon measures the luminous intensity by spectrometer CAS140, which sense the wavelength-weighted power and calculate the light source in X-axis, this simulates a standard model of the sensitivity of the human eye. The unit of Iv for SMD LED is mcd (mini-candela), a SI base unit



Tested with through beam splitter

iv. Viewing Angle

LED is a light emitting technology. Independent of which type of LED(SMD & Through Hole), whereas intensity of light depends on where it is adopted. This differs between maximum (perpendicular to the LED) and zero if the angle exceeds 90deg as per Fig. below.

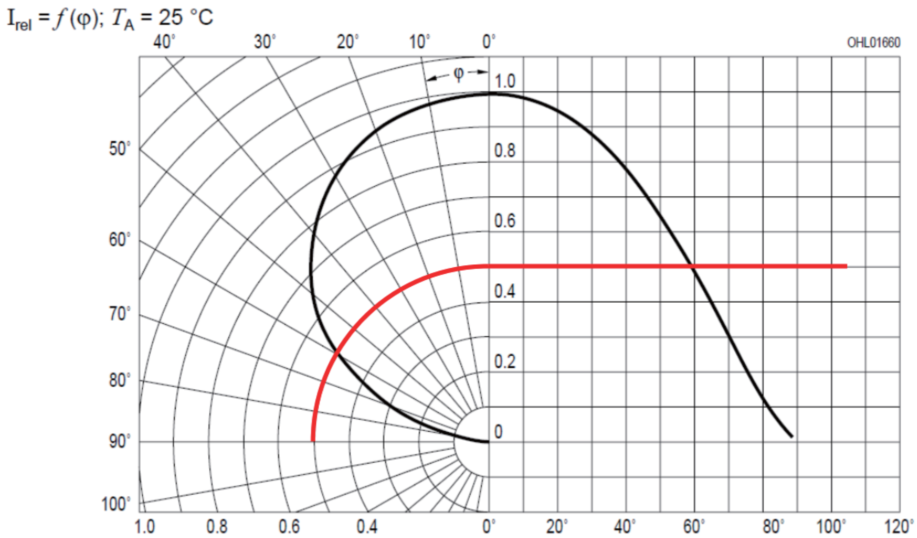


Fig.Typical radiation of an SMD LED

In the figure above the intensity is shown relative to the angle, whereas 0 is perpendicular to the light source or the LED. As per definition the viewing angle is defined as the angle where the measured light intensity is 50% of its maximum value, as per the **red line** in the fig. For this LED, which is typical for other SMD LED as well, the viewing angle to 50% brightness is 60%.

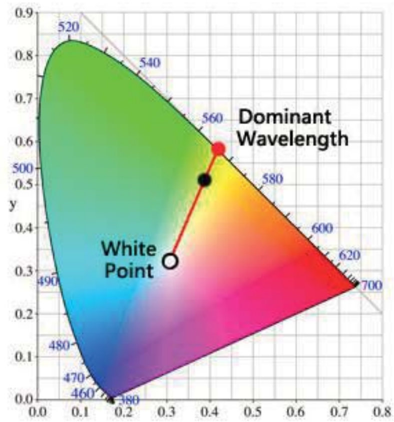
Since the SMD LEDs are of symmetrical lay-out, the viewing angle is 60% to all directions, both horizontally and vertically. This means the actual viewing angle of the L

LED can be specified as 120deg horizontally and 120deg vertically.
Some user will confused at the difference between nits and mcd, whereas the single LED is measured in candela (cd / mcd) , while a cluster/array of several LEDs is measured in candela per square meter (cd/m^2/nits). This value is always measured in product specifications , measured in perpendicular to the display surface and LEDs

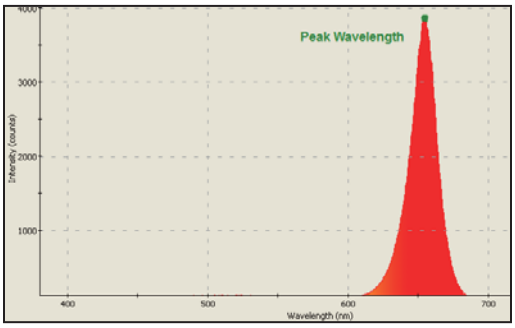
v. Peak Emission/Dominant Wavelength

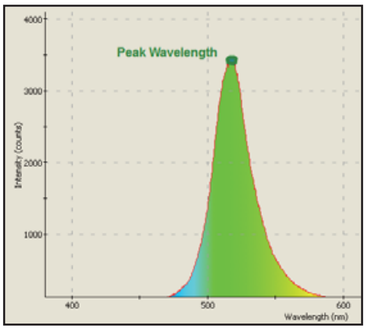
LED is a light emitting technology, emission wavelength of an LED is the wavelength that photons the LED can be. There are two types of the wavelengths that described in the datasheet. Dominant wavelength would be more critical in the normal applications.

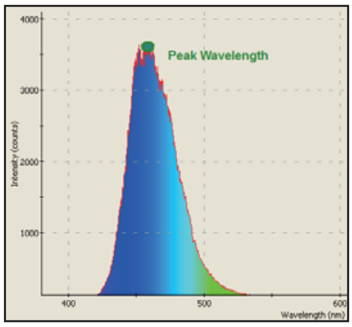
1. Dominant emission wavelength is the wavelength the LED emits the majority of the time, and this will be actually sensed by normal human eye. we generally follows CIE 1931 to calculate Actual (X,Y), and based on (X,Y), purity information we can calculate dominant wavelength.



2. The peak emission wavelength is a specification that shows that the LED can hit a higher wavelength than its typical wavelength, and serves as a maximum number. The difference in wavelength value may shift slightly and usually not enough to be noticeable.

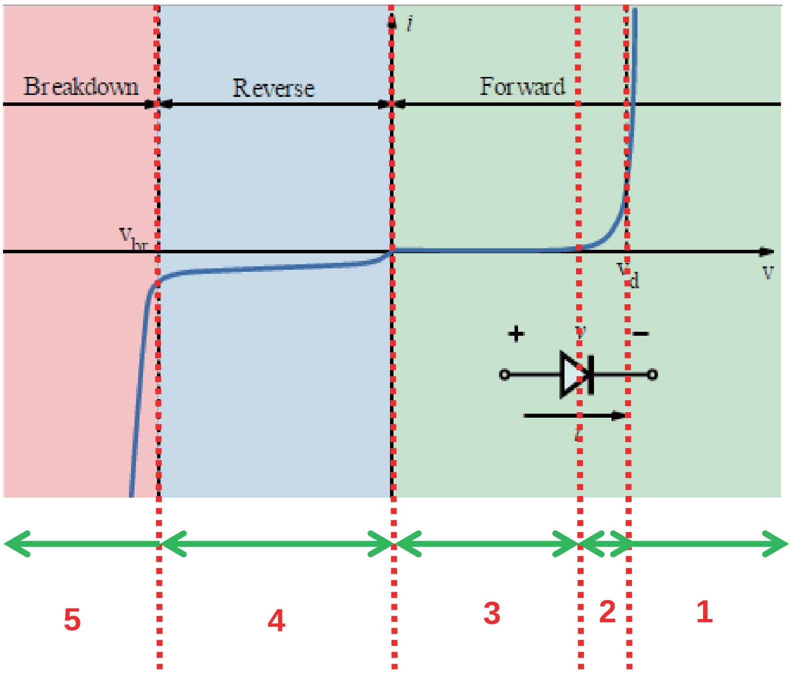






i. Forward voltage / Forward current

Forward voltage defines the amount of the voltage required in order to conduct electricity. Any voltages below this amount will cause the LED to remain open and non-conductive. This also means any components in-series with the LED will not have the current flowing them through either! Once the voltage dropped across the LED reaches the forward voltage, it will begin to conduct electricity.

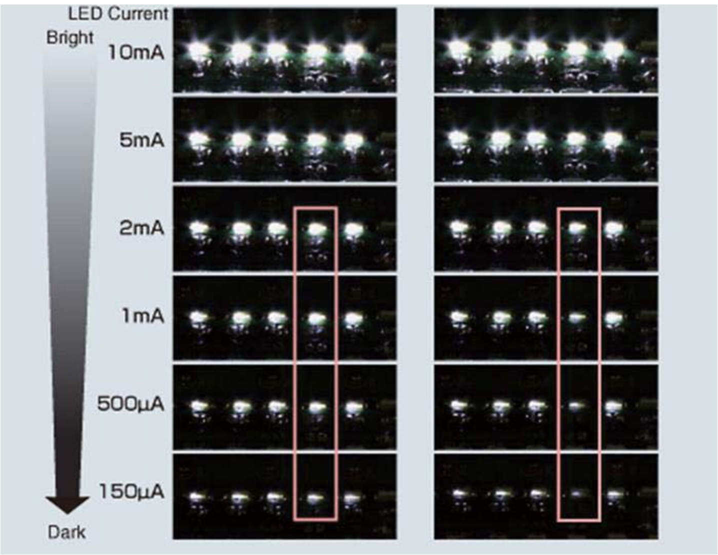


1. **V>V$_f$**:LED lits at Saturated/Active region
2. **V$_f$-0.2~0.3V<V<V$_f$**: Transient region, visibly LED is lit but unstable
3. **0< V< V$_f$-0.2~0.3V**: LED off
4. **V$_{br}$<V<0**: Reverse voltage before breakdown voltage, Reverse current occurred LED will not lit and potentially be damaged.
5. **V<V$_{br}$**: LED will be penetrate through with the reverse current, damage will not be recovered.

B. Uniformity issue - Phenomenon and intensity analysis

i. Phenomenon.

The uniformity issue often happens when several LEDs have been applied and operated in a limited space/section, humans can visibly compare their difference on its intensity and colors, and in general this comes from several causes. Especially in lower current has been applied (<5mA) since human eyes become more sensitive in dimmer intensity.



FigB1.Phenomenon of the uniformity issue

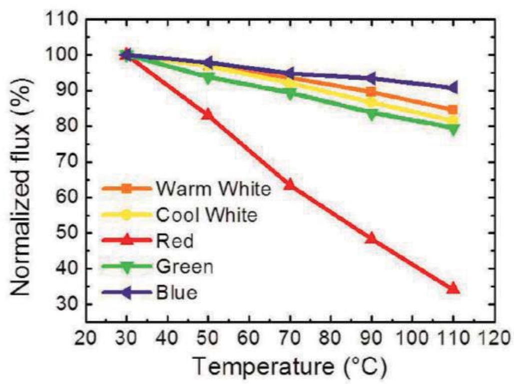
ii. Causes

1. Mixture of several different bins.

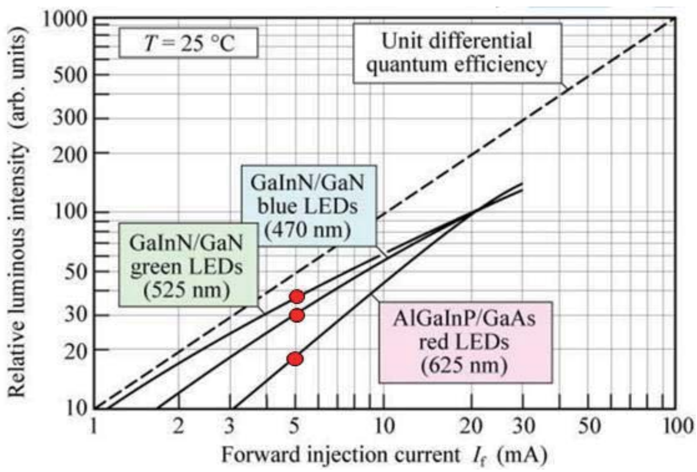
Mixture of bins usually results from lack of sufficient contact between customer and his SMT production line, for generic SMD LED part model, one complete Iv bin contains 40%~60% difference, and one Wd bin contains 4~6nm difference, this difference was defined based on customer's feedback for good uniformity. If customer/SMT production mix two different bins, Iv bin might reach 96%~156% intensity difference, while Wd would reach 8~12nm difference, this will definitely visibly be identified.

2. Applied condition far differs from test condition during production.

Some customer ignore it's binning test conditions, Liteon's SMD low power product line has several conditions on the forward current, normal/standard parts are 20mA , some parts has been applied with 2mA/5mA/10mA based on individual customer r equests or specific project applications. RD designer should take precautions on what actual forward current has been applied. Another key factor would be application temperature, since Liteon's test condition is based on 25 degree Celsius, change of the ambient temperature will impact its junction temperature to have different results of the intensity, please refer to the curve below.



FigB2.Temperature vs. Iv curve



FigB3.I_f vs. Iv curve

Some engineer will estimate the brightness for referring the If Iv curve, however, based on internal measurement, the curve have around 5~20% inaccuracy on the intensity estimation, this might occur uniformity issue when customer applied several LEDs in one section.

3. Ignorance of Vf bin impact.

Many of the designers apply the LEDs with the constant voltage, in many cases, some parts has no Vf bin , and therefore different forward current will be generated among different LEDs, that is intensity is out of control. Designers should take precautions to either add constant current circuitry or carefully control Vf bins during design, to avoid the problems.

4. RGB Signage application

Most RGB signage have already designed with constant current application, however, some signage design comes from ultra-fine pixel pitch, (<pitch 1.5mm), in this case, customer sometimes can visibly identify the difference, if for RGB binning, we would advise to narrow the Iv bin range to 50%, and Wd bin range to 30~40% and this can definitely eliminate this issue. Another effective solution is white CIE binning since human eyes is more sensitive for color mixing than separating into individual colors.

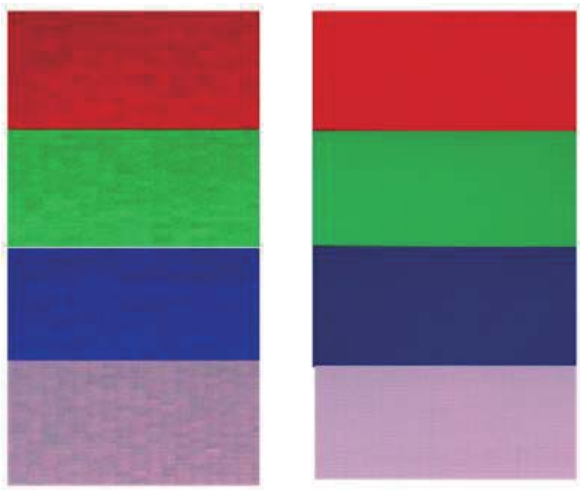
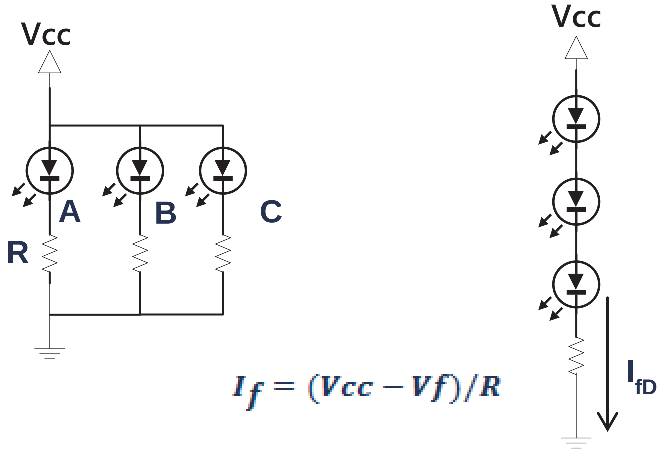


Fig.B4 Left: bad uniformity, Right: good uniformity

C. Design to dimming multi-LEDs with good uniformity

LED uniformity is critically relates to the LED forward current flow through to each individual LEDs, however the forward Below describes two ways to incorporate LEDs into circuit design:

i. **Fixed brightness (Turn On/Off only):** this sort of application is just simply connect the LEDs to the ground with a resistor, but when this circuitry has been applied with multi-LEDs, uniformity issues might happened if binning precautions has not been taken. An alternative option is to set up a simple circuitry with LDO, see Fig.B3 which makes the regulation more stable, and furthermore, constant current driving by LDO can avoid Vf mismatch issues, though more costly than resistor regulation. Just beware that Vf of the LED shall be less than output voltage of the LDO.



FigC1.Fixed Brightness=Serial FigC2.Fixed Brightness=Parallel

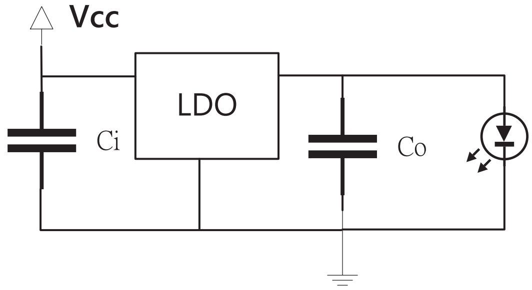
Example: Vcc = 3.3V, Vcc2 = 10 V R = 100ohm, Vf_{LEDA}= 2.8V, LED_{LEDB}= 3.0V, Vf_{LEDC} = 3.2V

If_{LEDA} = 5 mA

If_{LEDB} = 3 mA

If_{LEDC} = 1 mA

If_D = 10mA

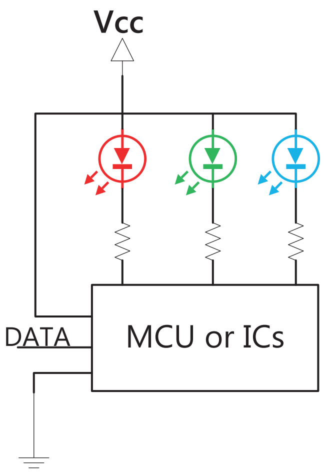


FigC3. Fix brightness by Linear Drive

Another solution is through linear regulator, with proper voltage adjustment and forward current selection, linear regulator can guarantee LED drives at the current without any forward voltage concern. The table below addresses the pros and cons between linear regulator and resistor driving.

	Resistor Drive	Linear Regulator
Vf mismatch between LEDs addressed	NO	YES
Vf change due to temperature addressed	NO	YES
Source voltage variation addressed	NO	YES
Tight current regulation	NO	YES
Simple solution	YES	YES
Costly solution	NO	YES (compared to resistor driver)
Efficient solution	NO	NO
Stable over wide-range of temperature	NO	YES

ii. **DC Dimming:** Dimming the LED with dynamic switching PWM through the ICs, this purpose can be achieved through DC dimming or constant current dimming. DC dimming is very popular in the past decades as this can change the PWM dynamically with simple circuitry, which can be supported by almost all types of MCU through GPIO control pins.



FigC4. DC Dimming (H= LED off/ L=LED on)

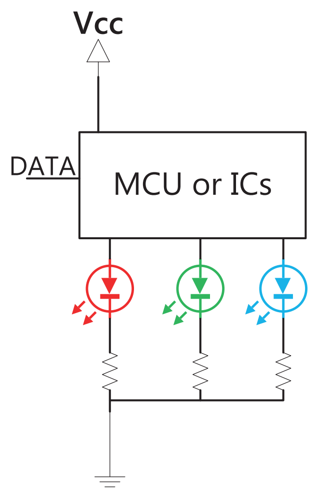


Fig.C5. DC Dimming (H=LED on/L=LED off)

iii. **Constant current Dimming:** Constant current circuitry also comes with several types, current can be set by external resistor, or some ICs are fixed or just program from the DATA pin. Since the current is fixed, Vf mismatch will not be a problem to cause uniformity issues.

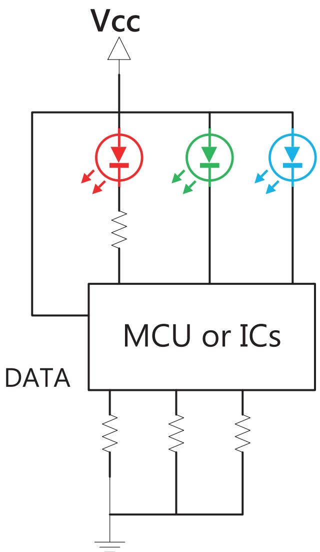


Fig C6.Constant current circuit, resistor defines the output current

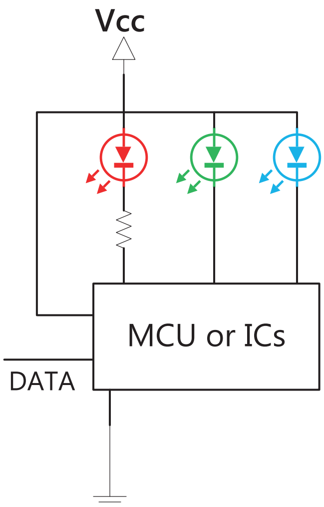


Fig C7. Constant current circuit, output current is either fixed or programmable through data pin.

iv. **Constant current dimming –** with multiplexing to reduce ICs: For some application like switch/LED matrix/ signs, connect one channel per LED would be a cost overhead for designer, in this case, we recommend users to incorporate with multiplexing IC to reduce input pins. The solution below can significantly reduce the qty. of LED driver usage.

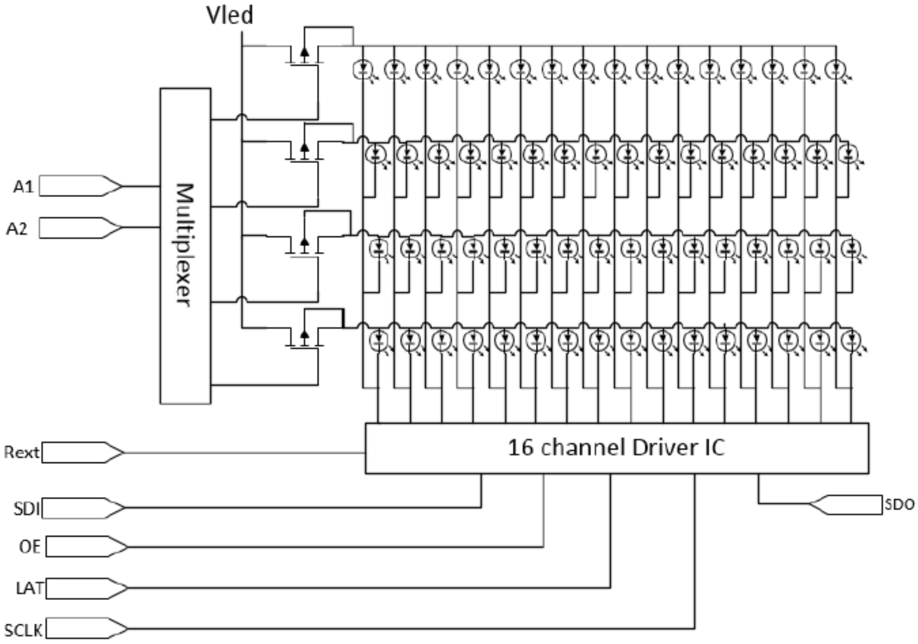


Fig C8. Constant current circuit design with driver IC

v. **Constant current Dimming –** Digital RGB (constant current driver embedded)

If the circuit overhead is critical and has no tolerance to create additional circuitry to achieve constant current purpose, Liteon has the IC embedded solution to simplify the circuit design, for example, LED strips/ curtains and decoration strings would be a suitable application for the design. Nevertheless, MCU GPIO is mandatory to create serial data signal for dimming each LED.

For more detailed information please refer to the application note the is specifically addressed for digital RGB operation.

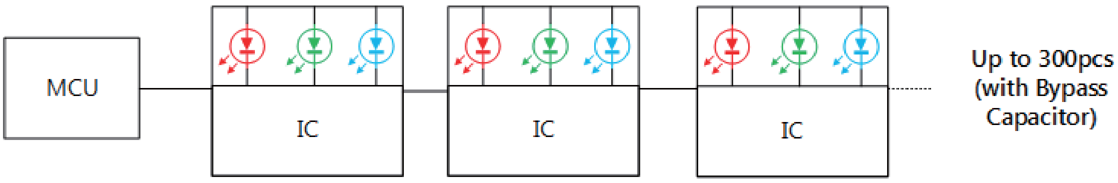


Fig C9. Digital RGB design – embedded with constant current IC

Here describes a short summary of guiding to select binning based on the application:

Requirement	LED Type	Wd(nm) [Appendix2,3]	Vf(Volt) [Appendix4]	Iv(Mcd ratio) [Appendix5]
I have no plan/space to add any IC/MCU in our design	Monochrome/dual	Other: 5~7nm per bin Red: no limitation	≦0.3V per bin	1:1.5~1.6
	RGB	CIE White binning	≦0.3V per bin	1:1.5~1.6
I will try to add LDO in the design	Monochrome/dual	Other: 5~7nm per bin Red: no limitation	No bin limitation	1:1.5~1.6
	RGB	CIE White binning	≦0.3V per bin	1:1.5~1.6
I will use MCU GPIO for LED in our design	Monochrome/dual	Other: 5~7nm per bin Red: no limitation	≦0.3V per bin	1:1.5~1.6
	RGB	CIE White binning	≦0.3V per bin	1:1.5~1.6
	Digital RGB	Other: 5~7nm per bin Red: no limitation Or CIE Bin	N/A	1:1.5~1.6
I will use MCU/IC with constant current design	Monochrome/dual	Other: 5~7nm per bin Red: no limitation	No bin limitation	1:1.5~1.6
	RGB	CIE White binning	No bin limitation	1:1.5~1.6

Note:

1. Apply current should be close to test current as possible[Appendix1.]
2. Please strictly follow “one bin” per set policy
3. Only used for apply “multi-leds” in one PCBA, no limit above if the usage is 1pcs per set
4. CIE binning represents x=0.025, y=0.025 per bin.
5. Please refer to appendix to get understand how to read datasheet binning.

D. Appendix.

1. Test current : current setting in the binning machine during operation

Luminous Intensity Color : Red , Unit : mcd @ 18mA		
Bin Code	Min.	Max.
S	180.0	280.0
T	280.0	450.0
U	450.0	710.0

2. Dominant Wavelength :

Dominant Wavelength Color : Red , Unit : nm @18mA		
Bin Code	Min.	Max.
R1	614.0	620.0
R2	620.0	6nm per bin 626.0
R3	626.0	632.0

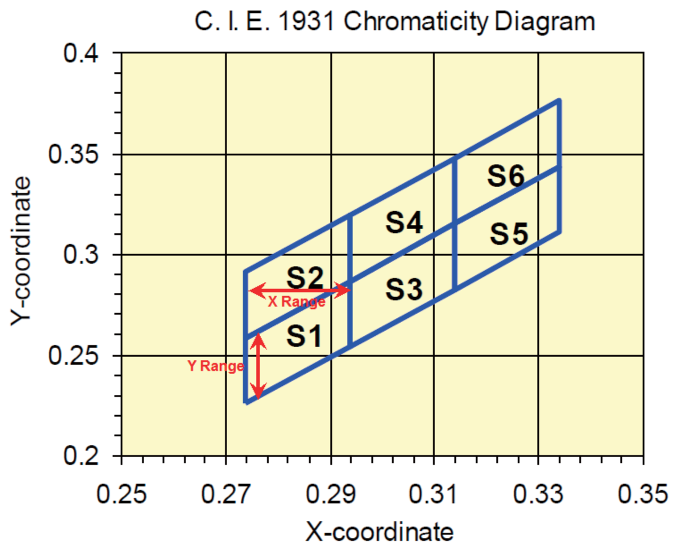
3. CIE binning:

■ **Hue Rank**

Color bin limits at IF = 5mA					
Bin Code	CIE 1931Chromaticity coordinates				
S1	x	0.274	0.274	0.294	0.294
	y	0.226	0.258	0.286	0.254
S2	x	0.274	0.274	0.294	0.294
	y	0.258	0.291	0.319	0.286
S3	x	0.294	0.294	0.314	0.314
	y	0.254	0.286	0.315	0.282
S4	x	0.294	0.294	0.314	0.314
	y	0.286	0.319	0.347	0.315
S5	x	0.314	0.314	0.334	0.334
	y	0.282	0.315	0.343	0.311
S6	x	0.314	0.314	0.334	0.334
	y	0.315	0.347	0.376	0.343

0.294-0.274 = 0.02
0.258-0.226=0.032

Tolerance on each Hue (x, y) bin is +/- 0.01



4. Vf binning: below example shows 0.1volt per bin

Forward Voltage Color : White , Unit : V @5mA		
Bin Code	Min.	Max.
V1	2.55	2.65
V2	2.65	2.75
V3	2.75	2.85
V4	2.85	2.95
V5	2.95	3.05
V6	3.05	3.15

Tolerance on each Forward Voltage bin is +/-0.1 volt

5. Iv(Luminous Intensity binnings)

■ **IV Rank**

Luminous Intensity Color : White , Unit : mcd @5mA			
Bin Code	Min.	Max.	
P	45.0	71.0	→ 71/45 = 1.58
Q	71.0	112.0	→ 112/71= 1.58
R	112.0	180.0	→ 180/112= 1.61

Tolerance on each Luminous Intensity bin is +/- 15%

LITE-ON TECHNOLOGY CORP.

About LITEON

Founded in 1975, Lite-On Technology is the longest running and largest-scale opto-electronic components supplier in Taiwan; based on the strong R&D resources, Lite-On has been able to cover extensive opto-electronic product lines including White LEDs, SMD LEDs, Lamp LEDs, LED Displays, Photo Couplers, Infrared Components etc. and is proven to be the leader in total opto-electronic components solutions.

Opto-electronic components products from Lite-On have been highly acclaimed and used by leading brands of information products, consumer electronics, and communication equipments. Lite-On opto-electronic components products are widely used for applications ranging from indicators and displays of household electronic appliances, backlights of personal handheld devices and IT products, active and passive lights in car electronics, industrial opto-electronic sensors, and light sources for all purposes.

Building on its professional packaging designs and sophisticated manufacturing experiences, Lite-On Technology not only has been able to provide customers with high-quality opto-electronic components solutions, but also has been constantly pursuing for high-performance and low-pollutant light sources as the major goal.

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