LIGHTING OF CARS & LOCOMOTIVES USING LED TECHNOLOGY

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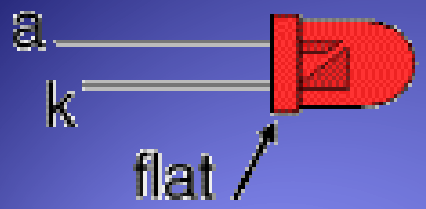
APRIL 3, 2013

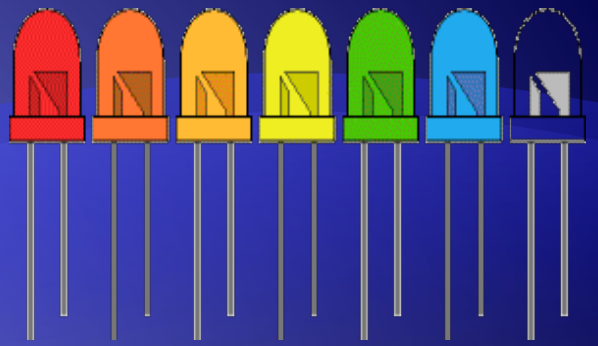
- Types of LED's available to the modeler
- LED Data Sheets
- Selecting the correct current limiting resistor
- SMD LED wiring, tools and soldering techniques
- Flicker-Free lighting
- Engine Lighting Effects

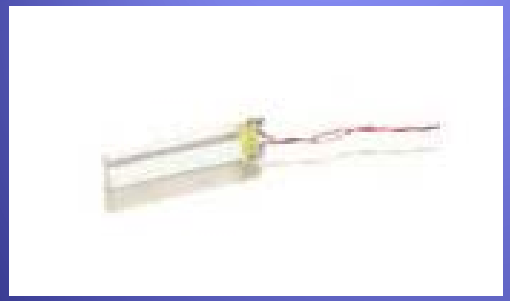
Types of LED's available to the modeler

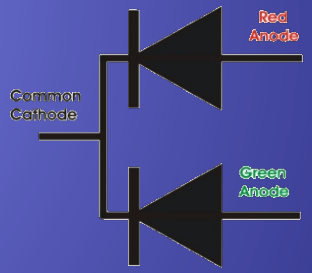
LED's come in many sizes, shapes and colors:

- T-1 3/4 – 5.0mm (.197")
- T-1 – 3.0mm (.118")
- 1.8mm Tower
- SMD (Surface Mount Device)
  - 1206 – .120 x .060 (3.05mm x 1.52mm)
  - 0805 – .080 x .050 (2.03mm x 1.27mm)
  - 0603 – .060 x .030 (1.52mm x 0.76mm)
  - 0402 – .040 x .020 (1.02mm x 0.51mm)
- PLCC (Plastic Leaded Chip Carrier)
  - Strips

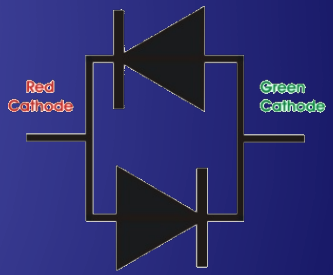




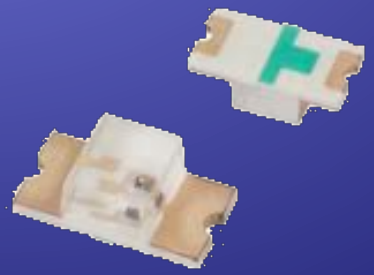


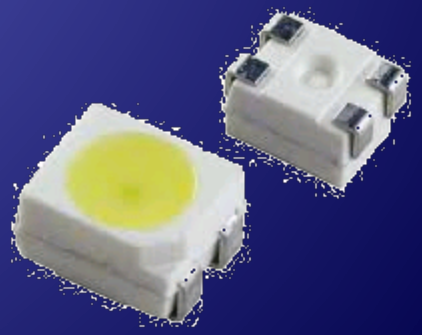


Bipolar
LED 3 Lead

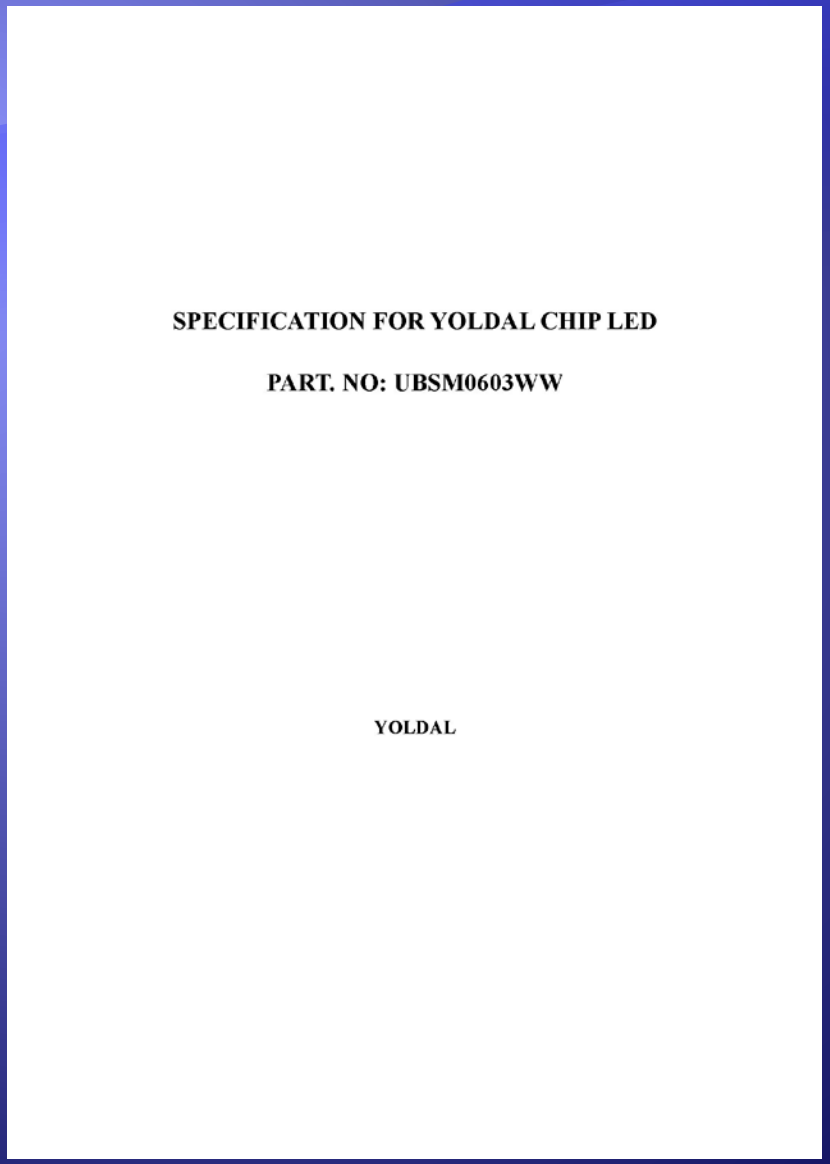


Bipolar
LED 2 Lead





LED Data Sheets



SPECIFICATION FOR YOLDAL CHIP LED

PART. NO: UBSM0603WW

YOLDAL

Features:

- Compatible with automatic placement equipment.
- Compatible with infrared and vapor phase reflow solder process.
- Uniform Sunny White color.

Descriptions:

- Much smaller than lead frame type components, enable smaller board size, higher packing density, reduced storage space and finally smaller equipment to be obtained.
- Lightweight for miniature applications.

Applications:

- **Model Railroad and Auto Headlights**
- Backlighting
- Indicators
- Switch and symbol
- General use

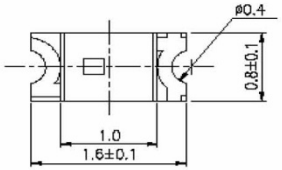
Benefits:

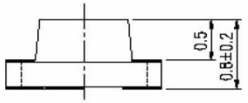
- Low Energy Consumptions
- Low Maintenance Costs
- High Application Design Flexibility
- High Reliability
- Very Competitive prices

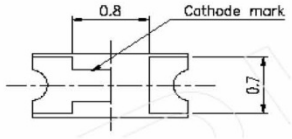
Device material descriptions:

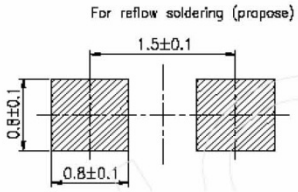
Part ID	Chip		Lens Color
UBSM0603WW	Material	Emitted Color	Yellow
	InGaN	Sunny White	Diffused

Package Outline Dimensions:









Notes: Tolerances Unless Dimensions, 0.1mm, Angles ± 0.5°, Unit: mm

■ **Absolute maximum ratings:**

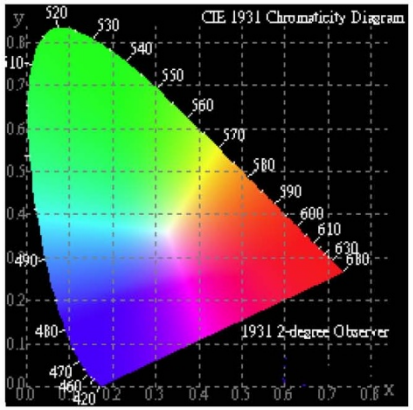
Parameter	Symbol	Rating	Unit
Reverse Voltage	V_R	5	V
Forward Current	I_F	20	mA
Operating temperature	Topr	-25 ~ +80	°C
Storage Temperature	Tstg	-30 ~ +85	°C
Soldering temperature	Tsol	260 (for 5 Second)	°C
Power Dissipation	Pd	80	mW
Electrostatic Discharge*	ESD	150	V
Peak Forward Current (Duty 1/10 @1KHz)	I_{PF}	100	mA

***Static Electricity Sensitive, care must be fully taken when handling this product.**

■ **Electro-Optical characteristics:**

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Luminous Intensity	I_V	-----	350	-----	mcd	I_F=20 mA
Viewing angle	2θ 1/2	-----	120	-----	Deg.	I_F=20 mA
Forward Voltage	V_F	-----	3.2	3.5	V	I_F=20 mA
Reverse Current	I_R	-----	-----	50	uA	V_R=5V
Chromaticity* X	X	-----	0.440	-----	-----	I_F=20 mA
Coordinate Y	Y	-----	0.450	-----	-----	

***C.I.E. 1931 Chromaticity Diagram.**



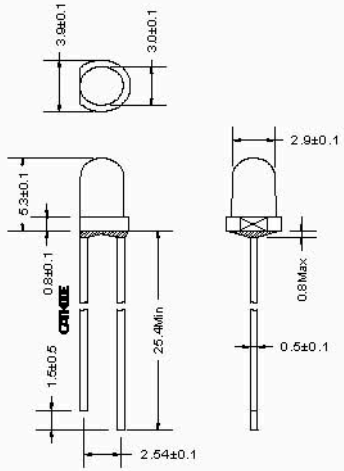
Part No./型号：330PWO4C

Features/特性：

- Single color/单色光
- High bright output/高亮度输出
- Low power consumption/低功耗
- High reliability and long life
  /可靠性高、寿命长

Descriptions/描述：

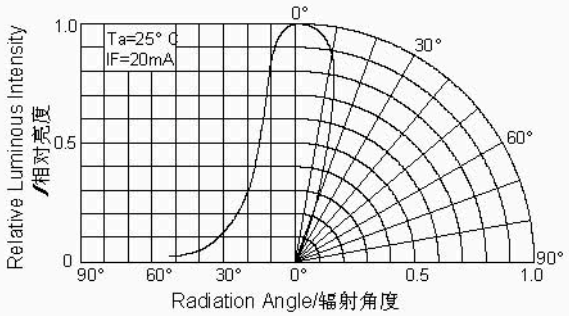
- Dice material/芯片材质：GaInN
- Emitting Color/发光颜色：
  Warm color white/暖白色
- Device Outline/产品外形：
  Φ3mm Cuppy Type/3mm 圆形
- Lens Type/胶体颜色：
- Water Clear/无色透明



NOTE/注意:

- All dimensions are millimeters/所有尺寸单位：mm.
- Tolerance is +/-0.20mmunless otherivise noted/未标注的公差均为±0.20mm

DIRECTIVITY/指向特性



Part No./型号：330PWO4C

Absolute maximum ratings/极限参数（Ta = 25℃）

Parameter 参数	Symbol 符号	Test Condition 测试条件	Value 数值		Unit 单位
			Min.	Max.	
Reverse Voltage 反向电压	V_R	I_R = 30μA	5	--	V
Forward Current 正向工作电流	I_F	----	----	25	mA
Power Dissipation 损耗功率	Pd	----	----	90	mW
Pulse Current 正向峰值电流	Ipeak	Duty=0.1mS，1kHz	----	100	mA
Operating Temperature 工作温度范围	Topr	----	-40	+85	℃
Storage Temperature 储存温度范围	Tstr	----	-40	+100	℃

Electrical and optical characteristics/光电参数（Ta = 25℃）

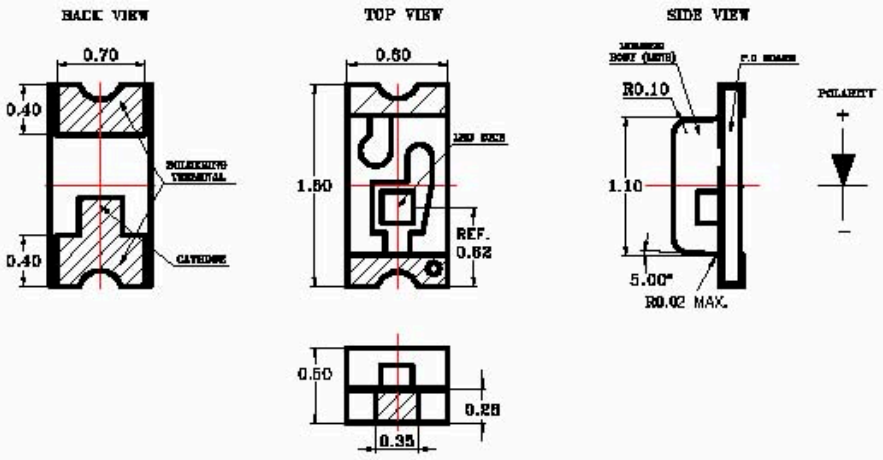
Parameter 参数	Symbol 符号	Test Condition 测试条件	Value 数值			Unit 单位
			Min.	Typ.	Max.	
Forward Voltage 正向电压	V_F	I_F = 20mA	----	3.2	3.6	V
Reverse Current 反向电流	I_R	V_R = 5V	----	----	30	μA
Luminous Intensity 发光强度	I_V	I_F = 20mA	----	4500	----	mcd
Viewing Angle 指向角度	2θ1/2	I_F = 20mA	----	30	----	Deg.

Luminous Intensity Bins Chart/亮度等级（Ta = 25℃）

Bin	W	X	Y	Z1
Min	3000	4000	6000	8000
Max	4000	6000	8000	10000

	SURFACE MOUNT DEVICE LED	
	Part No. : 0603KRCT	REV:A / 03

- PACKAGE OUTLINE DIMENSIONS



Notes:

1. All dimensions are in millimeters.
2. Tolerance is ± 0.1mm (.004") unless otherwise noted.

- Features

  - ✳ Top view, wide view angle, single color Chip LED.
  - ✳ Package in 8mm tape on 7" diameter reels.
  - ✳ Compatible with automatic Pick & Place equipment.
  - ✳ Compatible with Infrared and Wave soldering reflow solder processes.
  - ✳ EIA STD package.
  - ✳ I.C. compatible.

- Chip Materials
  - ＊ Dice Material : AlInGaP
  - ＊ Light Color : Super Red
  - ＊ Lens Color : Water Clear
- Absolute Maximum Ratings(Ta=25℃)

Symbol	Parameter	Rating	Unit
P_D	Power Dissipation	75	mW
I_{PF}	Peak Forward Current (1/10 Duty Cycle, 0.1ms Pulse Width)	80	mA
I_F	Continuous Forward Current	30	mA
-	De-rating Linear From 25℃	0.25	mA/℃
V_R	Reverse Voltage	5	V
ESD	Electrostatic Discharge Threshold(HBM)Note A	2000	V
Topr	Operating Temperature Range	-40 ~ +85	℃
Tstg	Storage Temperature Range	-40 ~ +85	℃
-	Wave Soldering Condition (Two times Max.)	260 (for 5 seconds)	℃
-	Infrared Soldering Condition (Two times MAX.)	240 (for 10 seconds)	℃

Note A :

HBM : Human Body Model. Seller gives no other assurances regarding the ability of to withstand ESD.

- Electro-Optical Characteristics(Ta=25℃)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Test Condition
Luminous Intensity	IV	16.0	40.0	80.0	mcd	IF=20mA
Viewing Angle	2θ1/2		130		deg	Note 2
Peak Emission Wavelength	λp		639		nm	Measurement @Peak
Dominant Wavelength	λd		631		nm	IF=20mA
Spectral Line Half-Width	Δλ		17		nm	
Forward Voltage	VF		1.9	2.4	V	IF=20mA
Reverse Current	IR			100	μA	VR=5V

- Typical Electro-Optical Characteristics Curves

(25℃ Ambient Temperature Unless Otherwise Noted)

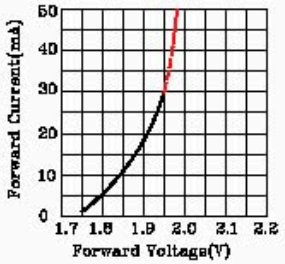


Fig.2 Forward Current vs. Forward Voltage

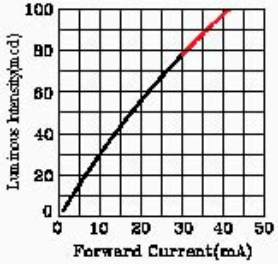


Fig.3 Luminous Intensity vs. Forward Current

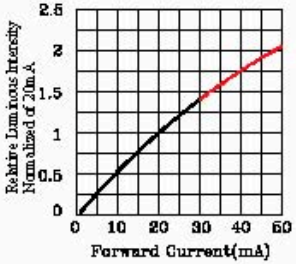


Fig.4 Relative Luminous Intensity vs. Forward Current

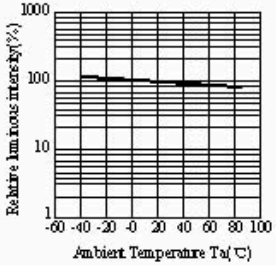


Fig.5 Luminous Intensity vs. Ambient Temperature

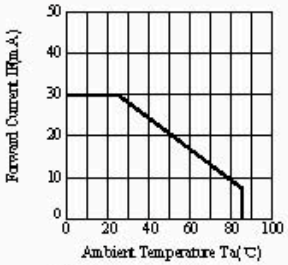


Fig.6 Forward Current Derating Curve

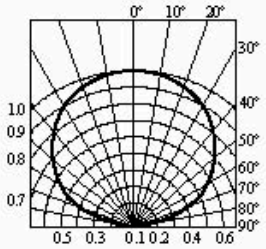


Fig.7 Relative Intensity vs. Angle

- Chip Materials
  - ＊ Dice Material : InGaN
  - ＊ Light Color : Super Green
  - ＊ Lens Color : Water Clear

- Absolute Maximum Ratings(Ta=25℃)

Symbol	Parameter	Rating	Unit
P_D	Power Dissipation	100	mW
I_{PF}	Peak Forward Current (1/10 Duty Cycle, 0.1ms Pulse Width)	100	mA
I_F	Continuous Forward Current	25	mA
-	De-rating Linear From 25℃	0.25	mA/℃
V_R	Reverse Voltage	5	V
ESD	Electrostatic Discharge Threshold(HBM)Note A	150	V
Topr	Operating Temperature Range	-40 ~ +85	℃
Tstg	Storage Temperature Range	-40 ~ +85	℃
-	Wave Soldering Condition (Two times Max.)	260 (for 5 seconds)	℃
-	Infrared Soldering Condition (Two times MAX.)	240 (for 10 seconds)	℃

Note A :
HBM : Human Body Model. Seller gives no other assurances regarding the ability of to withstand ESD.

- Electro-Optical Characteristics(Ta=25℃)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Test Condition
Luminous Intensity	IV	63.0	160	320	mcd	IF=20mA
Viewing Angle	2θ1/2		130		deg	Note 2
Peak Emission Wavelength	λp		518		nm	Measurement @Peak
Dominant Wavelength	λd		525		nm	IF=20mA
Spectral Line Half-Width	Δλ		15		nm	
Forward Voltage	VF		3.1	3.8	V	IF=20mA
Reverse Current	IR			100	μA	VR=5V

- Typical Electro-Optical Characteristics Curves

(25°C Ambient Temperature Unless Otherwise Noted)

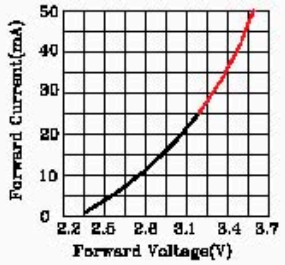


Fig.2 Forward Current vs Forward Voltage

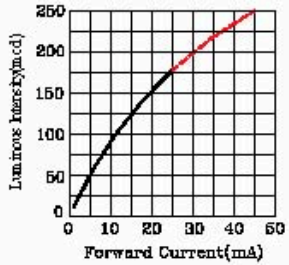


Fig.3 Luminous Intensity vs. Forward Current

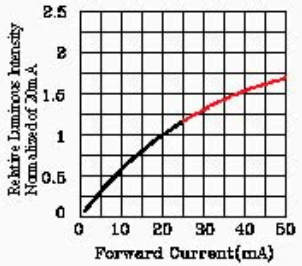


Fig.4 Relative Luminous Intensity vs. Forward Current

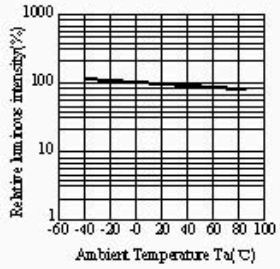


Fig.5 Luminous Intensity vs. Ambient Temperature

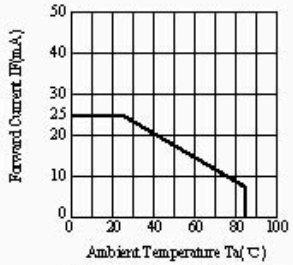


Fig.6 Forward Current Derating Curve

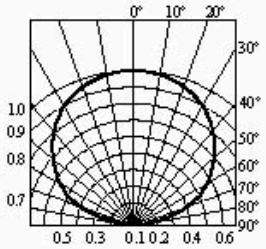
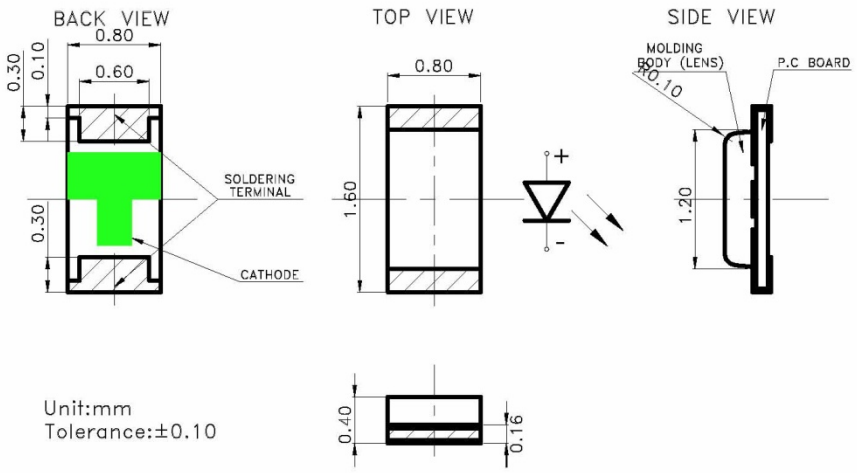


Fig.7 Relative Intensity vs. Angle

SURFACE MOUNT DEVICE LED

Part No. : 0603LWCT

- Features
  - ∗ Extra thin 0.4mm, Top view, Wide view angle, Bluish White color SMD chip LED .
  - ∗ Special for Cellular Phone keypad / LCD backlighting or thin touch button LED backlighting.
  - ∗ Packing in 8mm tape on 7" diameter reels.
  - ∗ Compatible with automatic Pick & Place equipment.
  - ∗ Compatible with Reflow soldering and Wave soldering processes.
  - ∗ EIA STD package.(ANSI/EIA-481-B-2001)
  - ∗ I.C. compatible, low current application
  - ∗ Pb free product and acceptable lead-free process!.
- PACKAGE OUTLINE DIMENSIONS



Notes:

1. All dimensions are in millimeters.
2. Tolerance is ± 0.1mm (.004") unless otherwise noted.

CHIP MATERIALS

* Dice Material : InGaN
* Light Color : Bluish White
* Lens Color : Light Yellow Diffused.

Absolute Maximum Ratings(Ta=25℃)

Symbol	Parameter	Rating	Unit
P_D	Power Dissipation	76	mW
I_{PF}	Peak Forward Current (1/10 Duty Cycle, 0.1ms Pulse Width)	80	mA
I_F	Continuous Forward Current	20	mA
-	De-rating Linear From 25℃	0.25	mA/℃
V_R	Reverse Voltage	5	V
ESD	Electrostatic Discharge Threshold(HBM)[Note A]	150	V
Topr	Operating Temperature Range	-20 + 85	℃
Tstg	Storage Temperature Range	-40 ~ + 85	℃
-	Wave Soldering Condition (Two times Max.)	260 (for 5 seconds)	℃
-	Infrared Soldering Condition (Two times MAX.)	240 (for 10 seconds)	℃

Note A :

HBM : Human Body Model. Seller gives no other assurances regarding the ability of to withstand ESD.

Electro-Optical Characteristics(Ta=25℃)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Test Condition
Luminous Intensity	IV	25	60		mcd	IF=5mA
Viewing Angle	2θ1/2		130		Deg	Note 2
CIE Chromaticity	X	0.19		0.22		IF=5mA
CIE Chromaticity	Y	0.14		0.18		
Forward Voltage	VF		2.8	3.15	V	IF = 5mA
Reverse Current	IR			50	μA	VR = 5V

- Typical Electro-Optical Characteristics Curves

(25℃ Ambient Temperature Unless Otherwise Noted)

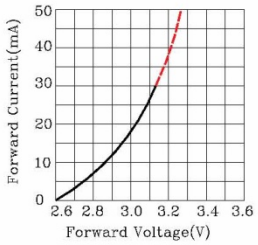


Fig.2 Forward Current vs.Forward Voltage

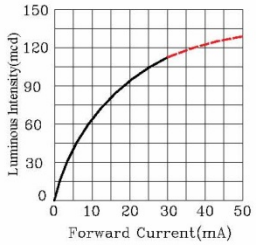


Fig.3 Luminous Intensity vs.Forward Current

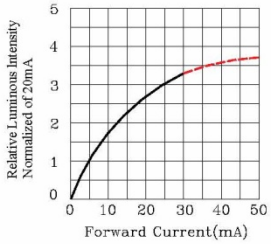


Fig.4 Relative Luminous Intensity vs.Forward Current

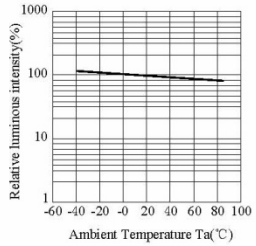


Fig.5 Luminous Intensity vs.Ambient Temperature

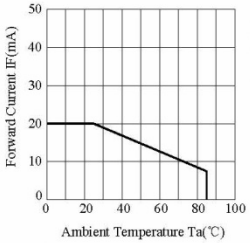


Fig.6 Forward Current Derating Curve

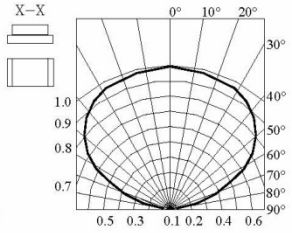


Fig.7 Relative Intensity vs.Angle

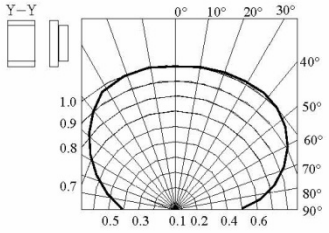
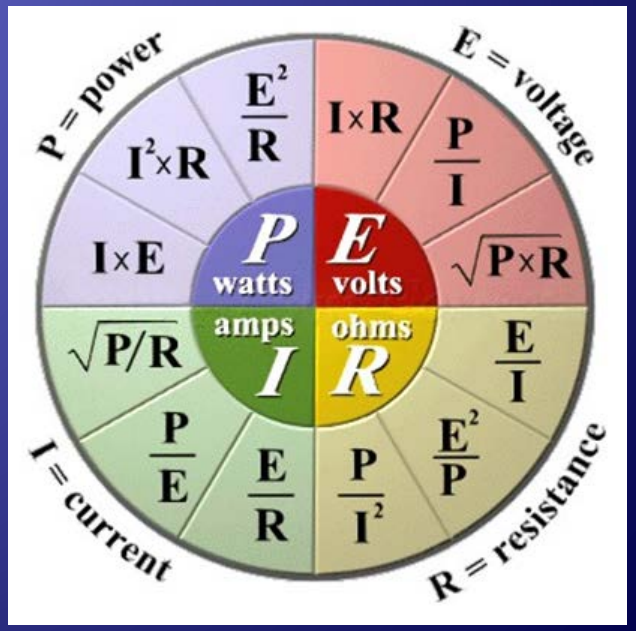


Fig.7 Relative Intensity vs.Angle

Selecting the correct current limiting resistor

- Oh, stick a 1K Ohm resistor in there and you're good to go!
- Get V_f and I_f from Data Sheet
- Measure Voltage source (If unknown)
  - In Series Circuits, Current is common
- Use Ohm's Law to calculate resistance
  - E = I x R, I = E/R, R = E/I
- Determine Wattage



Use Ohm's Law to calculate resistance

- George (Georg) Simon Ohm (1789 -1854), a German physicist, discovered the relationship between applied voltage, current flow and various lengths of wire (resistance).
- Ohm's Law expresses these relationships as follows:
- *The current flowing in a circuit is directly proportional to the applied EMF and is inversely proportional to the resistance.*
- When expressed as an equation it takes the form: I = E/R (I = E divided by R).
- Where:
  I = current in Amperes
  E = EMF (Electromotive Force) in Volts
  R = resistance in Ohms (The Greek letter Omega and the symbol - Ω)
- The equation above solves for the value of current flowing in a circuit when voltage and resistance values are known. This equation can be transposed, allowing any of the three quantities to be determined if the remaining two are known:
- E = IR (E = I times R) solves for the value of the voltage applied to a circuit when the current and resistance values are known.
- R = E/I (R = E divided by I) solves for circuit resistance when applied voltage and current flow are known.
- It is important to remember that the units of measurement used in the expression are Amperes, Volts and Ohms. Other units such as milliamperes (1/1000th of an ampere), Kilohms (K ohms) or Kilovolts (1000 volts) must be converted before using the equation.

Example:

- 10 mA (milliamperes) is flowing in a circuit with 12 Volts applied, what is the circuit resistance?
- 10 mA = .01 Ampere
  R = E/I
  R = 12/.01 = 1200 Ohms (1.2k Ohms)

- Ohm's Law Triangle
- The Ohm's Law Triangle shown above is a memory aid used to help remember the formula required to solve for an unknown circuit value.
- Simply cover the unknown quantity (the value that you are trying to find) and the remaining values and their relationship to each other will indicate mathematical operation required to solve for the unknown quantity.
- For example, to solve for voltage (E) cover the E, the remaining values I and R are side-by-side indicating multiplication. If solving for current (I), cover the I and the remaining value E is over R indicating division.

Example for engine or car lighting using an LED:

We'll assume DCC Voltage is 14Volts, the LED forward voltage (V_f) is 3V and the forward current (I_f) is 20mA and this is a Series circuit.

Subtract V_f from the source Voltage: 14V – 3V = 11V.

Using Ohm's Law, solve for resistance value:

11V / 20mA = 550 Ohms

Are we done????

Calculate Wattage

- Power, the rate of doing work, in an electrical circuit is equal to the applied voltage multiplied by current. The basic unit of electrical power, the Watt, is named after James Watt (1736 - 1819) in honor of his work contributing to the development of the steam engine. One Watt is equal to one Volt multiplied by one Ampere.
- When expressed as an equation it takes the form: P = IE (P = I times E).
- Where:
  P = power in Watts
  I = current in Amperes
  E = EMF (Electromotive Force) in Volts

- The equation above solves for the value of the power dissipated in a circuit when voltage and current values are known. This equation can be transposed allowing any of the three quantities to be determined if the remaining two are known:
- I = P/E (I = P divided by E) solves for the value of the current flowing in the circuit when the power and voltage values are known.
- E = P/I (E = P divided by I) solves for applied voltage when the power and current values are known.

SMD LED Wiring

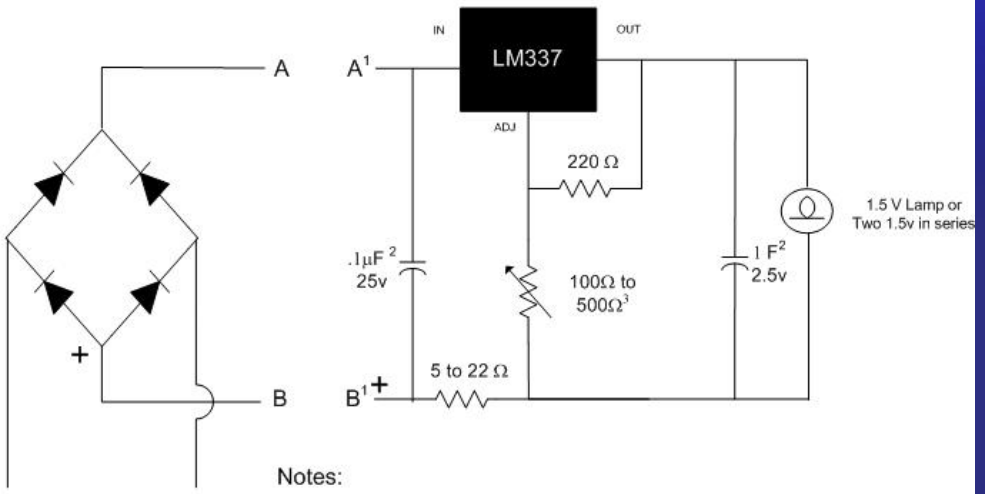
- Magnet Wire
- Wire Wrap Wire
- Teflon Coated Wire

Tools and Soldering Techniques

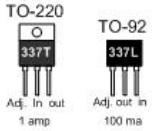
- Resistor Selection/Decade Box
- Soldering Iron/Station
- Workspace Lighting
- Magnifier
- Optivisor
- Tweezers
- SMD holding device
- Double Sided Tape
- Solder
- LED Tester

Flicker-Free Lighting

DC or DCC Car/Caboose Non-Flicker Lighting Circuit



DCC or DC Track Power



All resistors are ¼ watt.
Bridge Rectifier is 50v 1 amp

Notes:

1. This circuit can be connected either to the track through a bridge rectifier as shown or a function output of a decoder. The function output is connected to A and the + output on the decoder is connected to B. The 5 to 22Ω resistor reduces the capacitor inrush current below 120 ma, to prevent the DCC system from going into a short. It causes a delay of less than 30 seconds before the light comes on. The lower the resistor value the faster the capacitor charges, but the higher the inrush. I use 10Ω most of the time. It is required with a decoder connection or you will burn out the function output.

2. The capacitor is a super gel capacitor that can be purchased from almost any big internet supply house. I get mine from Digi-key or Mouser Electronics. They are low voltage. If you need more that 3 volts put two in series. The .1µF capacitor is needed when using the super gel capacitor to filter the input.

3. Use a 100Ω Potentiometer for less than 2 volts output and a 500Ω Potentiometer for 2 to 5 volts output.

By Bob Rohwer
Sacramento Model Railroad Society

Engine Lighting Effects

LED's Verses Incandescent

- Forward/Backup Lights
- Markers
- Car Lighting
- Ditch lights
- Mars Light
- Pyle Gyralite
- Strobes
- Flashers

Tamaya Clear Paints

X-23

X-24

X-25

X-26

X-27

Resources

- LED Sources:
  - LEDBaron - http://stores.ebay.com/ledbaron?_rdc=1 - Germany
  - BestShop - http://shop.ebay.com/bestshop2008hk/m.html?_trksid=p4340.l2562 - Hong Kong
  - HiTechWorld - http://shop.ebay.com/hitechledworld/m.html?_trksid=p4340.l2562 - Hong Kong
  - Kingbright - http://www.kingbrightusa.com/default.asp - USA
  - Hebei Ltd. - http://www.hebeiltd.com.cn/?p=product - Shanghai, China - $99.00 minimum order
  - Litchfield Station - http://www.litchfieldstation.com/xcart/home.php - USA
  - Ngineering - http://www.ngineering.com - USA
  - Richmond Controls - http://www.richmondcontrols.com – USA
  - LED-Switch - http://www.led-switch.com/ - USA
- Wire, etc.
  - Tech-Fixx - http://www.ebay.com/sch/tech-fixx/m.html?item=171006897477&pt=Motors_Car_Truck_Parts_Accessories&vxp=mtr&hash=item27doce2d45&rt=nc&_trksid=p2047675.l2562 - USA
  - Ngineering - http://www.ngineering.com - USA
- Fiberoptics
  - The Fiber Optic Store - http://www.thefiberopticstore.com/purchase/endglowfilament.htm#BTF - USA (by the foot sales)

Resources Continued

- Tool & Part Sources:
  - MCM Electronics – http://www.mcmelectronics.com
  - Jameco Electronics – http://www.jameco.com
  - Ngineering – http://www.ngineering.com
  - Micro-Mark – http://www/micromark.com
  - Harbor Freight – http://www.harborfreight.com
  - Ulrich Models Hobby Store – http://www.ulrichmodels.biz/servlet/StoreFront
- Surplus Sources
  - All Electronics – http://www.allelectronics.com/
  - Electronic Goldmine – http://www.goldmine-elec.com
  - Marlin P. Jones & Associates – http://www.mpja.com

The End…

…or is it?