

Reference Design Note

Magl³C Power Modules DNS001 Magl³C LED Driver



1. Introduction

The rated power and thus the lumen of LEDs on the lighting market is constantly increasing. High power LEDs require a current of 700 mA, 1 A or more. Although high output currents are commonly supported by voltage regulated modules, high current LED driver modules are difficult to find in the market.

The Magl³C LED Driver 178001 demonstrates how a Magl³C Power Module can be used for applications that require a current source for high power LEDs or for battery charging. This reference design is capable of driving up to 1.5 A of output current using a voltage regulated module and an external secondary regulation loop to establish current regulation. The external loop regulates a DC output current, which results in a constant photon output from the LED.

An adjustable output current limit can be set from 10mA to 1.5A, turning the module into a constant current source.

Output currents can have arbitrary waveforms, allowing the imitation of the flickering light of a candle with LEDs or light bulbs.

Batteries can be charged with a DC current or with a defined charging current waveform if a digital to analog converter or a PWM output of a microcontroller is used to adjust the output current of the Magl³C LED Driver.

During the development of a customer's prototype, the Magl³C LED Driver can be connected by wires or via SMD Footprint to the prototype PCB until the LED Driver is merged into the customers PCB for the final product.

Compared to other solutions with pulsed LED current, this solution is less harmful to the eyes due to the constant photon flow, allowing the pupil opening to be the proper size for the light intensity emitted.

Depending on the LED flux voltage, up to 4 white high power LEDs can be connected in series - or up to 6 color high power LEDs.



Figure 1. Magl³C LED Driver – Order Code 178001

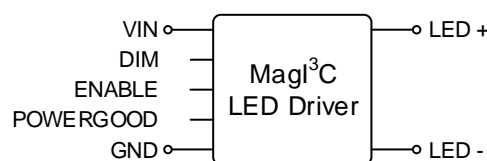


Figure 2. Typical Circuit Diagram

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2. Specifications

Electrical Specifications

- | | |
|---------------------------------------|-------------------------|
| ▪ Input Voltage Range | 7V – 36V |
| ▪ Input Voltage Transients | Max. 45V |
| ▪ Output Voltage Range | 0V – V_{IN} |
| ▪ Output Current Limit | 10mA – 1.5A |
| ▪ Output Current Ripple | 10mA _{pp} typ. |
| ▪ Maximum Output Power | 22.5W |
| ▪ Switching Frequency | 400kHz |
| ▪ Operating Ambient Temperature Range | -40°C to +85°C |
| ▪ DIM Voltage | 0V – 5V |

Features

- PWM or Voltage Dimming
- Enable/Disable Function
- Power Good Signal
- Allows SMD Pick & Place

3. Functional Diagram

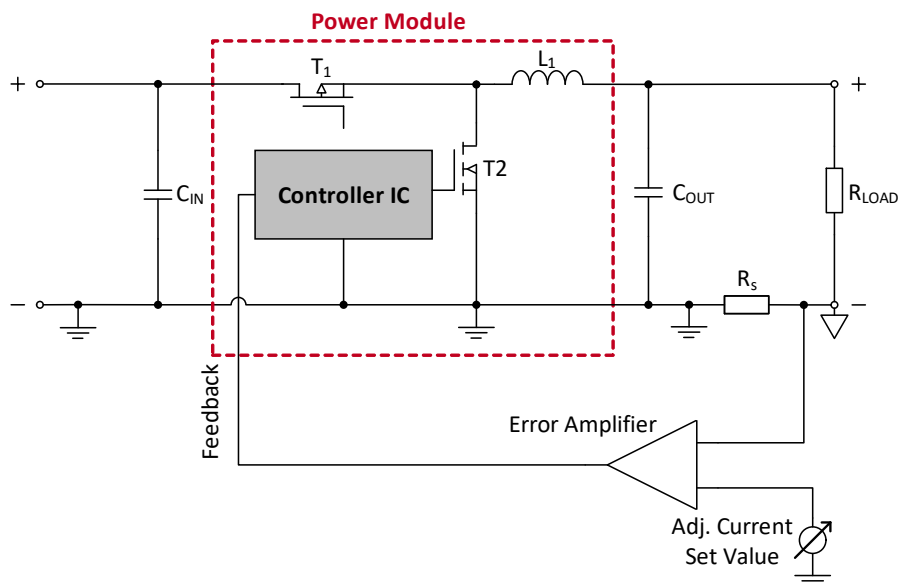


Figure 3. Functional Diagram

The error amplifier compares the set value of the output current to its actual value measured at R_S and adjusts the voltage at the power module's feedback pin maintaining the set output current value.

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4. Mounting on a PCB

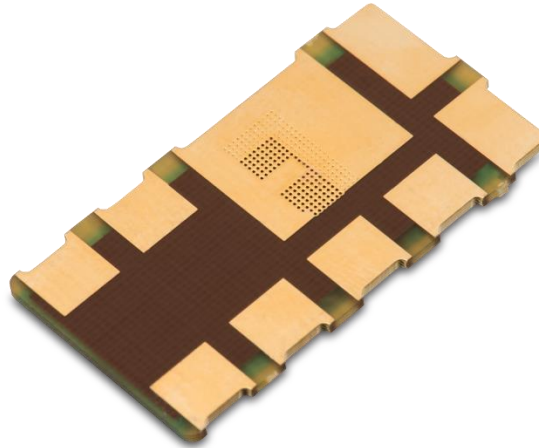


Figure 4. Bottom Side of the Magl³C LED Driver

The Magl³C LED Driver is designed as a 4 layer PCB with copper pads on the bottom for allowing for easy soldering of wired or other connectors. The Magl³C LED Driver can be soldered directly to a motherboard either by reflow or by hand, if an appropriate footprint is placed on the motherboard. For easy hand soldering, the edges of the Module's PCB are also covered with copper that can be used to heat up the Module's copper pads for soldering.

4.1 Footprint

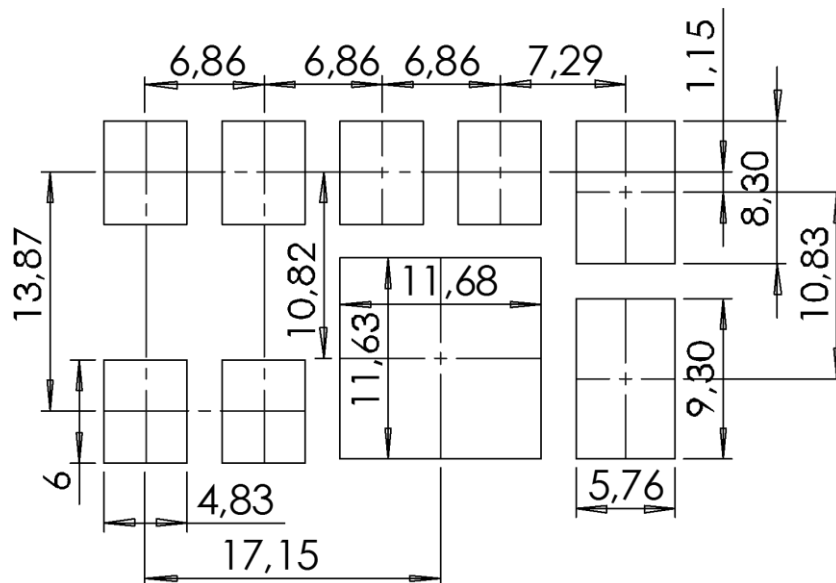


Figure 5. Footprint for Soldering the Magl³C LED Driver

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5. Circuit Description

In figure 6, C2 is the low impedance input capacitor for the MagI³C LED Driver. The switching current flows through this capacitor when the power module's high side FET conducts. It is recommended to choose all input capacitors of the same type (order code) to prevent resonance between capacitors with different impedances – if multiple ceramic capacitors at the input are used, for example, additional capacitors on the motherboard near the MagI³C LED Driver. C3 is the output capacitor of the MagI³C LED Driver. It is an MLCC type with very low ESR and assures a low output voltage ripple. The default internal switching frequency of 400kHz is used.

To set the LED current, an external dimming (adjusting) voltage is always required for operation. If 0V is applied at the DIM pin, the output current is about 10mA. Increasing the DIM voltage to 5V increases the output current linearly to 1.5A.

If the Enable pin is tied to GND, the MagI³C LED Driver is shut down and the output current will be 0A.

If no load is applied, the regulation loop increases the output voltage to a level close to the input voltage. The set value of the output current can not be reached as no load is connected. The Power Good Signal (POWERGOOD) is an open drain output and can be used to detect the no load condition.

5.1 Output Current Regulation

The voltage across the current sense resistor, R3 is proportional to the output current and referenced to the analog ground. This actual value of the output current is passed to the non inverting input (pin3) of the error amplifier IC3-a. The regulation loop maintains the actual value of the output current to the set value of the output current given by the voltage level at the DIM pin.

5.2 Auxiliary Power

The linear regulator IC2 is used to supply the error amplifier with 3.3V. IC2 is stable with output capacitors with at least 10mΩ ESR, so a 20mΩ resistor, R2 is used to increase the output capacitor's ESR by 20mΩ.

5.3 Optional Current Setting Using a Microcontroller

The output current can be dynamically set by a PWM signal from a microcontroller applied at the DIM pin. R7 and C10 averages this PWM signal into a DC voltage which acts as the current set value.

5.4 Design Limitations

The maximum operating input voltage of 36V has been chosen to allow the use of 50V ceramic input capacitors and a linear regulator in a very small package. The actual design limitation of 10mA output current at 0V DIM voltage can be overcome and reduced to 0mA, by using a level shift resistor of 1.00MΩ from the 3.3V auxiliary power IC2 pin3 to the error amplifier's non inverting input IC3-a pin 3. This moves the actual value of the output current out of the input offset's voltage range of the error amplifier.

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6. Schematic

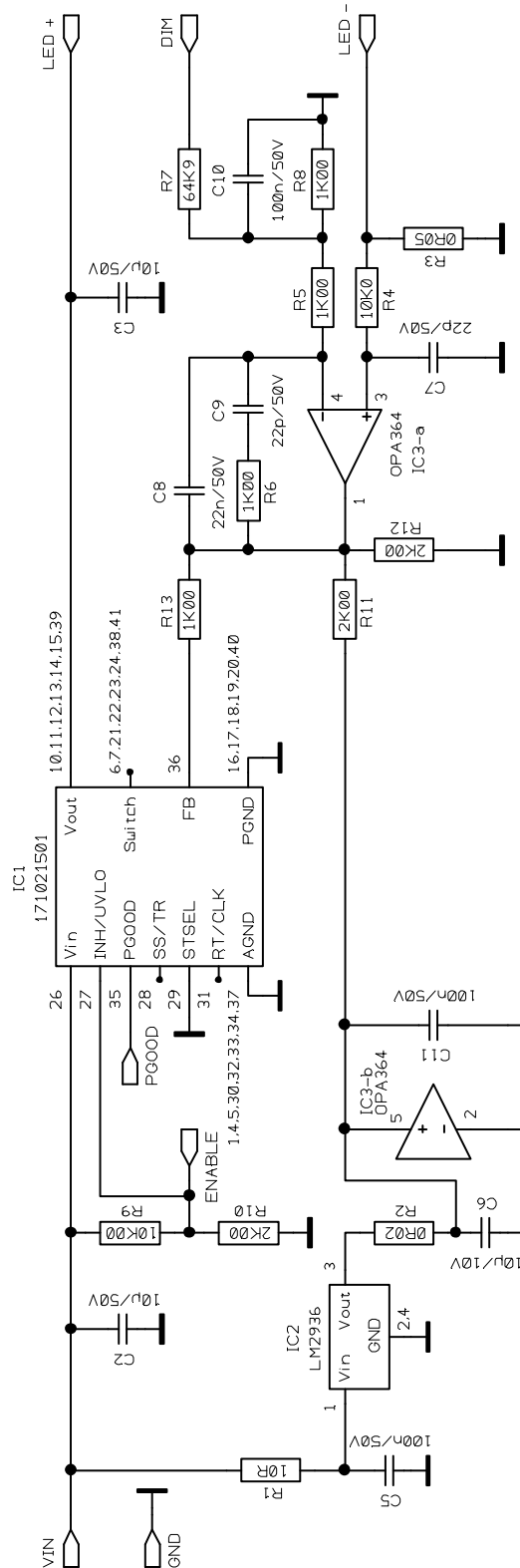


Figure 6. Schematic

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7. Assembly Drawing

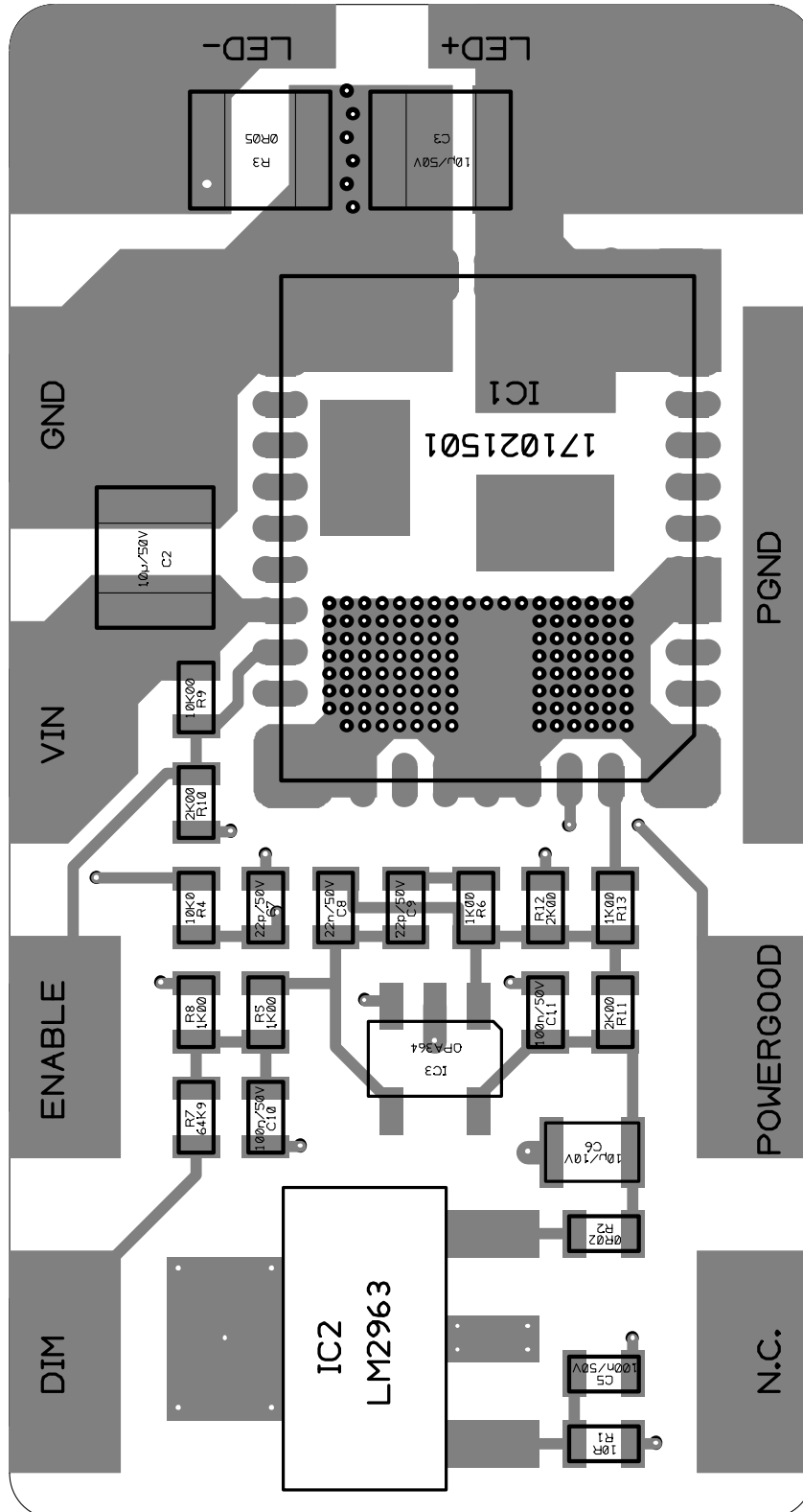


Figure 7. Assembly Drawing

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8. Bill of Material

Designator	Value	Description	Quantity	Package	Manufacturer	Order Code
IC1	171021501	Mag ³ C Power Module	1	BQFN-41	Würth Elektronik	171021501
IC2	LM2936MP-3.3	Linear Regulator	1	SOT223	Texas Instruments	LM2936MP-3.3
IC3	OPA364	Operational Amplifier	1	SOT23	Texas Instruments	OPA364
R5,R6 R8,R13	1.00kΩ/1%/100ppm	Resistor	4	0603	Rohm Semiconductor	TRR03EZPF1001
R10,R11 R12	2.00kΩ/1%/100ppm	Resistor	3	0603	Rohm Semiconductor	TRR03EZPF2001
R1	10.0Ω/5%/100ppm	Resistor	1	0603	Rohm Semiconductor	TRR03EZPF10R0
R2	20.0mΩ/5%/100ppm	Resistor	1	0603	Rohm Semiconductor	UCR03EWPFSR020
R4,R9	10.0kΩ/1%/100ppm	Resistor	2	0603	Rohm Semiconductor	TRR03EZPF1002
R7	64.9kΩ/1%/100ppm	Resistor	1	0603	Rohm Semiconductor	MCR03EZPFX6492
R3	50.0mΩ/0,5%/100ppm	Resistor	1	1210	Panasonic	ERJ-L14KF50MU
C2,C3	10μ/50V/X5R/10%	Ceramic Capacitor	2	1210	Tayo Juden	UMK325BJ106KM-T
C5,C10 C11	100n/50V/X7R/10%	Ceramic Capacitor	3	0603	Würth Elektronik	885012206095
C7,C9	22p/50V/NP0/10%	Ceramic Capacitor	2	0603	Würth Elektronik	885012006053
C8	22n/50V/X7R/10%	Ceramic Capacitor	1	0603	Würth Elektronik	885012206091
C6	10μ/10V/X5R/20%	Ceramic Capacitor	1	0805	Würth Elektronik	885012107010

Figure 8. Bill of Material

9. High Power Ceramic LEDs

Following high power LEDs are suitable for use with the Mag³C LED Driver in ambient and architecture lighting, horticulture, color mixing, infrared and ultraviolet applications.

9.1 WL-SMDC SMD Mono-color Ceramic LED Waterclear

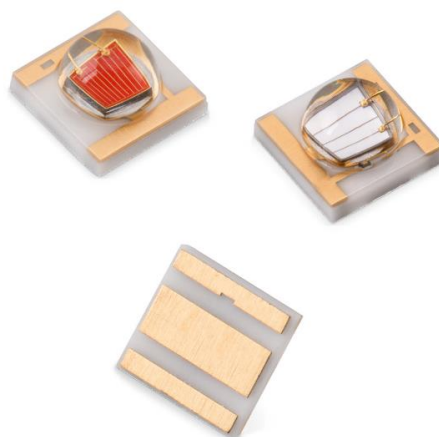


Figure 9. WL-SMDC SMD Mono-color Ceramic LED Waterclear

Emitting Color	λ_{Peak} typ.	λ_{Dom} typ.	Φ_V typ.	V_F typ.	Forward Current	Technology	Order Code
Blue	455nm	460nm	25lm	3.2V	1000mA	InGaN	150353BS74500
Green	520nm	525nm	85lm	3.4V	1000mA	InGaN	150353GS74500
Red	635nm	625nm	55lm	2.2V	700mA	AllnGaP	150353RS74500
Yellow	593nm	590nm	50lm	2.2V	700mA	AllnGaP	150353YS74500

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9.2 WL-SMDC SMD Mono-color Ceramic LED Waterclear for Horticulture

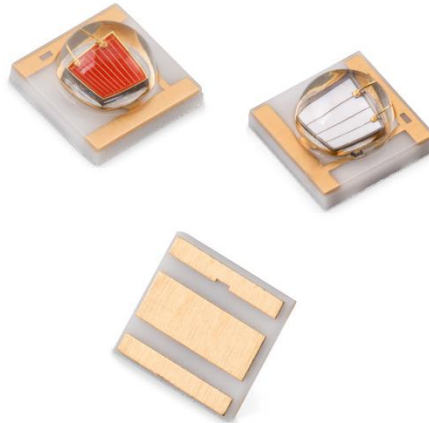


Figure 10. WL-SMDC SMD Mono-color Ceramic LED Waterclear for Horticulture

Emitting Color	λ_{Peak} typ.	λ_{Dom} typ.	Φ_e typ.	V_F typ.	Forward Current	Technology	Order Code
Deep Blue	450nm		660mW	3.2V	700mA	InGaN	150353DS74500
Far Red	730nm		330mW	1.8V	700mA	AllnGaP	150353FS74500
Hyper Red	660nm		400mW	2.4V	700mA	AllnGaP	150353HS74500

9.3 WL-SWTC SMD White Top view Ceramic LED

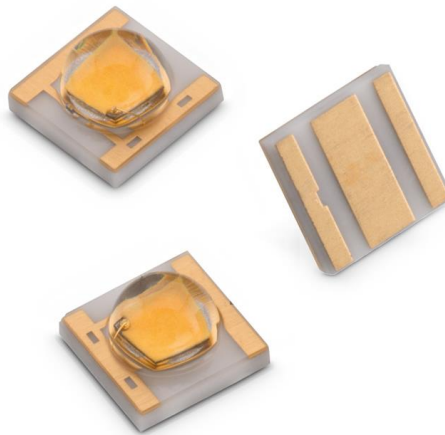


Figure 11. WL-SWTC SMD White Top view Ceramic LED

Emitting Color	CCT typ.	CRI typ.	Φ_v typ.	V_F typ.	Forward Current	Technology	Order Code
Cool White	6000K	70	121lm	3.2V	700mA	InGaN	158353060
Daylight	5000K	70	121lm	3.2V	700mA	InGaN	158353050
Moonlight	4000K	75	110lm	3.2V	700mA	InGaN	158353040

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9.4 WL-SUMW SMD Ultraviolet Ceramic Waterclear

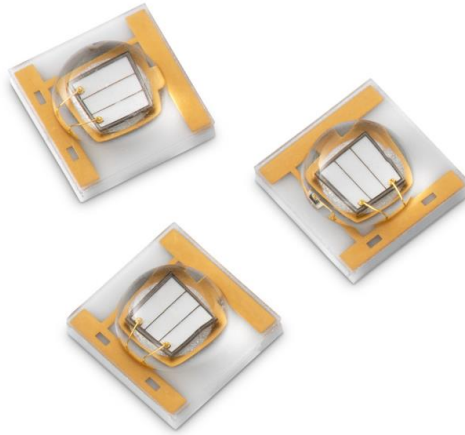


Figure 12. WL-SUMW SMD Ultraviolet Ceramic Waterclear

Emitting Color	λ_{Peak} typ.	Φ_{emin} typ.	Φ_{emax} typ.	V_F typ.	Forward Current	Technology	Order Code
Ultraviolet	385nm	800mW	1100mW	3.5V	800mA	AllnGaN	15335338AA350
Ultraviolet	385nm	800mW	1100mW	3.5V	800mA	AllnGaN	15335338AA350
Ultraviolet	385nm	800mW	1100mW	3.5V	800mA	AllnGaN	15335338AA350

9.5 WL-SIMW SMD Infrared Ceramic Waterclear

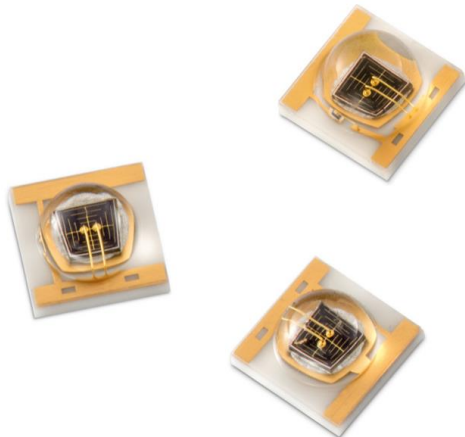


Figure 13. WL-SIMW SMD Infrared Ceramic Waterclear

Emitting Color	λ_{Peak} typ.	$\lambda_{\text{Centroid}}$ typ.	I_e typ.	V_F typ.	Forward Current	Technology	Order Code
Infrared	855nm	850nm	350mW/sr	2.2V	1000mA	AlGaAs	15435385A9050
Infrared	855nm	850nm	250mW/sr	2.2V	1000mA	AlGaAs	15435385AA350
Infrared	945nm	940nm	300mW/sr	1.9V	1000mA	AlGaAs	15435394A9050
Infrared	945nm	940nm	220mW/sr	1.9V	1000mA	AlGaAs	15435394AA350

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10. Important Notes

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