

# Design Principles to Design Most Efficient Luminaries



Highly skilled LED lighting professional with 40 years of experience in designing electronic products. 11 years in to LED LIGHTING designing energy-efficient LED lighting systems. Proven track record of delivering high-quality projects on time and on budget.



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LEDs can easily be integrated into a circuit design provided that certain design rules are observed.

## Some Simple Design Guidelines:

LED lamps are relatively simple to work with – requiring no ignition voltage to start, and generating no nasty spikes or surges. Observing some simple rules of thumb, however, will improve the efficiency of the lamp and prolong its life.

Applications with exacting requirements in terms of light wavelength or other performance can also be readily addressed, provided that some specific characteristics of LED operation are recognised by the designer.

## Driving LED light sources

LEDs are semiconductors with light-emitting

junctions designed to use low-voltage, constant current DC power to produce light. LEDs have polarity and, therefore, current only flows in one direction. Driving LEDs is relatively simple and, unlike fluorescent or discharge lamps, they do not require an ignition voltage to start. Too little current and voltage will result in little or no light, and too much current and voltage can damage the light-emitting junction of the LED diode.

If you refer to the data sheet

It can be seen that, for a given temperature, a small change in forward voltage produces a disproportionately large change in forward current. In addition, the forward voltage required to achieve a desired light output can vary with LED die size, LED die material, LED die lot variations, and temperature.



As LEDs heat up, the forward voltage drops and the current passing through the LED increases. The increased current generates additional heating of the junction. If nothing limits the current, the junction will fail due to the heat.

This phenomenon is referred to as thermal runaway.

By driving LED light sources with a regulated constant-current power supply the light output variation and lifetime issues resulting from voltage variation and voltage changes can be eliminated. Therefore, constant current drivers are generally recommended for powering LED light sources.

For some applications, current-limiting devices such as resistors can be an inexpensive alternative to constant-current drivers for restricting current flow. However, there are many trade-offs. First, resistors generate heat and, therefore, waste power. The heat generated by resistors needs to be dissipated.

In addition, voltage changes from supply voltage variations will translate into changes in light output, and with resistors alone there is no protection for the LEDs to prevent damage from high voltage. A few applications, such as portable lighting, may tolerate these trade-offs but, for most applications resistors are not recommended.

Light output of LED light sources increases with increasing drive current. However the efficiency, expressed in lumens per watt, is adversely affected.

LED lamps normally have a “Test” current listed on the product data sheets. This Test current is provided as a reference point for other technical information provided. Drive currents may be chosen at any current up to the maximum recommended current for the specific LED light source used. Driving LED light sources above the maximum recommended currents may result in lower lumen maintenance or, with excessive currents, catastrophic failure.

### Temperature effects

Performance characteristics of LED light sources are specified for a rated current and for an LED die junction temperature of 25°C. Since most LEDs operate well above 25°C, these values should be considered for reference only and the light output should be based on the anticipated

operating temperatures.

The light output from an LED light source decreases with increasing LED die junction temperature. Higher LED die junction temperatures, resulting from increased power dissipation or changes in ambient temperature, can have a significant effect on light output.

So it is always better to drive the LED at least 10% lower than the maximum specified current.

Red and amber die manufactured from the AlGaInP (aluminium indium gallium phosphorus) material system are more sensitive to temperature effects than blue and green InGaN (indium gallium nitride)-based devices.

Therefore, it is important to consider the effects of temperature when designing for specific light output or efficacy levels, and to maximize the thermal management of the system.

In addition to affecting light output, temperature also has an effect on the dominant and peak wavelength. LED die wavelength characteristics are commonly reported at 25°C junction temperatures. With increasing LED die junction temperatures resulting from higher drive currents or ambient conditions, wavelengths typically increase in from 0.03 to 0.13 nm/°C, depending on die type.

Temperature variation can also cause slight shifts in colour temperature for LED white light sources. Applications requiring specific wavelengths or colour temperature should take this effect into account when designing drive conditions and heat sinking.

### Electrical design

Driving single LED light sources in non-dimming applications is relatively simple. A constant-current driver is chosen to deliver the desired current, with enough forward voltage output to accommodate the maximum input voltage of the LED source. LED light sources are not designed to be driven with a reverse voltage.

Driving multiple LED light sources with one driver is generally done with the LEDs arranged in series strings to avoid uneven light levels resulting from voltage variations. When selecting a series string driver, the output voltage should be high enough to accommodate the sum of the maximum input voltages of LED light sources.



### Dimming and PWM

Dimming LEDs is most commonly done either by lowering the current, or through a technique called Pulsed Width Modulation (PWM).

LEDs have a very quick response time (~20 nanoseconds), and instantaneously reach full light output. Therefore, many of the undesirable effects resulting from varying current levels, such as wavelength shift or forward voltage changes, can be minimized by driving the light engine at its rated current and rapidly switching that current on and off. This technique, known as PWM, is the best way to achieve stable results for applications that require dimming to less than 40% of rated current. By keeping the current at the rated level and varying the ratio of the pulse “on” time versus the time from pulse to pulse (commonly referred to as the duty cycle), the brightness can be lowered. The human eye can not detect individual light pulses at a rate greater than 200 cycles per second and averages the light intensity thereby perceiving a lower level of light.

### Thermal design

With increasing power there is increased thermal load and more heat to dissipate. Higher temperatures of the LED light sources can result in reduced lumen maintenance and shorten useful life. When designing a new system, a heat sink should be selected with sufficient cooling capacity to keep the die junction below 85°C.

If designing around an existing heat sink the maximum operating current for a given heat sink design is the lower of (1) The maximum rated current for the LED light source, or (2) The current to maintain the LED die junction temperature below the maximum specified temperature. LEDs generally must be operated at or below a junction temperature of 85°C.

### Conclusion

Drive the led with less than rated voltage and current.

When making series parallel connection the maximum voltage of LED string should not exceed 56 volt for long durability.

Some drivers available in the market uses very high voltage string going up to 180-200 volt DC

As u all know the dieelectric used the aluminum PCB has a breakdown voltage of 1KV as per the data sheet of pcb manufacturer.

But this is at a given junction temperature.

During the prolonged use these dieelectric breaks and burn the junction of the LED resulting in failure of the luminaries.

So care must be taken to restrict the string voltage to 56/64 volt maximum.

