Dimming LEDs via PWM and CCR

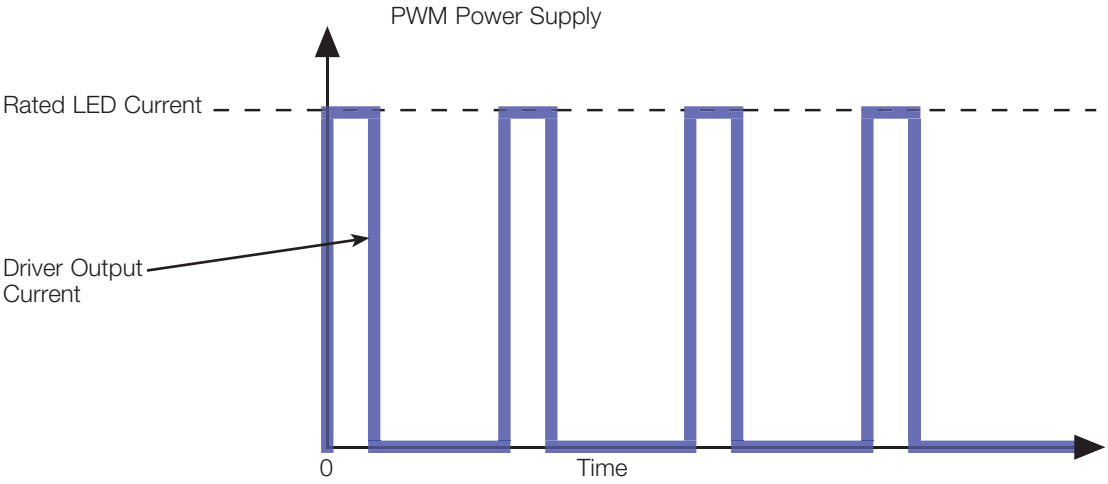
Overview

For constant-current LED drivers, there are two mechanisms for dimming: pulse-width modulation (PWM) and constant current reduction (CCR). This application note will explain the difference between the two methods, allowing you to select the proper approach for the application. **Note:** Constant-voltage LED drivers are primarily PWM dimming drivers and will not be addressed in this document.

Definitions

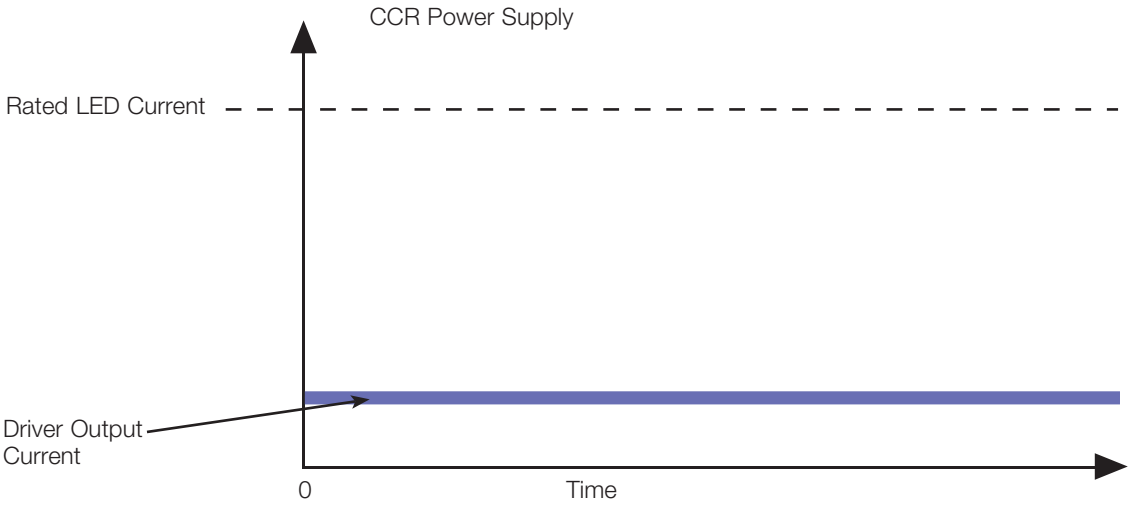
Pulse Width Modulation

Every LED has a rated current, which is the amount of current that needs to flow to get the maximum light output. In a PWM driver, the current is switched at a high frequency between 0 and the rated output current. This means the LED load is either off or running at its rated current. The ratio of on time to off time determines the LED brightness. See the following diagram for an example of an LED that is dimmed to approximately 25% using PWM. The 25% level is a result of the current flowing for 25% of the time, then being turned off for the remaining 75% of the time.



Constant Current Reduction (CCR)

In a CCR supply, the current flows continuously at a set amount for a given light level. Since the amount of light output is proportional to the current flowing through the LED, the current is reduced to reduce the brightness of the LED. See the following diagram for an example of an LED that is reduced to approximately 25% using CCR. Sometimes this type of dimming is referred to as “Analog Dimming”.



Details

Use of both CCR and PWM based drivers will have the desired effect of dimming the lights. However, other factors come into play when each method is used.

Why use PWM

- Typically, LED specification sheets provide a particular characteristic, such as color or efficiency (in lumens per watt), at a particular forward current. These characteristics will vary based on the forward current. For example, the color temperature may be 3000 K at 700 mA of current, but only 2700 K at 350 mA. A PWM driver will only run the LEDs at the rated current level or zero, preventing these characteristics from changing as the load is dimmed. Practically, this means the same color temperature is maintained throughout the dimming range.
- PWM based drivers can provide a very precise output level, since the LEDs are always on at the same current level. Changing the operating current linearly, as done with CCR, may not result in a linear change in light output.

Why use CCR

- For devices that need to be rated as UL Class 2 for dry or damp locations, there is a lower output voltage limit for Class 2 devices that use PWM (24.8 V⎓ for PWM frequencies between 10 Hz and 200 Hz) than those that use CCR (60 V⎓). Therefore, a Class 2 power supply that uses PWM will not be able to provide as much voltage as one that uses CCR.
- By definition, PWM power supplies have to run at frequencies high enough to be imperceptible to the human eye. The higher the frequency, the less likely someone is to observe flicker. Frequencies below 200 Hz may be observable in peripheral vision, and even higher frequencies are required to eliminate stroboscopic effects in fast motion environments. However, higher-frequency power supplies are generally more complex and expensive to manufacture, especially when low light levels are desired. Other programs, such as Energy Star, may place minimum requirements on PWM frequency.
- Because of the fast rising and falling edges of a PWM driver (faster edges allow for higher frequencies and lower light levels), electromagnetic interference (EMI) can be generated. This EMI may not be suitable for certain applications.
- PWM drivers, due to their fast edges, may experience performance issues if mounted remotely from the light source. This is because the electrical characteristics (capacitance and inductance) of the long wire runs interfere with the fast rise and fall times required for precise light levels.

Applications Suitable for PWM

- Fixtures that must be dimmed lower than 40% and still maintain consistent color
- Color mixing applications, because of their need for precise levels of each color

Applications Suitable for CCR

- Fixtures requiring a UL Class 2 rated output with an output voltage higher than the UL Class 2 PWM voltage level
- Applications where long wire runs may exist between the driver and the light engines and high performance dimming is required
- Applications that may have strict EMI requirements, such as medical suites
- Applications with high motion activity or rotating machinery

Conclusion

Both PWM and CCR drivers can be used to adequately dim LED loads. However, each method has advantages that may make it more suitable for a particular application.

Lutron drivers can be ordered as either PWM or CCR modes for the ultimate in LED dimming flexibility and performance. **Note:** Lutron PWM drivers do not operate within the range of 10 Hz to 200 Hz and can go up to 60 V⎓ while maintaining the Class 2 markings.

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