LED Driving

AP01 Application Note

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Introduction

With new developments in the LED industry, it has recently become available to build long longevity lighting equipment that consumes very little power compared to previous lighting requirements. These devices are now replacing traditional lighting equipment in many areas.

Since the need for high efficiency drivers exists, KMD Industries has designed a lineup of products for all high power LED driving needs.

This note explains how our LED drivers can be arranged in a multitude of applications, and also explains the basics of LED driving and requirements which need attention.

LED Basics

LEDs (**L**ight **E**mitting **D**iodes) are constant current devices that follow a relatively steep I-V characteristic (shown in figure 1). These devices also have a negative temperature coefficient, meaning the forward voltage drop will *decrease* as the junction temperature increases. These two characteristics force constant current drivers to be used, as running LEDs directly from a voltage source has a high risk of causing thermal runaway, where the LED forward voltage drops as its temperature increases.

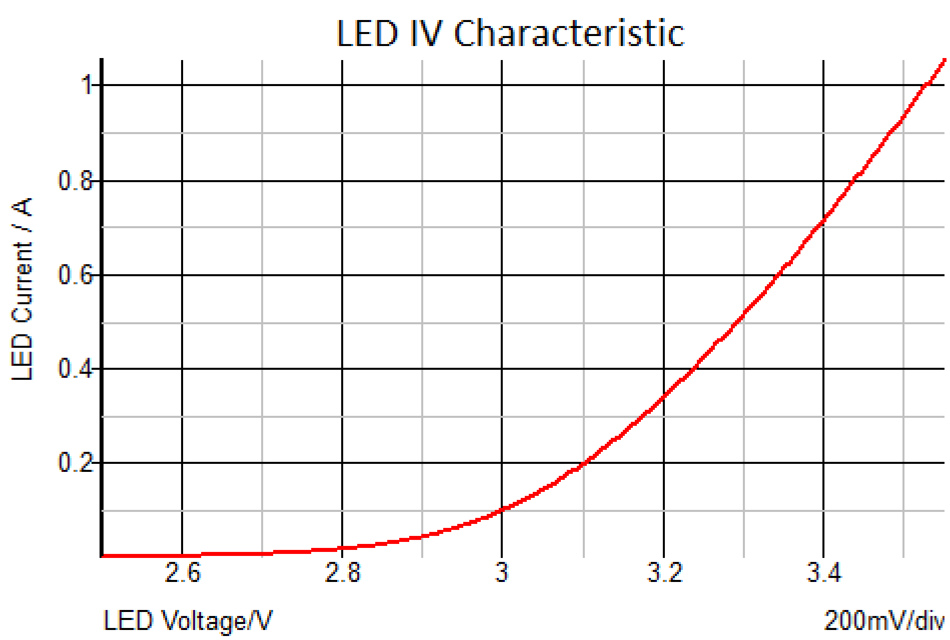

Figure 1

Constant current driving regulates current through the LED string, and automatically adjusts for the fluctuating voltage drop of the LEDs. As long as the input voltage exceeds the LED string voltage and a small dropout voltage (found on the device's datasheet), current through the LEDs will remain constant.

Wiring of the LED Set

There are several possible combinations when running a set of LEDs, although the best approach is to use one series string per driver. This makes certain that the current through each LED is always known (which is the set current value). Even if the individual LED voltages are different (which they always will be), there is no possibility of thermal runaway for the system.

Wiring the Buck Modules

The BKD family of buck drivers are a very simple to wire solution for driving a string of LEDs. 5 pins exist on this series, being the input voltage, a $\overline{\text{PWM}}$ input, and the LED outputs. As shown in Figure 2, if PWM was not used and the driver simply needs to emit full brightness, the $\overline{\text{PWM}}$ input should be grounded to eliminate any chance of an unwanted switching transition due to ambient noise.

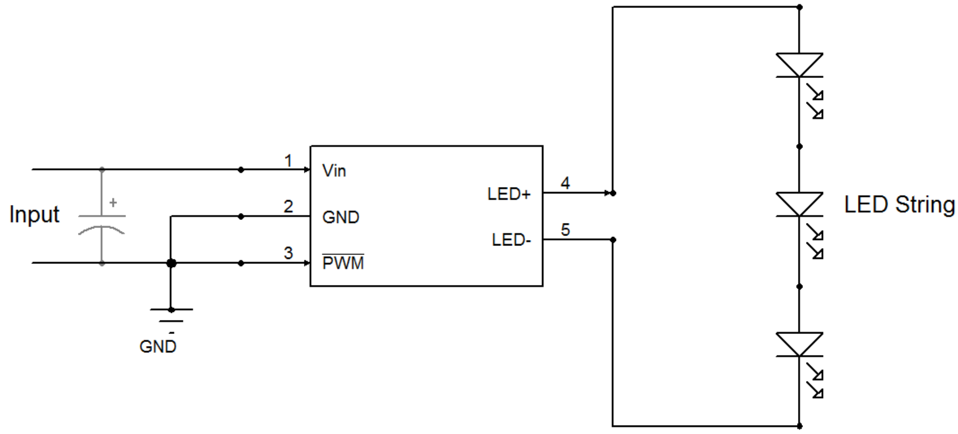

Figure 2

If the solution requires PWM dimming or an enable feature, the arrangement shown in Figure 3 will be used. The PWM line is an inverted input, meaning a low value here enables the module while a high value disables the module. The threshold voltage is typically 0.8V, so any 3V or higher logic interface will switch the line correctly.

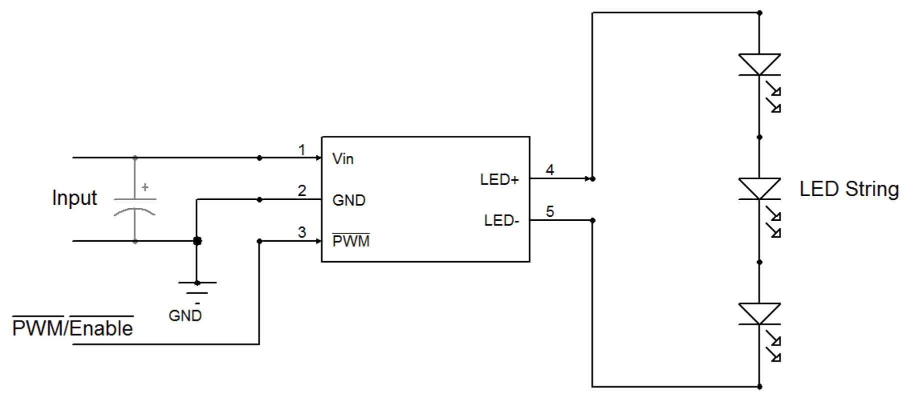

Figure 3

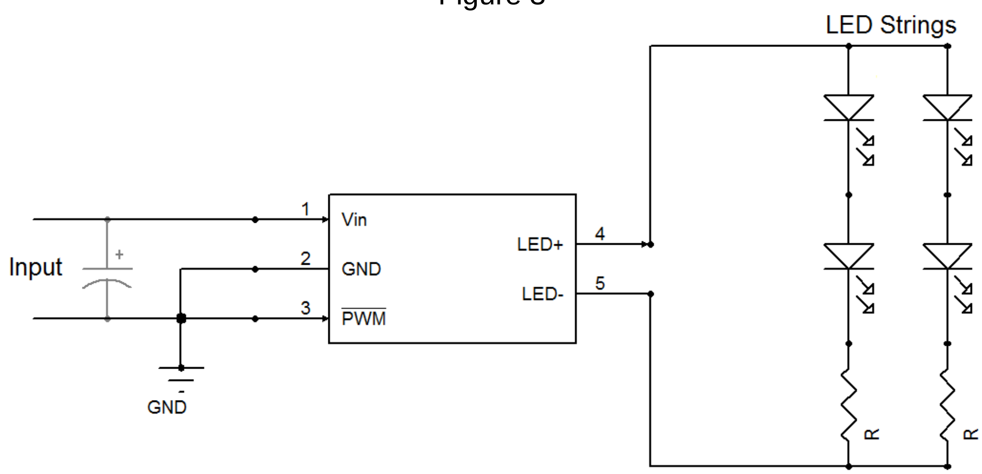

Figure 4

The final figure shows the recommended method of parallel LED strands. We recommend using separate drivers if possible so that no chance of thermal runaway exists. However, if several strings of LEDs are to be in parallel with the output, series resistors MUST be used to force current sharing. If these are left out or are too small a value, there will be high risk of thermal runaway since the individual LED dies are not the same temperature and will have varying voltage drops.

The value of these resistors needs to be determined, where we recommend at least 250mV drop on each sharing resistor per LED in each string. The following equation can then be used to determine the resistor values: $R \geq \frac{0.25*LEDs}{I_S}$

Where:

R is the resistor value
LEDs is the number of LEDs per string
I_S is the current per LED string

For example, if we have 4 LEDs per string, 2 strings on a 1A driver (500mA per string), we would have a resistance of 2 ohms.

AC Driving

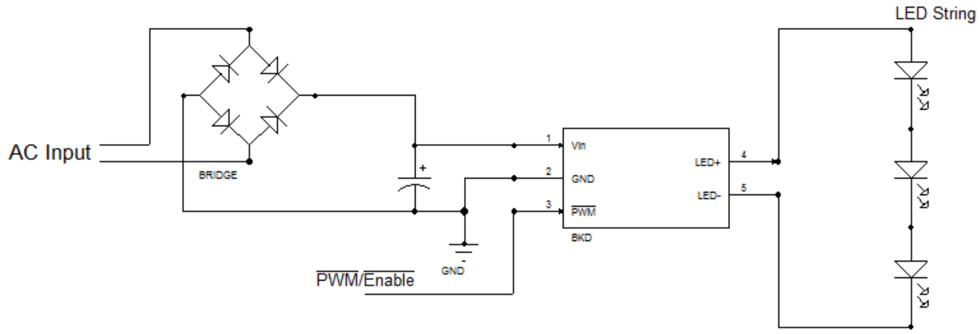

Figure 6

If the solution utilizes a low voltage AC input, a simple external bridge rectifier and bulk capacitor can be used, as shown in figure 6.

As long as the input voltage remains above the LED string voltage plus the driver's dropout voltage, the LED string will not flicker. This is beneficial if power factor is of concern, as current will be drawn on a larger portion of the input waveform.

We recommend using a Schottky diode bridge for improved efficiency over standard diodes, as Schottky diodes have a low voltage drop.

Capacitance needed for the circuit can be found: $C = \frac{I_{IN}}{2f\Delta V}$ where: C is the capacitance, I_{IN} is the driver's input current, *f* is mains frequency, and ΔV is the voltage ripple. Input current of the device can be found though power conservation: $P_{out} = \eta P_{IN} \Rightarrow \frac{V_{LED}I_{LED}}{\eta V_{IN}} = I_{IN}$, where η is the driver's efficiency at this load condition, V_{LED} and I_{LED} are the total LED string voltage and current, V_{IN} is the input voltage at the driver, and I_{IN} is the resulting input current.

PWM dimming

PWM dimming is common to all KMD converters and can be used via a microcontroller or analogue circuit to dim the LED string(s). The PWM input is a digital input, meaning below 0.8V the driver runs the LEDs at full brightness, and above 0.8V the driver turns off the LEDs.

The duty cycle of the PWM waveform is proportional to the brightness of the LEDs. For example, if a 50% PWM signal is present on the PWM pin, the average LED current will be 50% of nominal.

Depending on the driver chosen, the PWM frequency will result in varying brightness ranges. A low PWM drive frequency (i.e. from 100Hz to 500Hz) creates a wide PWM range of 1% to 100% output drive current. If the frequency is increased further (say to 10kHz), the PWM range effectively becomes about 20% to 100% of nominal. This is due to the soft-starting time of the driver to remove overshoot on the LED string when powering on. As the frequency drops, the useful PWM range is widened, however noticeable flicker may result when operating at very low frequencies. We recommend at least 100Hz.

If several drivers are to be dimmed via PWM, the clocks should be synchronized to remove of any possibility of imposing a "beat" frequency on the LED strings. This is caused from several clock sources being slightly off the desired frequency, thus creating time instances where the multiple LED strings are on together, both off, or one being on while the other is off. Since this would be repeated cyclically, there may be a noticeable oscillation ('beat') of the system brightness.

Usage Recommendations

The BKD05xxx and BKD10xxx series of LED drivers are sold as a convenient 5 pin PCB style layout. This makes the device very simple to implement in a variety of solutions, however a few guidelines should be followed.

Firstly, all switching converters create a small amount of heat which must be dissipated. The layout of the driver assists with this by moving heat away from several components. Forced cooling is not mandatory however the board must have adequate ventilation so that cooling is possible. If mounted within a chassis, there must be venting provisions so that the PCB does not overheat.

The output of these converters is also switching at a relatively high frequency. Therefore, in order not to induce stray EMI, wiring from the output to the LEDs should be kept as short as possible. This will also lead to good efficiency since there is less voltage drop along the wiring. If EMI is of a concern where cable lengths may be long, small capacitance to the output may be added. We recommend limiting this to 1μF as to not create long turn-on times for PWM dimming applications.

Handling of the modules should be done with care as to not damage the device through static shock (ESD). There are provisions in place to guard against this, although large voltage shocks will damage the device.