

## General Description

### LEDs vs CCFL

White LEDs (Light Emitting Diodes) are becoming more popular choice for backlighting color LCDs (Liquid Crystal Displays) in cellular phones, PDAs (Personal Digital Assistants), digital cameras and other handheld, portable devices. Blue LEDs are emerging as a popular backlight for monochrome LCDs. The advantages of white and blue LEDs over other light sources like CCFLs (Cold Cathode Fluorescent Lamps) are that the power source is simple to implement, the life span is longer, the size is smaller and the cost is lower. CCFL requires an AC power source ranging from 2kVAC at 30kHz-40kHz for operation. This requires DC-AC power source conversion for portable devices, which translates to bulky transformer-based circuits. A single white or blue LED requires a 3.6V to 4.2V DC power source. This means simple inductor-based circuits can be used to power the LEDs. Because of the low voltage power, the white and blue LEDs are ideal for Li-Ion battery applications. The life span of the CCFL is around 30kHrs to 35kHrs. For the LEDs, the life span is over 50kHrs. The only advantage to using the CCFL over the white and blue LEDs is that the CCFL is brighter but much larger and more expensive to implement.

### Overview

This application note describes and shows various application circuits to power white and blue LEDs using the MIC2142 and MIC2145. The MIC2142 is a micropower, boost-switching regulator housed in a SOT-23-5 package. The input voltage range is between 2.2V to 16V with an adjustable output voltage up to 22V. In addition, the 330kHz operation allows small surface mount external components to be used. The MIC2145 is an MSOP-8 boost-switching regulator with programmable peak switch current to allow the user to set the maximum efficiency to occur in the applications. The input voltage range for the MIC2145 is 2.4V to 16V with an adjustable output voltage up to 16V.

### Series Configuration

Figure 1 shows one of the most common applications for the white and blue LEDs, which is to configure them in series. In this particular circuit, three white LEDs are used. The advantage of this configuration is that the feedback voltage of the MIC2142, which is a tightly controlled parameter, and R1 set the LED's current. Equal amount of current goes through the series string of white LEDs. Because the LED's current is proportional to its brightness, the result is uniform brightness for all the LEDs.

A Zener diode in parallel with the LEDs is recommended to protect the MIC2142 if one of the white LEDs opens for any reason, causing the switch voltage to increase above the maximum rating of the switch pin.

The challenge of the series configuration is that the MIC2142 has to boost the output voltage up to the sum of all the forward drop of the white LEDs plus the feedback voltage.

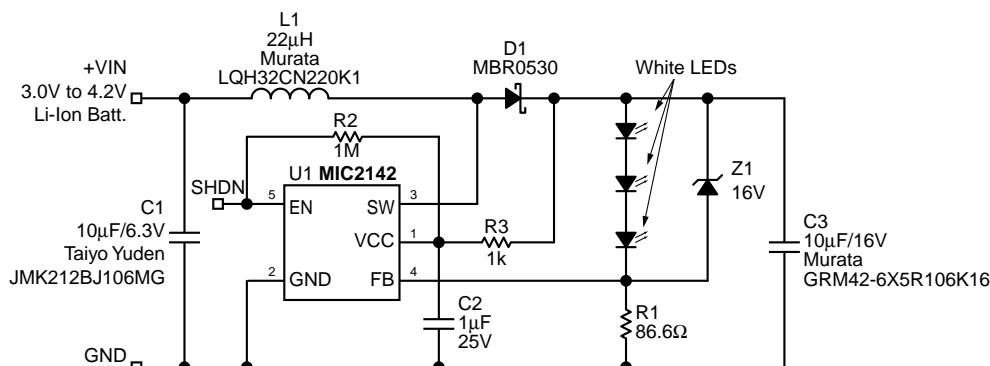
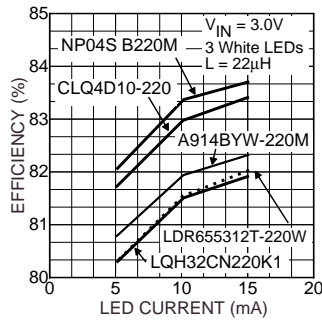


Figure 1. Constant-Current LED Driver



**Figure 2. Typical Efficiency vs. LED current**

Figure 2 shows the efficiency of the constant-current LED driver for various inductor manufacturers. With a constant-current LED driver, efficiencies above 80% can be achieved with low profile inductor and capacitors.

**Parallel Configuration**

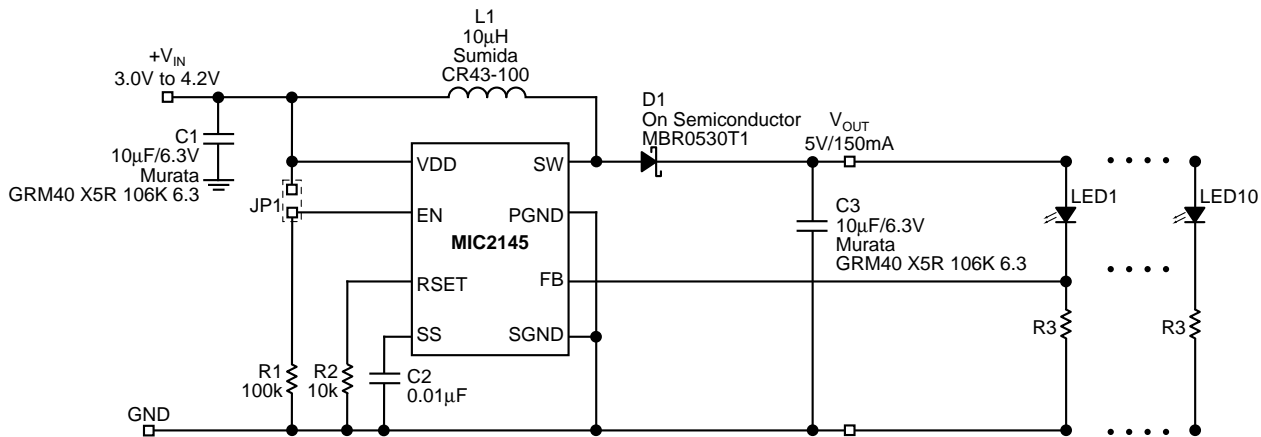
Figure 3 shows the parallel LED configuration with the MIC2145 as the LED driver. Similar to the series configuration, the feedback voltage of the MIC2145 and R3 set the current for one of the white LEDs. By using the same value resistor for each of the white LEDs, the rest of the white LEDs should have similar current. The current for each LED will not match perfectly due to the resistor tolerance, so there will be a tiny variation. This variation may cause the LED's brightness to be uneven as compared to the series configuration.

In shutdown mode, due to the nature of the boost architecture, the output voltage will equal the input voltage minus the voltage drop of the Schottky diode. This will cause the white LEDs to slightly turn on if the voltage of the battery is high enough. A small switch between the battery and VIN can be used to disconnect the white LEDs from the battery.

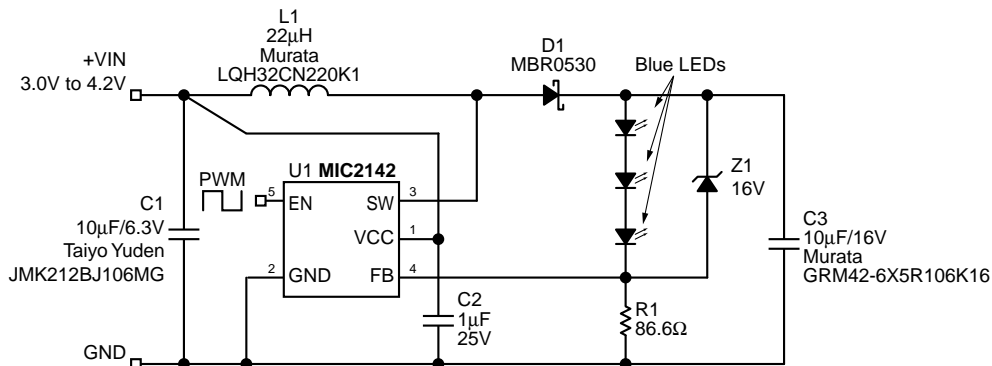
The advantage of the parallel configuration is that the MIC2145 only has to boost the output voltage up to one forward drop plus the feedback voltage. This allows the MIC2145 to drive at least 10 white LEDs in parallel with efficiency above 80% using low profile components.

**Brightness Control**

The brightness of the LEDs can be easily controlled by injecting a PWM (Pulse Width Modulation) signal into the enable pin of the regulator, using a logic control, or applying a DC voltage from the DAC. Figure 4 shows a 400Hz PWM signal can be used to control the LEDs' current by varying the duty cycle of the PWM signal. Figure 5 shows a logic signal and a transistor can be used to switch the LEDs current from 8mA to 1mA and vice versa. Figure 6 shows a DAC can be used to modulate the LED's current.



**Figure 3. Parallel Configuration**



**Figure 4. Series White LED Driver with PWM Brightness Control**

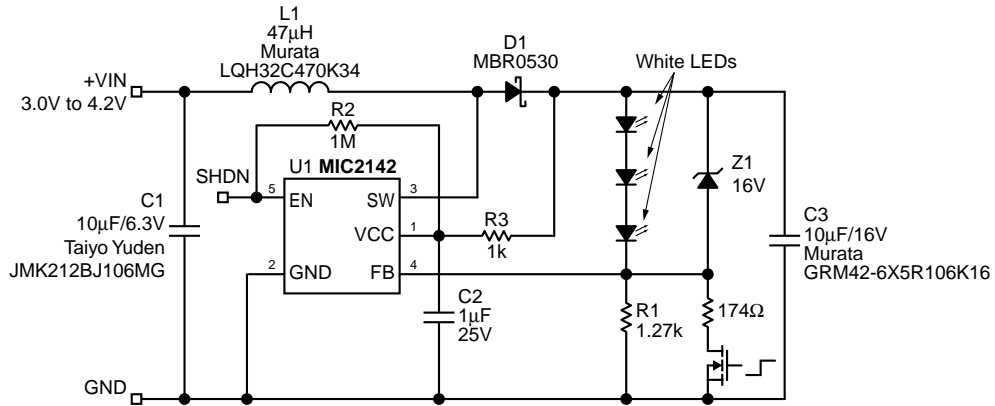


Figure 5. Dual Mode

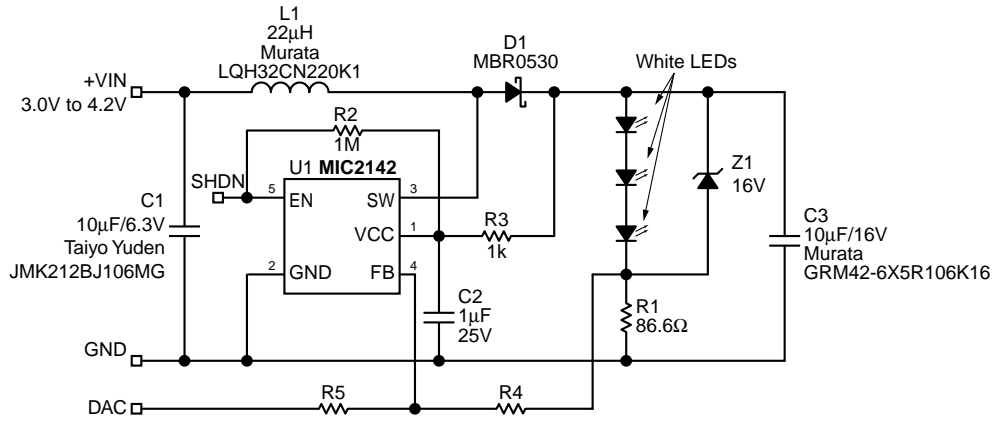


Figure 6. Series White LED Driver with Analog Dimming Control

**Summary**

The demand of white and blue LEDs will dramatically increase over the year due to their low voltage, small size, simplicity and long life-span. Micrel’s LED drivers will allow designer to easily power these white and blue LEDs with high efficiency, low profile components, and minimum component counts.

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