Using TPS61200 as WLED Driver

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ABSTRACT

This application report explains how to build a white LED (WLED) driver circuit using the TPS61200 Boost Converter from Texas Instruments. It also explains an analog dimming scheme for the LED drivers.

The TPS61200 integrated circuit (IC) is a low-input voltage synchronous boost converter with down-conversion mode when $V_{IN} > V_{OUT}$. This device provides output currents up to 600 mA with a 5-V output and 3.6-V input voltage. The boost converter is based on a fixed-frequency, pulse-width-modulation (PWM) controller using synchronous rectification to obtain maximum efficiency.

The WLED driver circuit is based on a basic circuit (see Figure 1) where the WLED is connected between the OUT pin and the FB (feedback) pin of the switcher. The current through the WLED is given by Equation 1.

$$ILED = VFB / Rsense \quad (1)$$

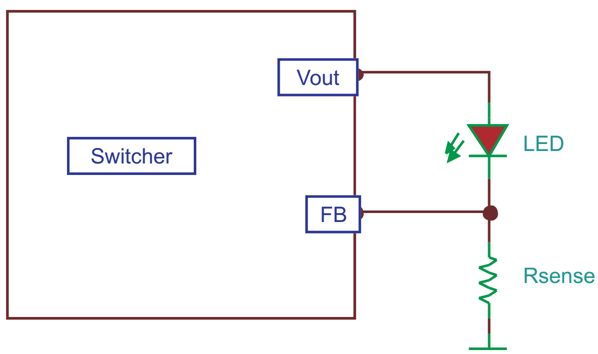

Figure 1. Basic WLED Driving Using a Switcher

The WLED driver circuit using TPS61200 is shown in Figure 2. The analog dimming function is implemented using variable voltage V_{ANALOG}.

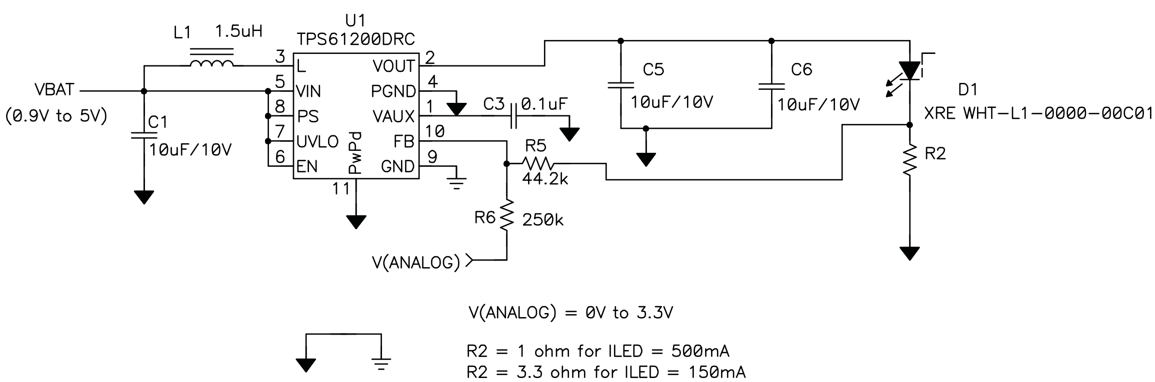

Figure 2. TPS61200 Used as WLED Driver

Being internally compensated, the TPS61200 requires a 1.5-µH inductor and two 10-µF ceramic outputs for small-signal loop stability when configured as a single WLED driver. Other configurations may be stable but it is the responsibility of the user to carefully test the loop stability of such configurations.

The following paragraph explains how to implement dimming with any adjustable dc/dc converter configured as a WLED driver. When a variable analog voltage source is available as shown in Figure 3(a), or can be filtered from a PWM signal with duty cycle D as shown in Figure 3(b), analog dimming can be implemented using two resistors connected between the FB pin and the junction of the cathode of the WLED and sense resistor. Equation 2 gives the maximum value for R3. Once R3 is selected, Equation 3 computes the value for R2. With R2 and R3, Equation 4 computes the value for R1. Equation 5 computes ILED current.

$$R3 \leq \frac{V_{ANALOG\_MAX} - V_{FB}}{10 \times I_{FB}} \tag{2}$$

$$R1 = \frac{V_{FB} \times R3 + V_{FB} \times R2 - V_{ANALOG\_MAX} \times R2}{I_{LED\_MIN} \times R3 - V_{FB} + V_{ANALOG\_MAX}} \tag{3}$$

$$R2 = V_{FB} \times \frac{\left(I_{LED\_MIN} \times R3 + V_{ANALOG\_MAX} - I_{LED\_MAX} \times R3 - V_{ANALOG\_MIN}\right)}{\left(V_{FB} \times I_{LED\_MAX} - V_{ANALOG\_MAX} \times I_{LED\_MAX} - V_{FB} \times I_{LED\_MIN} + V_{ANALOG\_MIN} \times I_{LED\_MIN}\right)} \tag{4}$$

$$I_{LED} = \frac{V_{FB}}{R1} - \frac{R2}{R1 \times R3} \times \left(V_{ANALOG} - V_{FB}\right) \tag{5}$$

This method provides maximum current through WLED when V_{ANALOG} is at its minimum value and minimum value of current through WLED when V_{ANALOG} is at its maximum value.

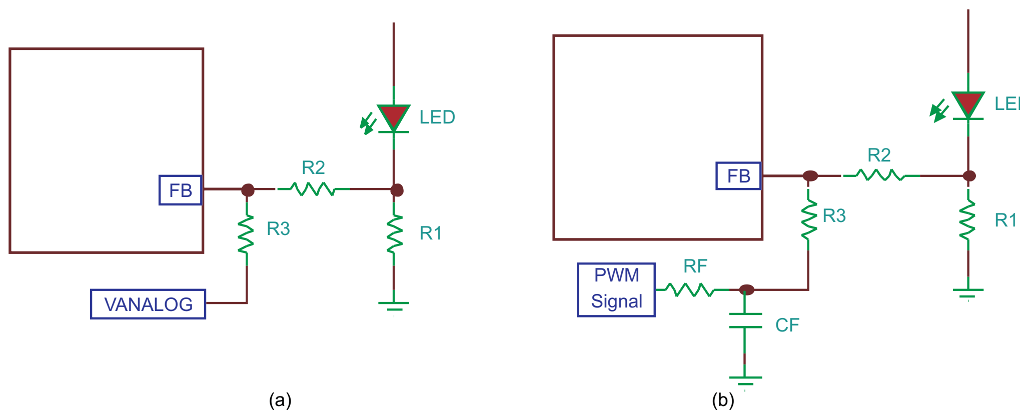

Figure 3. Analog Dimming Using (a) Variable DC voltage (b) PWM Signal

If the PWM signal is filtered to produce the analog drive voltage, it is recommended that the low-pass filter (LPF) corner frequency be 10x below the PWM frequency.

$$V_{ANALOG} = D \times V_{PWM\_MAX} \tag{6}$$

The TPS61200 configured as a WLED driver has the following advantages over other similarly configured converters:

1. The circuit can work for a wide input voltage from 0.9 V to 5 V.
2. For $V_{IN} \geq 2$ V, the current flowing through WLED can be as high as 500 mA.
3. For $V_{IN} = 0.9$ V, the current though WLED can go greater than 150 mA.

The efficiency graphs for different values of input voltages are shown in Figure 4.

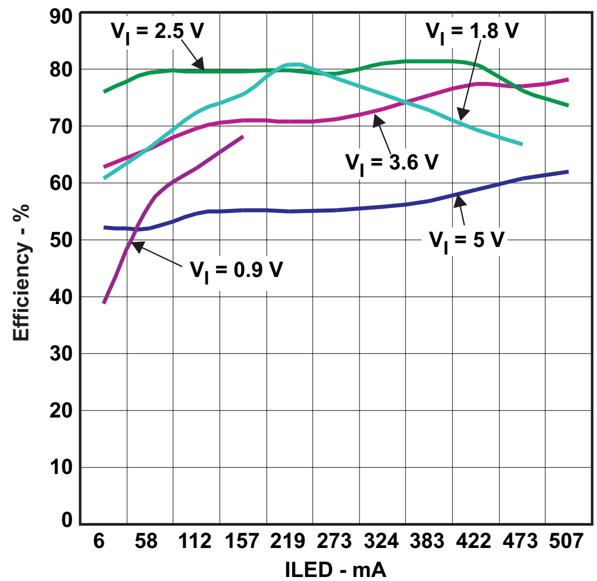

Figure 4. Efficiency vs VIN Graphs

The efficiency graphs show that the circuit works most efficiently for the input voltages less than 3.5 V, which is approximately the output voltage set by the LED. This is because the TPS61200 is optimized for use in boost mode. For input voltages greater than 3.5 V, the device enters down-conversion mode and has higher power dissipation. Note that if the sense resistor is selected properly per Equation 2, then the device can provide current I_{LED} up to 680 mA. Table 1 shows the typical battery voltages and corresponding currents flowing through the WLED. (Note that the value of sense resistor in each case is different and is selected to get the maximum amount of current flowing through the WLED and achieve stability. All the measurements are taken at room temperature of T_A = 25°C).

Table 1. Typical Battery Voltages and Corresponding Currents Through WLED

	Vin (V)	ILED (mA)
Li-ion	4.2	680
Li-ion Polymer	3.7	680
Li-ion	3.6	680
Lead Acid	2.1	550
Zinc Carbon D-type cell	1.5	370
NiCD and NiMH battery	1.2	280

The following figures show the start-up waveforms, loop gain measurement, and load transients (from 0 mA to 500 mA) with the circuit in Figure 2 configured to provide 500 mA from V_{IN}= V_{EN}= 3.6 V.

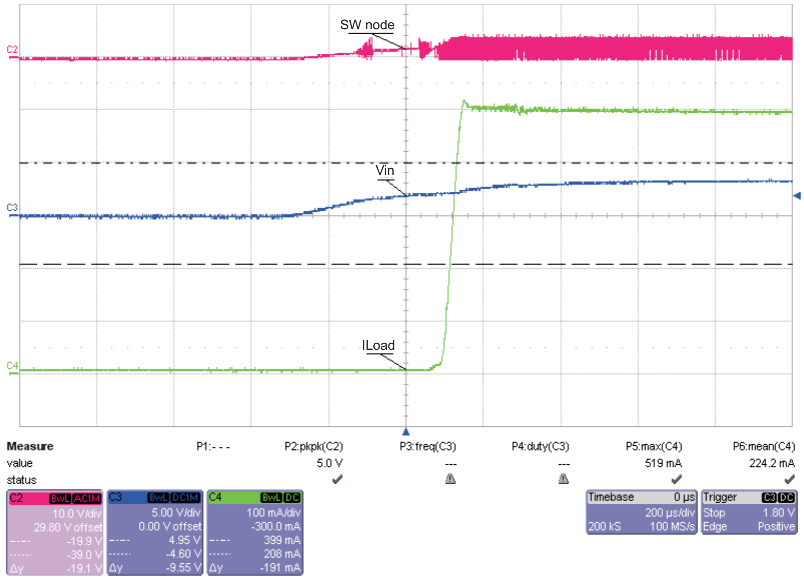

Figure 5. Start-Up Waveforms

Legends for Figure 5 are as follows. (Time scale is 200 µs/div for all the three channels.)

1. Channel 2 (red) : Switch-node waveform (Vertical scale is 10 V/div.)
2. Channel 3 (blue) : Input voltage waveform (Vertical scale is 5 V/div.)
3. Channel 4 (green) : ILED waveform (Vertical scale is 100 mA/div.)

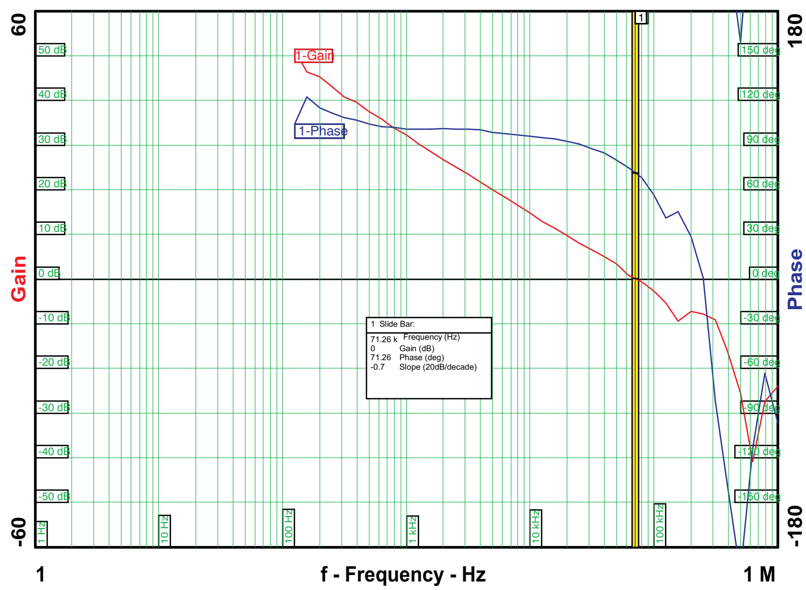

Figure 6. Loop Gain Measurements (PM = 71.26 deg, Fco = 71.26 kHz)

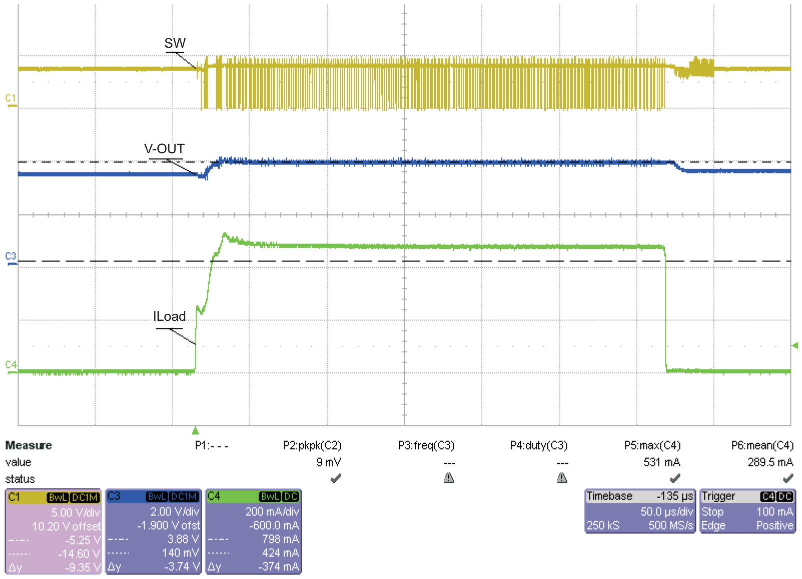

Figure 7. Load Transient (0 mA to 500 mA)

Legends for Figure 7 are as follows. (Time scale is 50 µs/div for all the three channels.)

1. Channel 1 (yellow) : Switch-node waveform (Vertical scale is 5 V/div.)
2. Channel 3 (blue) : Output voltage waveform (Vertical scale is 2-V/div.)
3. Channel 4 (green) : ILED waveform (Vertical scale is 200 mA/div.)

Testing at Vin = 0.9 V and Vin = 5 V resulted in similar results as those shown in Figure 7

Conclusion

The TPS61200 boost converter can be used as a WLED driver and can provide a current flowing through the WLED greater than 500 mA.

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