High-Brightness Portable Lighting

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ABSTRACT

High-power LED drivers designed for LCD monitors are also good choices for driving LEDs in general-purpose lighting applications. One such driver is the TPS61199 device, an 8-channel LED boost controller with integrated current sinks and an 8-V to 30-V input voltage range. The current in each sink can be programmed for a maximum of 70 mA. The boost-controller topology drives an external N-channel MOSFET that can handle a wide output-voltage range and inductor-current range. This allows the TPS61199 to be designed with a wide variety of white LEDs commonly used in general purpose lighting applications such as:

- 12-V Battery Power Lighting
- 18-V Battery Powered Lighting
- 24-V Battery Powered Lighting
- Marine Ambient Lighting
- Automotive Ambient Lighting

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1 Application Schematic

Figure 1 shows an applications schematic that drives 8 high-brightness LEDs. The LED current is controlled in low-side current sinks at IFB1 - IFB8. The maximum current is set via the external current setting resistor (R6). The design below is set for I_{FULL_SCALE} = 20 mA; however, other full-scale currents can be programmed up to 70 mA. Dimming is achieved via the PWM input, but in the design PWM is tied to VDD to force the device fully on.

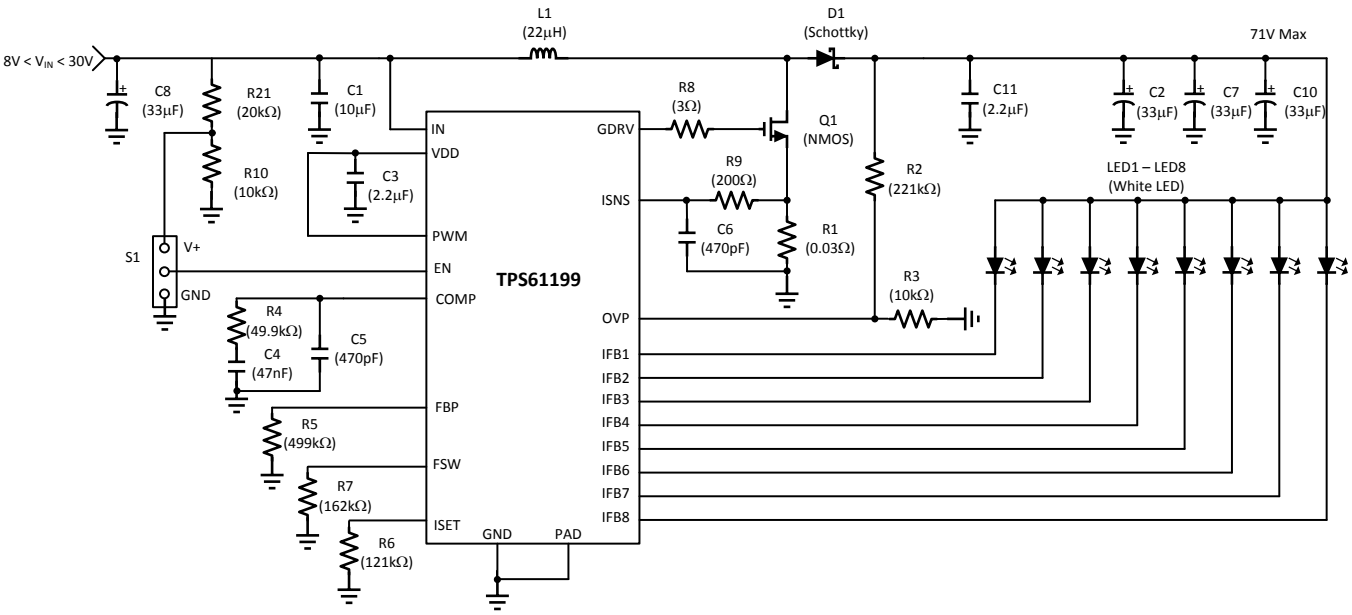

Figure 1. Applications Schematic

2 Materials List

Table 1. Bill of Materials and Component Description

DEVICE	VALUE	DESCRIPTION	PART NUMBER	SIZE	MANUFACTURER	PURPOSE
C1	10 µF	Ceramic, 50V, X7R, 10%	Standard	1210	Standard	Bypass for IN, keep close to IN for low inductance connection
C8	33 µF	Electrolytic, 100V, 20%	UPW2A330MPD6	8 × 11.5 mm	Nichicon	Bulk Bypass for VIN
C2, C7, C10	33 µF	Electrolytic, 100V, 20%	UPW2A330MPD6	8 × 11.5 mm	Nichicon	Bulk Bypass for VOUT
C11	2.2 µF	Ceramic, 100V, X7R, 20%	Standard	1206	Standard	High frequency bypass for VOUT. Keep close to D1 anode and GND for low inductance connection
C3	2.2 µF	Ceramic, 10V, X7R, 20%	Standard	0805	Standard	Bypass capacitor for VDD
C4	47 nF	Ceramic, 25V, X7R, 10%	Standard	0603	Standard	Compensation capacitor
C5	470 pF	Ceramic, 25V, X7R, 10%	Standard	0603	Standard	Compensation capacitor
C6	470 pF	Ceramic, 25V, X7R, 10%	Standard	0603	Standard	Filter capacitor for current sense input. C6 and R9 filter the current sense signal developed across R1
D1	Schottky Diode	100 V, 5 A continuous	SSP510	TO-277	Vishay	Boost rectifier diode
L1	22 µH	3.6 A, 43.2 mΩ	CDRH127NP-220MC	12.3 mm × 12.3 mm × 8 mm	Sumida	Boost Power Inductor. I_{SAT} = 3.6 A with 25% drop from nominal
Q1	NMOS Power Switch	80 V, 6 A, 35 mΩ	SI4480DY-T1-E3	SO8	Vishay	Boost Power switch. V_{OUT_MAX} < 80 V
R1	33 mΩ	1/2 W, 1%	Standard	1812	Standard	Current sense resistor
R2	232 kΩ	1/16 W, 1%	Standard	0603	Standard	Over Voltage Protection sense resistive divider. R2, R3 divide down VOUT to OVP sense input (2.95 V). V_{OUT_MAX} = (R2/R3 + 1) × 2.95 V = 71.3 V
R3	10 kΩ	1/16 W, 1%	Standard	0603	Standard	
R12	10 kΩ	1/16 W, 1%	Standard	0603	Standard	Resistive divider from VIN to SW1, divides down VIN. The divided down voltage is used to turn the device on when S1 is toggled. V+ = VIN × (R10/(R10 + R21) = (10V to 2.66V)
R21	20 kΩ	1/16 W, 1%	Standard	0603	Standard	
R10	10 kΩ	1/16 W, 1%	Standard	0603	Standard	Limiting resistor in case S1 is over voltaged.
R4	49.9 kΩ	1/16 W, 1%	Standard	0603	Standard	Compensation resistor
R5	499 kΩ	1/16 W, 1%	Standard	0603	Standard	LED short protection threshold setting resistor. V_{LED_SHORT} = R5/R6 × 1.229 V = 5.08 V
R6	121 kΩ	1/16 W, 1%	Standard	0603	Standard	ILED max current setting resistor. ILEDX = 1.229 V/R6 × 1990 = 20.2 mA per LED
R7	162 kΩ	1/16 W, 1%	Standard	0603	Standard	Boost frequency setting resistor. f_{SW} = 80,000/R7 (kΩ)
R8	3 Ω	1/16 W, 1%	Standard	0603	Standard	Gate drive filter resistor. R3 and CG of Q1 form a low pass filter for the gate drive signal.
R9	200 Ω	1/16 W, 1%	Standard	0603	Standard	Filter for current sense signal. R9 and C6 filter the current sense signal developed across R1

Table 1. Bill of Materials and Component Description (continued)

DEVICE	VALUE	DESCRIPTION	PART NUMBER	SIZE	MANUFACTURER	PURPOSE
S1	Switch	Various	Various	Various	Various	Typical switch. Low current
U1	White LED Driver	White LED Driver + Boost Controller	TPS61199PWP	20-pin HTSSOP	Texas Instruments	8-Channel Boost WLED Driver. See TPS61199 data sheet and SLVU421 for more information.
LED1-LED8	White LED	VF = 68 V max, IF = 20 mA, T_A = 25°C, 180 lumens	SAW0LH0A	5 mm × 5 mm	Seoul Semiconductor	High brightness LED (total 1440 Lumens)

3 Modifications to Existing TPS61199EVM

The TPS61199 high-brightness LED lighting circuit is very similar to the TPS61199EVM. Some minor modifications have been made:

1. Added C11 to reduce the switching noise at the circuits output. This (ceramic) capacitor must be place close to the Schottky diodes output (D1) and the GND return of the TPS61199. This reduces noise that can be conducted through the LEDs.
2. Adjusted the overvoltage protection threshold from 59.3 V to 71.3 V in order to accommodate the forward voltage of the SAW0LH0A (V_{F_MAX} = 68 V).
3. Adjusted the maximum current down to 20 mA.
4. Connected the PWM input directly to VDD in order to force the LED currents to 20 mA as soon as S1 is switched to V+.

4 Circuit Efficiency

Table 2 shows the measured efficiency with the specified components of Table 1.

Table 2. Typical Efficiency

VIN	ILED (per LED, 8 Total)	VOUT	INPUT CURRENT	EFFICIENCY
8 V	21.63 mA	64.74 V	1.55 A	90.3 %
10 V	21.53 mA	64.87 V	1.229 A	91 %
12 V	21.44 mA	64.87 V	1.019A	91 %
14 V	21.25 mA	64.77 V	0.865 A	90.9 %
16 V	21.13 mA	64.77 V	0.756 A	90.5 %
18 V	21.0 mA	64.77 V	0.669 A	90.4 %
20 V	20.99 mA	64.67 V	0.6026 A	90.1 %
22 V	20.88 mA	64.65 V	0.543 A	90.4 %
24 V	20.81 mA	64.61 V	0.489 A	91.7 %
26 V	20.63 mA	64.59 V	0.456 A	90 %
28 V	20.54 mA	64.58 V	0 4237 A	89.4 %
30 V	20.48 mA	64.57 V	0.392 A	90 %

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