Boost LED Driver with 1:3000 Dimming Ratio and Excellent Current Regulation

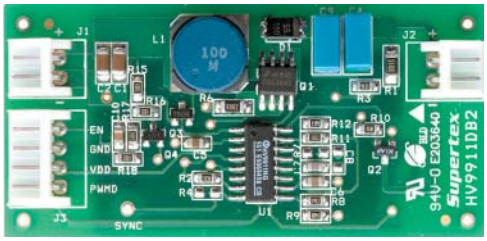
General Description

The HV9911DB2 is an LED driver capable of driving up to twenty 100mA LEDs in series from an input of 9 – 16V DC. The demoboard uses Supertex's HV9911 IC in a boost topology. The converter has a very good initial regulation, (+/-5%), and excellent line and load regulation over the entire input and output voltage range (<+/- 1%). The full load efficiency of the converter is typically greater than 85%.

The HV9911DB2 is also protected against open LED and output short circuit conditions. It has an excellent PWM dimming response, with typical rise and fall times less than 2µs, which will allow high PWM dimming ratios. The HV9911DB2 also features an ENABLE input which can be used to shut down the IC and allow a very small power draw from the input.

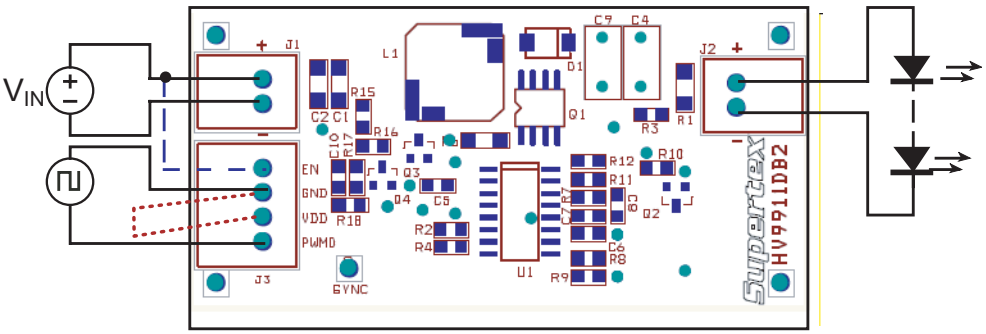
The switching frequency of the HV9911DB2 can be synchronized to other HV9911 boards or to an external 200kHz clock by connecting the clock to the SYNC pin of the HV9911DB2

Specifications	
Input voltage (steady state):	9V – 16V DC
Output LED string voltage:	35V min - 80V max
Output current:	100mA +/-5%
Output current ripple:	10% typical
Switching frequency:	200kHz
Full load efficiency:	87% (at 12V input)
Shut down current:	100µA (typ)
Open LED protection:	Shuts down at 92V
Output short circuit protection:	Included
PWM dimming frequency:	1:3000 dimming ratio at 200Hz



Actual Size: 64mm X 31mm

Board Layout and Connection Diagram



Connections:

Input: The input is connected between the terminals of connector J1 as shown in the Connection Diagram.

Output: The output is connected between the terminals of connector J2 as shown.

Enable: To Enable to board, connect the EN pin of the connector J3 to the input voltage as shown in the Connection Diagram. This will enable the IC and a small current will be drawn from the input. However, this will not start the converter. To start the converter, connect the PWMD pin to the V_{DD} pin of the connector J3.

PWM Dimming: To PWM dim the board, connect the external push-pull waveform source between terminals PWMD and GND of connector J3 as shown by the solid lines. Note that EN should be connected to the input voltage.

Note: During PWM dimming, pin V_{DD} of connector J3 should be left open. Also, the PWM signal must have the proper polarity with the positive connected to pin PWMD of J3. Note that pin GND of J3 is internally connected to the return path of the input voltage.

SYNC: To synchronize two or more boards, connect the SYNC pins of all the boards together. To synchronize the HV9911DB1 to an external 200kHz clock, connect the clock between the SYNC terminal and GND pin of terminal J3.

Testing The Demoboard:

Normal Operation: Connect the input source and the output LEDs as shown in the Connection Diagram and enable the board. The LEDs will glow with a steady intensity. Connecting an ammeter in series with the LEDs will allow measurement of the LED current. The current will be 100mA +/- 5%.

Current Regulation: With the input power to the converter disconnected, change the LED string voltage within the specifications mentioned. The current output of the HV9911DB2 will remain very steady over the entire load range. Vary the input voltage while the circuit is operational. The current will be regulated over the entire line range.

Open LED test: Connect a voltmeter across the output terminals of the HV9911DB2. Start the demoboard normally and once the LED current reaches steady state, unplug one end of the LED string from the demoboard. The output voltage will rise to about 92V and then the HV9911DB2 will shut down. To restart the converter, disconnect and reconnect the input voltage (recycle the power to the board).

Short Circuit Test: When the HV9911DB2 is operating in steady state, connect a jumper across the terminals of the LED string. Notice that the output current will immediately go to zero and the converter will shut down. To restart the HV9911DB2, recycle the input power to the demoboard.

PWM Dimming: With the input voltage to the board disconnected, apply a TTL compatible, push-pull square wave signal between PWMD and GND terminals of connector J3 as shown in the Connection Diagram. Turn the input voltage back on and adjust the duty cycle and / or frequency of the PWM dimming signal. The output current will track the PWM dimming signal. Note that although the converter operates perfectly well at 1kHz PWM dimming frequency, the widest PWM dimming ratio can be obtained at lower frequencies like 100 or 200Hz.

Typical Results

1. Efficiency: The efficiency of the converter at various LED string voltages are shown in Fig.1 (measured at the nominal input voltage of 24V). Fig.2 shows the full load efficiency of the converter at varying input voltages. The minimum efficiency of 86% for the converter occurs at 9V input and full load output.

2. Current Regulation: Figs. 3 and 4 show the output current regulation vs. input voltage and load voltage respectively. The total current regulation (line and load combined) is found to be less than 1%.

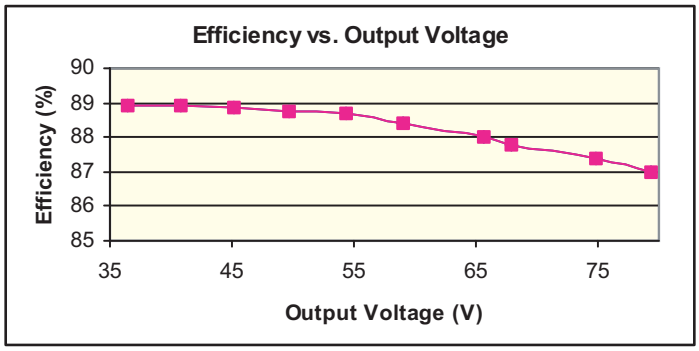


Fig. 1. Efficiency vs. Output Voltage

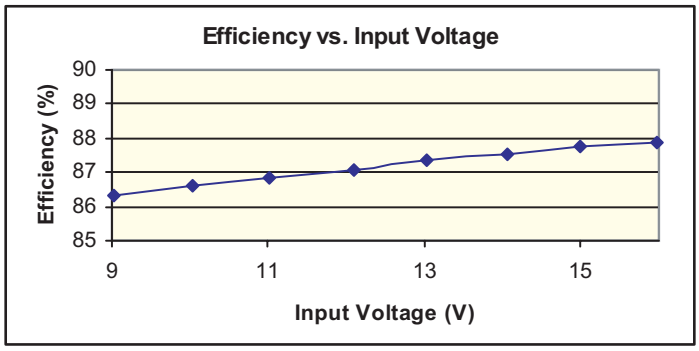


Fig. 2. Efficiency vs. Input Voltage

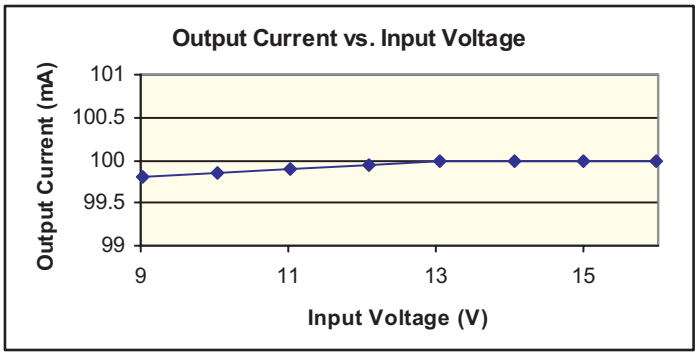


Fig. 3. Output Current vs. Input Voltage

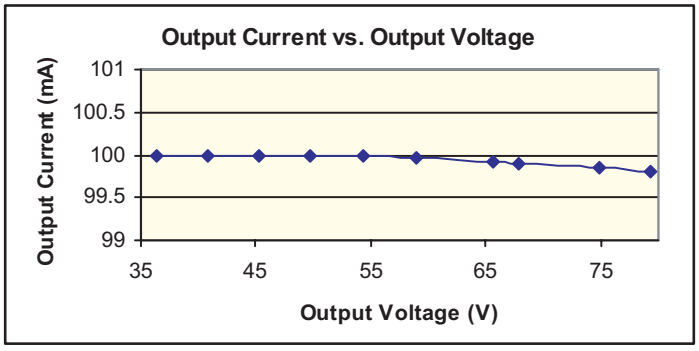


Fig. 4. Output Current vs. Load Voltage

3. Open LED Protection: Open LED protection for the circuit is set at 92V. The waveforms in Fig. 5 shows the output voltage, drain voltage and output current during an open LED condition. The time taken for the over voltage protection to shut the IC down will depend on the size of the output capacitor.

4. Output Short Circuit Protection: Fig. 6 shows the waveforms for output short circuit condition. The disconnected FET is turned off in less than 300ns. The rise in the output current will depend on the input voltage and the value of inductor L1. The same protection will also help in protecting the LEDs in case the output voltage increases beyond the LED string voltage.

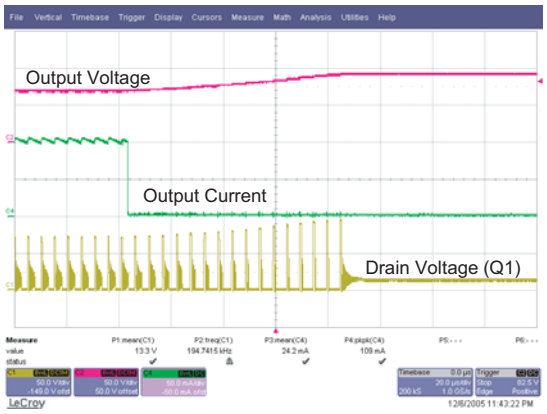


Fig. 5: Open LED Protection (20µ/div)

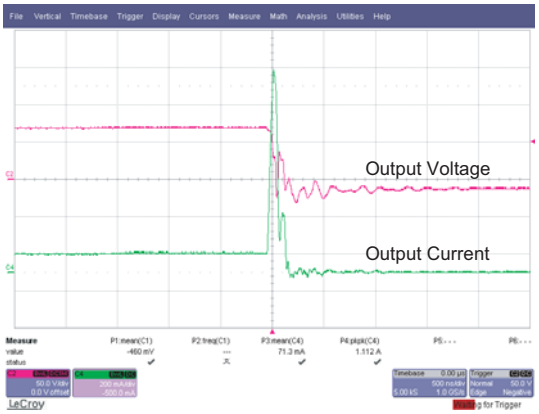


Fig. 6: Open Short Circuit Protection (500ns/div)

5. PWM Dimming: The rise and fall transitions of the LED current during PWM dimming are shown in Figs. 7 and 8, at output voltages of 80V and 40V respectively. The timescale for all waveforms is set at 5.0µs/div. The rise and fall times are less than 1.0µs in each case. Thus, a PWM dimming ratio of 1:3000 is achievable at a PWM dimming frequency of 200Hz.

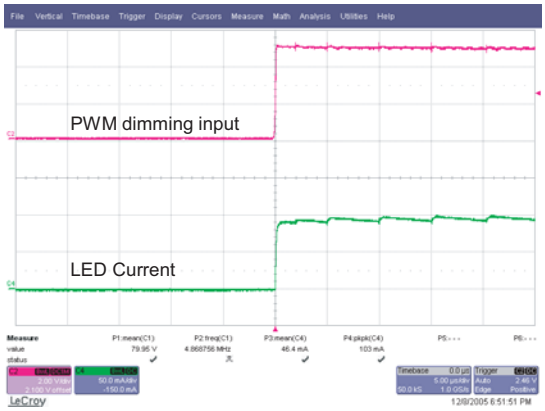


Fig. 7a: Rise time of LED Current at 80V output (5µs/div)

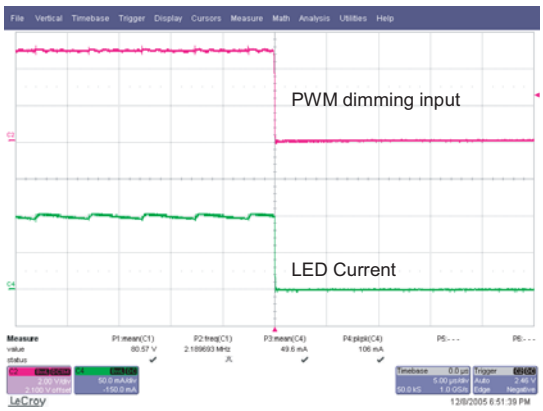


Fig. 7b: Fall time of LED Current at 80V output (5µs/div)

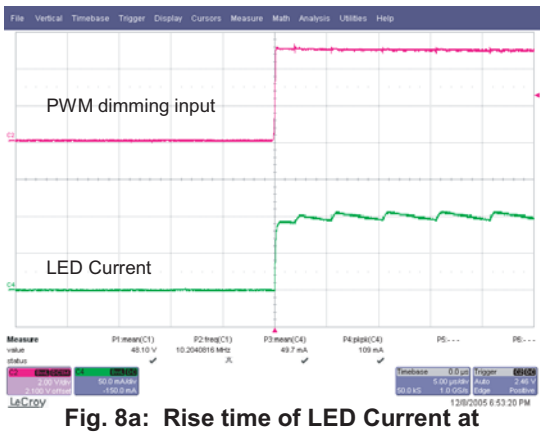
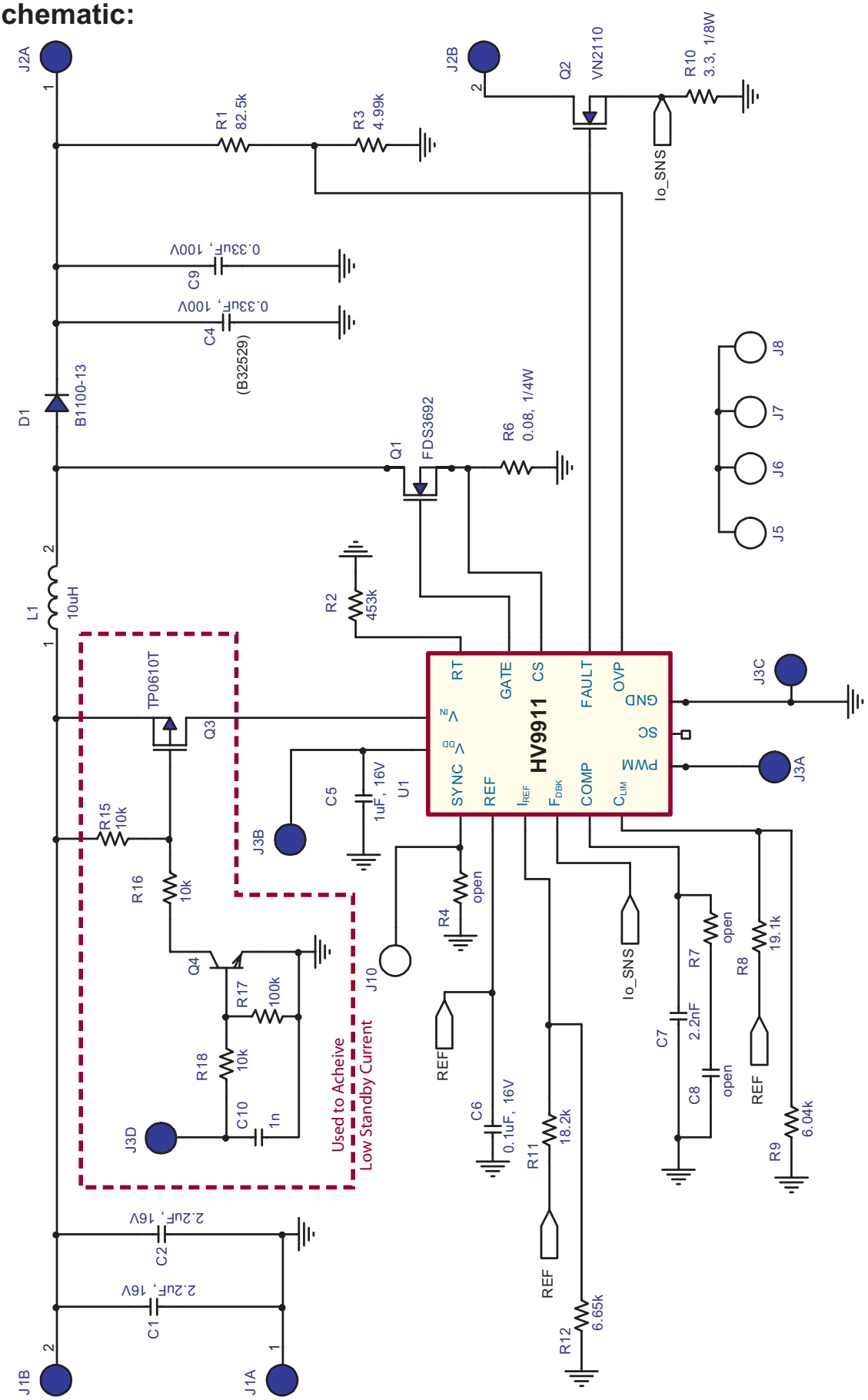


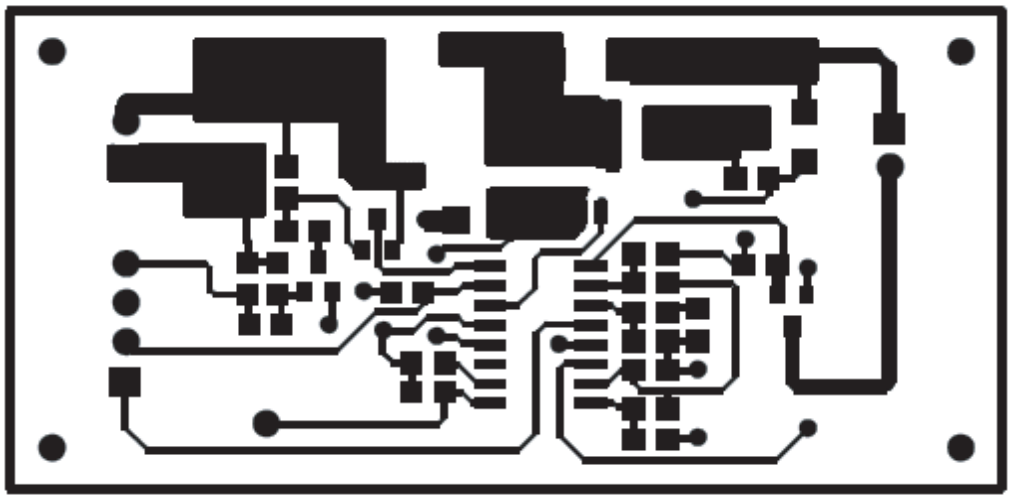
Fig. 8a: Rise time of LED Current at 40V output (5µs/div)

Fig. 8b: Fall time of LED Current at 40V output (5µs/div)

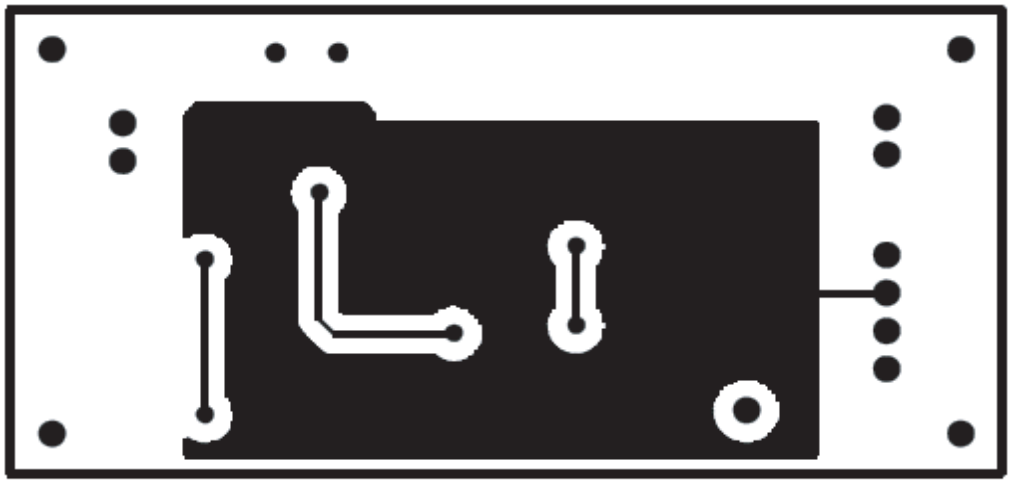
Circuit Schematic:



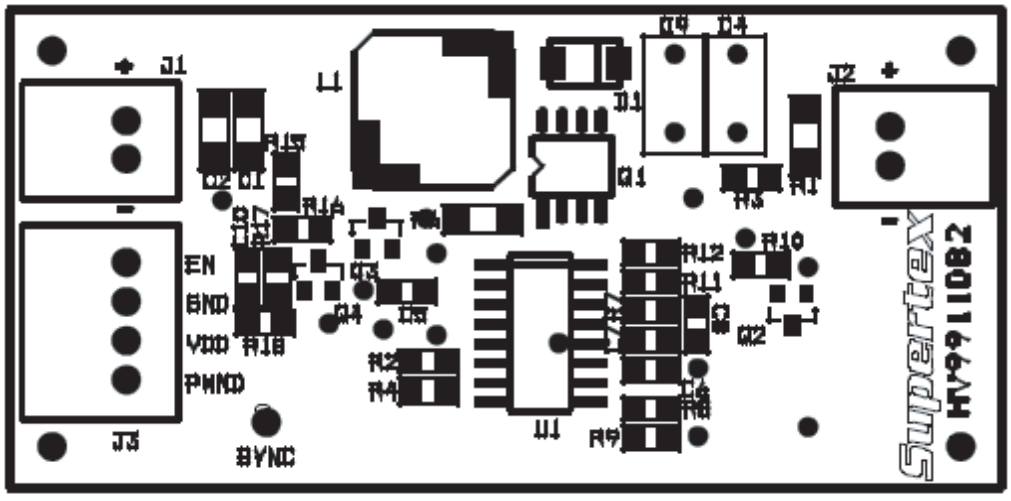
Top Layer:



Bottom Layer:



Silk Screen:



Bill of Materials

Item #	Quan.	RefDes	Description	Package	Manufacturer	Manufacturer's Part Number
1	2	C1,C2	2.2µF, 16V X7R ceramic chip capacitor	SMD1206	Murata	GRM31MR71C225MA35L
2	2	C4,C9	0.33µF, 100V metal Film capacitors	Thru-Hole	EPCOS Inc	B32529C1334J
3	1	C5	1µF, 16V X7R ceramic chip capacitor	SMD0805	TDK Corp	C2012X7R1C105K
4	1	C6	0.1µF, 16V X7R ceramic chip capacitor	SMD0805	Murata	GRM219R71C104KA01D
5	1	C7	2.2nF, 5%, 50V C0G ceramic chip capacitor	SMD0805	TDK Corp	C2012C0G1H222J
6	3	R4, R7, C8	open	-	-	-
7	1	C10	1nF, 50V, X7R ceramic chip capacitor	SMD0805	TDK Corp	C2012X7R1H102K
8	1	D1	100V, 1A schottky diode	SMA	Diodes Inc.	B1100-13
9	2	J1,J2	Side Entry 2-pin male header	Thru-Hole	JST Sales Amer.	S2B-EH
10	1	J3	Side Entry 4-pin male header	Thru-Hole	JST Sales Amer.	S4B-EH
11	1	L1	10µH, 5.5A sat, 4.3A rms inductor	SMT	Sumida	CDR10D48MN-100
12	1	Q1	100V, 4.55A N-Channel MOSFET	SO-8	Fairchild	FDS3692
13	1	Q2	100V, 4.0Ω N-Channel MOSFET	SOT-89	Supertex	VN2110K1
14	1	Q3	-60V, 10Ω P-Channel MOSFET	SOT-23	Supertex	TP0610T
15	1	Q4	40V, 600mA NPN Transistor	SOT-23	ST Micro	MMBT2222A
16	1	R1	82.5k, 1%, 1/8W chip resistor	SMD0805	Yageo	RC0805FR-0782K5L
17	1	R2	453k, 1%, 1/8W chip resistor	SMD0805	Yageo	RC0805FR-07453KL
18	1	R3	1.13k, 1%, 1/8W chip resistor	SMD0805	Yageo	RC0805FR-071K13L
19	1	R6	0.08, 1%, 1/4W chip resistor	SMD1206	Vishay/ Dale	WSL1206R0800FEA
20	1	R8	19.1k, 1%, 1/8W chip resistor	SMD0805	Yageo	RC0805FR-0719K1L
21	1	R9	6.04k, 1%, 1/8W chip resistor	SMD0805	Yageo	RC0805FR-076K04L
22	1	R10	3.3, 1%, 1/8W chip resistor	SMD0805	Panasonic	ERJ-6RQF3R3V
23	1	R11	18.2k, 1%, 1/8W chip resistor	SMD0805	Yageo	RC0805FR-0718K2L
24	1	R12	6.65k, 1%, 1/8W chip resistor	SMD0805	Yageo	RC0805FR-076K65L
25	1	R15, R16, R18	10.0k, 1%, 1/8W chip resistor	SMD0805	Yageo	RC0805JR-0710KL
26	1	R17	100k, 1%, 1/8W chip resistor	SMD0805	Yageo	RC0805JR-07100KL
27	1	U1	Switchmode LED Driver with High Current Accuracy	SO-16	Supertex	HV9911NG-G

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