

AN-1736 LM3433 HB LED Driver Evaluation Kit

1 Introduction

The LM3433 is an adaptive constant on-time DC/DC buck constant current controller designed to drive a high brightness LEDs (HB LED) at high forward currents. It is a true current source that provides a constant current with constant ripple current regardless of the LED forward voltage drop. The board can accept an input voltage ranging from -9V to -14V w.r.t. GND. The output configuration allows the anodes of multiple LEDs to be tied directly to the ground referenced chassis for maximum heat sink efficacy when a negative input voltage is used.

2 LM3433 Board Description

The evaluation board is designed to provide a constant current in the range of 2A to 9A. With some modification the board is capable of up to 20A. The LM3433 requires two input voltages for operation. A positive voltage with respect to GND is required for the bias and control circuitry and a negative voltage with respect to GND is required for the main power input. This allows for the capability of using common anode LEDs so that the anodes can be tied to the ground referenced chassis. The evaluation board only requires one input voltage of -12V with respect to GND. The positive voltage is supplied by the LM5002 circuit. The LM5002 circuit also provides a UVLO function to remove the possibility of the LM3433 from drawing high currents low input voltages during startup. Initially the output current is set at the minimum of approximately 2A with the POT P1 fully counter-clockwise. To set the desired current level a short may be connected between LED+ and LED-, then use a current probe and turn the POT clockwise until the desired current is reached. A PWM dimming FET is included on-board for testing when the LED can be connected directly next to the board. A shutdown post on J2, ENA, is included so that startup and shutdown functions can be tested using an external voltage. Included in the kit is a load board the emulates a high current LED and an LED adapter board used to place a dimming FET close to a remote LED.

3 LED Adapter Board Description

The LED adapter board is designed to allow placement of a dimming FET as close to an LED as possible. The high currents supplied by the LM3433 require that the FET be very close the LED to reduce the inductance between the two current paths. Placing the FET far from the LED could result in high voltage spikes due to the di/dt through the inductance between the FET and the LED. If the LED cannot be placed directly next to the LM3433 evaluation board then remove the dimming FET(s) from the LM3433 board (Q5 and Q6) and use this board. The LED adapter board connects to the LM3433 board with the supplied 26 pin ribbon cable.

4 Load Board Description

The load board is designed to emulate an LED load. This board provides the ability to test the LM3433 without the possibility of accidentally destroying high current LEDs. It connects to the LM3433 evaluation board with the supplied 26 pin ribbon cable. The load board has an adjustable voltage controlled with the POT R5 and it includes three small LEDs that light up when the forward voltage of each is reached. This allows for adjusting the voltage to the level desired corresponding to a red, green, or blue LED. Test points are included so that current can be measured across a low value resistor both before and after the included dimming FET.

These resistors can also be removed and replaced with a short loop of wire if using a current probe is desired. If the PWM dimming function is used with the load board the dimming FET(s) (Q5 and Q6) should be removed from the LM3433 evaluation board. The load board is designed for approximately 8A maximum. It includes thermal protection and will shut down if it gets too hot. The thermal protection may trip during normal testing especially if higher voltages are used. If the thermal protection trips let the board cool down and then resume testing.

5 Setting the LED Current

The LM3433 evaluation board is designed so that the LED current can be set in multiple ways. There is a shunt on J2 initially connecting the ADJ pin to the POT allowing the current to be adjusted using the POT P1. This POT will apply a voltage to the ADJ pin between 0.3V and 1.5V w.r.t. GND to adjust the voltage across the sense resistor (R_{SENSE}) R15. The shunt may also be removed and an external voltage positive w.r.t. GND can then be applied to the ADJ test point on the board. A 10m Ω resistor comes mounted on the board so using the V_{SENSE} vs. V_{ADJ} graph in the *Typical Performance Characteristics* section the current can be set using [Equation 1](#):

$$I_{\text{LED}} = V_{\text{SENSE}}/R_{\text{SENSE}} \quad (1)$$

Alternatively the shunt can be removed and connect the ADJ test point can be connected to the VINX test point to fix V_{SENSE} at 60mV.

6 PWM Dimming

The LM3433 is capable of high speed PWM dimming in excess of 40kHz. Dimming is accomplished by shorting across the LED with a FET. A dimming FET is included on the evaluation board for testing LEDs placed close to the board and also on the load board and adapter board for remote loads. The FET on the evaluation board should be removed if using dimming with the load board or adapter board.

To use the dimming function apply square wave to the PWM test point on the board that has a positive voltage w.r.t. GND. When this pin is pulled high the dimming FET is enabled and the LED turns off. When it is pulled low the dimming FET is turned off and the LED turns on. A scope plot of PWM dimming is included in the *Typical Performance Characteristics* section showing 30kHz dimming at 50% duty cycle.

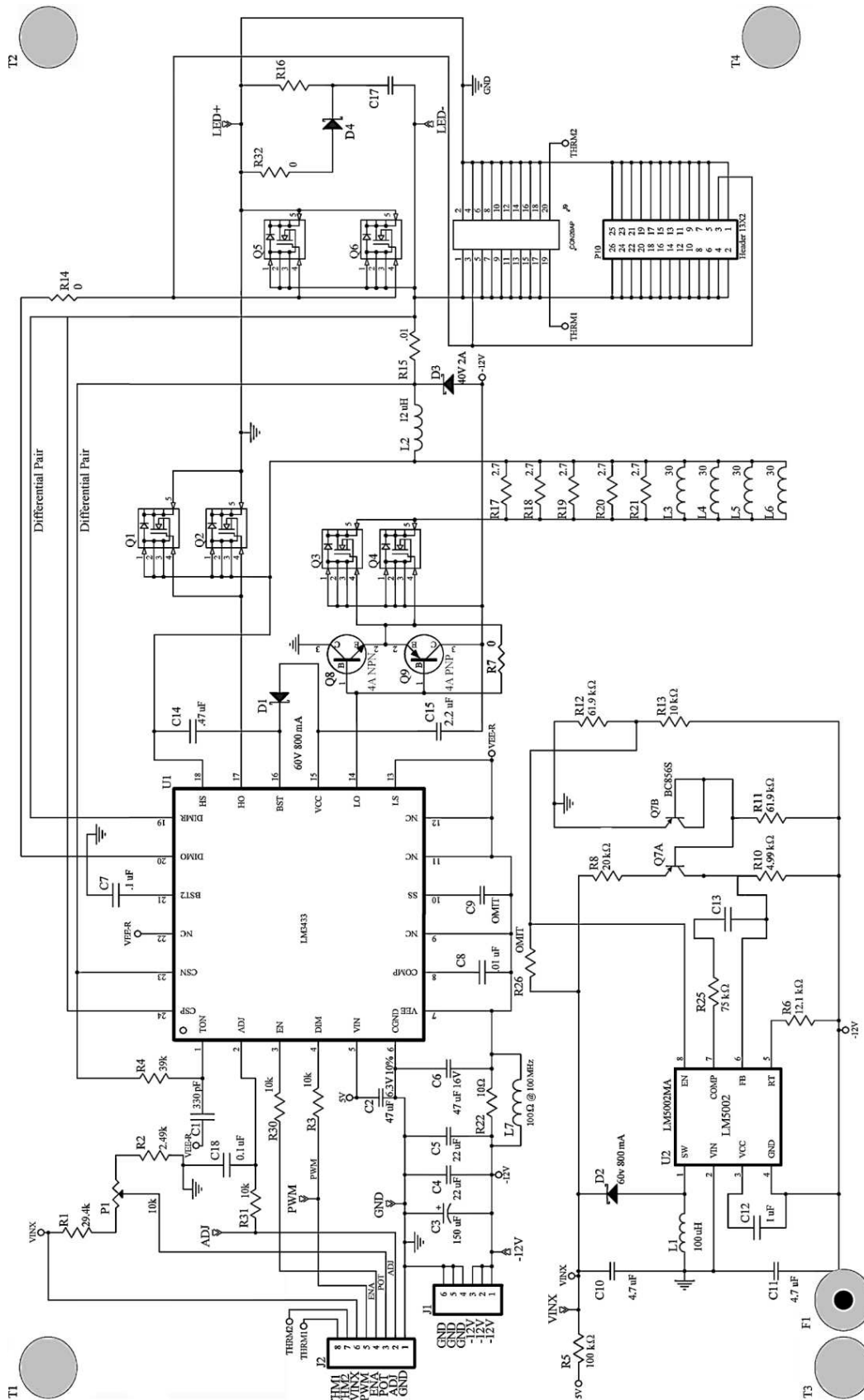


Figure 1. LM3433 Evaluation Board Schematic

Table 1. Bill of Materials (BOM) 1 (2A to 9A)

Qty	ID	Part Number	Type	Size	Parameters	Vendor
1	U1	LM3433	LED Driver	WQFN-24		TI
1	U2	LM5002	Boost Regulator	SOIC-8		TI
1	C1	C0805C331J5GACTU	Capacitor	0805	330pF, 50V	Kemet
1	C2	GRM31CR61C106KC3 1L	Capacitor	1206	10μF, 16V	Murata
1	C3	16SA150M	Capacitor	MULTICAP	150μF, 16V	Sanyo
2	C4, C5	GRM32ER61C226KE2 0L	Capacitor	1210	22μF, 16V	Murata
1	C6	GRM32ER61C476ME1 5L	Capacitor	1210	47μF, 16V	Murata
1	C7	C0805C104J5RACTU	Capacitor	0805	0.1μF, 50V	Kemet
2	C8, C13	HMK212BJ103KG-T	Capacitor	0805	10nF, 100V	Taiyo Yuden
	C9	OPEN		0805		
2	C10, C11	GRM21BR61C475KA	Capacitor	0805	4.7μF, 16V	Murata
1	C12	0805YD105KAT2A	Capacitor	0805	1μF, 16V	AVX
1	C14	B37941K9474K60	Capacitor	0805	0.47μF, 16V	EPCOS Inc .
1	C15	GRM21BF51E225ZA01 L	Capacitor	0805	2.2μF, 25V	Murata
	C17	OPEN		0805		
1	C18	08055C104JAT2A	Capacitor	0805	0.1μF, 50V	AVX
2	D1, D2	MA2YD2600L	Diode	SOD-123	60V, 800mA	Panasonic
1	D3	MBRS240LT3	Diode	SMB	40V, 2A	ON Semiconductor
	D4	OPEN		SMB		
	J1, J2	OPEN				
1	J9	TFML-110-02-S-D	Connector	TFM-110-02-X-D-LC		Samtec
1	L1	LPS3008-104ML	Inductor	3008	100μH, 150mA	Coilcraft
1	L2	GA3252-AL	Inductor	GA3252-AL	12μH, 14A	Coilcraft
	L3, L5	OPEN		0805		
2	L4, L6	MPZ2012S300A	Ferrite Bead	0805	30Ω @ 100MHz	TDK
1	L7	MPZ2012S101A	Ferrite Bead	0805	100Ω @ 100MHz	TDK
1	P1	3352T-1-103LF	Potentiometer	BOURNS2	10kΩ	Bourns
1	P10	3429-6002	Connector	HDR13x2	13X2 Pin Header	3M
	Q1, Q3, Q5	OPEN		PowerPAK		
2	Q4, Q6	Si7386DP	FET	PowerPAK	30V, 9.5mΩ	Vishay- Siliconix
1	Q2	NTMFS4841NH	FET	PowerPAK	30V, 11mΩ	ON Semiconductor
1	Q7	BC856S	Dual PNP	SOT363_N		Phillips
	Q8, Q9	OPEN				
1	R1	ERJ-6ENF2942V	Resistor	0805	29.4kΩ	Panasonic
1	R2	ERJ-6ENF2491V	Resistor	0805	2.49kΩ	Panasonic
3	R3, R30, R31	ERJ-6ENF1002V	Resistor	0805	10kΩ	Panasonic
1	R4	ERJ-6GEYJ393V	Resistor	0805	39kΩ	Panasonic
1	R5	ERJ-6GEYJ101V	Resistor	0805	100Ω	Panasonic
2	R7, R14	ERJ-6GEY0R00V	Resistor	0805	0Ω	Panasonic
1	R8	ERJ-6ENF2002V	Resistor	0805	20kΩ	Panasonic
1	R10	ERJ-6ENF4991V	Resistor	0805	4.99kΩ	Panasonic
2	R11, R12	ERJ-6ENF6192V	Resistor	0805	61.9kΩ	Panasonic
1	R13	ERJ-6GEYJ103V	Resistor	0805	10kΩ	Panasonic

Table 1. Bill of Materials (BOM) 1 (2A to 9A) (continued)

Qty	ID	Part Number	Type	Size	Parameters	Vendor
1	R15	WSL2512R0100FEA	Resistor	CR6332-2512	0.01Ω	Vishay
	R16, R18, R19	OPEN		0805		
3	R17, R20, R21	ERJ-6GEYJ2R7V	Resistor	0805	2.7Ω	Panasonic
1	R22	ERJ-6GEYJ100V	Resistor	0805	10Ω	Panasonic
1	R25	ERJ-6ENF7502V	Resistor	0805	75kΩ	Panasonic
	R26	OPEN		0805		
4	-12V, GND, LED+, LED-	1502-2	Test Post	TP 1502	0.109"	Keystone
3	ADJ, PWM, VINX	1593-2	Test Post	TP 1593	0.084"	Keystone

Table 2. Bill of Materials (BOM) 2(4A to 20A)

Qty	ID	Part Number	Type	Size	Parameters	Vendor
1	U1	LM3433	LED Driver	WQFN-24		TI
1	U2	LM5002	Boost Regulator	SOIC-8		TI
1	C1	C0805C331J5GACTU	Capacitor	0805	330pF, 50V	Kemet
1	C2	GRM31CR61C106KC31L	Capacitor	1206	10μF, 16V	Murata
1	C3	16SA150M	Capacitor	MULTICAP	150μF, 16V	Sanyo
2	C4, C5	GRM32ER61C226KE20L	Capacitor	1210	22μF, 16V	Murata
1	C6	GRM32ER61C476ME15L	Capacitor	1210	47μF, 16V	Murata
1	C7	C0805C104J5RACTU	Capacitor	0805	0.1μF, 50V	Kemet
2	C8, C13	HMK212BJ103KG-T	Capacitor	0805	10nF, 100V	Taiyo Yuden
	C9	OPEN		0805		
2	C10, C11	GRM21BR61C475KA	Capacitor	0805	4.7μF, 16V	Murata
1	C12	0805YD105KAT2A	Capacitor	0805	1μF, 16V	AVX
1	C14	B37941K9474K60	Capacitor	0805	0.47μF, 16V	EPCOS Inc .
1	C15	GRM21BF51E225ZA01L	Capacitor	0805	2.2μF, 25V	Murata
	C17	OPEN		0805		
1	C18	08055C104JAT2A	Capacitor	0805	0.1μF, 50V	AVX
2	D1, D2	MA2YD2600L	Diode	SOD-123	60V, 800mA	Panasonic
1	D3	MBRS240LT3	Diode	SMB	40V, 2A	ON Semiconductor
	D4	OPEN		SMB		
	J1, J2	OPEN				
1	J9	TFML-110-02-S-D	Connector	TFM-110-02-X-D-LC		Samtec
1	L1	LPS3008-104ML	Inductor	3008	100μH, 150mA	Coilcraft
1	L2	GA3252-AL	Inductor	GA3252-AL	12μH, 14A	Coilcraft
4	L3, L4, L5, L6	MPZ2012S300A	Ferrite Bead	0805	30Ω @ 100MHz	TDK
1	L7	MPZ2012S101A	Ferrite Bead	0805	100Ω @ 100MHz	TDK
1	P1	3352T-1-103LF	Potentiometer	BOURNS2	10kΩ	Bourns
1	P10	3429-6002	Connector	HDR13x2	13X2 Pin Header	3M
4	Q3, Q4, Q5, Q6	Si7386DP	FET	PowerPAK	30V, 9.5mΩ	Vishay-Siliconix
2	Q1, Q2	NTMFS4841NH	FET	PowerPAK	30V, 11mΩ	ON Semiconductor
1	Q7	BC856S	Dual PNP	SOT363_N		Phillips
1	Q8	ZXTN25040DFHTA	NPN	SOT-23B		Zetex Inc.

Table 2. Bill of Materials (BOM) 2(4A to 20A) (continued)

Qty	ID	Part Number	Type	Size	Parameters	Vendor
1	Q9	ZXTP25040DFHTA	PNP	SOT-23B		Zetex Inc.
1	R1	ERJ-6ENF2942V	Resistor	0805	29.4k Ω	Panasonic
1	R2	ERJ-6ENF2491V	Resistor	0805	2.49k Ω	Panasonic
3	R3, R30, R31	ERJ-6ENF1002V	Resistor	0805	10k Ω	Panasonic
1	R4	ERJ-6GEYJ393V	Resistor	0805	39k Ω	Panasonic
1	R5	ERJ-6GEYJ101V	Resistor	0805	100 Ω	Panasonic
	R7	OPEN				
2	R14	ERJ-6GEY0R00V	Resistor	0805	0 Ω	Panasonic
1	R8	ERJ-6ENF2002V	Resistor	0805	20k Ω	Panasonic
1	R10	ERJ-6ENF4991V	Resistor	0805	4.99k Ω	Panasonic
2	R11, R12	ERJ-6ENF6192V	Resistor	0805	61.9k Ω	Panasonic
1	R13	ERJ-6GEYJ103V	Resistor	0805	10k Ω	Panasonic
1	R15	WSL25125L000FEA	Resistor	CR6332-2512	0.005 Ω	Vishay
6	R16, R17, R18, R19, R20, R21	ERJ-6GEYJ2R7V	Resistor	0805	2.7 Ω	Panasonic
1	R22	ERJ-6GEYJ100V	Resistor	0805	10 Ω	Panasonic
1	R25	ERJ-6ENF7502V	Resistor	0805	75k Ω	Panasonic
	R26	OPEN		0805		
4	-12V, GND, LED+, LED-	1502-2	Test Post	TP 1502	0.109"	Keystone
3	ADJ, PWM, VINX	1593-2	Test Post	TP 1593	0.084"	Keystone

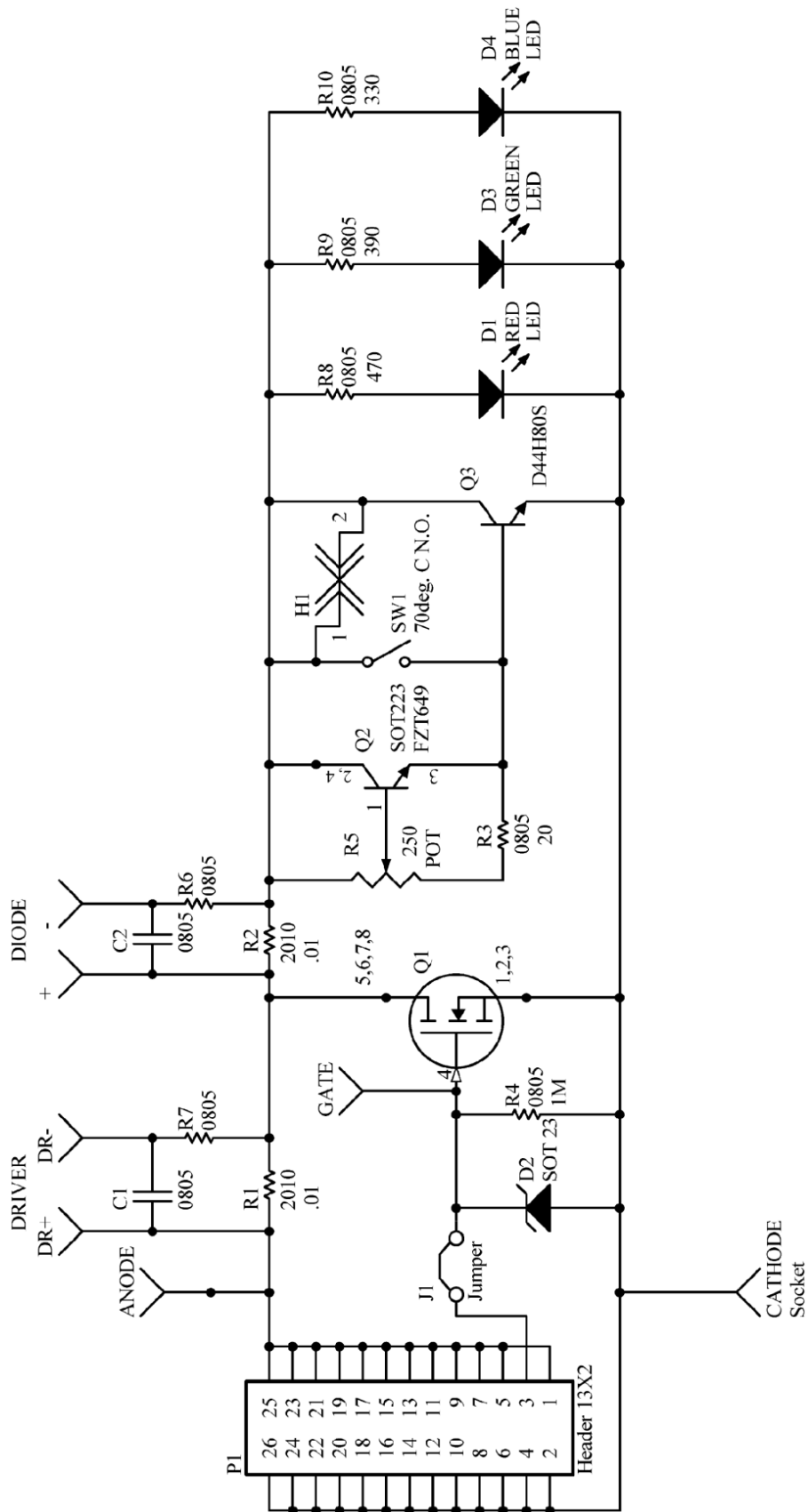


Figure 2. Load Board Schematic

Table 3. Load Board BOM

ID	Part Number	Type	Size	Parameters	Qty	Vendor
C1, C2	OPEN		0805			
D1	SSL-LX5063ID	Red LED	T 1 3/4		1	Lumex
D2	BZX84C15LT1	Zener Diode	SOT-23	225mW, 15V	1	ON Semiconductor
D3	SSL-LX5063GD	Green LED	T 1 3/4		1	Lumex
D4	SSL-LX5093USBD	Blue LED	T 1 3/4		1	Lumex
H1	7-339-4PP-BA	Heatsink	TO-220 Bolt On		1	IREC-CTS
J1	S9001	Connector	1X2 Header	1X2 Pin Header	1	Sullins Electronics Corp .
P1	3429-6002	Connector	HDR13x2	13X2 Pin Header	1	3M
Q1	Si4884DY	FET	SO-8	30V, 16mΩ	1	Vishay-Siliconix
Q2	FZT649	NPN	SOT-223		1	Zetex Inc.
Q3	D44H	NPN	TO-220	60V, 10A	1	ON Semiconductor
R1, R2	WSL2010R0100FEA18	Resistor	2010	0.01Ω	2	Vishay
R3	ERJ-6ENF20R0V	Resistor	0805	20Ω	1	Panasonic
R4	9C08052A1004JLHFT	Resistor	0805	1MΩ	1	Yageo Corporation
R5	PV36X102C01B00	Potentiometer	0805	250Ω	1	Murata
R6, R7	ERJ-6ENF1000V	Resistor	0805	100Ω	2	Panasonic
R8	MCR10EZHF4700	Resistor	0805	470Ω	1	Rohm
R9	ERJ-6GEYJ391V	Resistor	0805	390Ω	1	Panasonic
R10	ERJ-6GEYJ331V	Resistor	0805	330Ω	1	Panasonic
SW1	F1107015ACFA06E		TO-220 w/leads	70deg. C.N.O.	1	Canthem
+, -, ANODE, +, -, CATHODE, GATE	1502-2	Test Post	TP 1502	0.109"	7	Keystone

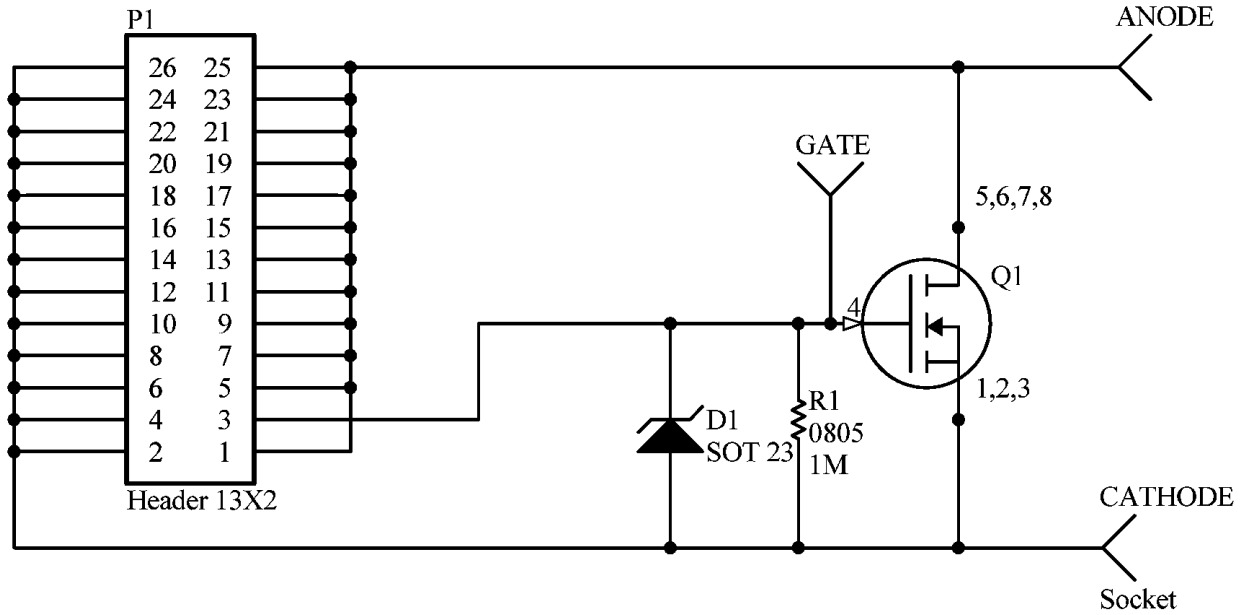


Figure 3. LED DIM Adapter Board Schematic

Table 4. Adapter Board Bill of Materials (BOM)

Qty	ID	Part Number	Type	Size	Parameters	Vendor
	R1	OPEN		0805		
1	D1	BZX84C15LT1	Zener Diode	SOT-23	225mW, 15V	ON Semiconductor
1	P1	3429-6002	Connector	HDR13x2	13X2 Pin Header	3M
1	Q1	Si4884DY	FET	SO-8	30V, 16mΩ	Vishay-Siliconix
7	ANODE, CATHODE, GATE	1502-2	Test Post	TP 1502	0.109"	Keystone

7 Typical Performance Characteristics

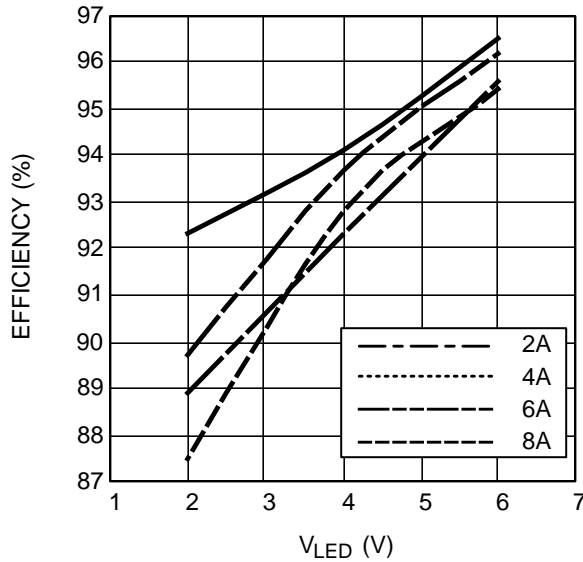


Figure 4. Efficiency vs. LED Forward Voltage ($V_{CGND} - V_{EE} = 9V$)

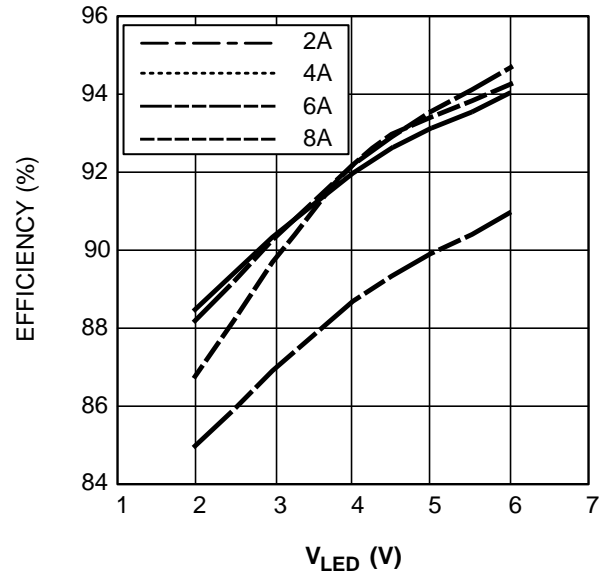


Figure 5. Efficiency vs. LED Forward Voltage ($V_{CGND} - V_{EE} = 12V$)

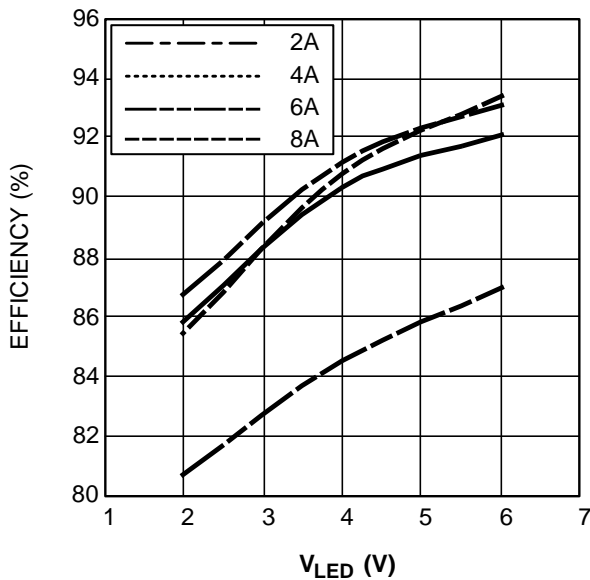


Figure 6. Efficiency vs. LED Forward Voltage ($V_{CGND} - V_{EE} = 14V$)

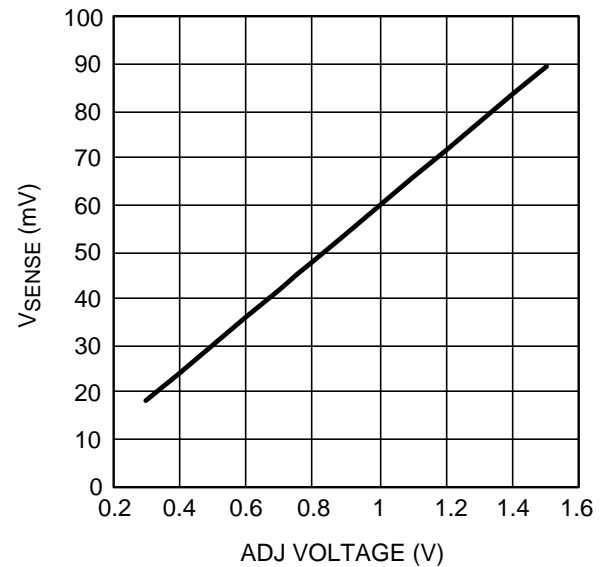
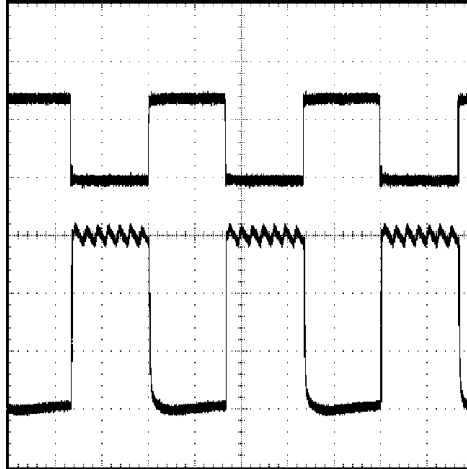


Figure 7. V_{SENSE} vs. V_{ADJ}



I_{LED} = 6A nominal, V_{IN} = 3.3V, V_{EE} = -12V Top trace: DIM input, 2V/div, DC Bottom trace: I_{LED}, 2A/div, DC T = 10 μ s/div
Figure 8. 30kHz PWM Dimming Waveform Showing Inductor Ripple Current

8 Layout

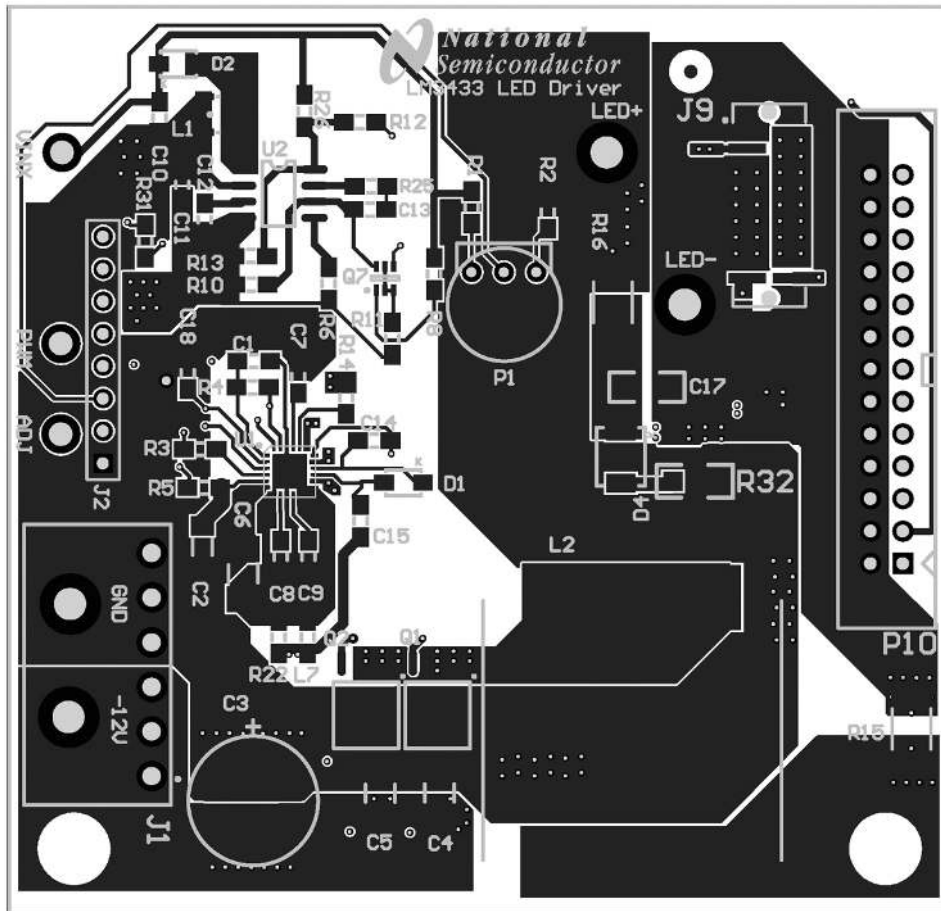


Figure 9. Top Layer and Top Overlay

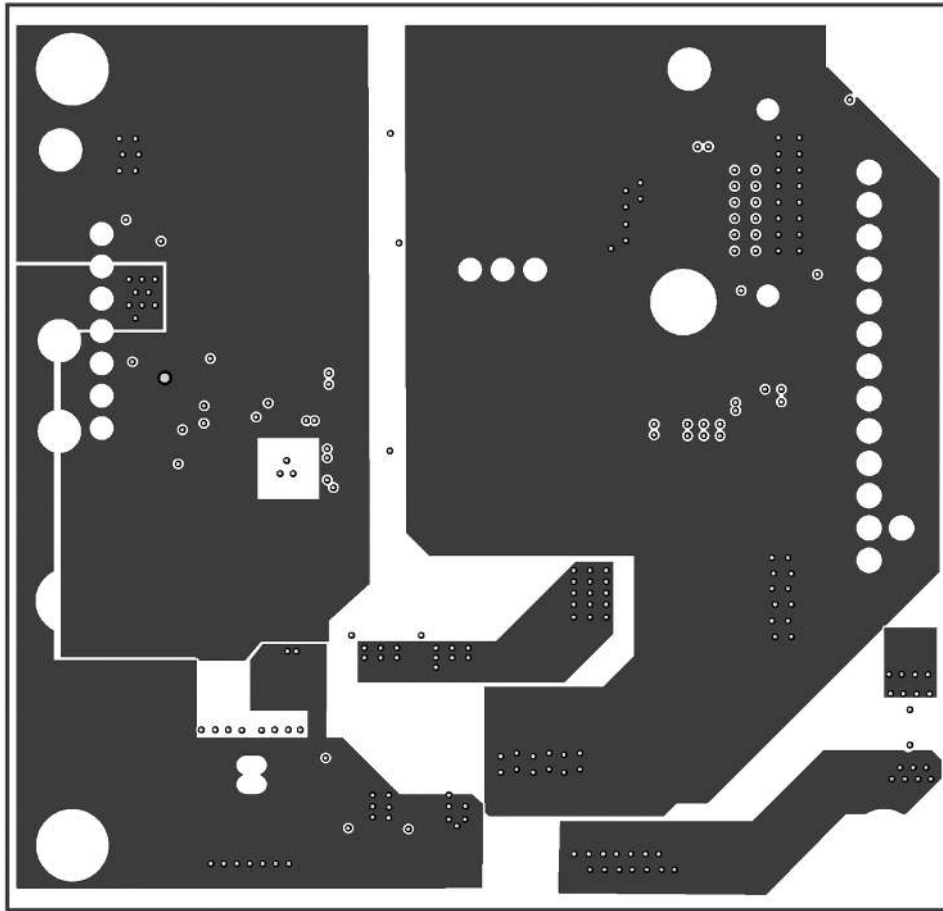


Figure 10. Upper Middle Layer

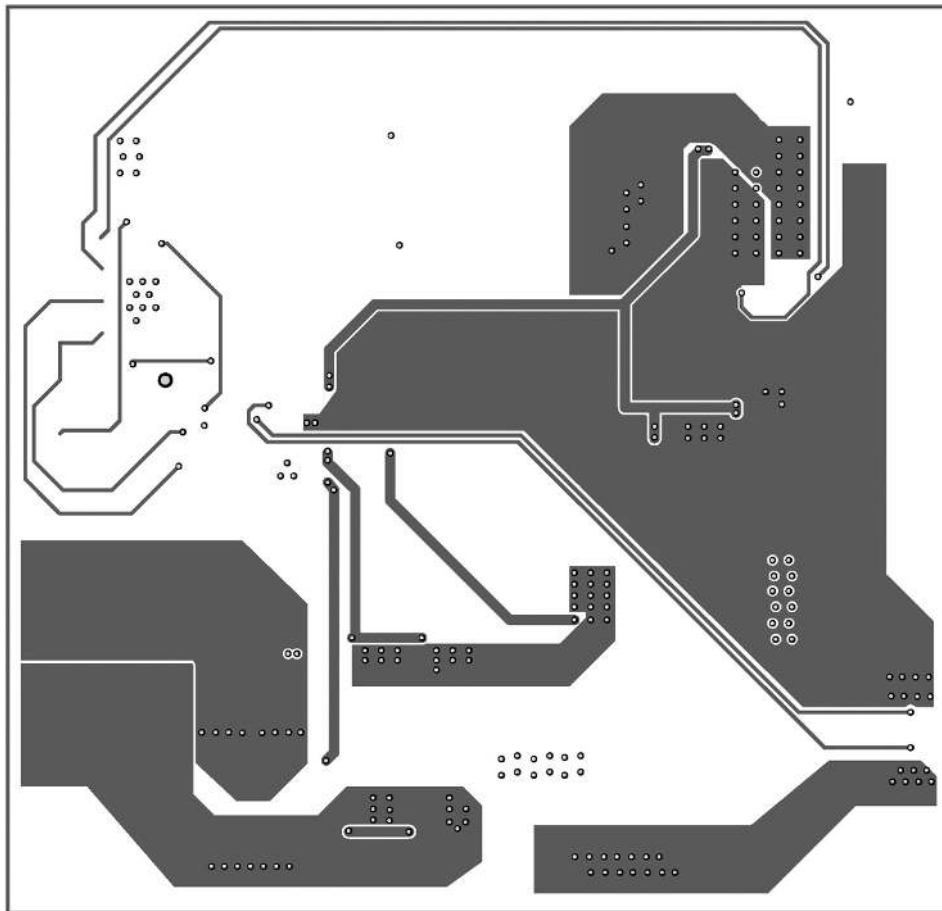


Figure 11. Lower Middle Layer

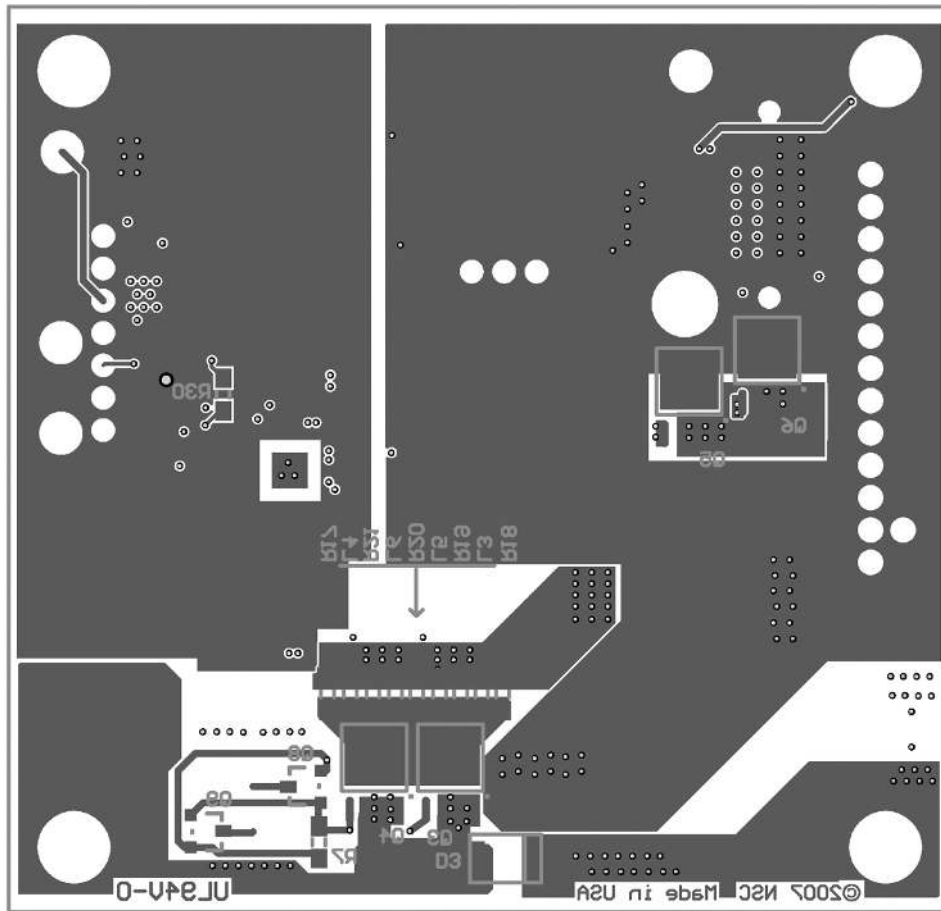


Figure 12. Bottom Layer and Bottom Overlay

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