

LT8356-1

100V_{IN}/120V_{OUT} LED Controller with SSFM**DESCRIPTION**

Evaluation Board EVAL-LT8356-1-AZ is a high-voltage LED controller featuring the LT8356-1. It is assembled as a Buck-Boost mode LED driver but can be altered to a Boost LED driver by adjusting the FB network and LED- connection. EVAL-LT8356-1-AZ drives a single string of LEDs up to 36V at 1A when input is between 8V and 36V. It has an undervoltage lockout (UVLO) set at 6.5V falling and 7.5V rising. The eval board features PWM dimming, analog dimming, shutdown, open LED and short LED fault protection and reporting.

EVAL-LT8356-1-AZ runs at 250kHz switching frequency and features spread spectrum frequency modulation (SSFM) modulating its switching frequency from 250kHz to 310kHz to reduce EMI emissions. Small ceramic input and output capacitors are used to save space and cost. A high voltage 100V external power switch and 100V catch diode are used for up to 36W buck-boost mode output as assembled. The open LED overvoltage protection (OVP) uses the IC's constant voltage regulation loop to limit the LED+ to LED- voltage to approximately 41V if the LED string is opened. The V_{OUT}, when referenced to GND, will jump to V_{IN} + 41V if the LED string is opened.

The input and output filters on EVAL-LT8356-1-AZ help further reduce its EMI. These filters consist of a small ferrite bead or inductor and high frequency ceramic capacitors. A small resistor on the gate pin of the power MOSFET is used to reduce high-frequency EMI. These filters, combined with proper board layout and SSFM, are very effective in reducing EMI to comply with CISPR 25 class 5 limits. Please follow the recommended layout and the four-layer PCB thickness of EVAL-LT8356-1-AZ. For best efficiency and PWM dimming performance, the EMI filters can be removed.

The LT8356-1's integrated PWMTG high-side PMOS driver assists with PWM dimming of the connected LEDs. The LED string can be PWM-dimmed for accurate brightness control with an externally-generated PWM signal for highest achievable dimming ratio. It can also utilize LT8356-1's internally-generated PWM feature for up to 128:1 exponential dimming. When running PWM dimming, the SSFM aligns itself with the PWM signal for flicker-free operation of the LED string. This applies to both internal and external PWM dimming. The LT8356-1 uses CTRL and IADJ pins for two-pin analog dimming.

The input under-voltage lockout (UVLO), LED current, output overvoltage protection (OVP), and switching frequency, can all be easily adjusted with simple resistor changes to EVAL-LT8356-1-AZ. Modifications can be made to convert the board from Buck-Boost mode LED Driver to Boost and Buck mode LED driver, and maintain low EMI, PWM dimming and fault diagnostic features. Buck mode and Boost LED Driver schematics are provided in the datasheet. Please consult the datasheet or the applications team regarding how to customize EVAL-LT8356-1-AZ.

The LT8356-1 datasheet gives a complete description of the part, operation, and applications information. The datasheet must be read in conjunction with this demo manual for evaluation board EVAL-LT8356-1-AZ. The LT8356IUDCM-1 is assembled in a 20-lead side solderable plastic QFN package with a thermally-enhanced exposed ground pad. Proper board layout is essential for maximum performance. See the datasheet section "Designing the Printed Circuit Board".

Design files for this circuit board are available.

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DEMO MANUAL EVAL-LT8356-1-AZ

PERFORMANCE SUMMARY

Specifications are at $T_A = 25^\circ\text{C}$

PARAMETER	CONDITION	MIN	TYP	MAX	UNITS
Input Voltage PV_{IN} Range	Operating	8		36	V
Switching Frequency (f_{SW} , SSFM ON)	$R6 = 110k$	250		310	kHz
I_{LED}	$RS2 = 0.25\Omega$ $8V < PV_{IN} < 36V$, $V_{LED} \leq 36V$ $V_{CTRL} = 2V$, $V_{IADJ} = 2V$		1		A
Open LED Protection (LED+ - LED-)	$R8 = 10k$, $R20 = 10k$, $R22 = 340k$		41		V
Peak Efficiency (SSFM ON)	$PV_{IN} = 12V$, $V_{LED} = 36V$, $I_{LED} = 1A$ With Filters Without Filters		91.5 92		%
Peak Switch Current Limit	$RS1 = 0.01\Omega$		10		A
Internally-Generated PWM Dimming Range	$0.5V < V_{PWM} < 1.5V$	1/128		100%	
Internally-Generated PWM Dimming Frequency	$R6 = 110k$		260		Hz
PV_{IN} Undervoltage Lockout (UVLO) falling	$R4 = 499k$, $R5 = 127k$		6.5		V
PV_{IN} Enable Turn-On (EN) rising			7.5		V

QUICK START PROCEDURE

Demonstration circuit EVAL-LT8356-1-AZ is easy to set up to evaluate the performance of the LT8356-1. Follow the procedure below:

1. With power off, connect a string of LEDs that will run with forward voltage less than or equal to 36V (at 1A) to the LED+ and LED- (Buck-Boost) turrets on the PCB as shown in Figure 1.
2. With power off, connect the input power supply to the PV_{IN} and GND turrets. Make sure that the DC input voltage will not exceed 36V.
3. Turn the input power supply on and make sure the voltage is between 8V and 36V for proper operation at max LED current.
4. Observe the LED string running at the programmed LED current.
5. To change the brightness with **analog dimming**, the CTRL pin and IADJ are used. The product of the offset CTRL and IADJ pin voltages set the current when the two voltages vary between 0.5V and 1.5V. Please refer to datasheet for more details.
6. To change the brightness with **external PWM dimming**, attach a 1.6V-15V rectangular waveform with varying duty cycle to the PWM terminal.
7. To change the brightness **with internally-generated PWM dimming**, adjust the setting voltage at the PWM pin between 0.5V and 1.5V. A linear ramp of voltage on the PWM pin between 0.5V and 1.5V will result in an exponentially increasing PWM duty ratio.

QUICK START PROCEDURE

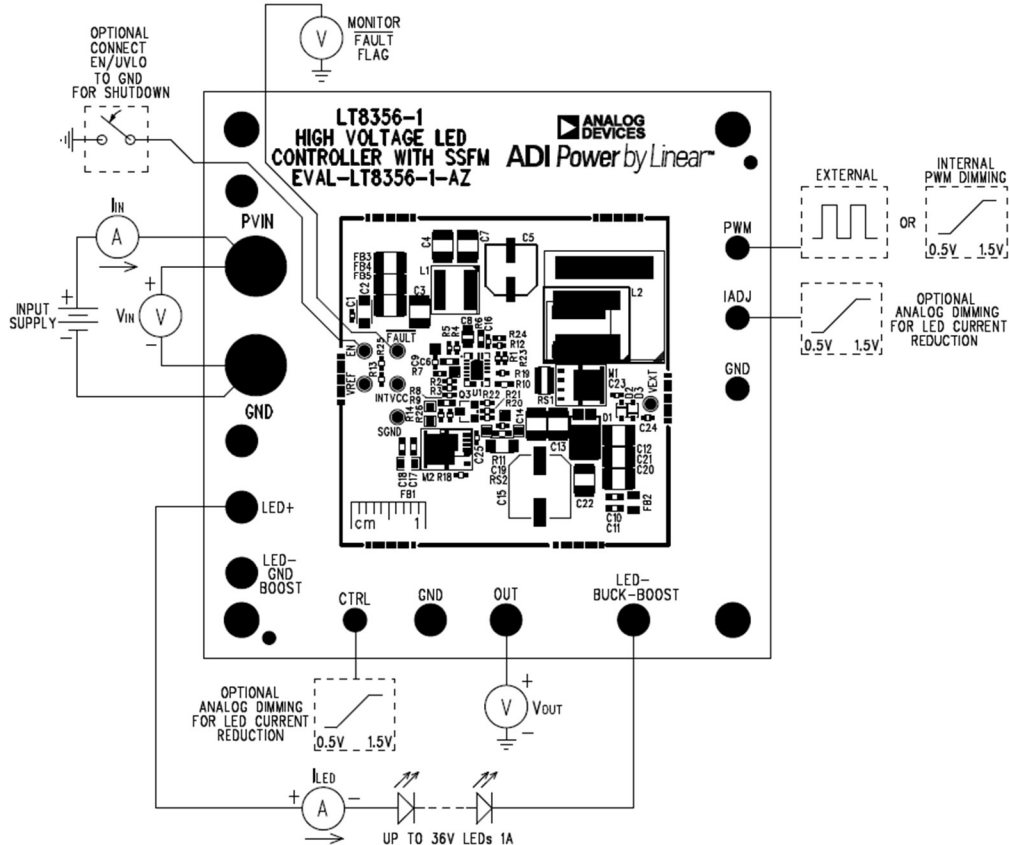


Figure 1. Setup Drawing for EVAL-LT8356-1-AZ as Buck-Boost Mode LED Driver

TEST RESULTS

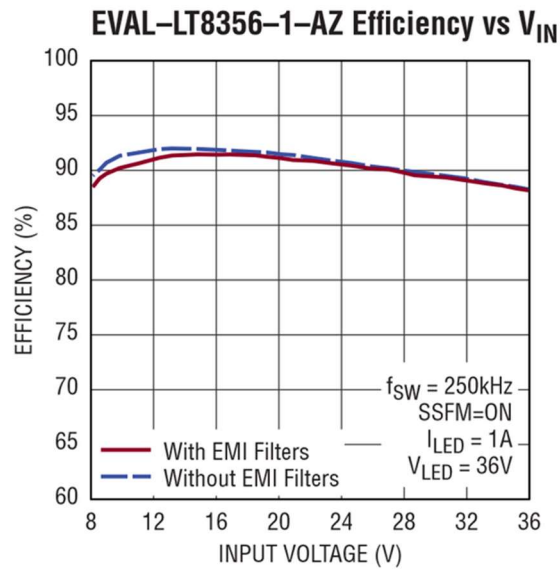


Figure 2. EVAL-LT8356-1-AZ as Buck-Boost Mode LED Driver Efficiency Versus Input Voltage

TEST RESULTS

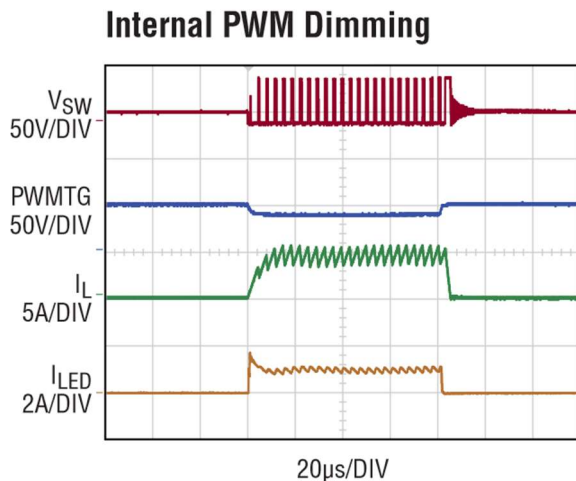


Figure 3. EVAL-LT8356-1-AZ as Buck-Boost Mode LED Driver Internal PWM Dimming with EMI Filters and SSFM ON – 12V_{IN} 36V_{LED} 1A – 260Hz 2%

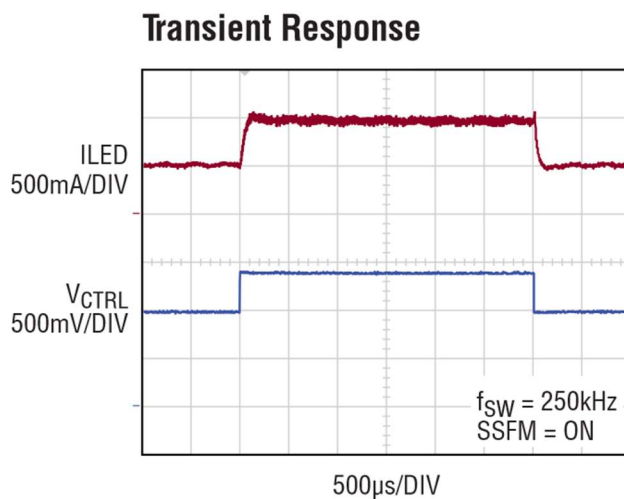


Figure 4. EVAL-LT8356-1-AZ as Buck-Boost Mode LED Driver 50% - 100% - 50% Load Step Transient Response – 12V_{IN} 36V_{LED}

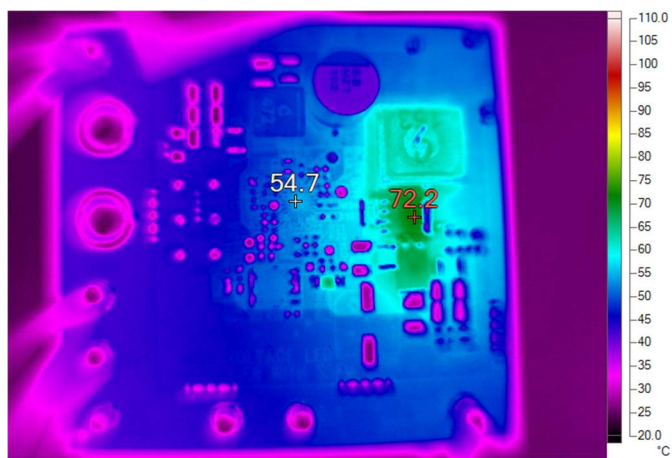


Figure 5. EVAL-LT8356-1-AZ as Buck-Boost Mode LED Driver Board Thermal Image – 12V_{IN} 36V_{LED} 1A (SSFM ON)

TEST RESULTS

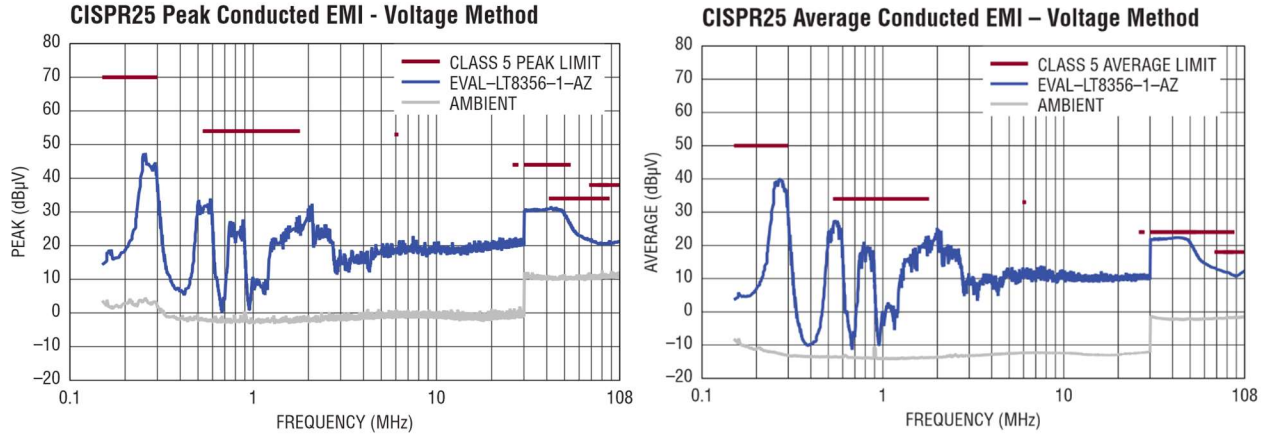


Figure 6. EVAL-LT8356-1-AZ as Buck-Boost Mode LED Driver Conducted Emissions (Voltage Method) – 12V_{IN} 36V_{LED} 1A

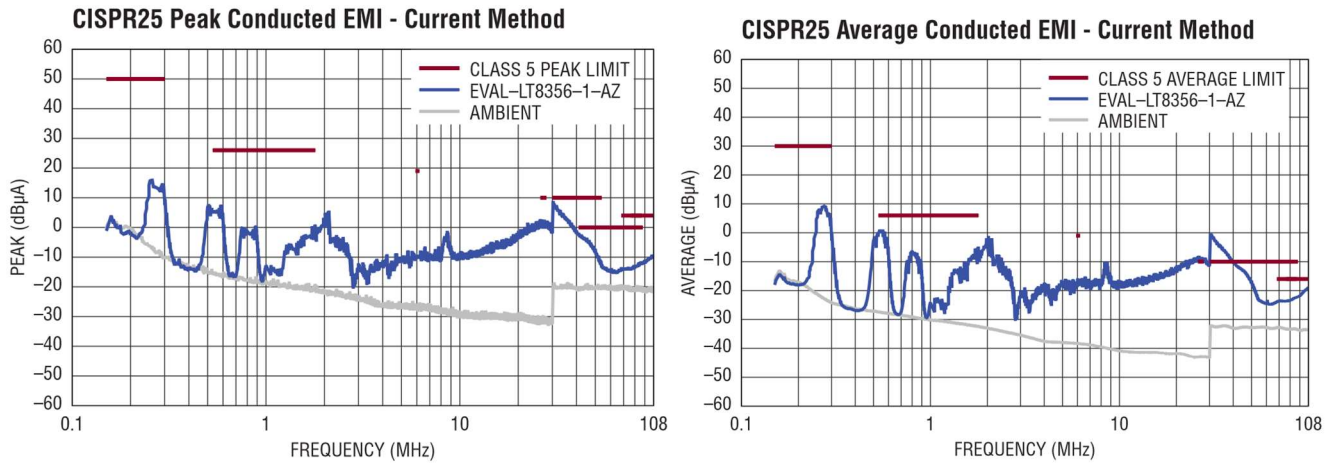


Figure 7. EVAL-LT8356-1-AZ as Buck-Boost Mode LED Driver Conducted Emissions (Current Method) – 12V_{IN} 36V_{LED} 1A

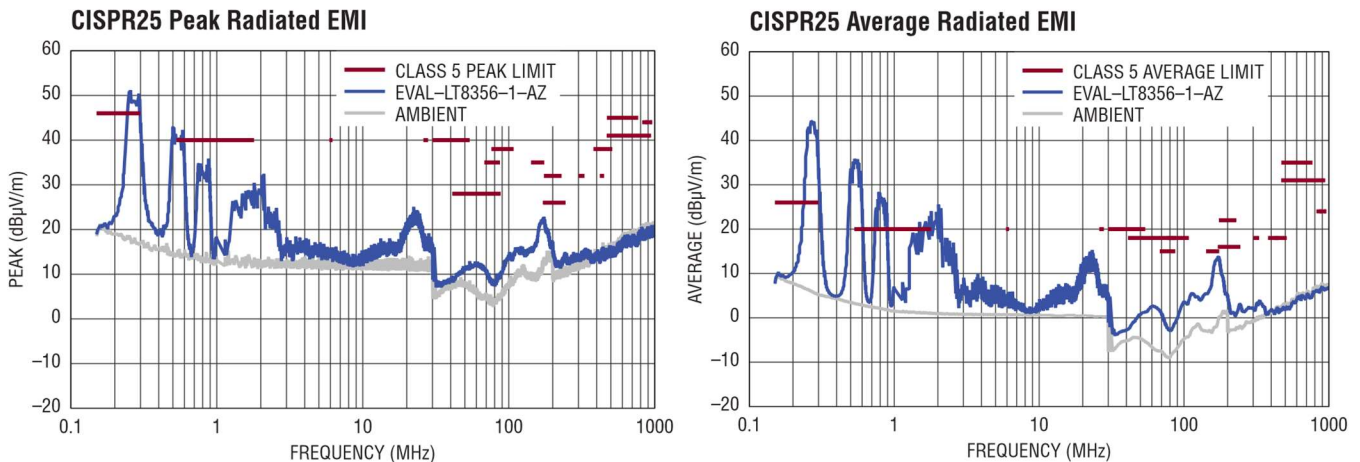


Figure 8. EVAL-LT8356-1-AZ as Buck-Boost Mode LED Driver Radiated Emissions – 12V_{IN} 36V_{LED} 1A

EMISSIONS SHIELD (OPTION)

For the lowest emissions, an EMI shield can be attached to EVAL-LT8356-1-AZ. The PCB was fabricated with placeholders for six shield clips that can hold a 44mm x 44mm metal shield. Part number for an example shield can be found in the Parts List below in the Optional EMI Filter Components section.

The Top silkscreen picture below shows the placeholders for the six surface mount shield clips. Emissions can be tested with and without the removeable clip-shield.

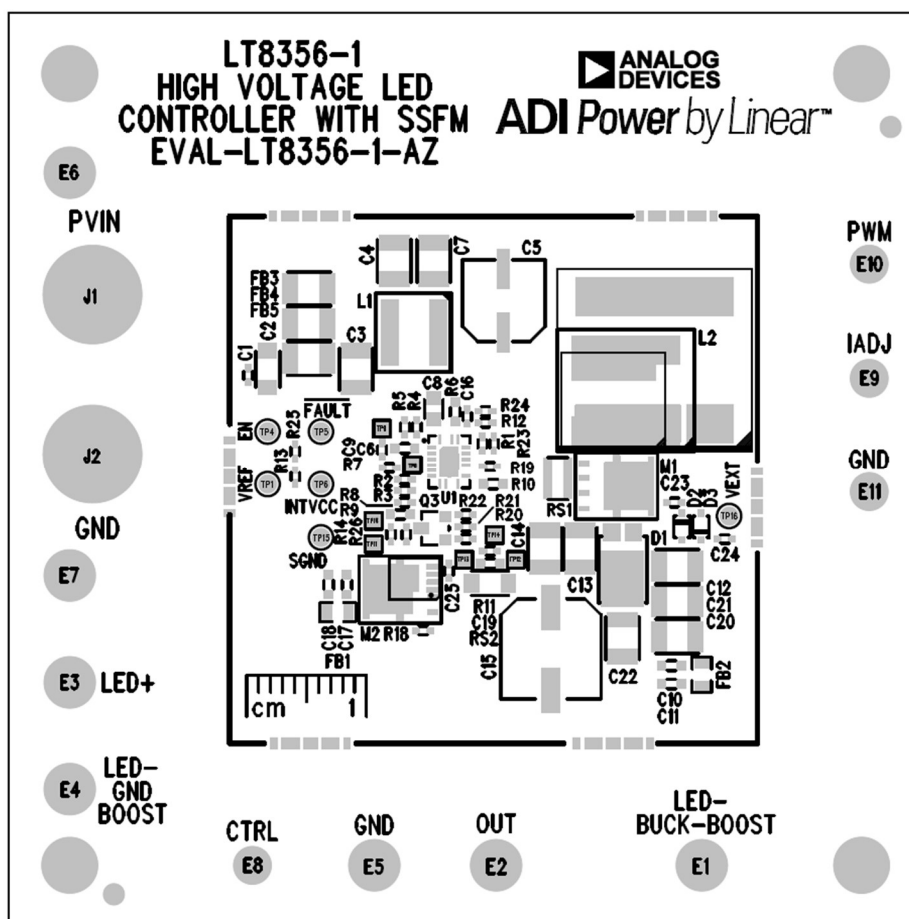


Figure 8. EVAL-LT8356-1-AZ Top Silkscreen outlining placement of shield clips and EMI shield on PCB.

BOOST AND BUCK-BOOST MODE SETUP

EVAL-LT8356-1-AZ is assembled as a Buck-Boost Mode LED Driver, but with minor adjustments can be reconfigured as a Boost LED driver. In Buck-Boost Mode LED driver, the LED- connection is at V_{IN} , and a level shifter is used for the FB network. In a Boost LED driver, the LED- connection is at GND and a resistor divider is used for the FB network.

To configure EVAL-LT8356-1-AZ as a Boost LED driver, remove R20, R22, Q3, FB2, C12 and C11. Install 0Ω for R14 and 1M for R9. Consult the

datasheet for OVP calculations and details about the FB pin. Connect the LED string from LED+ to LED- (GND Boost) as seen in Figure 8 below.

Note that when EVAL-LT8356-1-AZ is reconfigured as a Boost LED Driver other components may need to be adjusted depending on voltage rating and power capabilities.

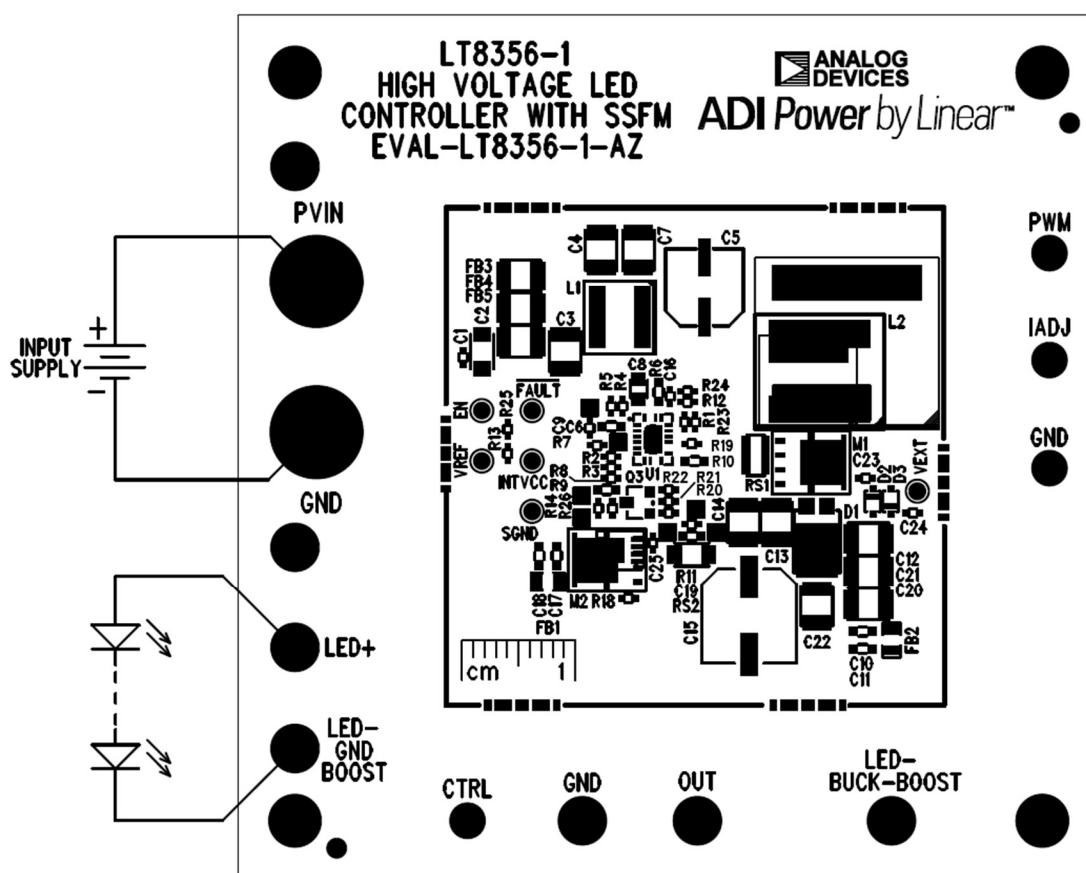


Figure 8. EVAL-LT8356-1-AZ connected as a Boost LED Driver

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PARTS LIST

Item	Qty	Reference	Part Description	Manufacturer / Part #
REQUIRED CIRCUIT COMPONENTS				
1	1	C5	CAP.,68uF,ALUM ELECT,50V,20%,6.3x7.7mm,SMD,RADIAL,AEC-Q200	PANASONIC, EEEFN1H680XP
2	1	C6	CAP.,4.7uF,X5R,10V,10%,0603,AEC-Q200	Taiyo Yuden, LMK107BJ475KAHT
3	1	C7	CAP.,10uF,X7S,50V,10%,1210,AEC-Q200, NO SUBS ALLOWED	MURATA, GCM32EC71H106KA03L
4	1	C8	CAP.,1uF,X7R,50V,10%,0805,AEC-Q200	MURATA, GCM21BR71H105KA03L
5	1	C9	CAP.,1000pF,X7R,50V,10%,0402,AEC-Q200	MURATA, GCM155R71H102KA37D
6	1	C12	CAP.,10uF,X7S,50V,10%,1210,AEC-Q200	MURATA, GCM32EC71H106KA03L
7	1	C13	CAP.,4.7uF,X7S,100V,10%,1210,AEC-Q200	MURATA, GCM32DC72A475KE02L
8	1	C16	CAP.,2.2uF,X6S,10V,10%,0402,AEC-Q200	MURATA, GRT155C81A225KE13D
9	1	C19	CAP.,2.2uF,X5R,25V,10%,0603,AEC-Q200	TAIYO YUDEN, TMK107BBJ225KAHT
10	1	D1	DIODE,SCHOTTKY,100V,3A,POWERDI5,AEC-Q101	DIODES INC., PDS3100Q-13
11	1	L2	IND.,15uH,PWR,SHIELDED,20%,13.8A,18.6mOHMS,11.8x10.5mm,XAL1010,AEC-Q200	COILCRAFT, XAL1010-153MEB
12	1	M1	XSTR.,MOSFET,N-CH,100V,37A,PowerPAK SO-8L,AEC-Q101	VISHAY, SQJA72EP-T1_GE3
13	1	M2	XSTR.,MOSFET,P-CH,100V,33.6A,PowerPAK SO-8L,AEC-Q101	VISHAY, SQJ211ELP-T1_GE3
14	1	Q3	XSTR.,PNP,100V,1A,SOT-23-3,AEC-Q101	DIODES INC., FMMT593QTA
15	4	R1,R2,R12,R25	RES.,100k OHMS,5%,1/16W,0402,AEC-Q200	VISHAY, CRCW0402100KJNED
16	1	R4	RES.,499k OHMS,1%,1/16W,0402,AEC-Q200	VISHAY, CRCW0402499KFKED
17	1	R5	RES.,127k OHMS,1%,1/16W,0402,AEC-Q200	VISHAY, CRCW0402127KFKED
18	1	R6	RES.,110k OHMS,1%,1/10W,0603,AEC-Q200	VISHAY, CRCW0603110KFKEA
19	1	R7	RES.,16K OHMS,5%,1/16W,0402,AEC-Q200	VISHAY, CRCW040216K0JNED
20	2	R8,R20	RES.,10k OHMS,1%,1/16W,0402,AEC-Q200	VISHAY, CRCW040210K0FKED
21	1	R19	RES.,10 OHMS,5%,1/16W,0402,AEC-Q200	VISHAY, CRCW040210R0JNED
22	1	R22	RES.,340k OHMS,1%,1/16W,0402,AEC-Q200	VISHAY, CRCW0402340KFKED
23	1	RS1	RES.,0.01 OHM,1%,1.5A,1206, LONG-SIDE TERM.,METAL, SENSE, AEC-Q200	SUSUMU, KRL3216E-C-R010-F-T1
24	1	RS2	RES.,0.25 OHM,1%,1/2W,1206,SENSE,AEC-Q200	YAGEO, PT1206FR-7W0R25L
25	1	U1	IC,LED DRIVER CTRLR,QFN-20	ANALOG DEVICES, LT8356JUDCM-1#PBF
OPTIONAL EMI FILTER COMPONENTS				
26	1	C3	CAP.,10uF,X7S,50V,10%,1210,AEC-Q200, NO SUBS ALLOWED	MURATA, GCM32EC71H106KA03L
27	1	C11	CAP.,0.1uF,X7R,50V,10%,0603,AEC-Q200	TDK, CGA3E2X7R1H104K080AA
28	1	C18	CAP.,0.1uF,X7S,100V,10%,0603,AEC-Q200	TDK, CGA3E3X7S2A104K080AB
29	2	FB1,FB2	IND.,3300OHMS@100MHz,FERRITE BEAD,25%,1.8A,80mOHMS,0805,1LN	TAIYO YUDEN, FBMH2012HM331-T
30	1	L1	IND.,4.7uH,PWR,SHIELDED,20%,11A,14.4mOHMS,6.76x6.56mm,XAL6060,AEC-Q200	COILCRAFT, XAL6060-472MEB
31	1	R10	RES.,10 OHMS,5%,1/10W,0603,AEC-Q200	VISHAY, CRCW060310R0JNEA
32	0	FB3-FB5	IND.,OPTION,FERRITE BEAD,1210	
33	0	C1	CAP., OPTION, 0402	
34	0	C2	CAP., OPTION, 1206	
35	0	C4	CAP., OPTION, 1210	
36	0	C10,C17	CAP., OPTION, 0603	
37	0	CL1-CL6	OPTION, WE-SHC Cabinet Clip 6.5x0.8x1.27mm	WURTH, 369 000 00
38	0	SH1	OPTION, WE-SHC Cabinet Shield 44.37x44.37mm	WURTH, 369 074 06S
OPTIONAL ELECTRICAL COMPONENTS				
39	0	C23-C25	CAP., OPTION, 0402	
40	0	C14,C20-C22	CAP., OPTION, 1210	
41	0	C15	CAP.,OPTION,ALUM. ELECT.,SMD	
42	0	D2,D3	DIODE,OPTION, SOD-323F	
43	0	R3,R11,R13,R14,R18,R21,R23,R24,R26	RES., OPTION, 0402	
44	0	R9	RES., OPTION, 0603	
HARDWARE				
45	7	E1-E7	TEST POINT,TURRET,0.094" MTG. HOLE,PCB 0.062" THK	MILL-MAX, 2501-2-00-80-00-00-07-0

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46	4	E8-E11	TEST POINT,TURRET,0.064" MTG. HOLE,PCB 0.062" THK	MILL-MAX, 2308-2-00-80-00-00-07-0
47	2	J1,J2	CONN.,BANANA JACK,FEMALE,THT,NON-INSULATED,SWAGE,0.218"	KEYSTONE, 575-4
48	4	MH1-MH4	STANDOFF,NYLON,SNAP-ON,0.50"	KEYSTONE, 8833



1. ALL RESISTORS 5%, 0402.
2. ALL CAPACITORS 0402