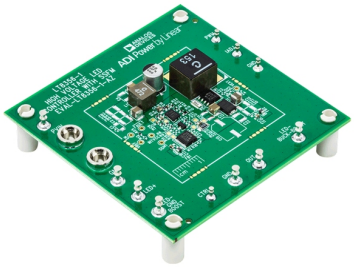


ANALOG DEVICES LT8356-1 LED Controller Instruction Manual

DEMO MANUAL EVAL-LT8356-1-AZ

LT8356-1
100VIN /120V OUT LED
Controller with SSFM

Contents

DESCRIPTION

Evaluation board EVAL-LT8356-1-AZ is a high voltage LED controller featuring the LT® 8356-1. 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 the input is between 8V and 36V. It has an undervoltage lockout (UVLO) set at 6.5V falling and 7.5V rising. The evaluation 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, if 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 CISPR25 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 bright- ness 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 dim- ming, 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 undervoltage lockout (UVLO), LED current, output overvoltage protection (OVP), and switching frequency, can all be easy adjusted with simple resis- tor 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 pro- vided in the data sheet. Please consult the data sheet or the applications team regarding how to customize EVAL-LT8356-1-AZ.

The LT8356-1 data sheet gives a complete description of the part, operation, and applications information. The data sheet 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 sol- derable plastic QFN package with a thermally enhanced exposed ground pad. Proper board layout is essential for maximum performance. See the data sheet section "Designing the Printed Circuit Board".

Design files for this circuit board are available.

BOARD PHOTO

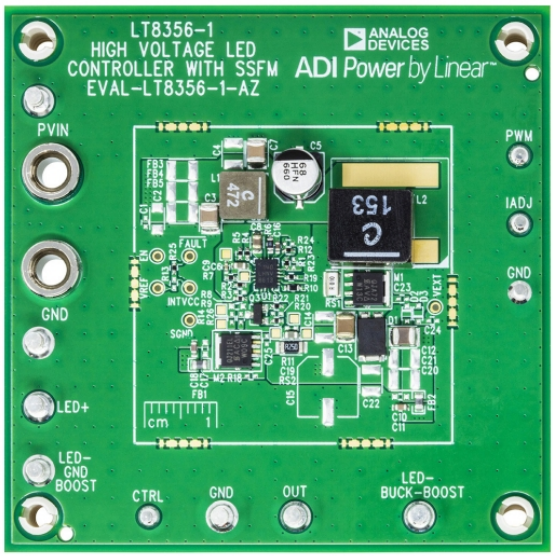


Figure 1. EVAL-LT8356-1-AZ Demo Board

PERFORMANCE SUMMARY

Specifications are at TA = 25°C

PARAMETER	CONDITION	MIN	TYP	MAX	UNITS
Input Voltage PVIN Range	Operating	8		36	V
Switching Frequency (fSW, SSFM ON)	R6 = 110k	250		310	kHz
ILED	RS2 = 0.25Ω, 8V < PVIN < 36V, VLED ≤ 36V, CTRL and ADJ Turrets = Float	1			A
Open LED Protection (LED+ to LED–)	R8 = 10k, R20 = 10k, R22 = 340k	41			V
Peak Efficiency (SSFM ON)	PVIN = 12V, VLED = 36V, ILED = 1A with Filters PVIN = 12V, VLED = 36V, ILED = 1A without Filters	91.5 92			% %
Peak Switch Current Limit	RS1 = 0.01Ω	10			A
Internally-Generated PWM Dimming Range	0.5V < VPWM < 1.5V	1/128		100	%
Internally-Generated PWM Dimming Frequency	R6 = 110k	260			Hz
PVIN Undervoltage Lockout (UVLO) falling	R4 = 499k, R5 = 127k	6.5			V
PVIN Enable Turn-On (EN) rising	R4 = 499k, R5 = 127k	7.5			V

QUICK START PROCEDURE

Evaluation board 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 2.
2. With power off, connect the input power supply to the PVIN 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 and IADJ pins 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 data sheet for more details.
6. To change the brightness with external PWM dimming, attach a rectangular waveform with varying duty cycle to the PWM turret. The ON and OFF voltages should be above 1.6V and below 0.4V, respectively.
7. To change the brightness with internally generated PWM dimming, adjust the voltage at the PWM pin between

0.5V and 1.5V to vary the duty ratio of the internal PWM generator.

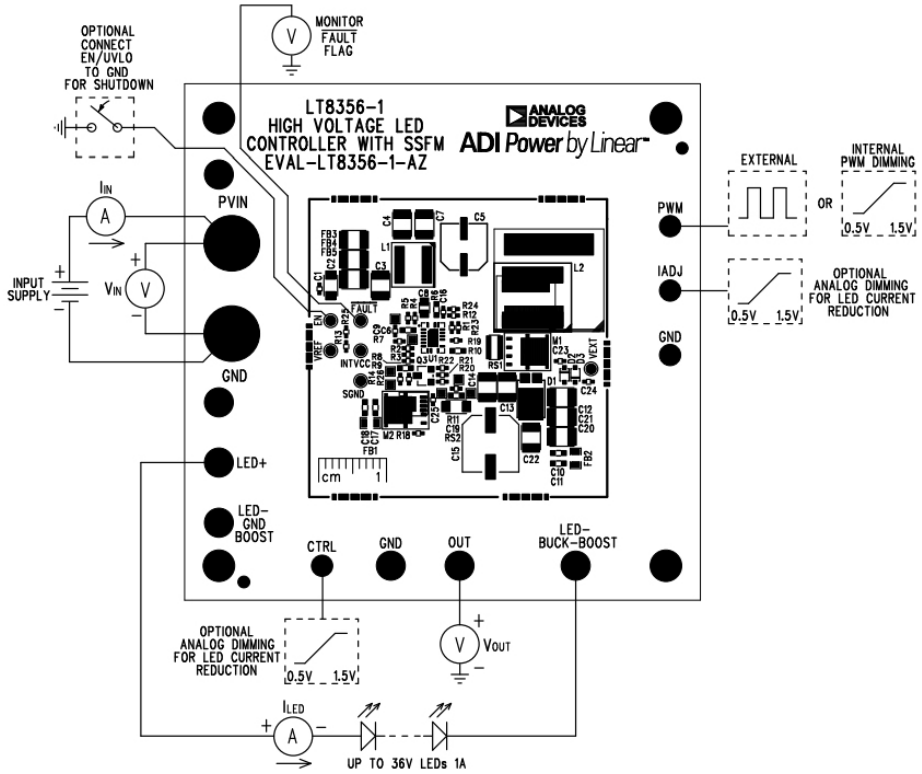


Figure 2. Setup Drawing for EVAL-LT8356-1-AZ as Buck-Boost Mode LED Driver
(*See Boost LED Driver Setup Section for More Information on Boost-Only Topology)

BOOST LED DRIVER 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, the LED connection is at VIN, 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 data sheet for OVP calculations and details about the FB pin. Connect the LED string from LED+ to LED– (GND boost) as seen in Figure 3.
Note that when EVAL-LT8356-1-AZ is reconfigured as a boost LED Driver, other components may need to be adjusted depending on their voltage rating and power capabilities.

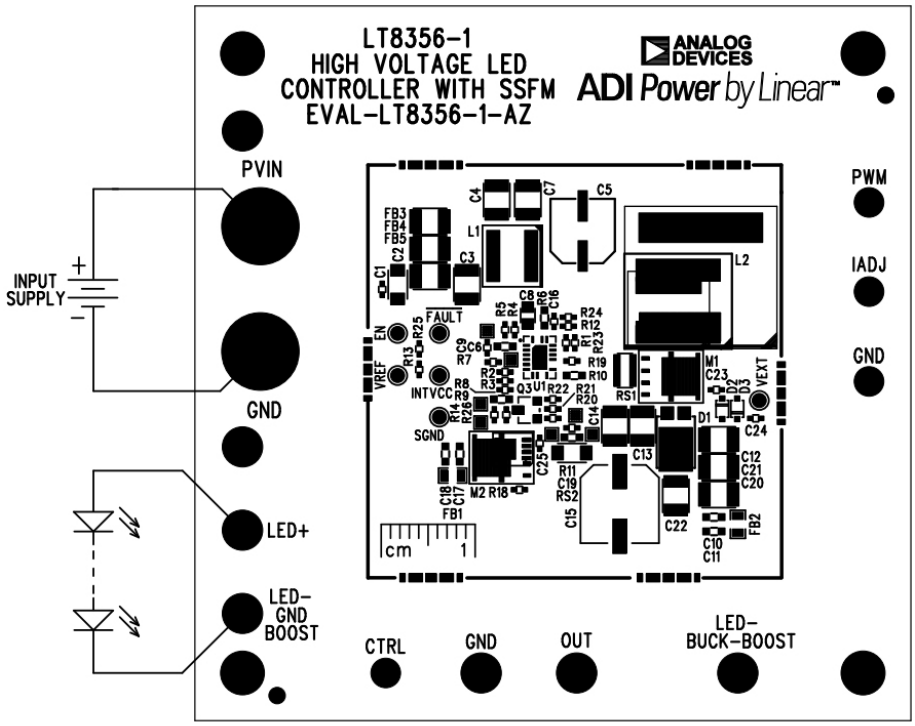


Figure 3. EVAL-LT8356-1-AZ as a Boost LED Driver

Figure 3. EVAL-LT8356-1-AZ as a Boost LED Driver

START-UP WITH LOW VISP-VISN

Full-scale LED current sense threshold voltage (VISP to VISN) for LT8356-1 is 250mV, which sets fullscale LED current according to Equation 1.

$$I_{LED} = \frac{1}{4 \bullet R_{ILED}} A \quad (1)$$

The LED current sense threshold voltage can be trimmed to be lower than 250mV when analog dimming is desired. This includes but is not limited to, when a single sense resistor is used for multiple designs with different current levels needed for each design, and when low current level is required at start-up and increases at steady state, etc.

For configurations where the LED current sense threshold (VISP to VISN) is configured for 120mV or lower via CTRL or IADJ pin, an additional resistor connecting VREF to FB is needed to allow for proper start-up of the LT8356-1 (see Figure 4). Refer to data sheet for more information. See Equation 2 and Equation 3 to set resistor values for boost and buck-boost mode topologies.

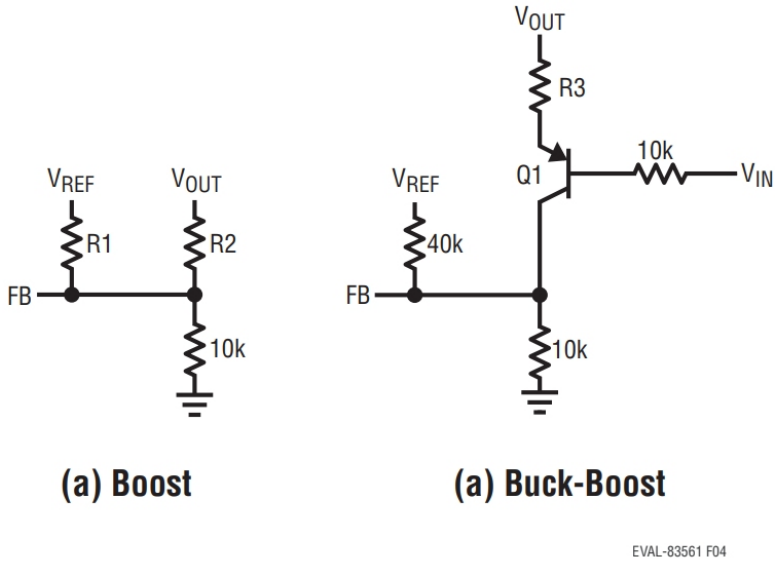


Figure 4. Proper Start-Up Configuration

Boost: Calculate R1 and R2 to set desired VOUT_OVP and VFB to 400mV at VIN_MIN.

$$V_{IN\_MIN} = 400mV + \left(40\mu A - \frac{1.6V}{R1}\right)R2$$
$$V_{OUT\_OVP} = 1.2V + \left(120\mu A - \frac{800mV}{R1}\right)R2 \quad (2)$$

Buck-Boost: Calculate R3 to set VLED_OVP (VOUT – VIN) to desired voltage.
VLED_OVP = VBE + 100µA • R3 (3)

TEST RESULTS

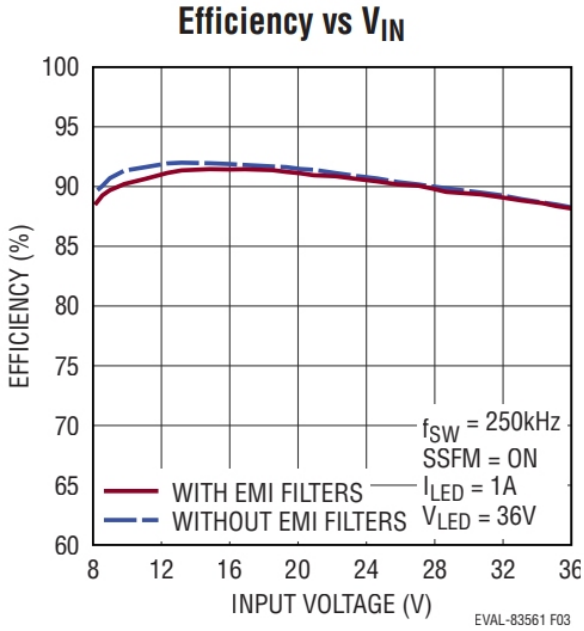


Figure 5. EVAL-LT8356-1-AZ as Buck-Boost Mode LED Driver Efficiency vs Input Voltage

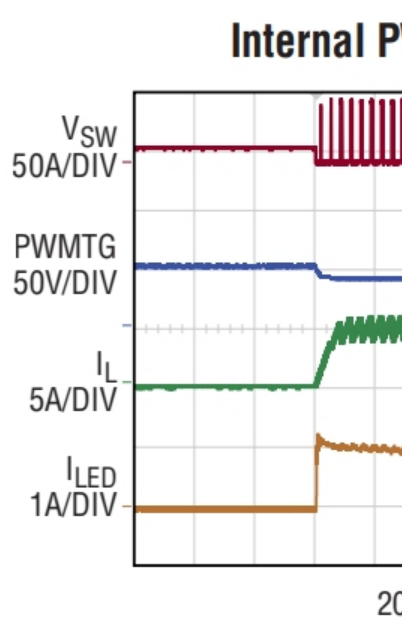


Figure 6. EVAL-LT8356-1-AZ as Buck-260Hz 2% PWM Dimming with EMI 36VLED

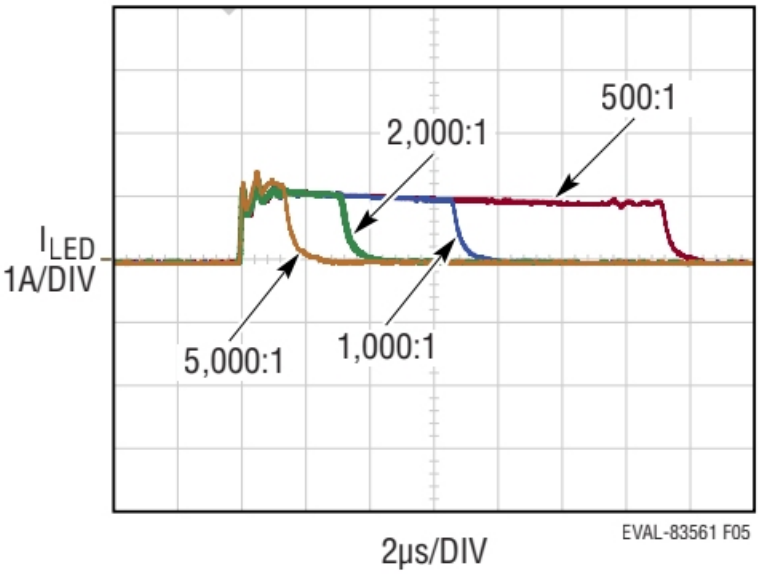


Figure 7. EVAL-LT8356-1-AZ as Buck-Boost Mode LED Driver External 150Hz PWM Dimming with EMI Filters and SSFM ON: 12VIN, 36VLED, 1A

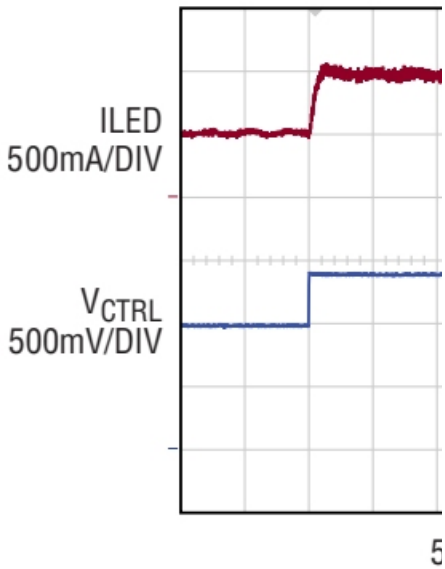


Figure 8. EVAL-LT8356-1-AZ as Buck-100% to 50% Load Step Tra

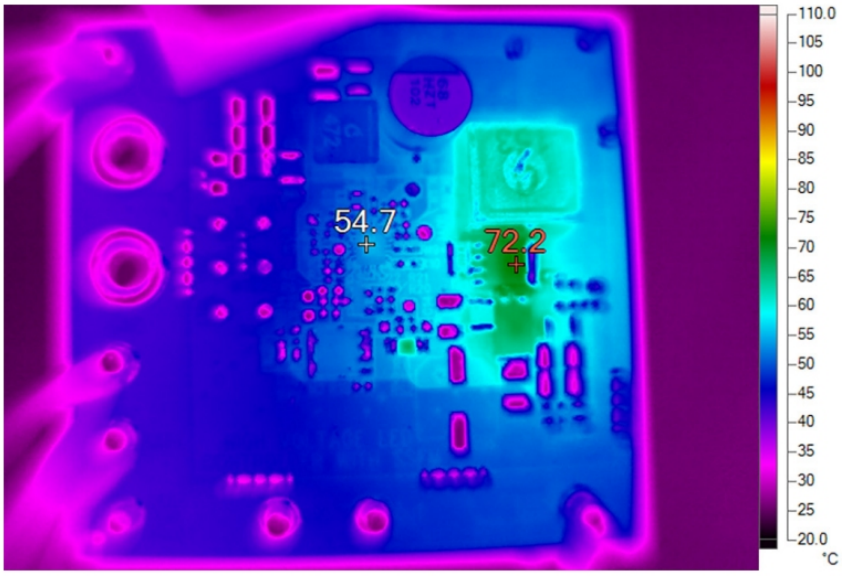
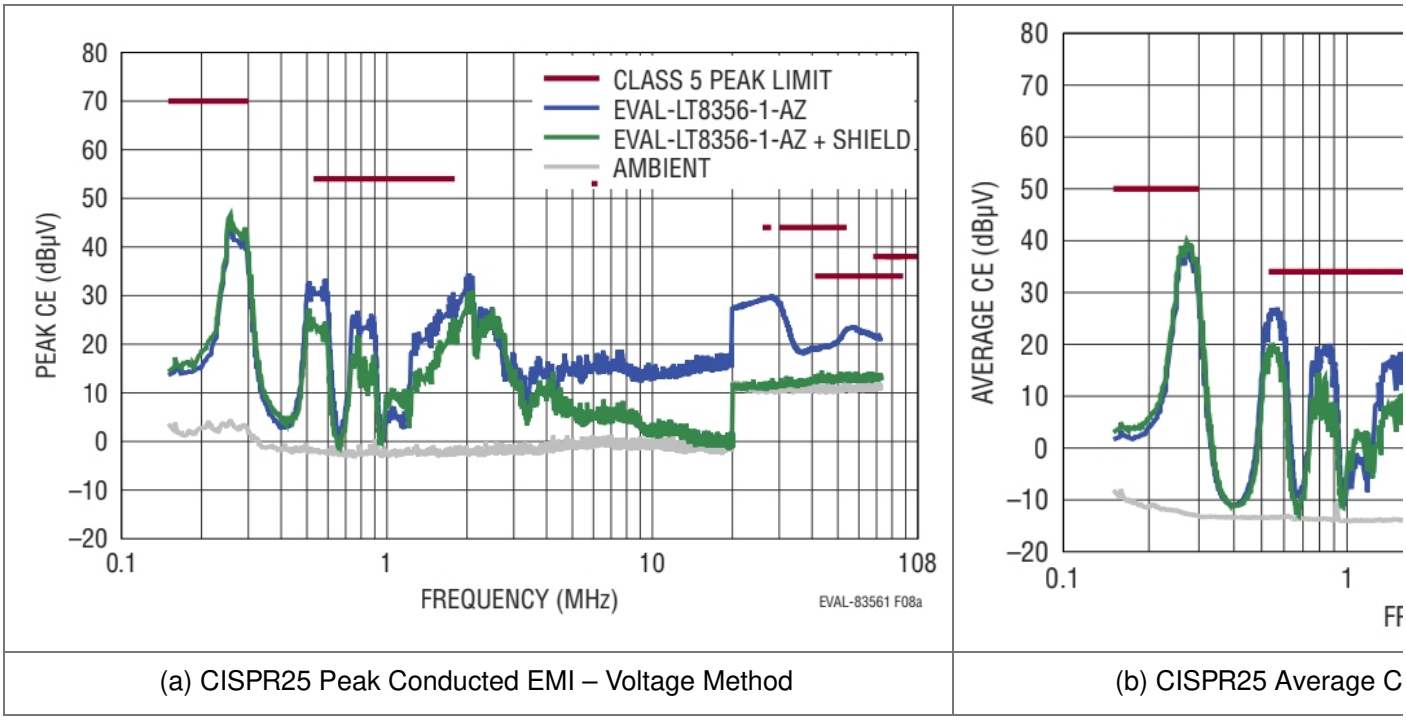


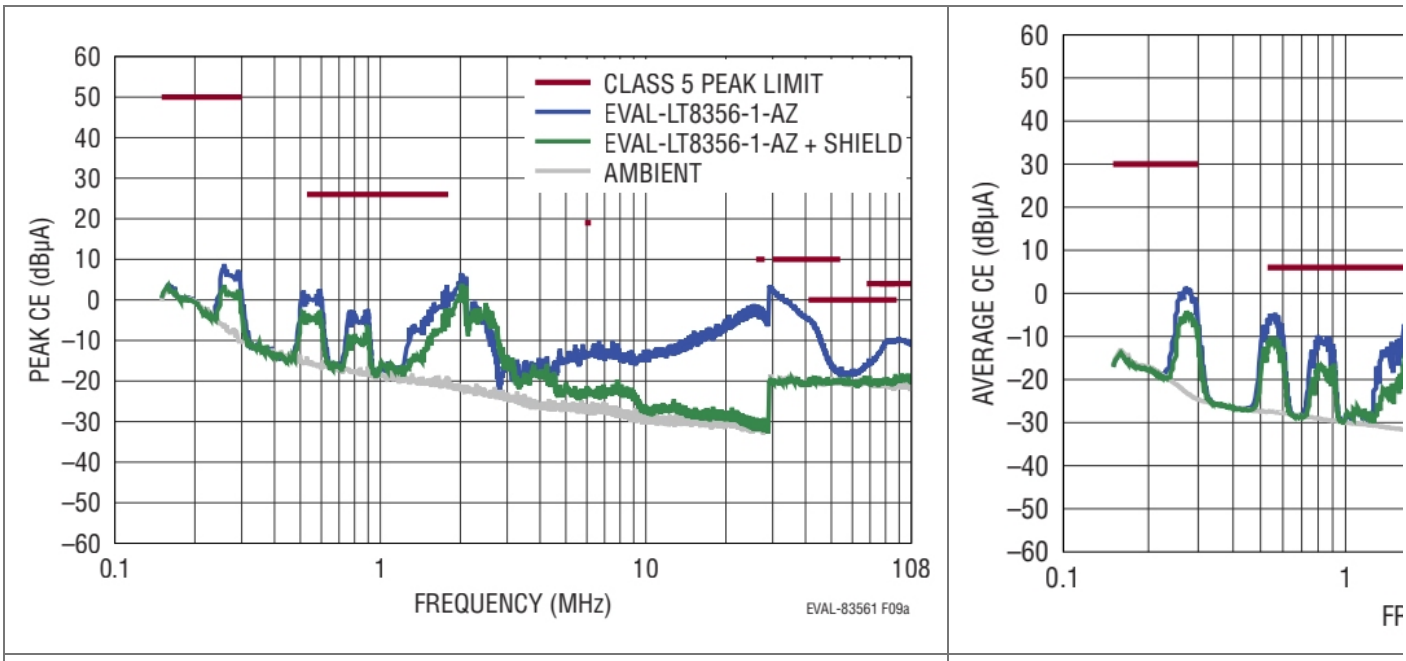
Figure 9. EVAL-LT8356-1-AZ as Buck-Boost Mode LED Driver Board Thermal Image with Filters and SSFM ON: 12VIN, 36VLED, 1A



(a) CISPR25 Peak Conducted EMI – Voltage Method

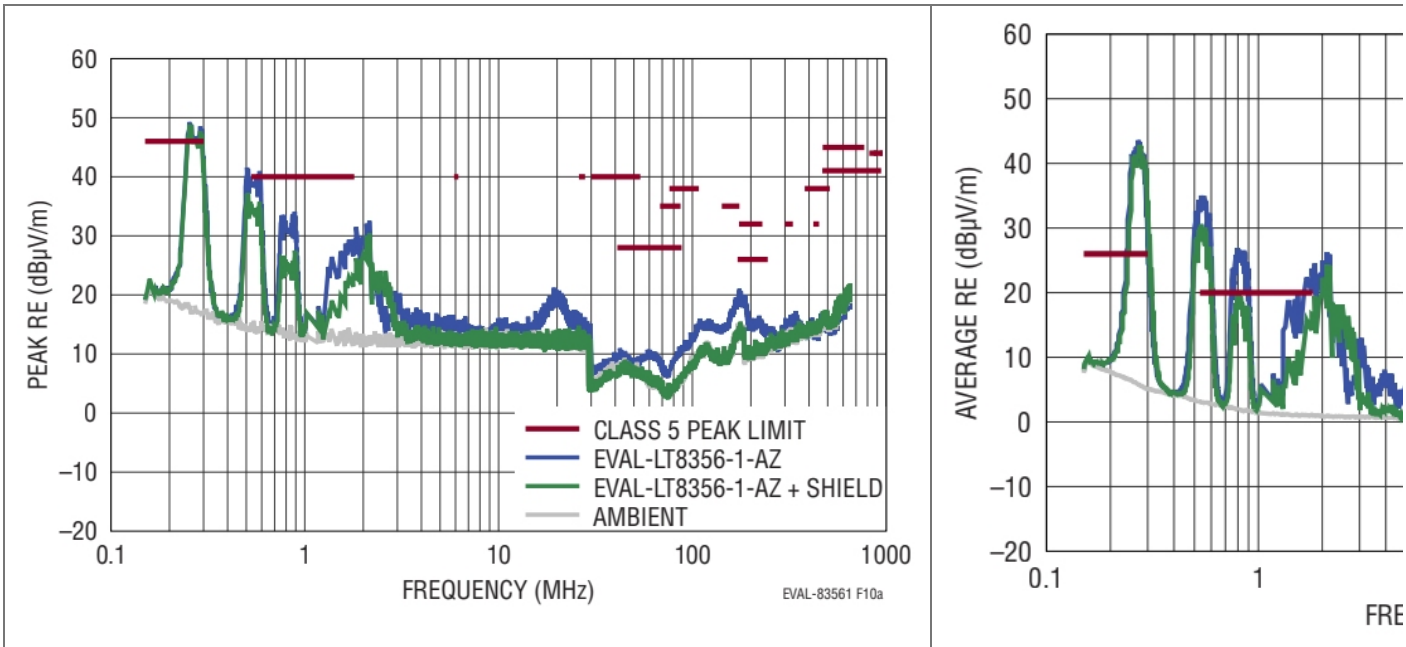
(b) CISPR25 Average C

Figure 10. EVAL-LT8356-1-AZ as Buck-Boost Mode LED Driver Conducted Emissions (Voltage Method): 12VIN, 36VLED, 1A (SSFM ON)



(a) CISPR25 Peak Conducted EMI – Current Method | **(b) CISPR25 Average Co**

Figure 11. EVAL-LT8356-1-AZ as Buck-Boost Mode LED Driver Conducted Emissions (Current Method): 12VIN, 36VLED, 1A (SSFM ON)



(a) CISPR25 Peak Radiated EMI | **(b) CISPR25 Av**

Figure 12. EVAL-LT8356-1-AZ as Buck-Boost Mode LED Driver Radiated Emissions: 12VIN, 36VLED, 1A (SSFM ON)

EMISSIONS SHIELD (OPTION)

For the lowest emissions, an EMI shield can be attached to EVAL-LT8356-1-AZ. The PCB was fabricated with place- holders for six shield clips that can hold a 44mm × 44mm metal shield. Part number for an example shield can be found in the Parts List section in the Optional EMI Filter Components section. The Top silkscreen picture, Figure 13, shows the placeholders for the six surface mount shield clips. Emissions can be tested with and without the removable clip-shield.

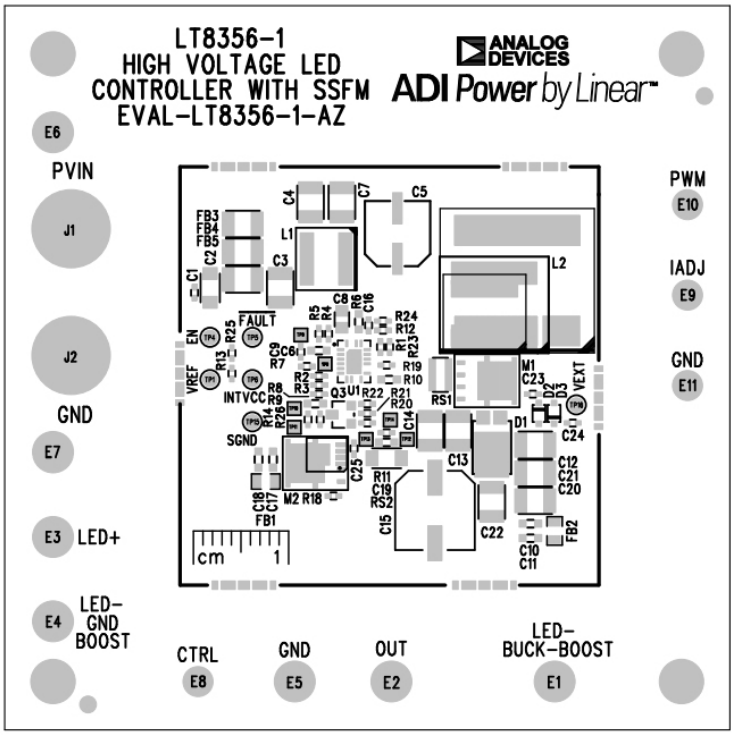


Figure 13. EVAL-LT8356-1-AZ Top Silkscreen Outlining Placement of Shield Clips and EMI Shield on PCB

PARTS LIST

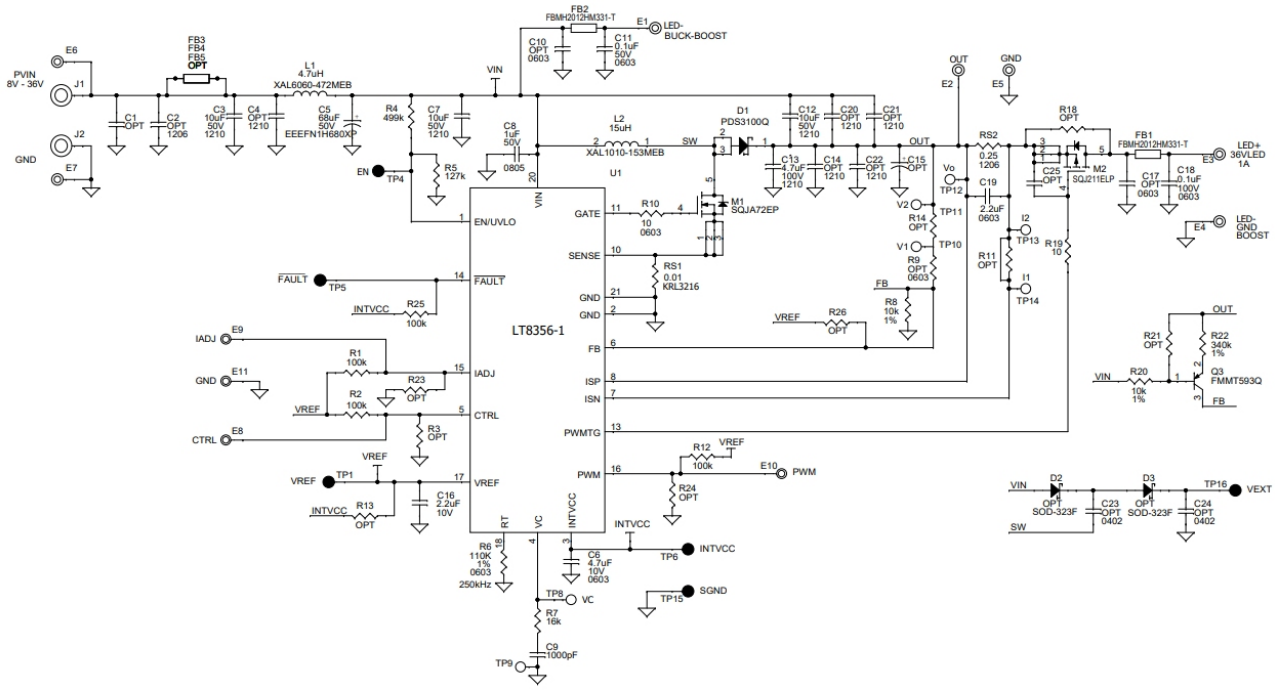
ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	1	C7	CAP., 10µF, X7S, 50V, 10%, 1210, AEC-Q200, NO SUBS ALLOWED	MURATA, GCM32EC71H106KA03L
2	1	C5	CAP., 68µF, ALUM ELECT, 50V, 20%, 6.3mm × 7.7mm, SMD, RADIAL, AEC-Q200	PANASONIC, EEEFN1H680XP
3	1	C6	CAP., 4.7µF, X5R, 10V, 10%, 0603, AEC-Q200	TAIYO YUDEN, LMK107BJ475KAHT
4	1	C8	CAP., 1µF, 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., 10µF, X7S, 50V, 10%, 1210, AEC-Q200	MURATA, GCM32EC71H106KA03L
7	1	C13	CAP., 4.7µF, X7S, 100V, 10%, 1210, AEC-Q200	MURATA, GCM32DC72A475KE02L
8	1	C16	CAP., 2.2µF, X6S, 10V, 10%, 0402, AEC-Q200	MURATA, GRT155C81A225KE13D
9	1	C19	CAP., 2.2µF, 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., 15µH, PWR, SHIELDED, 20%, 13.8A, 18.6mΩ, 11.8mm × 10.5mm, 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, 5%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW0402100KJNED
16	1	R4	RES., 499k, 1%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW0402499KFKED
17	1	R5	RES., 127k, 1%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW0402127KFKED
18	1	R6	RES., 110k, 1%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW0603110KFKEA
19	1	R7	RES., 16k, 5%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW040216K0JNED
20	2	R8, R20	RES., 10k, 1%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW040210K0FKED
21	1	R19	RES., 10Ω, 5%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW040210R0JNED
22	1	R22	RES., 340k, 1%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW0402340KFKED
23	1	RS1	RES., 0.01Ω, 1%, 1.5A, 1206, LONG-SIDE TERM., METAL, SENSE, AEC-Q200	SUSUMU, KRL3216E-C-R010-F-T1
24	1	RS2	RES., 0.25Ω, 1%, 1/2W, 1206, SENSE, AEC-Q200	YAGEO, PT1206FR-7W0R25L
25	1	U1	IC, LED DRIVER CTRLR, QFN-20	ANALOG DEVICES, LT8356IUDCM-1#WPBF
Optional EMI Filter Components				
26	1	C3	CAP., 10µF, X7S, 50V, 10%, 1210, AEC-Q200, NO SUBS ALLOWED	MURATA, GCM32EC71H106KA03L
27	1	C11	CAP., 0.1µF, X7R, 50V, 10%, 0603, AEC-Q200	TDK, CGA3E2X7R1H104K080AA
28	1	C18	CAP., 0.1µF, X7S, 100V, 10%, 0603, AEC-Q200	TDK, CGA3E3X7S2A104K080AB

29	2	FB1, FB2	IND., 330Ω AT 100MHz, FERRITE BEAD, 25%, 1.8A, 80mΩ, 0805, 1LN	TAIYO YUDEN, FBMH2012HM331-T
30	1	L1	IND., 4.7µH, PWR, SHIELDED, 20%, 11A, 14.4mΩ, 6.76mm × 6.56mm, XAL6060, AEC-Q200	COILCRAFT, XAL6060-472MEB
31	1	R10	RES., 10Ω, 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 6.5mm × 0.8mm × 1.27mm	WURTH, 369 000 00
38	0	SH1	OPTION, WE-SHC CABINET SHIELD 44.37mm × 44.37mm	WURTH, 369 074 06S
Optional Electrical Components				
39	0	C1, C23-C25	CAP., OPTION, 0402	
40	0	C4, 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: For Demo Board Only				
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
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

SCHEMATIC DIAGRAM



NOTES: UNLESS OTHERWISE SPECIFIED.

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

REVISION HISTORY

REV	DATE	DESCRIPTION	PAGE NUMBER
B	02/24	Added Caption to Figure 1. Added Start-Up with Low VISP to VISN section.	2 5

ESD Caution

ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

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https://www.analog.com/en/index.html

02/24

www.analog.com

Documents / Resources

	**ANALOG DEVICES LT8356-1 LED Controller** [pdf] Instruction Manual LT8356-1, LT8356-1 LED Controller, LED Controller, Controller

References

- **User Manual**