LT8355-1
$60V_{IN}/120V_{OUT}$ Dual LED Controller with SSFM

DESCRIPTION

Evaluation board EVAL-LT8355-1-AZ is a high voltage dual LED controller featuring the LT®8355-1. Channel 1 is assembled as a boost LED driver and channel 2 as a buck-boost mode LED driver. Either channel can be altered to a boost LED driver or buck-boost mode LED driver by adjusting the FB network and LED connection. EVAL-LT8355-1-AZ drives a single string of LEDs per channel when the input is between 8V and 18V. Channel 1 drives up to 72V of LEDs at 450mA and channel 2 drives up to 30V of LEDs at 1A. EVAL-LT8355-1-AZ has an undervoltage lockout (UVLO) set at 6.2V falling and 7.5V rising. EVAL-LT8355-1-AZ features PWM dimming, analog dimming, shutdown, open LED and short LED fault protection and reporting.

EVAL-LT8355-1-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 on each channel for up to 32W boost output for channel 1 and up to 30W buck-boost mode output for channel 2 as assembled. The open LED overvoltage protection (OVP) uses the IC's constant voltage regulation loop to limit the LED+ to LED– voltage if the LED string is opened to approximately 81V for channel 1 and 36V for channel 2.

The input and output filters on EVAL-LT8355-1-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-LT8355-1-AZ. For best efficiency and PWM dimming performance, the EMI filters can be removed.

The LT8355-1's integrated PWMTG high-side PMOS drivers assist with PWM dimming of the connected LEDs. The LED strings can be PWM-dimmed for accurate brightness control with externally generated PWM signals for highest achievable dimming ratios. They can also utilize LT8355-1'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 each channel's LED string. This applies to both internal and external PWM dimming. The LT8355-1 uses CTRL1 analog dimming for channel 1, and CTRL2 and IADJ2 pins for two-pin analog dimming for channel 2.

The input undervoltage lockout (UVLO), LED current, output overvoltage protection (OVP), and switching frequency, can all be easy adjusted with simple resistor changes to EVAL-LT8355-1-AZ. Modifications can be made to convert the channels to boost, buck-boost mode and buck mode LED drivers, and maintain low EMI, PWM dimming and fault diagnostic features. Buck mode, buck-boost mode and boost LED driver schematics are provided in the data sheet. Please consult the data sheet or the applications team regarding how to customize EVAL-LT8355-1-AZ.

The LT8355-1 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-LT8355-1-AZ. The LT8355IUFDM-1 is assembled in a 28-lead side solderable plastic QFN package with a thermally enhanced exposed ground pad and is AEC-Q100 qualified for automotive applications. 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

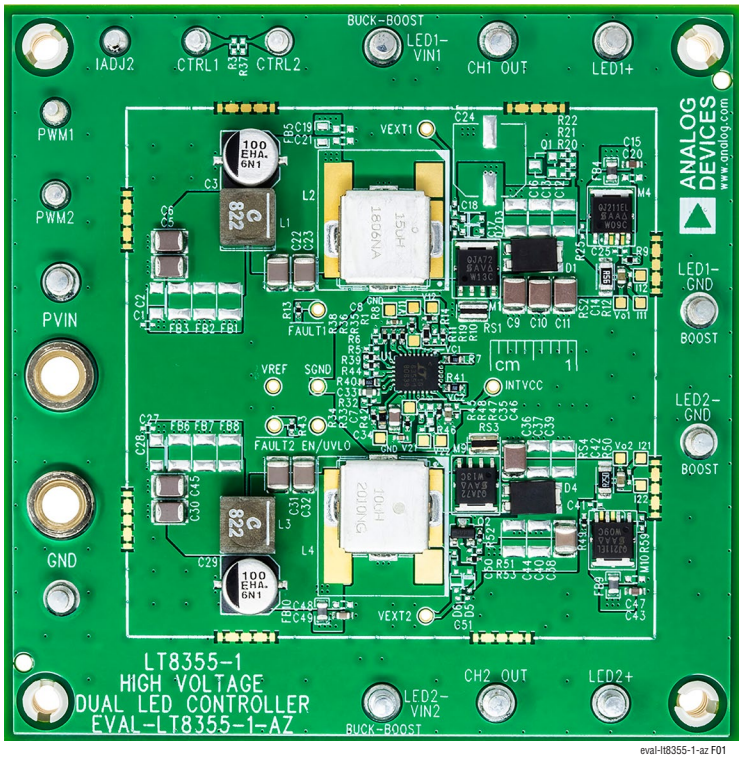


Figure 1. EVAL-LT8355-1-AZ Demo Board

PERFORMANCE SUMMARY

Specifications are at T_A = 25°C

PARAMETER	CONDITION	MIN	TYP	MAX	UNITS
Input Voltage PVIN Range	Operating	8		18	V
Switching Frequency (f_{SW}, 100% to 125% SSFM)	R40 = 86.6k	250		312	kHz
I_{LED}	8V < PVIN < 18V, CTRL1, CTRL2, ADJ2 Turrets = Float CH1: RS2 = 0.56Ω, V_{LED} ≤ 72V CH2: RS4 = 0.25Ω, V_{LED} ≤ 30V		 450 1		 mA A
Open LED Protection (LED+ to LED–)	CH1: R14 = 0, R11 = 1M, R10 = 15k CH2: R52 = 287k, R53 = 10k, R47 = 10k		81 36		V V
Peak Efficiency (SSFM ON)	PVIN = 12V, CH1: V_{LED} = 72V, I_{LED} = 450mA, CH2: V_{LED} = 30V, I_{LED} = 1A with Filters without Filters		 90 91		 % %
Peak Switch Current Limit	CH1: RS1 = 0.013Ω CH2: RS3 = 0.012Ω		7.7 8.3		A A
Internally-Generated PWM Dimming Range	0.5V < V_{PWM} < 1.5V	1/128		100	%
Internally-Generated PWM Dimming Frequency	R40 = 86.6k		250		Hz
PV_{IN} Undervoltage Lockout (UVLO) Falling	R33 = 499k, R34 = 127k		6.2		V
PV_{IN} Enable Turn-On (EN) Rising			7.5		V

QUICK START PROCEDURE

Evaluation board EVAL-LT8355-1-AZ is easy to set up to evaluate the performance of the LT8355-1. Follow the procedure below.

1. With power off, connect a string of LEDs that will run with forward voltage less than or equal to 72V (at 450mA) to the LED1+ and LED1– (boost) turrets and another string of LEDs that will run with forward voltage less than or equal to 30V (at 1A) to the LED2+ and LED2– (buck-boost) turrets 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 18V.
3. Turn the input power supply on and make sure the voltage is between 8V and 18V for proper operation at max LED current.
4. Observe the LED strings running at the programmed LED current.
5. To change the brightness with **analog dimming**, the CTRL1 pin is used for channel 1 and CTRL2 and IADJ2 pins are used for channel 2. The product of the offset CTRL and IADJ pin voltages sets 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 respective PWM turret for channel 1 and channel 2. 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 respective PWM pin for channel 1 and channel 2 between 0.5V and 1.5V to vary the duty ratio of the internal PWM generator.

QUICK START PROCEDURE

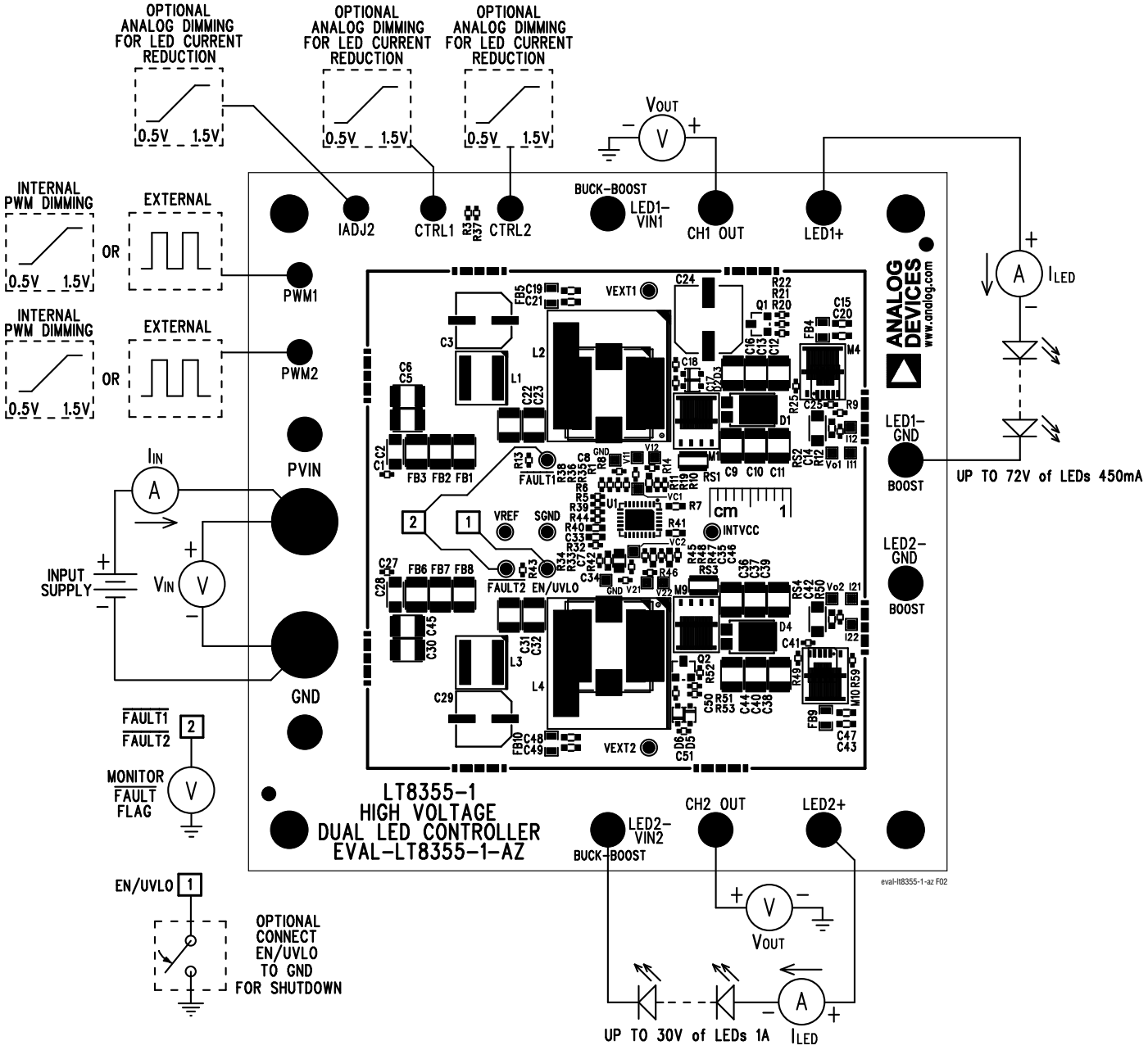


Figure 2. Setup Drawing for EVAL-LT8355-1-AZ: Channel 1 as Boost LED Driver, and Channel 2 as Buck-Boost Mode LED Driver (See Boost LED Driver Setup Section for More Information on Boost Topology)

START-UP WITH LOW V_{ISP} TO V_{ISN}

Full-scale LED current sense threshold voltage (V_{ISP} to V_{ISN}) for LT8355-1 is 250mV, which sets full-scale LED current according to Equation 1.

$$I_{LED} = \frac{250mV}{R_{SENSE}} \quad (1)$$

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 (V_{ISP} to V_{ISN}) is configured for 75mV or lower via CTRL or IADJ pin, an additional resistor connecting V_{REF} to FB is needed to allow for proper start-up of the LT8355-1 (see Figure 3). Refer to data sheet for more information. See Equation 2 and Equation 3 to set resistor values for boost and buck-boost mode topologies.

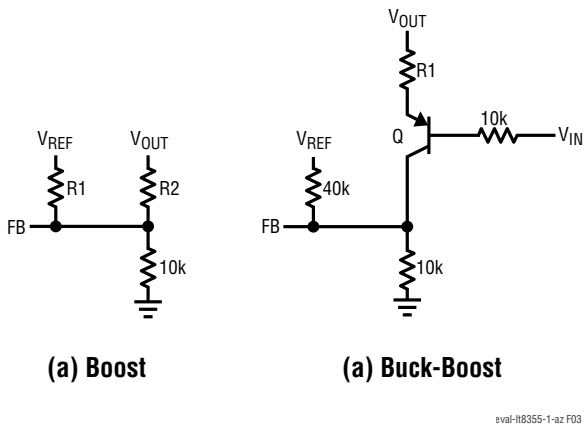


Figure 3. Proper Star-Up Configuration

Boost: Calculate R1 and R2 to set desired V_{OUT_OVP} voltage and V_{FB} to 400mV at V_{IN_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 R1 to set V_{LED_OVP} ($V_{OUT} - V_{IN}$) to desired OVP voltage.

$$V_{LED\_OVP} = V_{BE} + 120\mu A \bullet R1 \quad (3)$$

BOOST LED DRIVER SETUP

EVAL-LT8355-1-AZ has channel 1 assembled as a boost LED driver and channel 2 as a buck-boost mode LED driver. With minor adjustments channel 2 can be reconfigured as a boost LED driver. In buck-boost mode, 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-LT8355-1-AZ channel 2 as a boost LED driver, remove R53, R52, Q2, FB10, C38 and C49. Install 0Ω for R46 and 1M for R48. Consult the data sheet for OVP calculations and details about the FB pin. Connect the LED string from LED+ to LED– (GND boost).

Note that when EVAL-LT8355-1-AZ is reconfigured as a boost LED driver, other components may need to be adjusted depending on their voltage rating and power capabilities.

TEST RESULTS

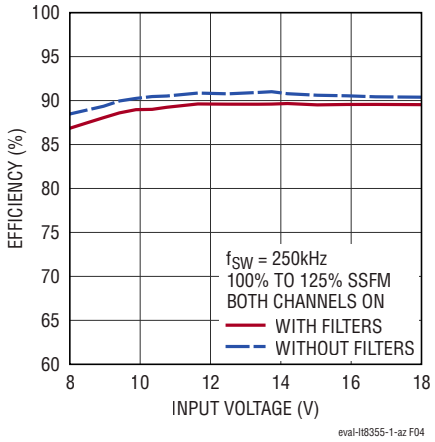


Figure 4. EVAL-LT8355-1-AZ, Efficiency vs Input Voltage: Channel 1, 72V_{LED} 450mA, Channel 2, 30V_{LED} 1A

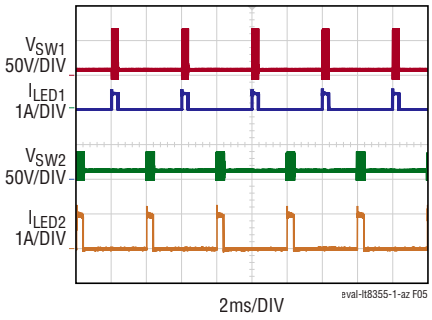


Figure 5. EVAL-LT8355-1-AZ, Internal 250Hz 10% PWM Dimming with EMI Filters: 12V_{IN}, Channel 1, 72V_{LED} 450mA, Channel 2, 30V_{LED} 1A

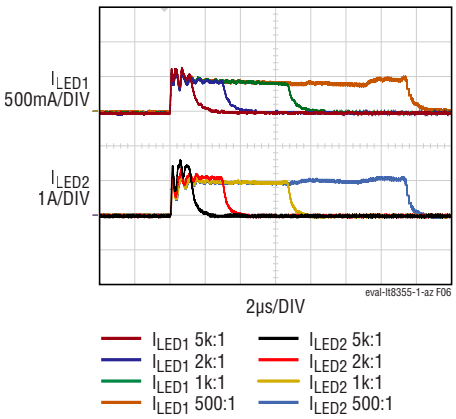


Figure 6. EVAL-LT8355-1-AZ, External 150Hz PWM Dimming with EMI Filters: 12V_{IN}, Channel 1, 72V_{LED} 450mA, Channel 2, 30V_{LED} 1A

TEST RESULTS

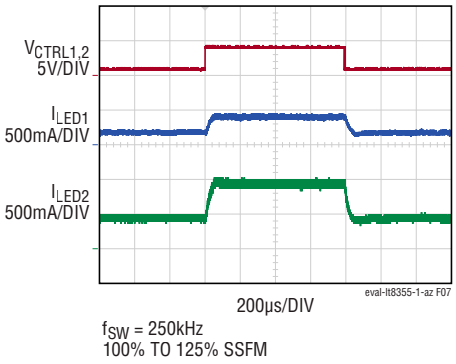


Figure 7. EVAL-LT8355-1-AZ: 50% to 100% to 50% Load Step Transient Response, $12V_{IN}$

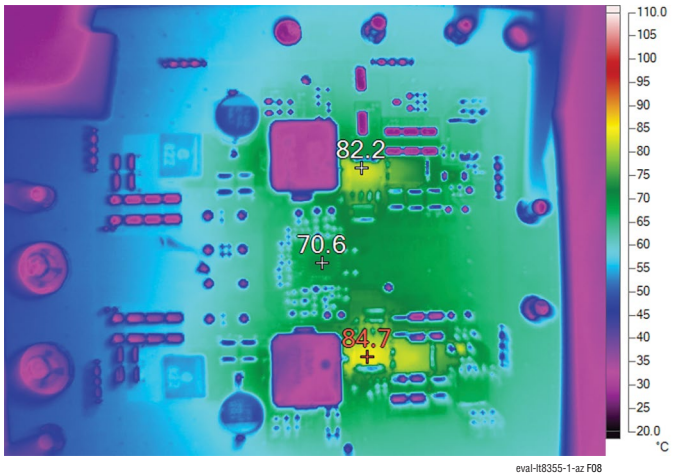
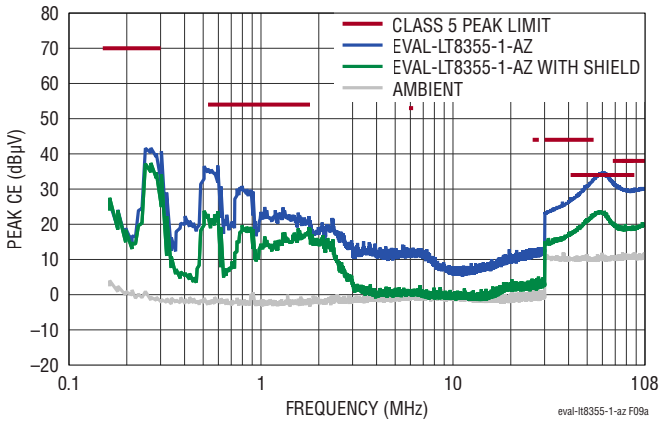
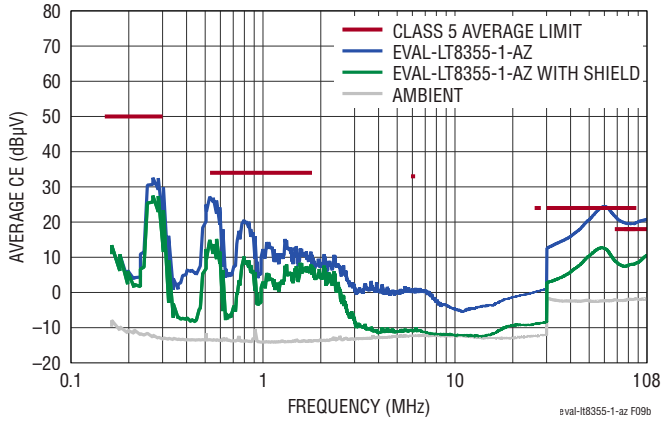


Figure 8. EVAL-LT8355-1-AZ, Thermal Image with EMI Filters: $12V_{IN}$, Channel 1, $72V_{LED}$ 450mA, Channel 2, $30V_{LED}$ 1A

TEST RESULTS

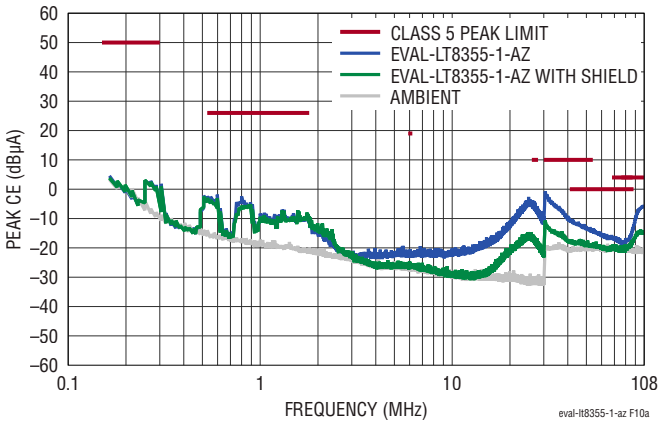


(a) CISPR25 Peak

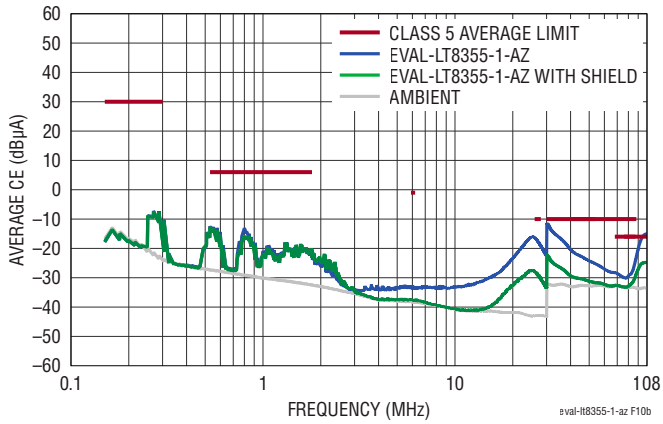


(b) CISPR25 Average

Figure 9. Conducted Emissions (Voltage Method): $12V_{IN}$, Channel 1, $72V_{LED}$ 450mA, Channel 2, $30V_{LED}$ 1A

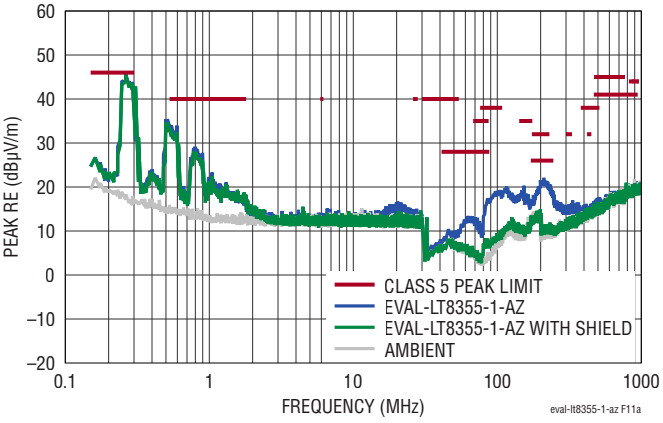


(a) CISPR25 Peak

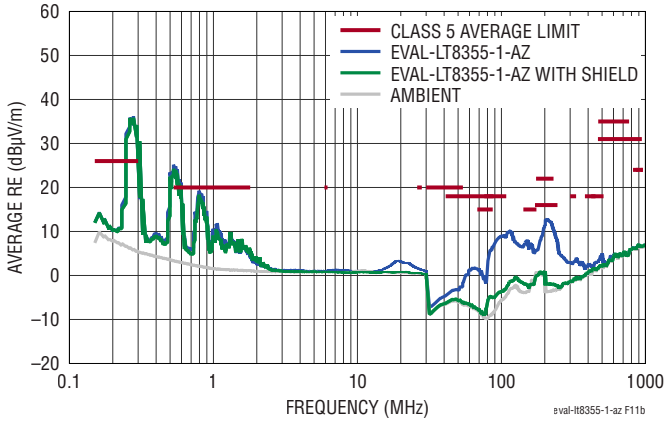


(b) CISPR25 Average

Figure 10. Conducted Emissions (Current Method): $12V_{IN}$, Channel 1, $72V_{LED}$ 450mA, Channel 2, $30V_{LED}$ 1A



(a) CISPR25 Peak

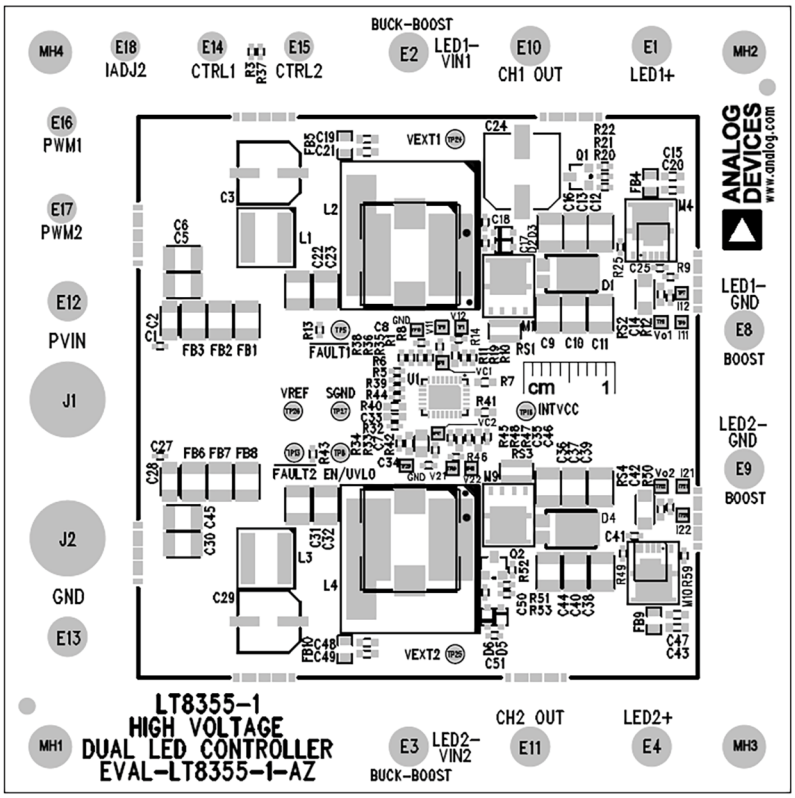


(b) CISPR25 Average

Figure 11. Radiated Emissions: $12V_{IN}$, Channel 1, $72V_{LED}$ 450mA, Channel 2, $30V_{LED}$ 1A

EMISSIONS SHIELD (OPTION)

For the lowest emissions, an EMI shield can be attached to EVAL-LT8355-1-AZ. The PCB was fabricated with placeholders for six shield clips that can hold a 61.5mm × 61.5mm 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 (Figure 12) shows the placeholders for the six-surface mount shield clips. Emissions can be tested with and without the removable clip shield.



eval-lt8355-1-az F12

Figure 12. EVAL-LT8355-1-AZ Top Silkscreen Outlining Placement of Shield Clips and EMI Shield on PCB

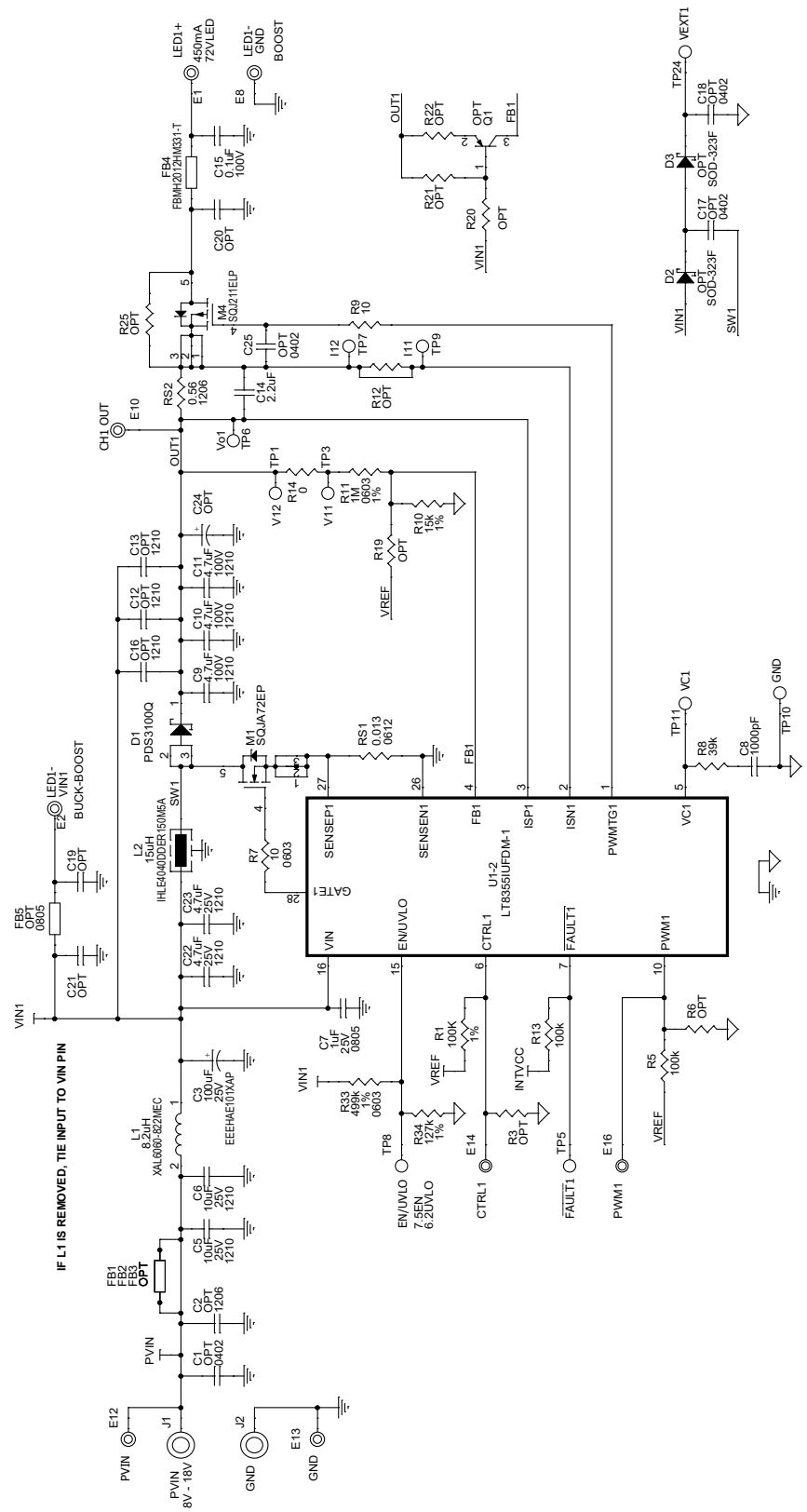
PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	2	C3, C29	CAP., 100µF, ALUM ELECT, 25V, 20%, 6.3mm × 7.7mm, D8, SMD, RADIAL, EEEHA, AEC-Q200	PANASONIC, EEEHAE101XAP
2	1	C7	CAP., 1µF, X7R, 25V, 10%, 0805, AEC-Q200	TDK, CGA4J3X7R1E105K125AB
3	1	C8	CAP., 1000pF, X7R, 50V, 10%, 0402, AEC-Q200	MURATA, GCM155R71H102KA37D
4	4	C9-C11, C36	CAP., 4.7µF, X7S, 100V, 10%, 1210, AEC-Q200	MURATA, GCM32DC72A475KE02L
5	2	C14, C42	CAP., 2.2µF, X5R, 25V, 10%, 0603, AEC-Q200	TAIYO YUDEN, TMK107BBJ225KAHT
6	4	C22, C23, C31, C32	CAP., 4.7µF, X7R, 25V, 10%, 1210, AEC-Q200	TAIYO YUDEN, TMF325B7475KMHP
7	1	C33	CAP., 2.2µF, X5R, 10V, 10%, 0603, AEC-Q200	TAIYO YUDEN, LMK107BJ225KAHT
8	1	C34	CAP., 680pF, X7R, 50V, 10%, 0402, AEC-Q200	TDK, CGA2B2X7R1H681K050BA
9	1	C35	CAP., 4.7µF, X5R, 10V, 10%, 0603, AEC-Q200	TAIYO YUDEN, LMK107BJ475KAHT
10	1	C38	CAP., 10µF, X7S, 50V, 10%, 1210, AEC-Q200, NO SUBS ALLOWED	MURATA, GCM32EC71H106KA03L
11	2	D1, D4	DIODE, SCHOTTKY, 100V, 3A, POWERDI5, AEC-Q101	DIODES INC., PDS3100Q-13
12	1	L2	IND., 15µH, PWR, SHIELDED, 20%, 7.7A, 50.29mΩ, 4040DD, IHLE-5A, AEC-Q200	VISHAY, IHLE4040DDER150M5A
13	1	L4	IND., 10µH, PWR, SHIELDED, 20%, 8.5A, 33.06mΩ, 4040DD, IHLE-5A SERIES, AEC-Q200	VISHAY, IHLE4040DDER100M5A
14	2	M1, M9	XSTR., MOSFET, N-CH, 100V, 37A, POWERPAK SO-8L, AEC-Q101	VISHAY, SQJA72EP-T1_GE3
15	2	M4, M10	XSTR., MOSFET, P-CH, 100V, 33.6A, POWERPAK SO-8L, AEC-Q101	VISHAY, SQJ211ELP-T1_GE3
16	1	Q2	XSTR., PNP, 100V, 1A, SOT-23-3, AEC-Q101	DIODES INC., FMMT593QTA
17	3	R1, R35, R36	RES., 100k, 1%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW0402100KFKED
18	4	R5, R13, R39, R43	RES., 100k, 5%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW0402100KJNED
19	1	R8	RES., 39k, 1%, 1/16W, 0402, AEC-Q200	YAGEO, AC0402FR-0739KL
20	2	R9, R49	RES., 10Ω, 5%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW040210R0JNED
21	1	R10	RES., 15k, 1%, 1/16W, 0402, AEC-Q200	YAGEO, AC0402FR-0715KL
22	1	R11	RES., 1M, 1%, 1/10W, 0603	VISHAY, CRCW06031M00FKEA
23	1	R14	RES., 0Ω, 1/10W, 0402, AEC-Q200	PANASONIC, ERJ2GE0R00X
24	1	R33	RES., 499k, 1%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW0603499KFKEA
25	1	R34	RES., 127k, 1%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW0402127KFKED
26	1	R40	RES., 86.6k, 1%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW060386K6FKEA
27	1	R42	RES., 30k, 1%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW040230K0FKED
28	1	R47	RES., 10k, 1%, 1/10W, 0402, AEC-Q200	PANASONIC, ERJ2RKF1002X
29	1	R52	RES., 287k, 1%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW0402287KFKED
30	1	R53	RES., 10k, 5%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW040210K0JNED
31	1	RS1	RES., 0.013Ω, 1%, 1W, 1206, LONG-SIDE TERM, SENSE, AEC-Q200	ROHM, LTR18EZPFSR013
32	1	RS2	RES., 0.56Ω, 1%, 1/2W, 1206, SENSE, AEC-Q200	PANASONIC, ERJ8BQFR56V
33	1	RS3	RES., 0.012Ω, 1%, 1.5W, 1206, LONG-SIDE TERM, METAL, SENSE, AEC-Q200	KOA SPEER, WU732B15TTD12L0F
34	1	RS4	RES., 0.25Ω, 1%, 1/2W, 1206, SENSE, AEC-Q200	YAGEO, PT1206FR-7W0R25L
35	1	U1	IC, DUAL LED CONTROLLER, QFN-28, AEC-Q100	ANALOG DEVICES, LT8355IUFDM-1#WPBF

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Optional EMI Filter Components				
36	0	C1, C27	CAP., OPTION, 0402	
37	0	C2, C28	CAP., OPTION, 1206	
38	4	C5, C6, C30, C45	CAP., 10µF, X7R, 25V, 10%, 1210, AEC-Q200	TDK, CGA6P1X7R1E106K250AC
39	2	C15, C43	CAP., 0.1µF, X7S, 100V, 10%, 0603, AEC-Q200	TDK, CGA3E3X7S2A104K080AB
40	0	C19-C21, C47, C48	CAP., OPTION, 0603	
41	1	C49	CAP., 0.1µF, X7R, 50V, 10%, 0603, AEC-Q200	TDK, CGA3E2X7R1H104K080AA
42	3	FB4, FB9, FB10	IND., 330Ω AT 100MHz, FERRITE BEAD, 25%, 1.8A, 80mΩ, 0805, 1LN	TAIYO YUDEN, FBMH2012HM331-T
43	0	FB5	IND., FERRITE BEAD, OPT, 0805	
44	2	L1, L3	IND., 8.2µH, PWR, SHIELDED, 20%, 8A, 26.4mΩ, 6.56mm × 6.36mm, XAL6060, AEC-Q200	COILCRAFT, XAL6060-822MEC
45	2	R7, R41	RES., 10Ω, 5%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW060310R0JNEA
46	0	CL1-CL6	OPTION, WE-SHC CABINET CLIP 6.5mm × 0.8mm × 1.27mm	WURTH, 369 000 00
47	0	SH1	OPTION, WE-SHC SHIELDIY 61.5mm × 61.5mm	WURTH, 360002
Optional Electrical Components				
48	0	C17, C18, C25, C41, C46, C50, C51	CAP., OPTION, 0402	
49	0	C12, C13, C16, C37, C39, C40, C44	CAP., OPTION, 1210	
50	0	C24	CAP., OPTION, ALUM. ELECT., SMD	
51	0	D2, D3, D5, D6	DIODE, OPTION, SOD-323F	
52	0	FB1-FB3, FB6-FB8	IND., OPTION, FERRITE BEAD, 1210	
53	0	Q1	XSTR., OPTION, PNP, SOT-23	
54	0	R3, R6, R12, R19-R22, R25, R32, R37, R38, R44-R46, R50, R51, R59	RES., OPTION, 0402	
55	0	R48	RES., OPTION, 0603	
Hardware: For Demo Board Only				
56	10	E1-E4, E8-E13	TEST POINT, TURRET, 0.094" MTG. HOLE, PCB 0.062" THK	MILL-MAX, 2501-2-00-80-00-00-07-0
57	5	E14-E18	TEST POINT, TURRET, 0.064" MTG. HOLE, PCB 0.062" THK	MILL-MAX, 2308-2-00-80-00-00-07-0
58	2	J1, J2	CONN., BANANA JACK, FEMALE, THT, NON-INSULATED, SWAGE, 0.218"	KEYSTONE, 575-4
59	4	MP1-MP4	STANDOFF, NYLON, SNAP-ON, 0.50"	KEYSTONE, 8833

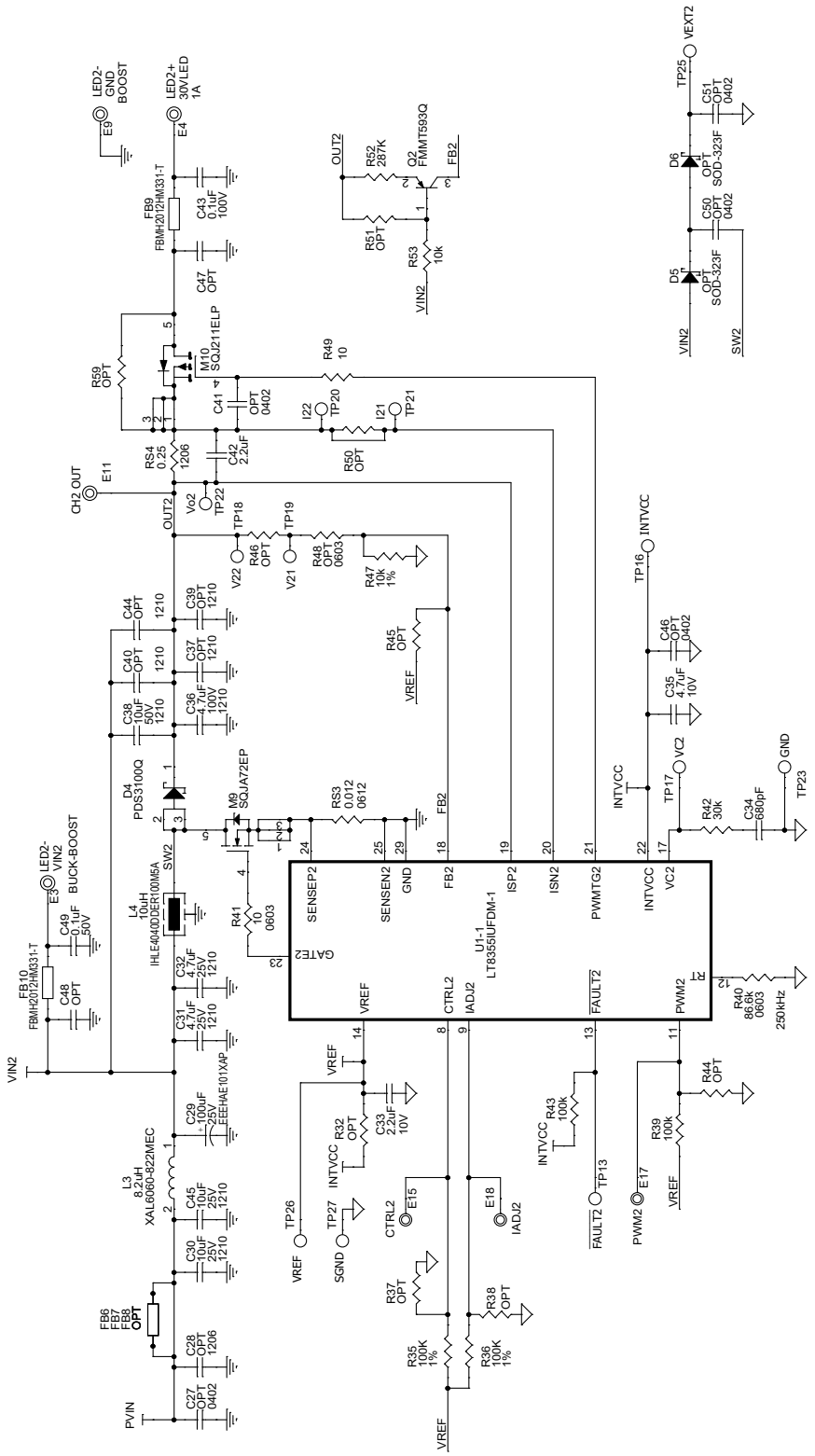
SCHEMATIC DIAGRAM



NOTES: UNLESS OTHERWISE SPECIFIED.

1. ALL RESISTORS 5%, 0402.
2. ALL CAPACITORS 0603.

SCHEMATIC DIAGRAM



NOTES: UNLESS OTHERWISE SPECIFIED.

1. ALL RESISTORS 5%, 0402.

2. ALL CAPACITORS 0603.

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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