

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 [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 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 undervoltage 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 data sheet. Please consult the data sheet or the applications team regarding how to customize EVAL-LT8356-1-AZ.

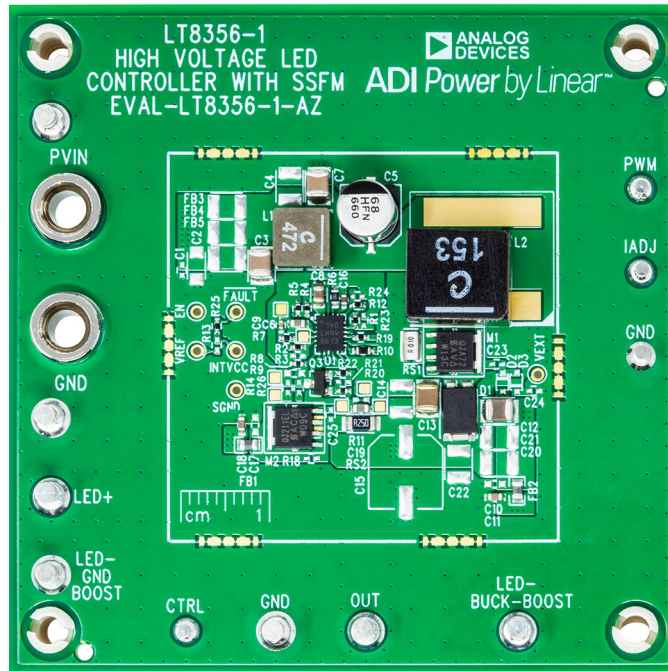
The LT8356-1 data sheet gives a complete description of the part, operation, and applications information. The data sheet must be read in conjunction with this demo manual for evaluation board EVAL-LT8356-1-AZ. The LT8356IUDCM-1 is assembled in a 20-lead side solderable plastic QFN package with a thermally 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.](#)

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DEMO MANUAL EVAL-LT8356-1-AZ

BOARD PHOTO



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

| PARAMETER | CONDITION | MIN | TYP | MAX | UNITS |
|--|---|-------|------------|-----|--------|
| Input Voltage PVIN Range | Operating | 8 | | 36 | V |
| Switching Frequency (f_{sw} , SSFM ON) | R6 = 110k | 250 | | 310 | kHz |
| I_{LED} | RS2 = 0.25 Ω , 8V < PVIN < 36V, $V_{LED} \leq 36V$, 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, $V_{LED} = 36V$, $I_{LED} = 1A$ with Filters PVIN = 12V, $V_{LED} = 36V$, $I_{LED} = 1A$ without Filters | | 91.5 92 | | % % |
| Peak Switch Current Limit | RS1 = 0.01 Ω | | 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 |
| 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 1.
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.

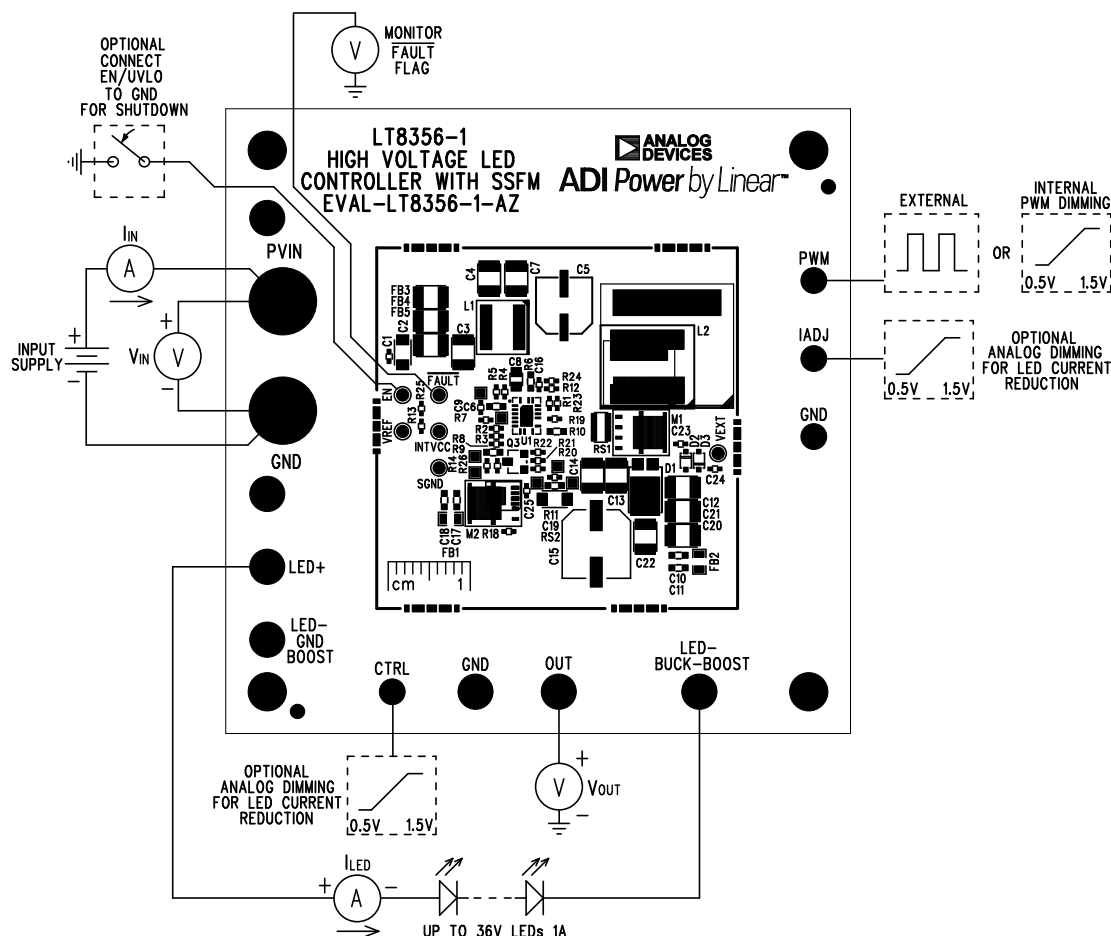


Figure 1. Setup Drawing for EVAL-LT8356-1-AZ as Buck-Boost Mode LED Driver (*See Boost LED Driver Setup Section for More Information on Boost-Only Topology)

TEST RESULTS

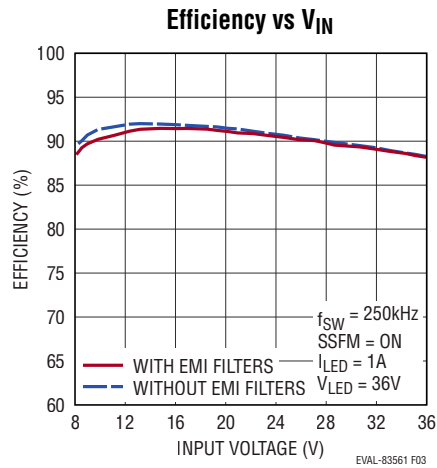


Figure 3. EVAL-LT8356-1-AZ as Buck-Boost Mode LED Driver Efficiency vs Input Voltage

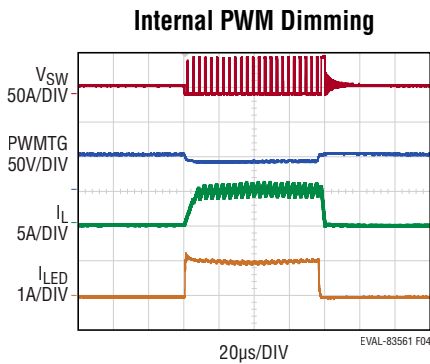


Figure 4. EVAL-LT8356-1-AZ as Buck-Boost Mode LED Driver Internal 260Hz 2% PWM Dimming with EMI Filters and SSFM ON: 12VIN, 36VLED, 1A

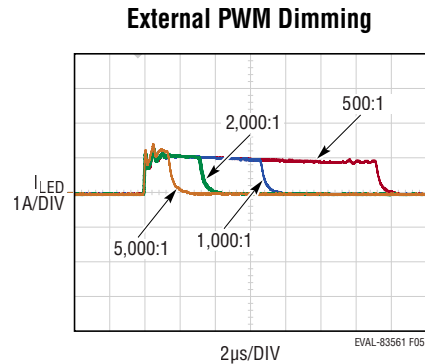


Figure 5. EVAL-LT8356-1-AZ as Buck-Boost Mode LED Driver External 150Hz PWM Dimming with EMI Filters and SSFM ON: 12VIN, 36VLED, 1A

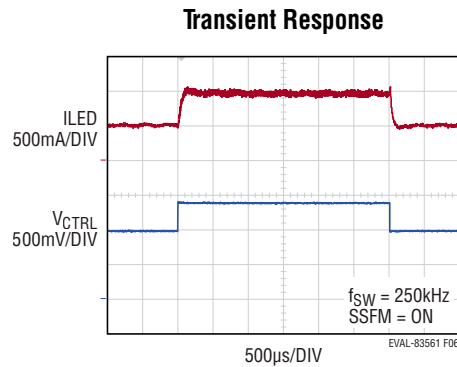


Figure 6. EVAL-LT8356-1-AZ as Buck-Boost Mode LED Driver: 50% to 100% to 50% Load Step Transient Response, 12VIN

TEST RESULTS

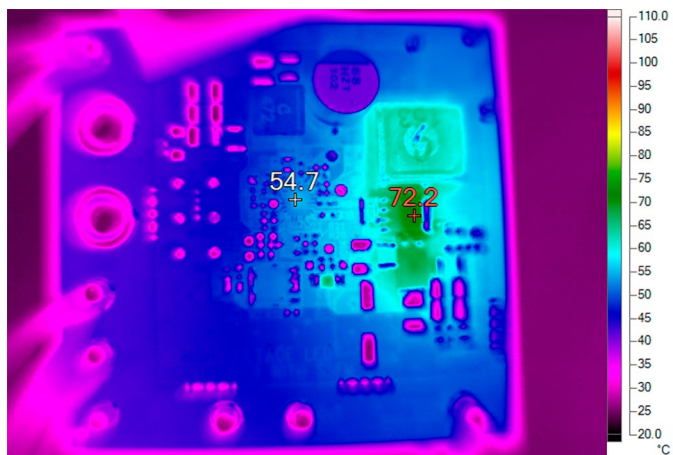
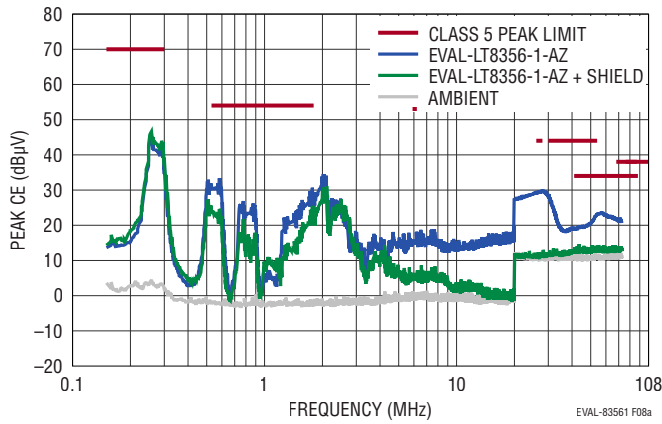
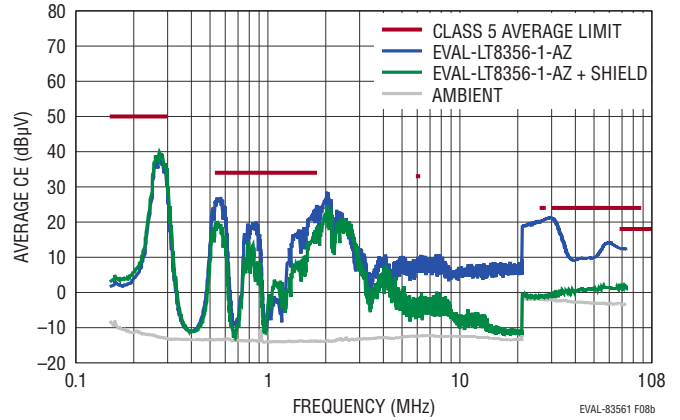


Figure 7. EVAL-LT8356-1-AZ as Buck-Boost Mode LED Driver Board
Thermal Image with Filters and SSFM ON: 12V_{IN}, 36V_{LED}, 1A

TEST RESULTS

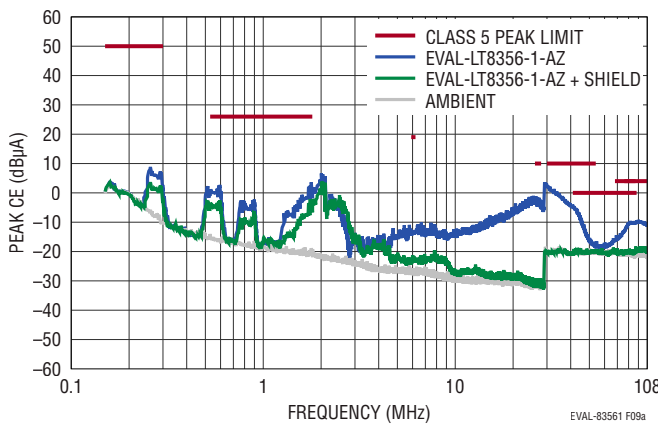


(a) CISPR25 Peak Conducted EMI – Voltage Method

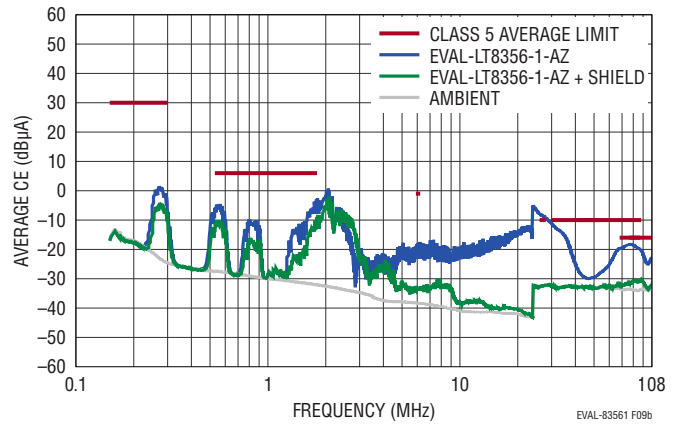


(b) CISPR25 Average Conducted EMI – Voltage Method

Figure 8. EVAL-LT8356-1-AZ as Buck-Boost Mode LED Driver Conducted Emissions (Voltage Method): 12V_{IN}, 36V_{LED}, 1A (SSFM ON)

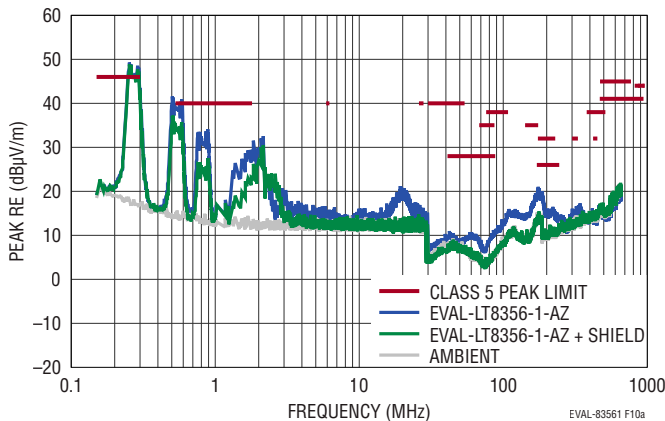


(a) CISPR25 Peak Conducted EMI – Current Method

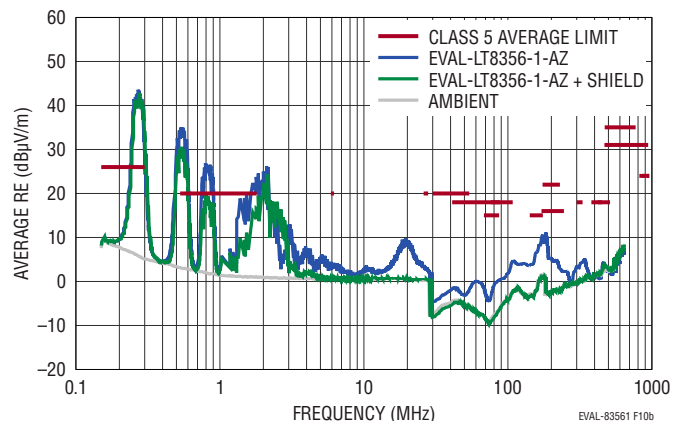


(b) CISPR25 Average Conducted EMI – Current Method

Figure 9. EVAL-LT8356-1-AZ as Buck-Boost Mode LED Driver Conducted Emissions (Current Method): 12V_{IN}, 36V_{LED}, 1A (SSFM ON)



(a) CISPR25 Peak Radiated EMI



(b) CISPR25 Average Radiated EMI

Figure 10. EVAL-LT8356-1-AZ as Buck-Boost Mode LED Driver Radiated Emissions: 12V_{IN}, 36V_{LED}, 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 placeholders 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 11, shows the placeholders for the six surface mount shield clips. Emissions can be tested with and without the removable clip-shield.

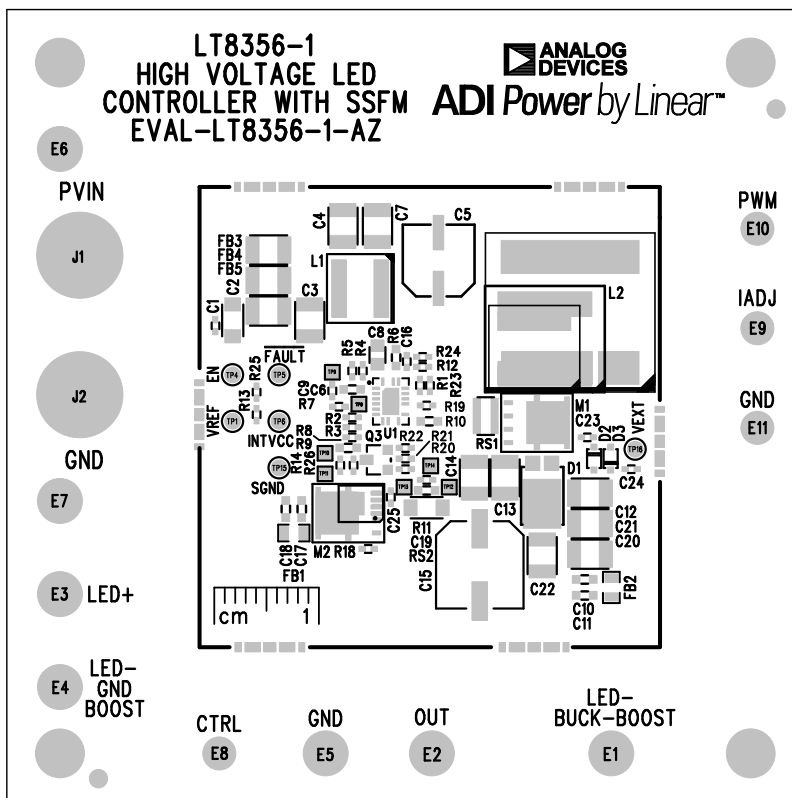


Figure 11. EVAL-LT8356-1-AZ Top Silkscreen Outlining Placement of Shield Clips and EMI Shield on PCB

PARTS LIST

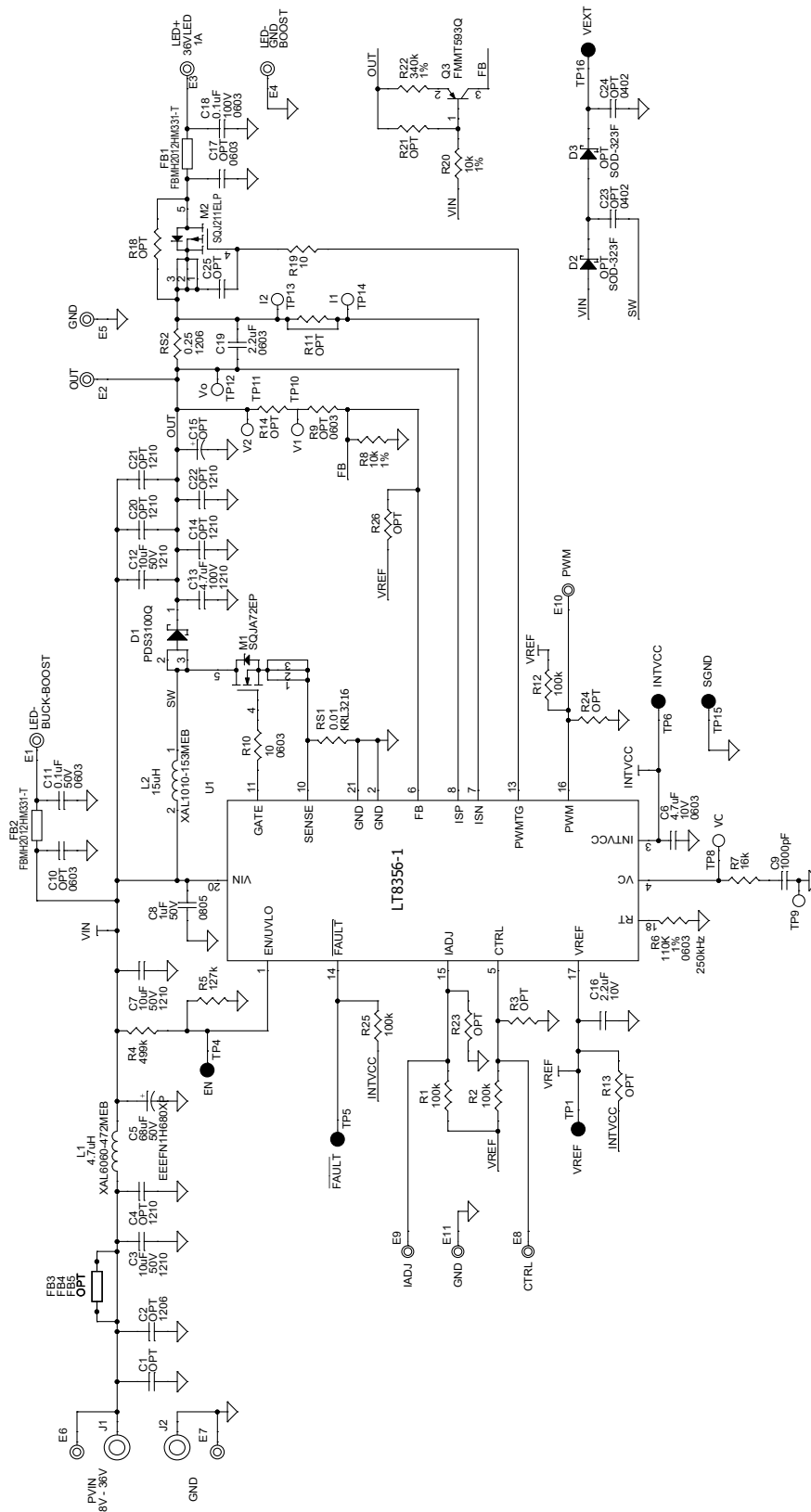
| ITEM | QTY | REFERENCE | PART DESCRIPTION | MANUFACTURER/PART NUMBER |
|---------------------------------------|-----|------------------|---|------------------------------------|
| Required Circuit Components | | | | |
| 1 | 1 | C7 | CAP., 10 μ F, X7S, 50V, 10%, 1210, AEC-Q200, NO SUBS ALLOWED | MURATA, GCM32EC71H106KA03L |
| 2 | 1 | C5 | CAP., 68 μ F, ALUM ELECT, 50V, 20%, 6.3mm \times 7.7mm, SMD, RADIAL, AEC-Q200 | PANASONIC, EEEFN1H680XP |
| 3 | 1 | C6 | CAP., 4.7 μ F, X5R, 10V, 10%, 0603, AEC-Q200 | TAIYO YUDEN, LMK107BJ475KAHT |
| 4 | 1 | C8 | CAP., 1 μ F, 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., 10 μ F, X7S, 50V, 10%, 1210, AEC-Q200 | MURATA, GCM32EC71H106KA03L |
| 7 | 1 | C13 | CAP., 4.7 μ F, X7S, 100V, 10%, 1210, AEC-Q200 | MURATA, GCM32DC72A475KE02L |
| 8 | 1 | C16 | CAP., 2.2 μ F, X6S, 10V, 10%, 0402, AEC-Q200 | MURATA, GRT155C81A225KE13D |
| 9 | 1 | C19 | CAP., 2.2 μ F, 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., 15 μ H, PWR, SHIELDED, 20%, 13.8A, 18.6m Ω , 11.8mm \times 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., 10 Ω , 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., 0.01 Ω , 1%, 1.5A, 1206, LONG-SIDE TERM., METAL, SENSE, AEC-Q200 | SUSUMU, KRL3216E-C-R010-F-T1 |
| 24 | 1 | RS2 | RES., 0.25 Ω , 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., 10 μ F, X7S, 50V, 10%, 1210, AEC-Q200, NO SUBS ALLOWED | MURATA, GCM32EC71H106KA03L |
| 27 | 1 | C11 | CAP., 0.1 μ F, X7R, 50V, 10%, 0603, AEC-Q200 | TDK, CGA3E2X7R1H104K080AA |
| 28 | 1 | C18 | CAP., 0.1 μ F, X7S, 100V, 10%, 0603, AEC-Q200 | TDK, CGA3E3X7S2A104K080AB |
| 29 | 2 | FB1, FB2 | IND., 330 Ω AT 100MHz, FERRITE BEAD, 25%, 1.8A, 80m Ω , 0805, 1LN | TAIYO YUDEN, FBMH2012HM331-T |
| 30 | 1 | L1 | IND., 4.7 μ H, PWR, SHIELDED, 20%, 11A, 14.4m Ω , 6.76mm \times 6.56mm, XAL6060, AEC-Q200 | COILCRAFT, XAL6060-472MEB |
| 31 | 1 | R10 | RES., 10 Ω , 5%, 1/10W, 0603, AEC-Q200 | VISHAY, CRCW060310R0JNEA |
| 32 | 0 | FB3-FB5 | IND., OPTION, FERRITE BEAD, 1210 | |
| 33 | 0 | C1 | CAP., OPTION, 0402 | |

DEMO MANUAL EVAL-LT8356-1-AZ

PARTS LIST

| ITEM | QTY | REFERENCE | PART DESCRIPTION | MANUFACTURER/PART NUMBER |
|---------------------------------------|-----|--|--|-----------------------------------|
| 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



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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