LT8391D
Synchronous 4-Switch Buck-Boost LED Driver 6V to 45V Input, Up to 50V LED

DESCRIPTION

Evaluation circuit EVAL-LT8391D-AZ is a 4-switch synchronous buck-boost LED driver featuring the LT®8391D. It drives a single string of LEDs at up to 1.5A and up to 50V when V_{IN} is between 6V and 45V. EVAL-LT8391D-AZ runs at 400kHz switching frequency and efficiency can exceed 97%. It comes with low EMI features including optimized layout, spread spectrum frequency modulation (SSFM) and input EMI filter. SSFM can be turned on or off with a simple jumper.

The LT8391D 4-swich buck-boost controller is the new member of the LT8391 family (see Table 1). It has an input voltage range of 4V to 60V and output voltage range of 0V to 60V. It has input under voltage lockout (UVLO) which can also be used to enable or disable the controller. On the output side, it is protected against both open and short LED conditions.

The LT8391D allows adjustable switching frequency between 150kHz and 650kHz. It can be PWM dimmed with an external PWM signal. When run with PWM dimming and either fixed switching frequency or SSFM, the internal oscillator aligns itself with the PWM signal for flicker-free operation. On EVAL-LT8391D-AZ, the PWM pin is pulled up to $INTV_{CC}$ through a 100k resistor. Therefore, the LED string is 100% ON when there is no external PWM signal. It can also be analog dimmed with a control voltage on its control pin (CTRL).

EVAL-LT8391D-AZ features MOSFETs that complement the 5V gate drive of the LT8391D to achieve high efficiency. All MOSFETs used on the 4-switch topology are rated at 60V and AEC-Q101 qualified. Ceramic capacitors are used at both input and output side due to their small size and high ripple current capability. In addition to ceramic capacitors, there is one aluminum electrolytic capacitor at the input side to mitigate the effects of the input and output transients.

Sense resistor for LED current can be placed either on high side (LED+) or low side (GND). With high side sense resistor, LED– is directly connected to GND. This gives the option to run only one wire (LED+) to LED string and use chassis ground as return path in automotive or similar applications. LT8391D guarantees ±4% current regulation accuracy with high side sense resistor. Low side sense resistor gives the most accurate LED current regulation. EVAL-LT8391D-AZ implemented both high side and low side sense resistors, with high side sense resistor as default and low side sense resistor as optional.

The LT8391D data sheet gives a complete description of the part, operation and applications information. The data sheet must be read in conjunction with this user guide for evaluation circuit EVAL-LT8391D-AZ. The LT8391DJUFDM is assembled in a 28-lead plastic 4mm × 5mm QFN package with a thermally enhanced GND pad. Proper board layout is essential for maximum thermal performance and EMI performance. Please see the evaluation kit design files for details, including top layer layout, inner traces and grounding.

Refer to the Emission Results section for the excellent EMI performance of this evaluation board.

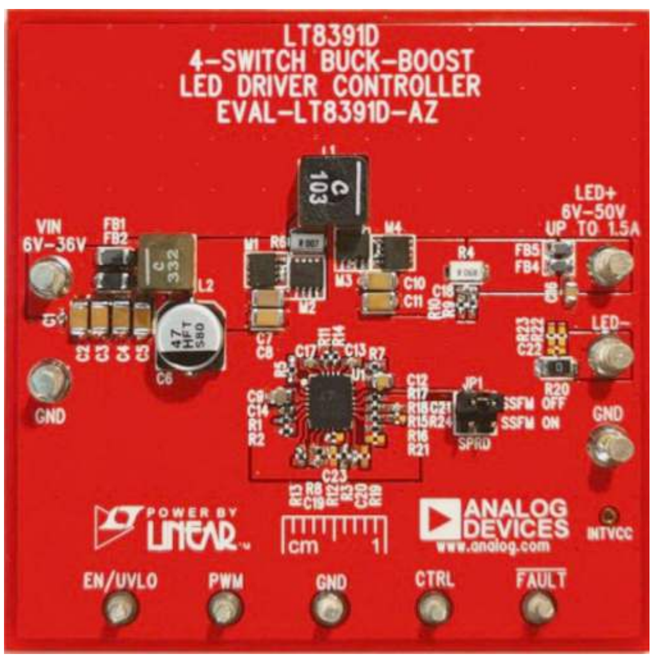
Design files for this circuit board are available.

DESCRIPTION

Table 1. Comparison of LT839X Family

	LT8391	LT8391A	LT8391D	LT8393
V_{IN} Range	4V ~ 60V	4V ~ 60V	4V ~ 60V	4V ~ 60V
V_{OUT} Range	0V ~ 60V	0V ~ 60V	0V ~ 60V	0V ~ 100V
f_{SW}	150kHz ~ 650kHz	600kHz ~ 2MHz	150kHz ~ 650kHz	350kHz ~ 2MHz
Clock Sync	Yes	Yes	No	Yes
SSFM	Yes	Yes	Yes	Yes
PWM Dimming	External and 128:1 Internal	External and 128:1 Internal	External	External and 128:1 Internal
PWM Driver	5V High Side	5V High Side	N/A	10V High Side
FB Short LED Threshold	0.25V Falling	0.25V Falling	0.05V Falling	0.25V Falling
Package	FE28 and UFD28	FE28 and UFD28	UFDM28	FE28 and UFDM28
Temperature Range	–40°C to 150°C	–40°C to 150°C	–40°C to 150°C	–40°C to 150°C
Price	Normal	Low	Lowest	Normal

BOARD PHOTO



PERFORMANCE SUMMARY Specifications are at T_A = 25°C

PARAMETER	CONDITION	MIN	TYP	MAX	UNIT
Input Voltage V_{IN} Range (Output ≤ 22.5W)	Operating, 6V ≤ V_{LED} ≤ 50V, I_{LED} ≤ 1.5A	6		45	V
Input Voltage V_{IN} Range (Output ≤ 45W)	Operating, 6V ≤ V_{LED} ≤ 36V, I_{LED} ≤ 1.5A	9		45	V
Safe Input Voltage V_{IN} Range		0		50	V
V_{IN} Undervoltage Lockout (UVLO) Falling	Operating, V_{LED} = 30V, I_{LED} = 1.5A		4.2		V
V_{IN} Enable Turn-On (EN) Rising			5.0		V
Switching Frequency (f_{SW})	R17 = 100k, SSFM = OFF R17 = 100k, SSFM = ON		400 340 to 460		kHz kHz
LED Current I_{LED}	R4 = 0.068Ω, 9V < V_{IN} < 45V, 6V ≤ V_{LED} ≤ 30V, V_{CTRL} = 2V		1.47		A
LED Voltage V_{LED} Range	R15 = 1M, R16 = 17.4k	6		50	V
Open LED Voltage V_{OUT}	R15 = 1M, R16 = 17.4k		55.5		V
Efficiency (100% PWM DC)	V_{IN} = 12.0V, V_{LED} = 30V, I_{LED} = 1.5A, SSFM = ON or OFF, EMI Filters Included		94		%

QUICK START PROCEDURE

The EVAL-LT8391D-AZ is easy to set up to evaluate the performance of the LT8391D. Refer to Figure 1 for proper measurement equipment setup and follow the procedure below.

NOTE: Make sure that the voltage applied to VIN does not exceed 50V.

1. With power off, connect a string of LEDs that runs with a forward voltage less than or equal to 50V at 1.5A to the LED+ and LED– terminals.
2. Connect the EN/UVLO terminal to GND.
3. To enable spread spectrum frequency modulation, set JP1 to “SSFM ON”. Setting JP1 to “SSFM OFF” turns off SSFM.
4. With power off, connect the input power supply to the VIN and GND terminals.
5. Turn the input power supply on and make sure the voltage is between 6V and 45V for proper operation.
6. Release the EN/UVLO-to-GND connection.
7. Observe the LED string running at the programmed LED current.
8. To change the brightness with analog dimming, simply attach a voltage source to the CTRL terminal and set the voltage between 0V and 1.35V. See data sheet for details.
9. To change brightness with external PWM dimming, attach a 0V to 3V rectangular waveform with varying duty cycle to the PWM terminal.

Optimize Efficiency

If the EMI performance is less of a priority than efficiency and thermal performance, the EMI filters and gate resistors for MOSFETs can be removed (short the ferrite beads and inductor in EMI filters and short all gate resistors). The components for EMI filters are listed separately in the parts list. The gate resistors are R5, R7, R11 and R14. Figure 2 gives the efficiency curves with and without EMI filters and gate resistors.

QUICK START PROCEDURE

High Side and Low Side Sense Resistors

EVAL-LT8391D-AZ implemented both high side and low side LED current sense resistors to facilitate different application requirements. With high side sense resistor, LED– is directly connected to GND. This gives the option to run only one wire (LED+) to LED string and use chassis ground as return path in automotive or similar applications. If this feature is not necessary, the sense resistor can be placed on the low side to get the most accurate current regulation. By default, EVAL-LT8391D-AZ is assembled with high-side sense resistor. To switch to low side sense resistor, please follow these steps:

1. Remove R9, R10 and short R4.
2. Populate R22 and R23 with 0Ω resistors.
3. Populate C22 with 2.2µF/6.3V capacitor (same part number as C18).
4. Cut the trace that shorts R20 and populate R20 with 0.068Ω resistor (same part number as R4).

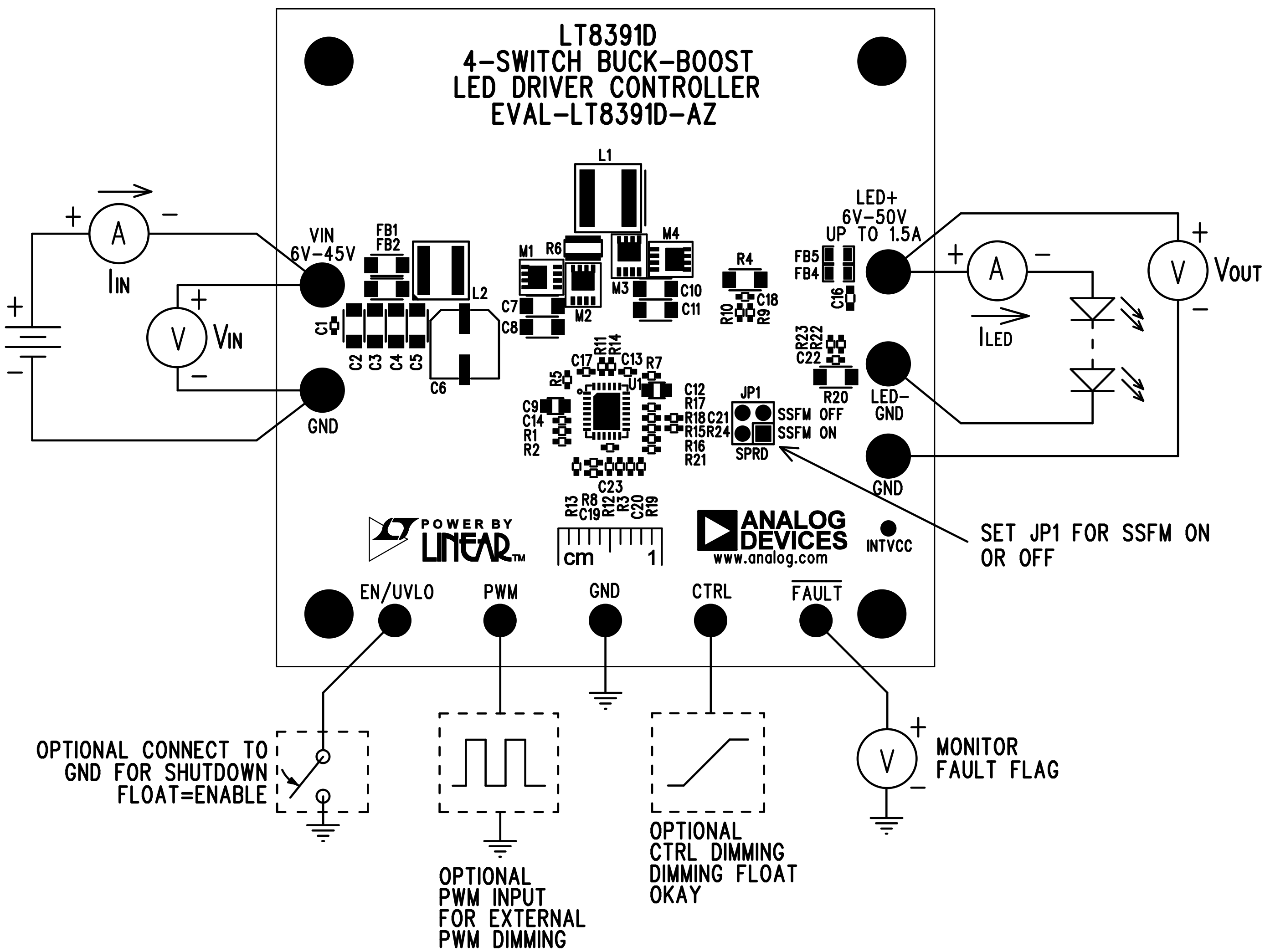


Figure 1. Test Procedure Setup Drawing for EVAL-LT8391D-AZ

TEST RESULTS

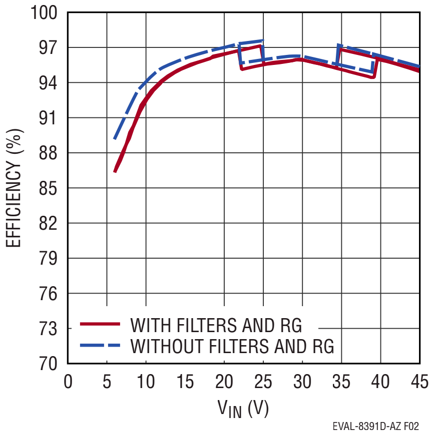


Figure 2. Efficiency vs V_{IN} with and without Filters and Gate Resistors (V_{LED} = 30V, I_{LED} = 1.5A, SSFM OFF)

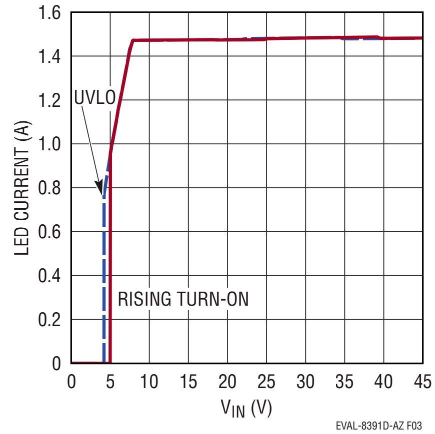
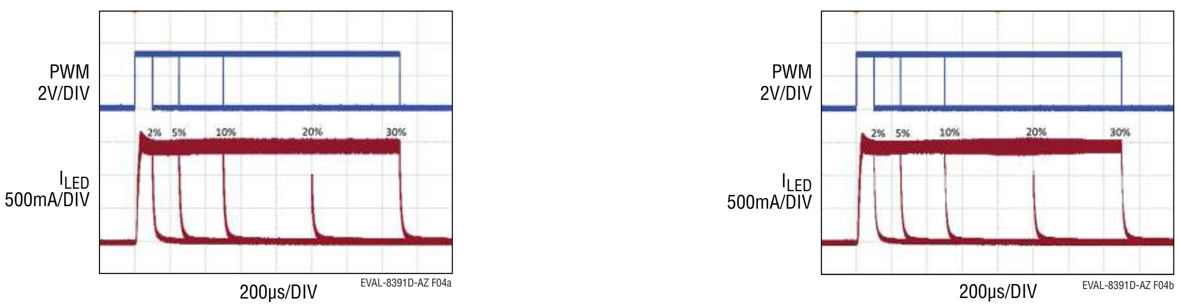


Figure 3. I_{LED} vs V_{IN} (V_{LED} = 30V, I_{LED} = 1.5A, SSFM OFF); Below 8V_{IN}, I_{LED} Scales Back Based Upon $I_{SW,P-P}$



(a) SSFM OFF

(b) SSFM ON

Figure 4. PWM Dimming (V_{IN} = 12V, V_{LED} = 30V, 200Hz PWM)

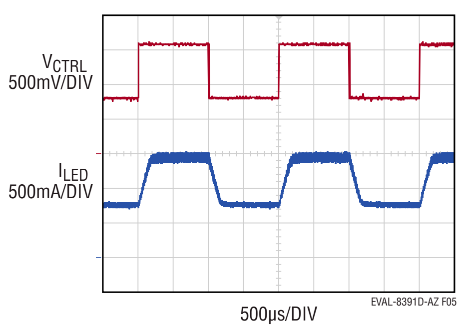
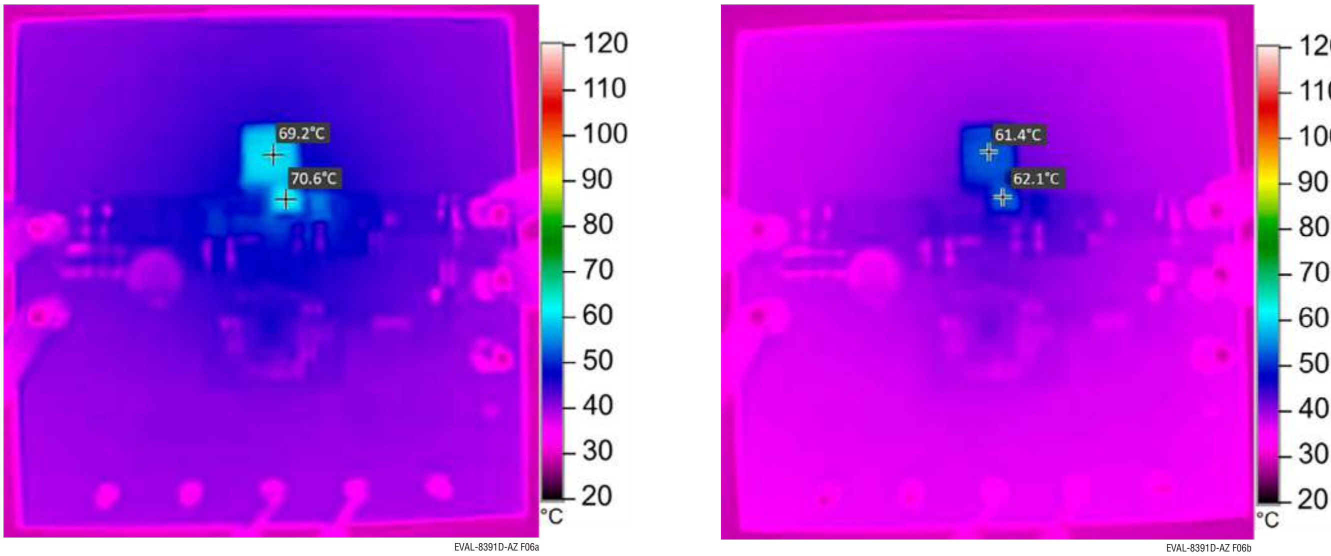


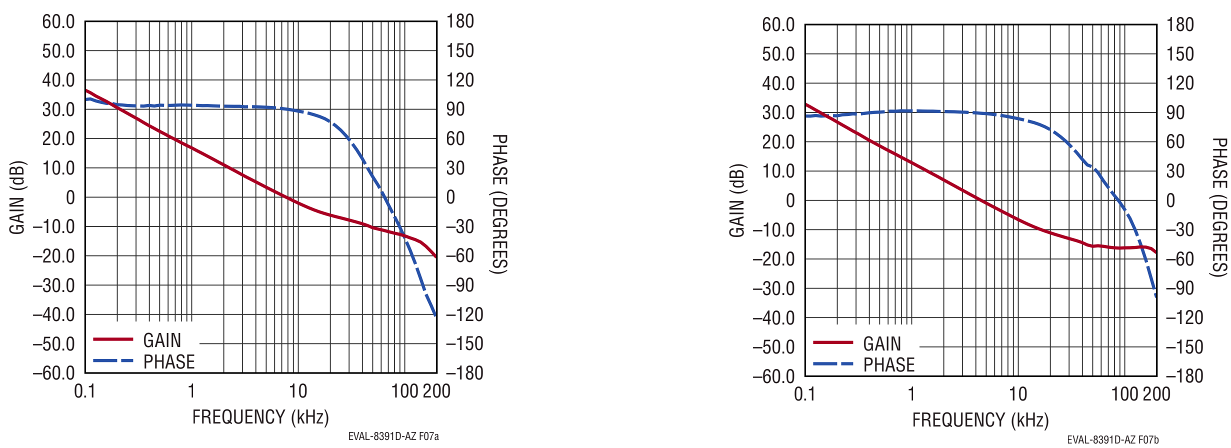
Figure 5. I_{LED} Load Transient with CTRL Input (V_{IN} = 12V, V_{LED} = 30V, SSFM OFF, I_{LED} Transient Between 0.75A and 1.5A)

TEST RESULTS



(a) 45W **(b) 40W**

Figure 6. Thermal Image with $12V_{IN}$, $30V_{LED}$, SSFM OFF

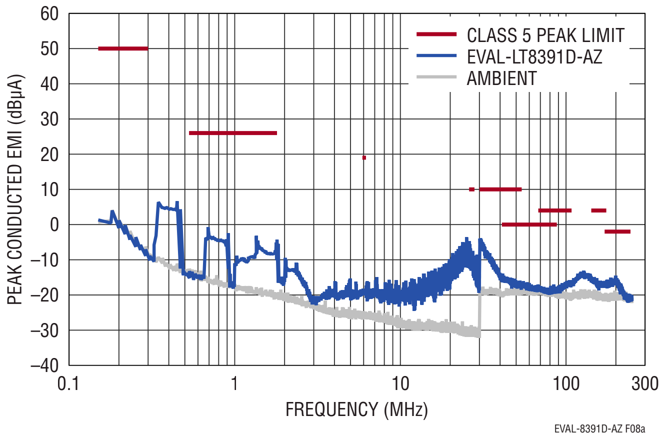


(a) $30V_{LED}$, 1.5A **(b) $50V_{LED}$, 0.9A**

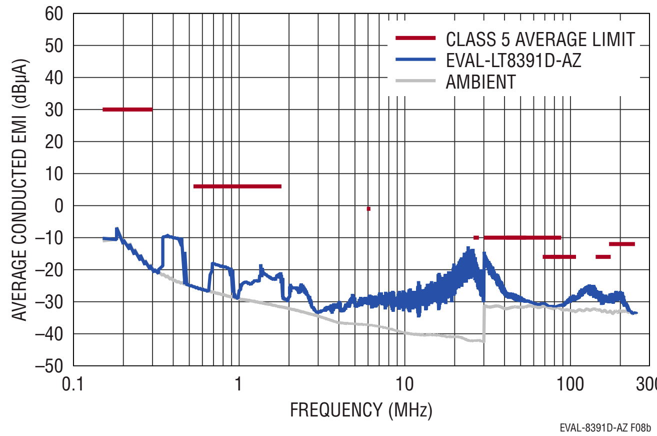
Figure 7. Bode Plots with $12V_{IN}$

Rev. 0

EMISSION RESULTS

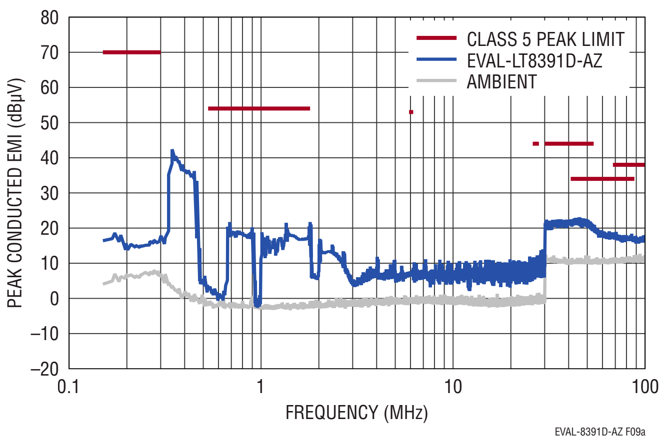


(a) CISPR25 Peak Conducted EMI – Current Method

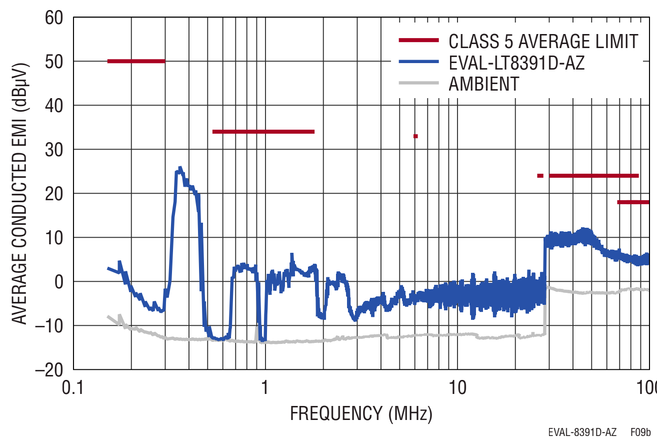


(b) CISPR25 Average Conducted EMI – Current Method

Figure 8. Conducted Emissions (Current Method): V_{LED} = 30V, I_{LED} = 1.5A, SSFM ON

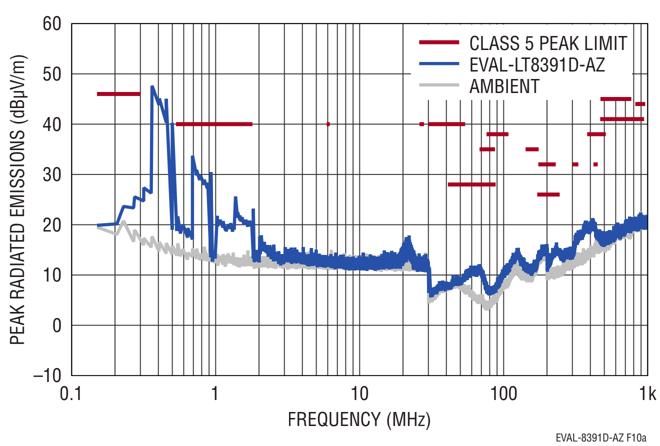


(a) CISPR25 Peak Conducted EMI – Voltage Method

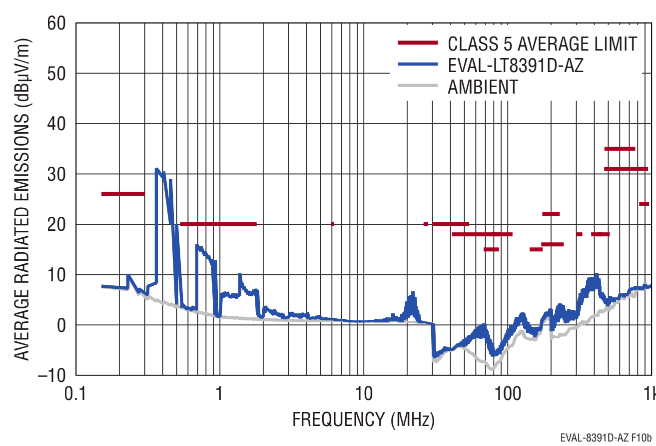


(b) CISPR25 Average Conducted EMI – Voltage Method

Figure 9. Conducted Emissions (Voltage Method): V_{LED} = 30V, I_{LED} = 1.5A, SSFM ON



(a) CISPR25 Peak Radiated EMI



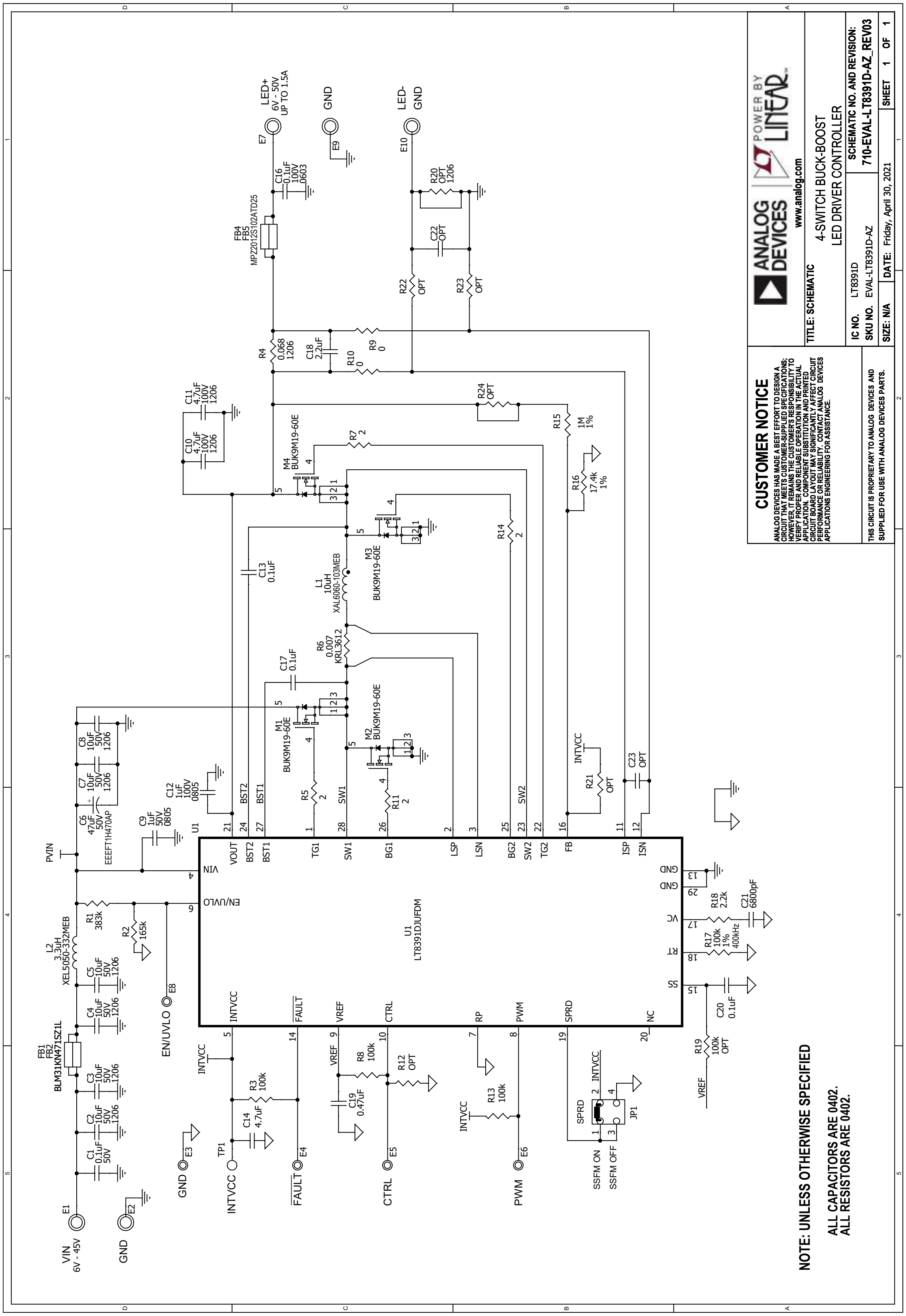
(b) CISPR25 Average Radiated EMI

Figure 10. Radiated Emissions: V_{LED} = 30V, I_{LED} = 1.5A, SSFM ON

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Electrical Components				
1	2	C7, C8	CAP., 10µF, X5R, 50V,10%, 1206, AEC-Q200	MURATA, GRT31CR61H106KE01L
2	1	C9	CAP., 1µF, X7R, 50V, 10%, 0805, AEC-Q200	MURATA, GCM21BR71H105KA03L
3	2	C10, C11	CAP., 4.7µF, X7S, 100V, 20%, 1206	MURATA, GRM31CC72A475ME11L
4	1	C12	CAP., 1µF, X7S, 100V, 10%, 0805, AEC-Q200	MURATA, GCM21BC72A105KE36L
5	3	C13, C17, C20	CAP., 0.1µF, X7R, 16V, 10%, 0402, AEC-Q200	MURATA, GCM155R71C104KA55D
6	1	C14	CAP., 4.7µF, X5R, 6.3V, 20%, 0402, AEC-Q200	TAIYO YUDEN, JMK105BBJ475MVHF
7	1	C18	CAP., 2.2µF, X5R, 6.3V, 20%, 0402, AEC-Q200	TAIYO YUDEN, JMK105BJ225MVHF
8	1	C19	CAP., 0.47µF, X7R, 6.3V, 10%, 0402, AEC-Q200	TAIYO YUDEN, JMK105B7474KVHF
9	1	C21	CAP., 6800pF, X7R, 50V, 10%, 0402, AEC-Q200	MURATA, GCM155R71H682KA55D
10	1	L1	IND., 10µH, SHIELDED PWR, 20%, 7A, 29.82mΩ, 6.56mm × 6.36mm, AEC-Q200	COILCRAFT, XAL6060-103MEB
11	4	M1-M4	XSTR., MOSFET, N-CH, 60V, 38A, LFPAK33, AEC-Q101	NEXPERIA, BUK9M19-60EX
12	1	R1	RES., 383k, 1%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW0402383KFKED
13	1	R2	RES., 165k, 1%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW0402165KFKED
14	2	R3, R17	RES., 100k, 1%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW0402100KFKED
15	1	R4	RES., 0.068Ω, 1%, 3/4W, 1206, SHORT SIDE TERM, AEC-Q200	SUSUMU, KRL1632E-M-R068-F-T5
16	4	R5, R7, R11, R14	RES., 2Ω, 1%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW04022R00FKED
17	1	R6	RES., 0.007Ω, 1%, 1.5W, 1206, LONG SIDE TERM, METAL, SENSE, AEC-Q200	SUSUMU, KRL3216E-M-R007-F-T1
18	2	R8, R13	RES., 100k, 5%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW0402100KJNED
19	2	R9, R10	RES., 0Ω, 1/10W, 0402, AEC-Q200	PANASONIC, ERJ2GE0R00X
20	1	R15	RES., 1M, 1%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW04021M00FKED
21	1	R16	RES., 17.4k, 1%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW040217K4FKED
22	1	R18	RES., 2.2k, 1%, 1/10W, 0402, AEC-Q200	PANASONIC, ERJ2RKF2201X
23	1	R20	RES., 0Ω, 1/4W, 1206, AEC-Q200	VISHAY, CRCW12060000Z0EA
24	1	U1	IC, 4-SWITCH BUCK-BOOST CTRLR, QFN-28, WETTABLE	ANALOG DEVICES, LT8391DJUFDM#WPBF
Optional EMI Filter Components				
25	1	C1	CAP., 0.1µF, X7R, 50V, 10%, 0402, AEC-Q200	MURATA, GCM155R71H104KE02D
26	4	C2-C5	CAP., 10µF, X5R, 50V, 10%, 1206, AEC-Q200	MURATA, GRT31CR61H106KE01L
27	1	C6	CAP., 47µF, ALUM ELECT, 50V, 20%, 6.3mm × 5.8mm SMD, RADIAL, AEC-Q200	PANASONIC, EEEFT1H470AP
29	1	C16	CAP., 0.1µF, X7R, 100V, 10%, 0805, AEC-Q200	MURATA, GCM21BR72A104KA37L
30	2	FB1, FB2	IND., 470Ω AT 100MHz, FERRITE BEAD, 25%, 4A, 20mΩ, 1206, AEC-Q200	MURATA, BLM31KN471SZ1L
31	2	FB4, FB5	IND., 1k AT 100MHz, FERRITE BEAD, 25%, 1.5A, 150mΩ, 0805, AEC-Q200	TDK, MPZ2012S102ATD25
32	1	L2	IND., 3.3µH, SHIELDED, 20%, 10.6A, 14.6mΩ, 5.48mm × 5.28mm, AEC-Q200	COILCRAFT, XEL5050-332MEB
Additional Electrical Components				
33	2	C22, C23	CAP., OPTION, 0402	
34	6	R12, R19, R21-R24	RES., OPTION, 0402	
Hardware: For Demo Board Only				
35	5	E1, E2, E7, E9, E10	TEST POINT, TURRET, 0.094" MTG. HOLE, PCB 0.062" THK	MILL-MAX, 2501-2-00-80-00-00-07-0
36	5	E3-E6, E8	TEST POINT, TURRET, 0.064" MTG. HOLE, PCB 0.062" THK	MILL-MAX, 2308-2-00-80-00-00-07-0
37	1	JP1	CONN., HDR, MALE, 2×2, 2mm, VERT, STR, THT	WURTH ELEKTRONIK, 62000421121
38	1	XJP1	CONN., SHUNT, FEMALE, 2 POS, 2mm	WURTH ELEKTRONIK, 60800213421

SCHEMATIC DIAGRAM



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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