LT8350
$40V_{IN}$, $18V_{OUT}$, 6A Synchronous Buck-Boost Silent Switcher®

DESCRIPTION

Evaluation circuit EVAL-LT8350-AZ is a 40V synchronous buck-boost converter featuring the LT®8350. It drives up to 2.5A load at 12V output when V_{IN} is between 9V and 40V and will run down to $3V_{IN}$ with reduced output current. EVAL-LT8350-AZ runs at 350kHz switching frequency with spread spectrum frequency modulation (SSFM) disabled. When enabled, SSFM spreads the switching frequency of the LT8350 from f_{SW} to f_{SW} + 25% for reduced EMI emission.

The LT8350 has an operating input voltage range of 3V to 40V. It has internal, synchronous 42V MOSFETs at buck-side and 20V MOSFETs at boost-side for high efficiency and small size. It has an adjustable switching frequency between 200kHz and 2MHz. The LT8350 can be synchronized to an external source, programmed with SSFM enabled for low EMI, or set to normal operation.

The LT8350's integrated LOADTG high side PMOS driver assists with disconnecting load when a fault is triggered. LOADTG turns off the PMOS when FB < 0.25V or FB > 1.1V or ISP–ISN > 0.75V. LOADEN can be used directly to turn off LOADTG and all power switches.

The LT8350 can regulate output current using ISP and ISN. Maximum load current can be limited when LT8350 is used for a constant voltage regulator. It can be also used for a LED driver or a battery charger where constant current regulation is required. Output current can be adjusted by placing a controllable DC voltage on the CTRL pin.

The output current can be monitored through the ISMON output pin. ISMON can be used to improve load transient response by injecting load current to V_C. The load current injection is described in the following sections.

Undervoltage lockout can be adjusted on EVAL-LT8350-AZ with a few simple resistor choices.

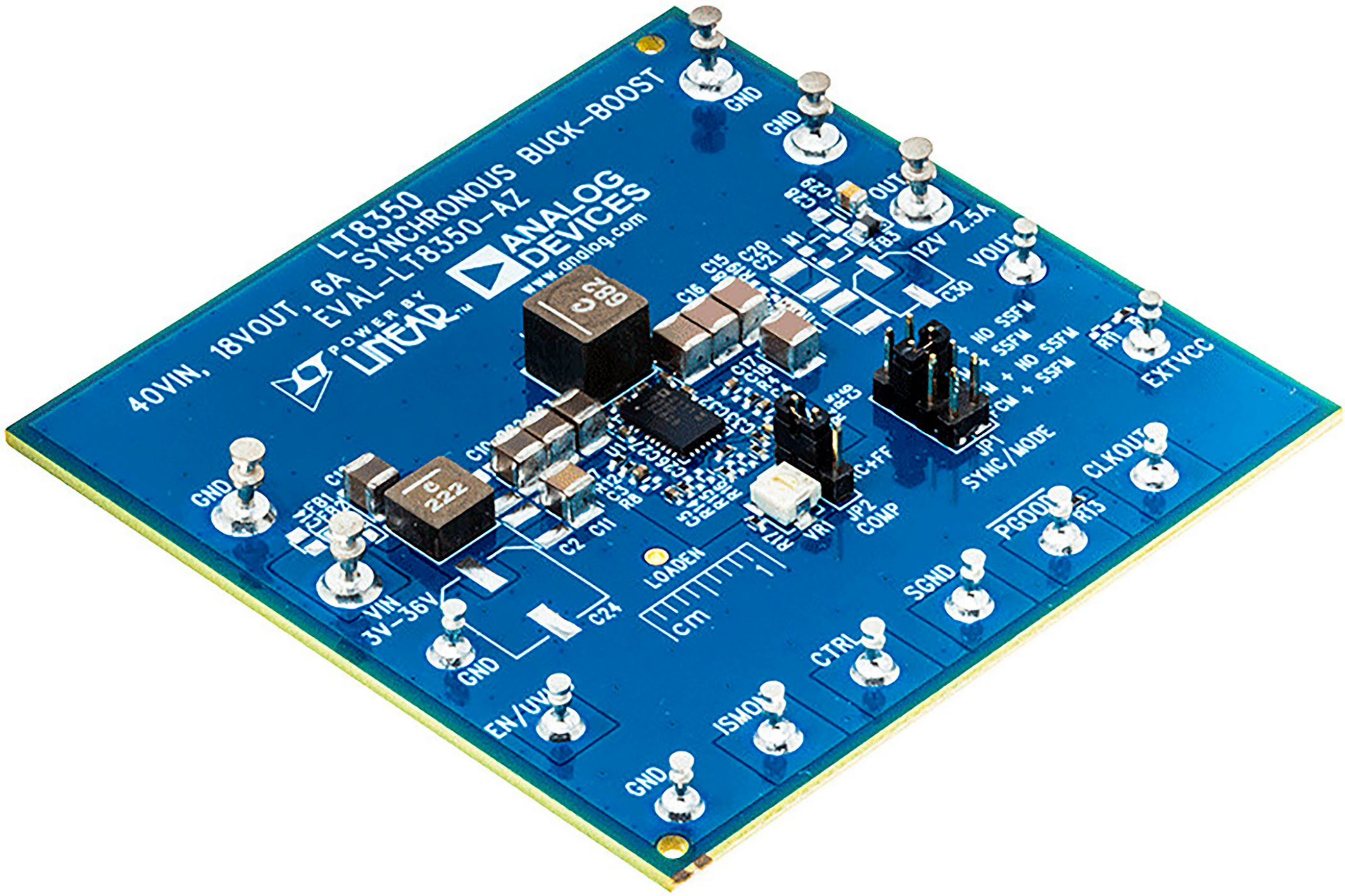
Small ceramic input and output capacitors are used to save space and cost. The board is designed with tiny, high frequency capacitors placed near the V_{IN} and V_{OUT} pins for a reduction in radiated EMI.

There is an inductor EMI filter and a small ferrite bead EMI filter on the input and output of EVAL-LT8350-AZ. These filters, combined with proper board layout and SSFM, are effective in reducing EMI to pass CISPR25 class 5 conducted EMI. Please follow the recommended layout and four-layer PCB thickness of EVAL-LT8350-AZ for low EMI applications.

The LT8350 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 EVAL-LT8350-AZ. The LT8350RV is assembled in a 32-lead laminate package with QFN footprint (LQFN) with thermally enhanced exposed ground pads. Proper board layout is essential for maximum thermal performance.

Design files for this circuit board are available.

BOARD PHOTO



PERFORMANCE SUMMARY **Specifications are at T_A = 25°C**

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage V_{IN} Range	Operating, R7 = 402k, **R12 = OPEN**	3		40	V
Full Load (2.5A) Input Voltage Range	Component Temperature < 85°C at Room Temperature with No Airflow	7		40	V
Output Voltage (V_{OUT})	R22 = 110k, R3 = 10.0k		12.0		V
Output Voltage Ripple	V_{IN} = 12V, V_{OUT} = 12V, I_{OUT} = 2.5A		50		mV
Maximum Output Current	7.0V < V_{IN} < 40V, V_{OUT} = 12V	2.5			A
Switching Frequency (f_{SW})	R4 = 143k, SSFM = OFF R4 = 143k, SSFM = ON		350 350 to 440		kHz kHz
Typical Efficiency without EMI filters	V_{IN} = 12V, V_{OUT} = 12V, I_{OUT} = 2.5A		95		%
Typical Efficiency with EMI filters	V_{IN} = 12V, V_{OUT} = 12V, I_{OUT} = 2.5A		94		%
Peak Switch Current Limit		6	7	8	A
V_{OUT} Overvoltage Threshold	R22 = 110k, R3 = 10.0k		13.2		V
V_{IN} Undervoltage Lockout (UVLO) Falling	R7 = 402k, R12 = 84.5k, I_{OUT} = 2.5A		7.2		V
V_{IN} Enable Turn-On (EN) Rising	R7 = 402k, R12 = 84.5k, I_{OUT} = 2.5A		8.0		V

QUICK START PROCEDURE

Evaluation circuit EVAL-LT8350-AZ is easy to set up to evaluate the performance of the LT8350. Refer to Figure 1 for proper measurement equipment setup and follow the procedure below.

NOTE: Make sure that the voltage applied to V_{IN} does not exceed 40V, which is the voltage rating for input side MOSFETs.

1. With power off, connect a load capable of 12V 2.5A operation between OUT and GND turrets on the PCB as shown in Figure 1 .
2. Connect the EN/UVLO terminal to GND with a clip-on lead. Connect the power supply (with power off) and meters as shown in Figure 1 .
3. Set JP1 at NO SSFM to disable SSFM, at SSFM to enable SSFM.
4. Set JP2 at RC for typical loop compensation, at RC+FF for load current injection scheme which improves load transient response.
5. After all connections are made, turn on the input power and verify that the input voltage is between 7V and 40V.
6. Remove the clip-on lead from EN/UVLO. Verify that the output voltage is 12V.

   NOTE: If the output voltage is low, temporarily disconnect the load to make sure that it is not set too high.
7. Once the proper output voltage is established, adjust the input voltage and load within the operating ranges and observe the output voltage regulation, ripple voltage, efficiency, and other parameters.

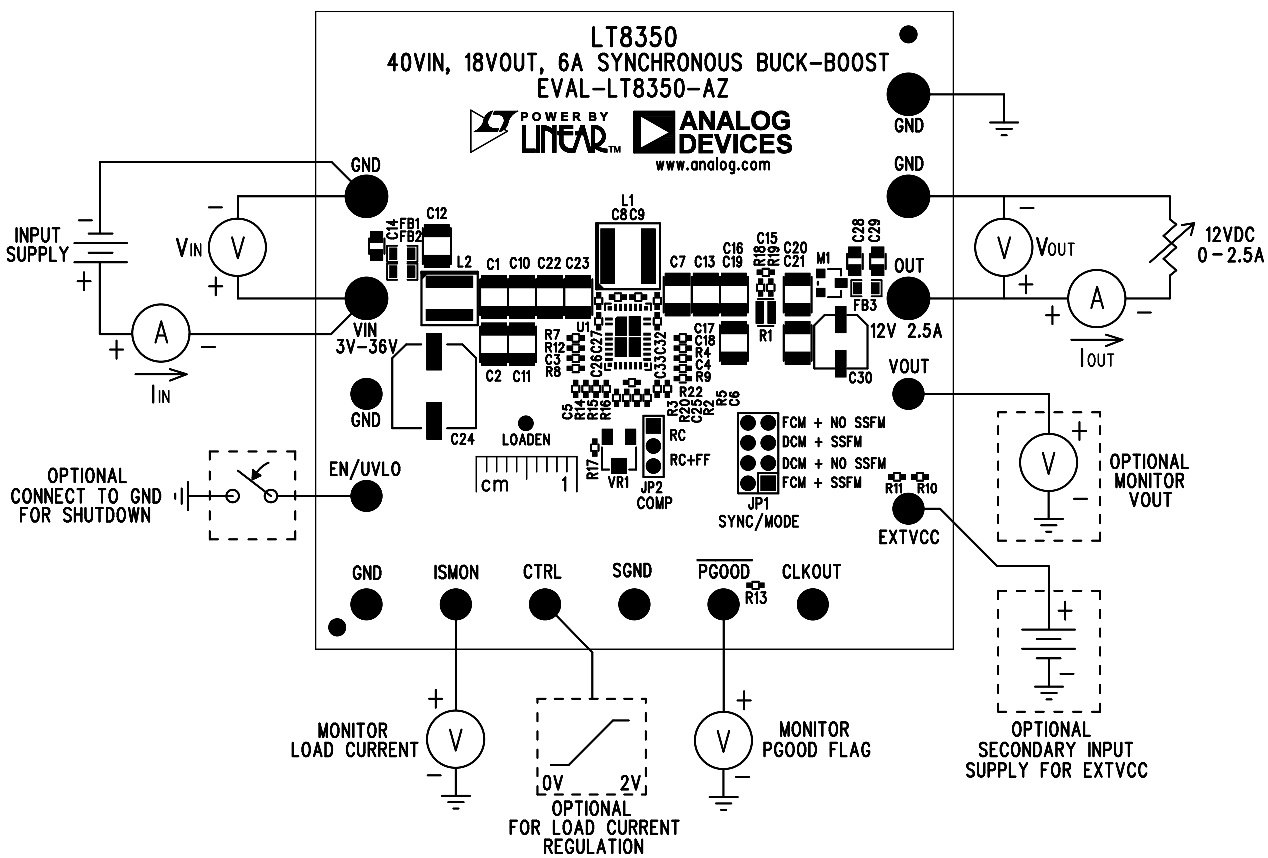


Figure 1. Test Procedure Setup Drawing for EVAL-LT8350-AZ

TEST RESULTS

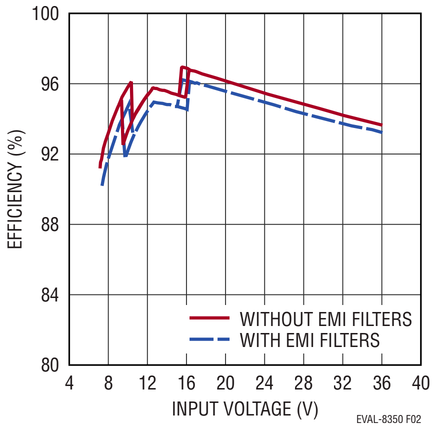


Figure 2. EVAL-LT8350-AZ Efficiency vs Input Voltage for 2.5A Load with SSFM

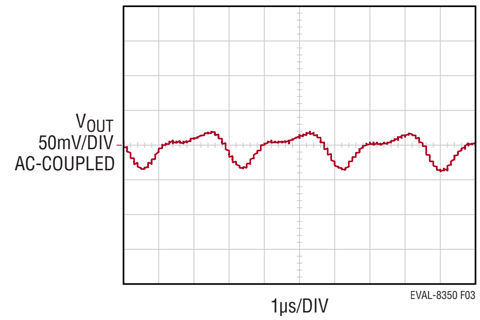


Figure 3. EVAL-LT8350-AZ Output Voltage Ripple at 12V Input Voltage and 2.5A Load

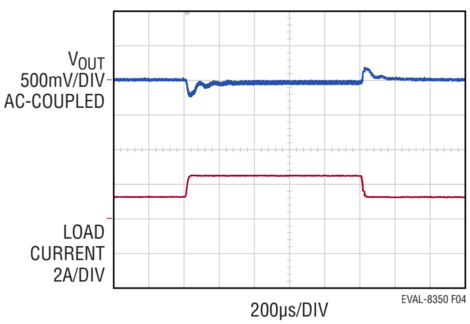


Figure 4. EVAL-LT8350-AZ Transient Response with JP1 = FCM+SSFM and JP2 = RC ($12V_{IN}$ $12V_{OUT}$ 2.5A to 1.25A)

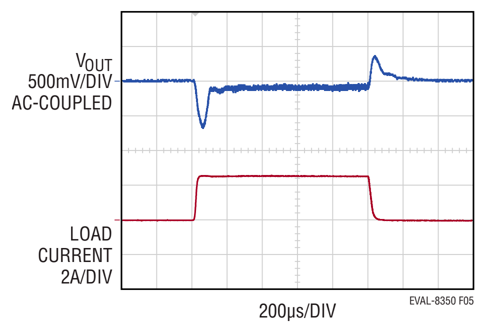


Figure 5. EVAL-LT8350-AZ Transient Response with JP1 = FCM+SSFM and JP2 = RC ($12V_{IN}$ $12V_{OUT}$ 2.5A to 0A)

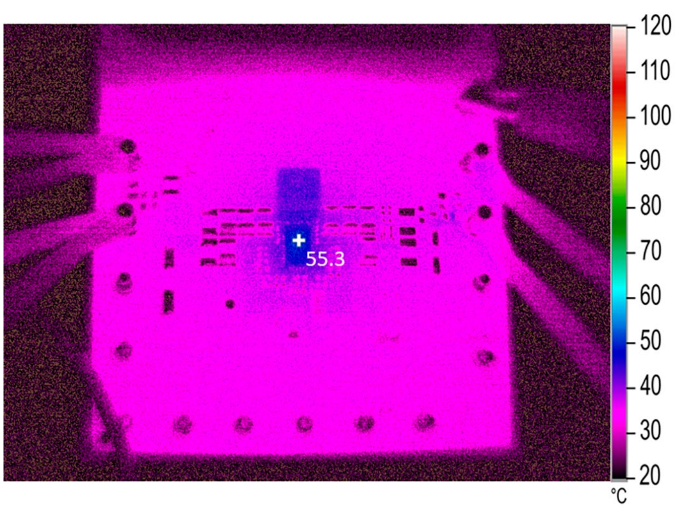


Figure 6. EVAL-LT8350-AZ Thermals $12V_{IN}$ to $12V_{OUT}$ 2.5A with SSFM ON

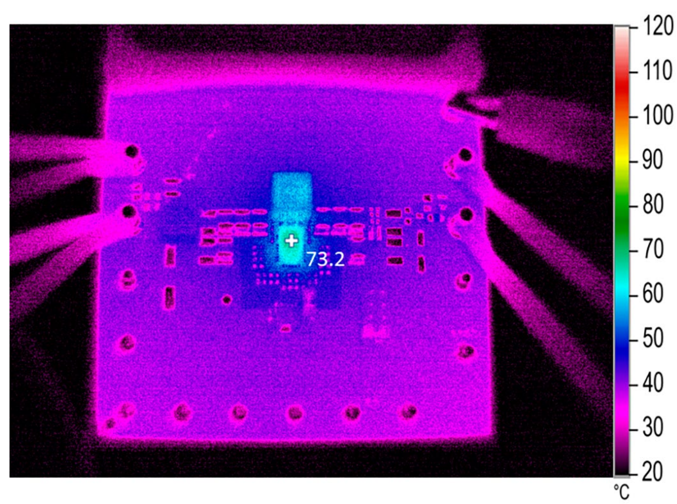


Figure 7. EVAL-LT8350-AZ Thermals, Worst Case (4-Switch Operation) $9.5V_{IN}$ to $12V_{OUT}$ 2.5A with SSFM ON

LOAD CURRENT INJECTION FOR FASTER LOAD TRANSIENT RESPONSE

Load transient response can be improved with JP2 = RC+FF, which is called load current injection. The idea is to inject or feedforward load current to V_C using ISMON and a voltage divider (VR1 and R17). With JP2 = RC+FF, the RC compensation, R5 and C6, is connected to ISMON through the voltage divider instead of GND. When the load current rises stepwise, ISMON rises immediately and thus, V_C is boosted faster compared to when the load current injection is not used (JP2 = RC). To determine the proper amount of load current injection, Equation 1 can be used.

$$140 \bullet R1 \bullet \frac{R17}{VR1 + R17} = 1 \quad (1)$$

As EVAL-LT8350-AZ uses R1 = 10mΩ and R17 = 3.01kΩ, VR1 is determined to 1.2kΩ. Figure 8 and Figure 9 show half to full load transient response and zero to full load transient response, respectively, with the load current injection scheme (JP2 = RC+FF and VR1 = 1.2kΩ). It is shown that the output voltage drop is smaller than Figure 4 and Figure 5. With the load current injection, output voltage drop can be reduced keeping the same output capacitance or output capacitance can be reduced keeping the same output voltage drop.

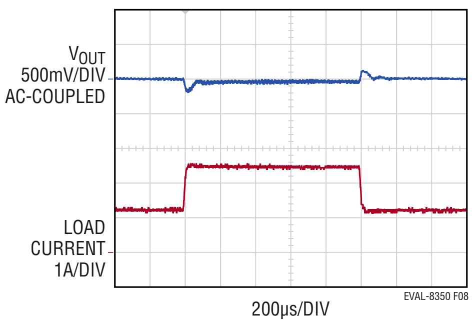


Figure 8. EVAL-LT8350-AZ Transient Response with JP1 = FCM+SSFM, JP2 = RC+FF (12V_{IN} 12V_{OUT} 2.5A to 1.25A)

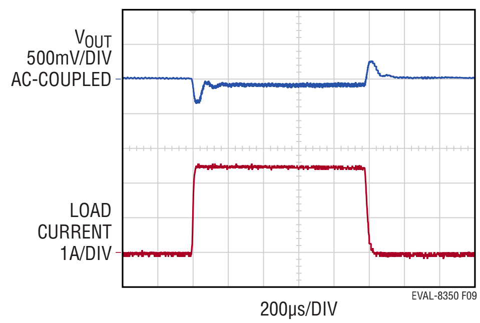
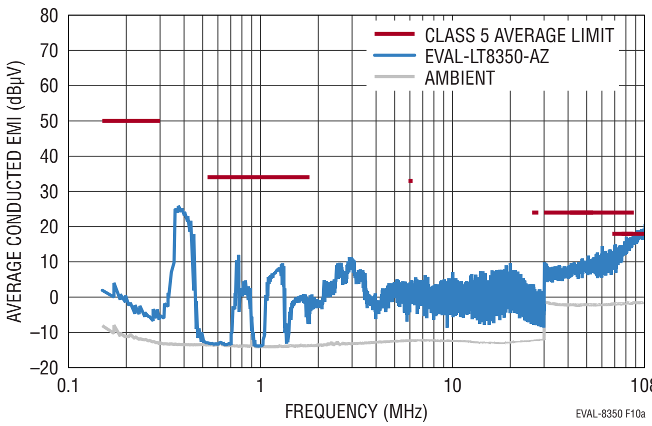
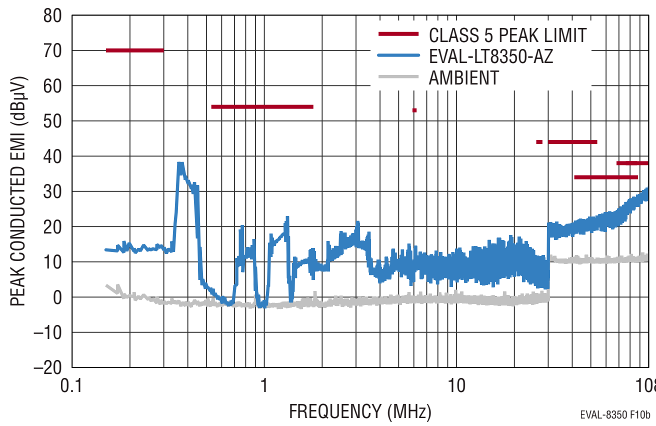


Figure 9. EVAL-LT8350-AZ Transient Response with JP1 = FCM+SSFM and JP2 = RC+FF (12V_{IN} 12V_{OUT} 2.5A to 0A)

EMISSION RESULT

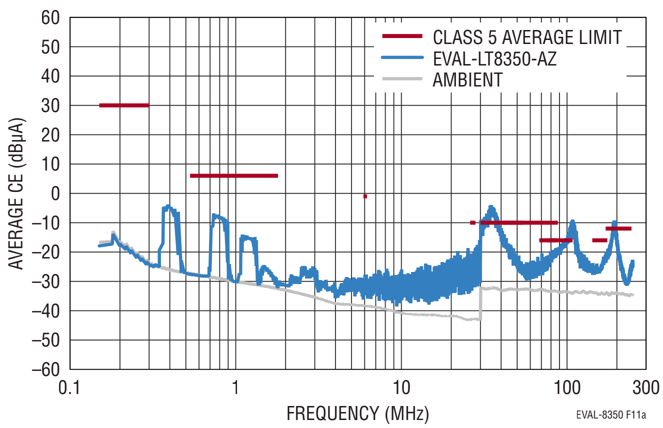


(a) CISPR25 Average, Voltage Method

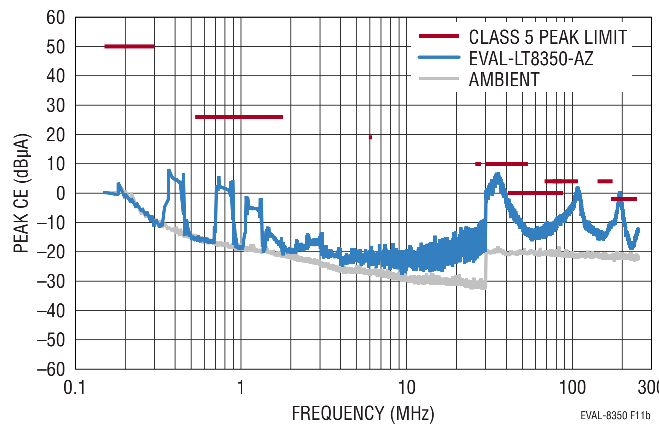


(b) CISPR25 Peak, Voltage Method

Figure 10. EVAL-LT8350-AZ CISPR25 Voltage Conducted EMI Performance with $12V_{IN}$ to $12V_{OUT}$ at 2.5A, JP1 = DCM+SSFM

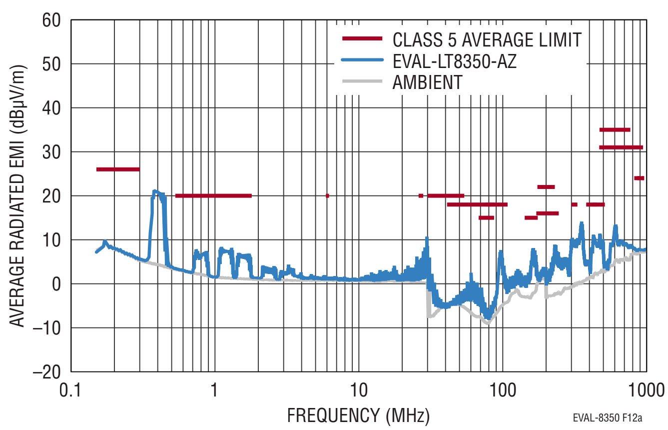


(a) CISPR25 Average, Current Method

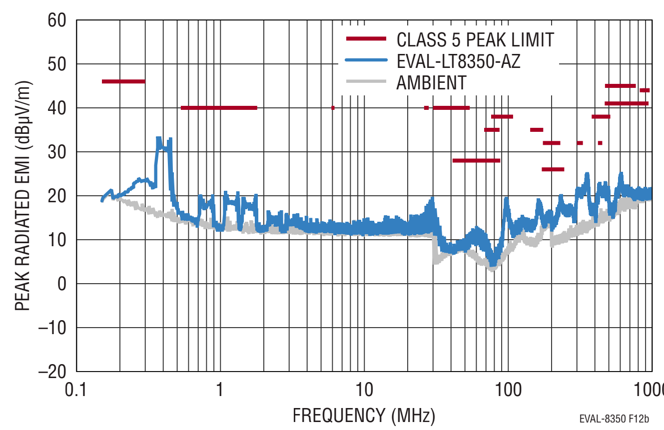


(b) CISPR25 Peak, Current Method

Figure 11. EVAL-LT8350-AZ CISPR25 Current Conducted EMI Performance with $12V_{IN}$ to $12V_{OUT}$ at 2.5A, JP1 = DCM+SSFM



(a) CISPR25 Average, Radiated



(b) CISPR25 Peak, Radiated

Figure 12. EVAL-LT8350-AZ CISPR25 Radiated EMI Performance with $12V_{IN}$ to $12V_{OUT}$ at 2.5A, JP1 = DCM + SSFM

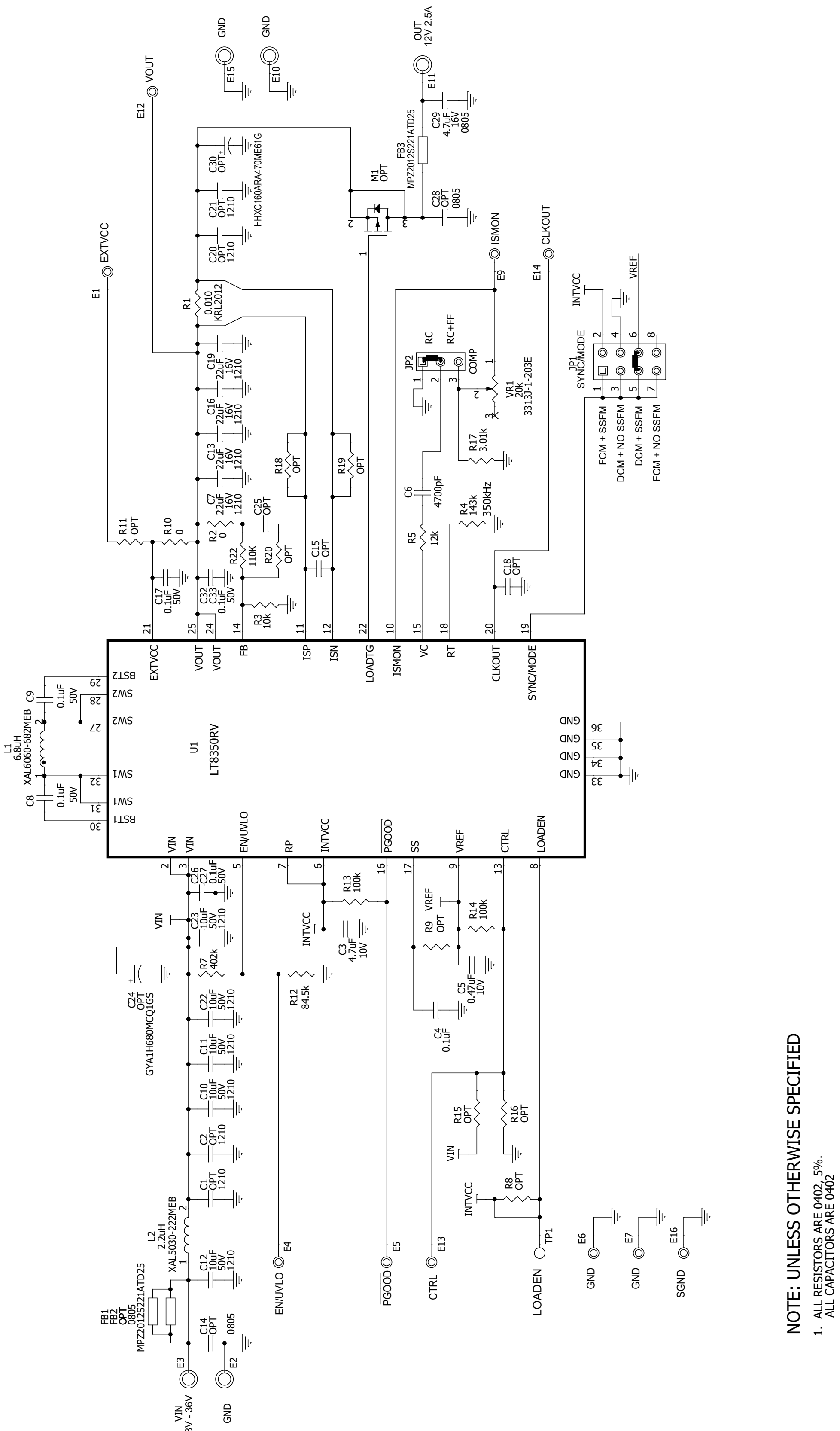
PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Electrical Components				
1	1	U1	IC, BUCK-BOOST VOLTAGE REGULATOR, LQFN-32	ANALOG DEVICES, LT8350RV#PBF
2	1	L1	IND., 6.8µH, PWR, SHIELDED, 20%, 9A, 20.80mΩ, 6.56mm × 6.36mm, AEC-Q200, XAL6060	COILCRAFT, XAL6060-682MEB
3	1	C3	CAP., 4.7µF, X5R, 10V, 20%, 0402, AEC-Q200	MURATA, GRT155R61A475ME13D
4	8	C4, C8, C9, C17, C26, C27, C32, C33	CAP., 0.1µF, X7R, 50V, 10%, 0402, AEC-Q200	MURATA, GCM155R71H104KE02D
5	1	C5	CAP., 0.47µF, X7S, 10V, 10%, 0402, AEC-Q200	MURATA, GCM155C71A474KE36D
6	1	C6	CAP., 4700pF, X7R, 25V, 10%, 0402, AEC-Q200	YAGEO, AC0402KRX7R8BB472
7	4	C7, C13, C16, C19	CAP., 22µF, X7R, 16V, 20%, 1210, AEC-Q200	TDK, CGA6P1X7R1C226M250AC
8	4	C10, C11, C22, C23	CAP., 10µF, X7S, 50V, 10%, 1210, AEC-Q200	MURATA, GCM32EC71H106KA03L
9	1	R3	RES., 10k, 1%, 1/10W, 0402, AEC-Q200	PANASONIC, ERJ2RKF1002X
10	1	R4	RES., 143k, 1%, 1/16W, 0402	VISHAY, CRCW0402143KFKED
11	1	R5	RES., 12k, 1%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW040212K0FKED
12	1	R7	RES., 402k, 1%, 1/10W, 0402, AEC-Q200	PANASONIC, ERJ2RKF4023X
13	1	R12	RES., 84.5k, 1%, 1/10W, 0402, AEC-Q200	PANASONIC, ERJ2RKF8452X
14	2	R13, R14	RES., 100k, 5%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW0402100KJNED
15	1	R22	RES., 110k, 1%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW0402110KFKED
Optional Low EMI Components				
16	1	L2 (REMOVE AND SHORT)	IND., 2.2µH, PWR, SHIELDED, 20%, 9.7A, 14.5mΩ, 5.48mm × 5.28mm, XAL5030, AEC-Q200	COILCRAFT, XAL5030-222MEB
17	1	C12 (REMOVE)	CAP., 10µF, X7S, 50V, 10%, 1210, AEC-Q200	MURATA, GCM32EC71H106KA03L
18	1	C29 (REMOVE)	CAP., 4.7µF, X7R, 16V, 10%, 0805, AEC-Q200	MURATA, GCM21BR71C475KA73L
19	1	FB3 (REMOVE AND SHORT)	IND., 220Ω AT 100MHz, FERRITE BEAD, 25%, 3A, 40mΩ, 0805, AEC-Q200	TDK, MPZ2012S221ATD25
20	0	C1, C2, C20, C21	CAP., OPTION, 1210	
21	0	C14, C28	CAP., OPTION, 0805	
22	0	FB1, FB2	IND., 220Ω AT 100MHz, FERRITE BEAD, 25%, 3A, 40mΩ, 0805, AEC-Q200	TDK, MPZ2012S221ATD25
Optional Electrical Components				
23	1	R1 (REMOVE AND SHORT)	RES., 0.010Ω, 1%, 1W, 0805 LONG-SIDE, AEC-Q200, CURRENT SENSE	SUSUMU, KRL2012E-M-R010-F-T5
24	2	R2, R10 (REMOVE AND SHORT)	RES., 0Ω, 1/16W, 0402, AEC-Q200	VISHAY, CRCW04020000Z0ED
25	1	R17 (REMOVE)	RES., 3.01k, 1%, 1/10W, 0402, AEC-Q200	PANASONIC, ERJ2RKF3011X
26	1	VR1 (REMOVE)	RES., 20k, 20%, 1/8W, SMD 3mm SQ, 1-TURN, TOP ADJ., TRIMPOT	BOURNS, 3313J-1-203E
27	0	R8, R9, R11, R15, R16, R18-R20	RES., OPTION, 0402	

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
28	0	M1	XSTR., OPTION, MOSFET, P-CH, SOT-23	
29	0	C15, C18, C25	CAP., OPTION, 0402	
30	0	C24	CAP., 68μF, ALUM POLY, 50V, 20%, SMD, 8.0mm × 10.0mm	NICHICON, GYA1H680MCQ1GS
31	0	C30	CAP., 47μF, ALUM POLY, 16V, 20%, SMD, 5.0mm × 5.8mm, AEC-Q200	UNITED-CHEMI-CON, HHXC160ARA470ME61G
Hardware : For Evaluation Circuit Only				
32	1	JP1	CONN., HDR, MALE, 2×4, 2mm, VERT, ST, THT	WURTH ELEKTRONIK, 62000821121
33	1	JP2	CONN., HDR, MALE, 1×3, 2mm, VERT, ST, THT	WURTH ELEKTRONIK, 62000311121
34	2	XJP1, XJP2	CONN., SHUNT, FEMALE, 2-POS, 2mm	WURTH ELEKTRONIK, 60800213421
35	10	E1, E4-E7, E9, E12-E14, E16	TEST POINT, TURRET, 0.064" MTG. HOLE, PCB 0.062" THK	MILL-MAX, 2308-2-00-80-00-00-07-0
36	5	E2, E3, E10, E11, E15	TEST POINT, TURRET, 0.094" MTG. HOLE, PCB 0.062" THK	MILL-MAX, 2501-2-00-80-00-00-07-0

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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