LT8333
Low I_Q Boost/SEPIC/Inverting Converter with 3A, 40V Switch

DESCRIPTION

Evaluation circuit EVAL-LT8333-AZ features the LT®8333 in a SEPIC configuration. It operates with a switching frequency of 2MHz and is designed to convert a 3V to 26V source to 12V output. The converter can output up to 1.25A depending on the input voltage (see Figure 3 maximum output current vs V_{IN} curve).

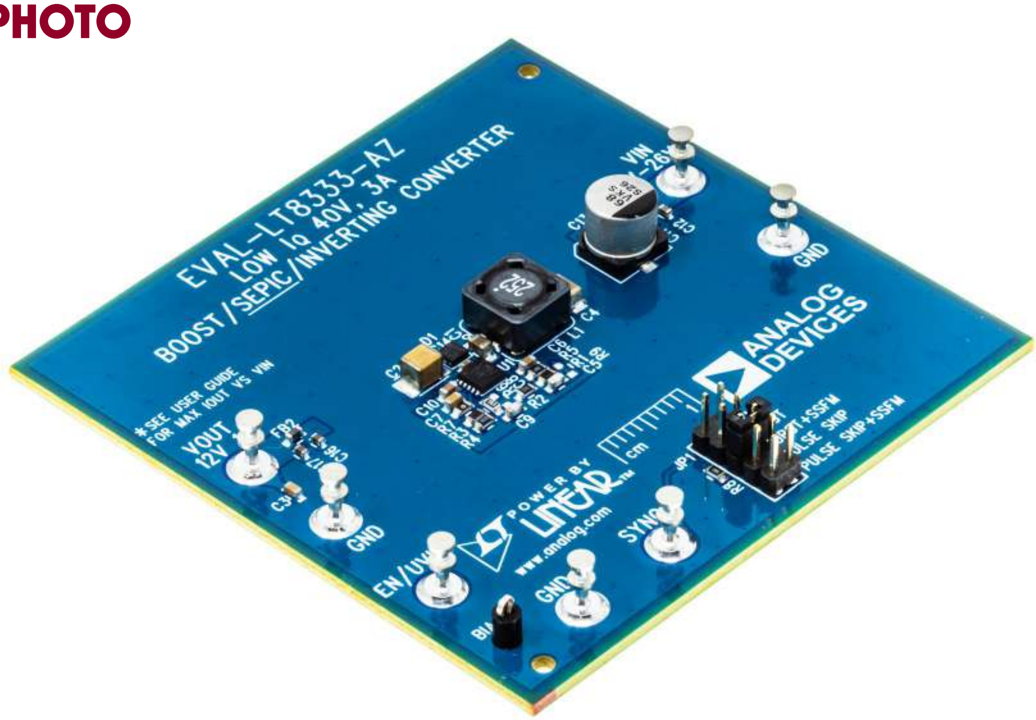
This evaluation circuit features Spread Spectrum Frequency Modulation (SSFM) and EMI filters to provide optimum EMI performance. This PCB layout is optimized for good EMI performance and small solution size. The evaluation board contains a selectable jumper, JP1, to aid in the selection of the desired SYNC pin mode of operation. At light load, either pulse-skipping (PULSE SKIP) or low-ripple Burst Mode® operation (BURST) can be selected to improve the efficiency.

The LT8333 boost/SEPIC/inverting converter IC operates over an input range of 2.8V to 40V, suitable for automotive, telecom, and industrial applications. The converter provides adjustable and synchronizable operation from 300kHz to 2MHz with SSFM option. The LT8333 packs other popular features such as soft-start, bias pin, input undervoltage lockout. The IC can exhibit a low quiescent current down to 9μA in BURST mode and 1μA in shutdown, which makes it ideal for battery-operated systems. The LT8333 is assembled in a thermally enhanced 10-lead 3mm × 3mm DFN package.

The data sheet gives a complete description of the device, operation, and application information. The data sheet must be read in conjunction with this demo manual for EVAL-LT8333-AZ.

Design files for this circuit board are available.

BOARD PHOTO



PERFORMANCE SUMMARY Specifications are at T_A = 25°C

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
Input Voltage (V_{IN})	V_{OUT} = 12V	3		26	V
Output Voltage (V_{OUT})	R1 = 1MΩ, R2 = 154kΩ		12		V
Output Voltage Ripple (ΔV_{OUT})	V_{IN} = 12V, V_{OUT} = 12V, I_{OUT} = 1.1A (Measured at C2)		40		mV
Maximum Output Current (I_{OUT})	V_{OUT} = 12V, V_{IN} = 9V		1		A
	V_{OUT} = 12V, V_{IN} = 12V		1.1		A
	V_{OUT} = 12V, V_{IN} = 16V to 26V		1.25		A
Switching Frequency (f_{SW})	R5 = 20.0kΩ, SSFM OFF		2		MHz
	R5 = 20.0kΩ, SSFM ON	2		2.4	MHz
Input EN Voltage (Rising)	R3 = 1MΩ, R4 = 1.15MΩ		3.2		V
Input UVLO Voltage (Falling)	R3 = 1MΩ, R4 = 1.15MΩ		3.0		V
Typical Efficiency (with EMI Filters)	V_{IN} = 9V, V_{OUT} = 12V, I_{OUT} = 1A		86		%
	V_{IN} = 12V, V_{OUT} = 12V, I_{OUT} = 1.1A		87		%
	V_{IN} = 16V, V_{OUT} = 12V, I_{OUT} = 1.25A		87		%
Zero Load Quiescent Current (V_{OUT} = 12V)*	V_{IN} = 9V, JP1 = BURST		37		µA
R1 = 1MΩ, R2 = 154kΩ	V_{IN} = 9V, JP1 = PULSE SKIP		1.2		mA
R3 = 1MΩ, R4 = 1.15MΩ	V_{IN} = 12V, JP1 = BURST		33		µA
	V_{IN} = 12V, JP1 = PULSE SKIP		1.1		mA

*Please see PULSE SKIP, BURST, SSFM, SYNC section on how to achieve lower quiescent current.

QUICK START PROCEDURE

Evaluation circuit EVAL-LT8333-AZ is easy to set up to evaluate the performance of the LT8333. Refer to Figure 1 for proper measurement equipment setup and follow the procedure below.

NOTE: Make sure that the input voltage is always with the specification.

1. Connect EN/UVLO turret to GND.
2. With power off, connect the input power supply to V_{IN} and GND terminals of the board. Include voltage and current meters as shown in Figure 1 if desired.
3. Connect the load to the V_{OUT} and GND terminals.
4. Turn on the power at the input. Increase V_{IN} slowly to 12V.
5. Disconnect EN/UVLO turret from GND and the output turns on.
6. Check for the proper output voltage. The output should be regulated at 12V.

   If there is no output, temporarily disconnect the load to make sure that the load is not set too high.
7. Once the proper output voltage is established, adjust the input voltage and load current within the operating range and observe the output voltage regulation, ripple voltage, efficiency, and other parameters.

   NOTE: When measuring the input or output voltage ripple, care must be taken to avoid a long ground lead on the oscilloscope probe. Measure the input or output voltage ripple by touching the probe tip directly across the input and output capacitors.

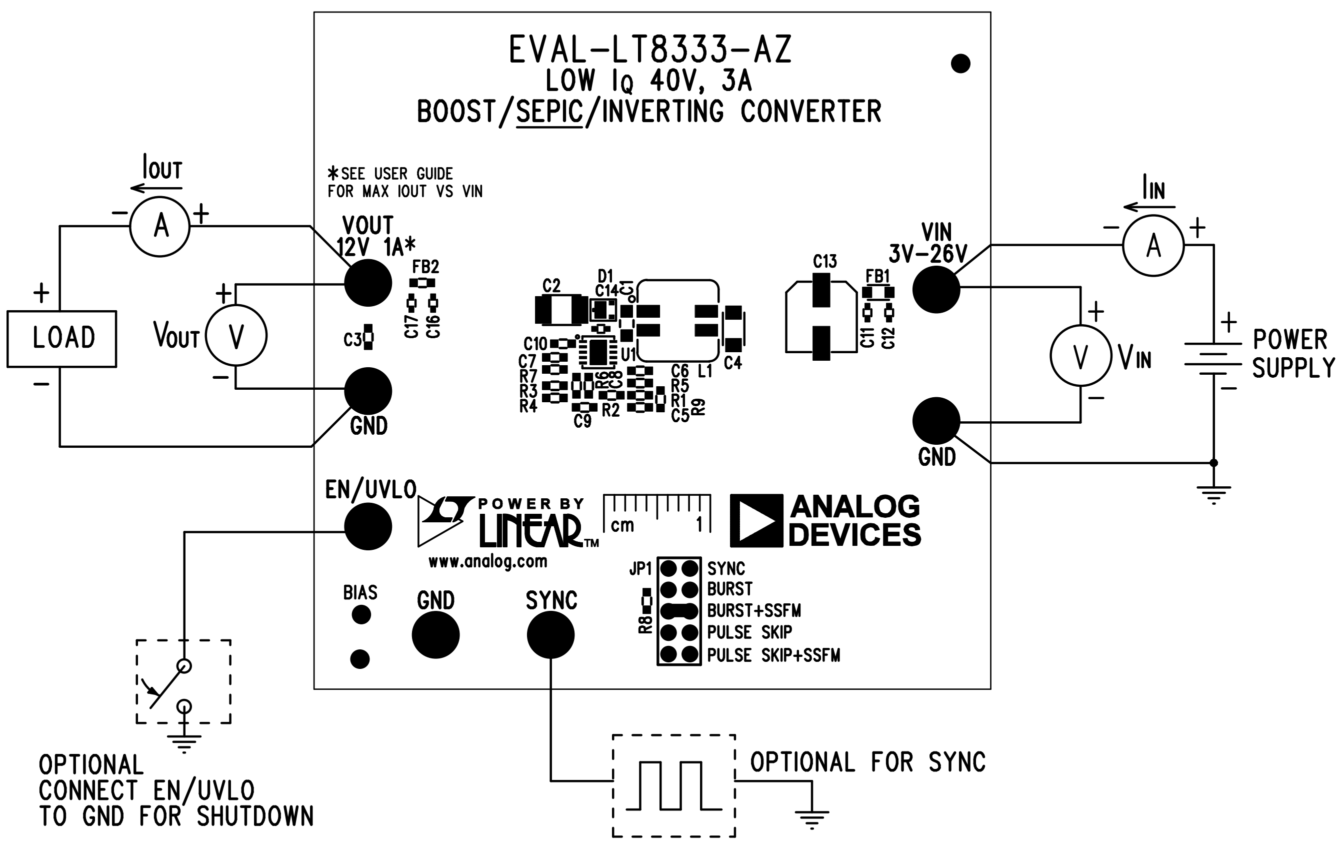


Figure 1. Proper Equipment Setup for EVAL-LT8333-AZ

QUICK START PROCEDURE

OUTPUT VOLTAGE AND POWER

The LT8333 is a low I_Q non-synchronous DC/DC converter that can be configured in boost, SEPIC, or inverting converters. Although EVAL-LT8333-AZ is designed to regulate 12V output from a 3V to 26V source, the feedback resistors R1 and R2 can be easily adjusted for higher or lower output voltage. In addition to adjusting feedback resistors, the input and output capacitors should be sized appropriately. The catch diode, D1, must also be able to handle the switch voltage.

The 3A peak switch current limit and EMI filters allow a maximum 1.25A output current at $16V_{IN}$ or higher. Figure 3 shows the maximum output current versus V_{IN}.

PULSE SKIP, BURST, SSFM, SYNC

The LT8333 achieves low power consumption at light loads. The different SYNC/MODE pin states can be evaluated by changing the position of jumper JP1. It is easy to change from BURST to PULSE SKIP and to explore SSFM ON, SSFM OFF, and external SYNC with this jumper.

PULSE SKIP allows low quiescent current at light load consumption without changing switching frequency until a very light load. BURST allows the lowest light load power consumption and has a unique low ripple feature on the LT8333. These two features can be explored further in the data sheet of the LT8333. The feedback resistors, R1 and R2, can be replaced with higher resistance values for better no-load input current results. For even lower no-load input current, the EN/UVLO pin should be shorted to V_{IN} and the R4 resistor should be removed.

Spread Spectrum Frequency Modulation (SSFM) can be enabled to reduce the emissions of the converter. SSFM spreads the frequency between the R_T-programmed frequency and +20% higher.

If an external SYNC signal is provided, the SYNC option of JP1 can be used to synchronize with an external clock. The clock frequency should be slightly higher than the R_T-programmed frequency for best performance.

EN/UVLO

R3 and R4 set the undervoltage lockout falling and rising thresholds. The LT8333 data sheet gives a formula for calculating these values. EVAL-LT8333-AZ has a falling UVLO threshold of 3V and a rising threshold of 3.2V. This threshold can easily be adjusted by changing resistors R3 and R4 according to the data sheet equations.

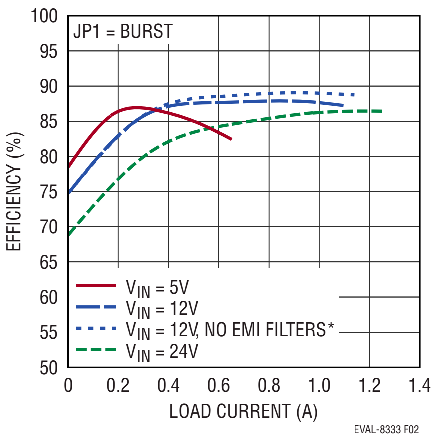
BIAS

In this evaluation circuit, the bias pin is unused and tied to GND through R7. However, the bias pin can be connected to an auxiliary input supply for powering $INTV_{CC}$ to improve efficiency when $4.4V \le BIAS \le V_{IN}$. To use the BIAS pin, R7 needs to be replaced by an 0603 sized ceramic capacitor with a value of at least 1µF, and BIAS terminal should be connected to an auxiliary source, which could be V_{OUT}.

OUTPUT SHORT-CIRCUIT PROTECTION

The LT8333 configured in a SEPIC configuration protects the circuitry when the output is shorted. Thus, the EVAL-LT8333-AZ prevents damage to circuitry during quick transient output short-circuits. However, the existing diode on the evaluation circuit is selected for optimizing efficiency and quiescent current, but not for protecting continuous short-circuits. If continuous output short-circuit protection is required, a diode with the current rating above the “Switch Overcurrent Threshold” stated in the data sheet is recommended.

TEST RESULTS



*FB1 AND FB2 REPLACED WITH 0Ω RESISTORS

Figure 2. EVAL-LT8333-AZ Efficiency with and without EMI Filters at V_{OUT} = 12V

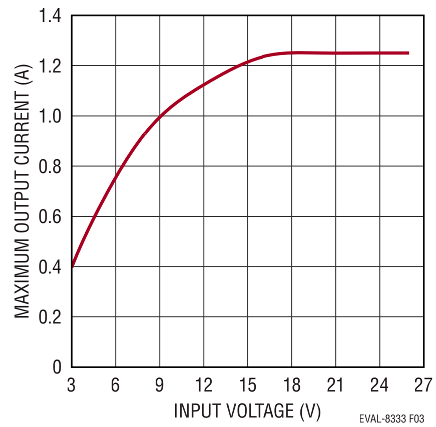


Figure 3. EVAL-LT8333-AZ Steady State Maximum Output Current vs Input Voltage

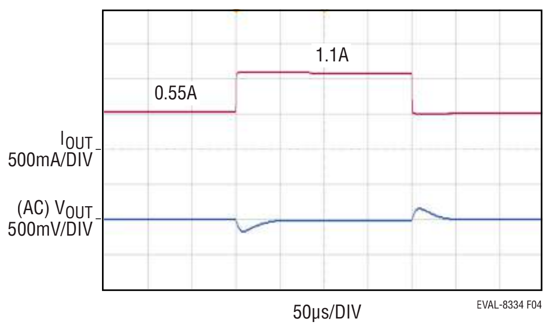


Figure 4. EVAL-LT8333-AZ Output Voltage Transient Response at V_{IN} = 12V, V_{OUT} = 12V, I_{OUT} = 0.55A to 1.1A (JP1 = PULSE SKIP)

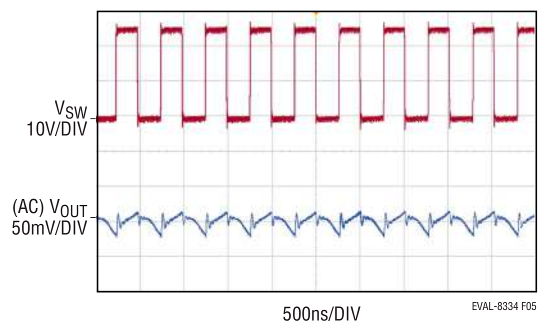
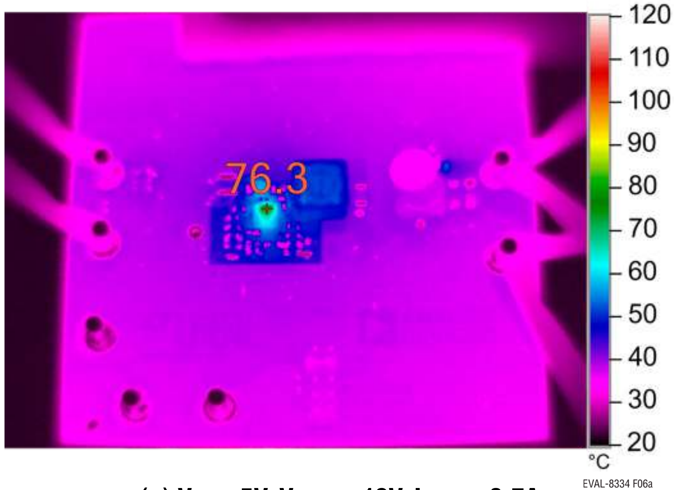
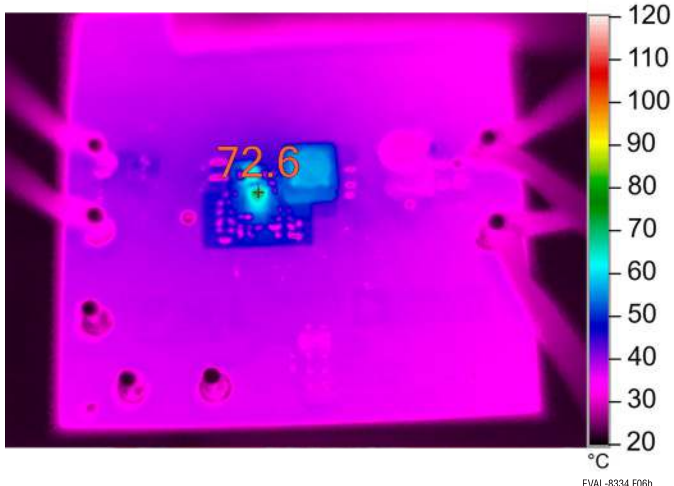


Figure 5. EVAL-LT8333-AZ Output Voltage Ripple ΔV_{OUT} Across C2 at V_{IN} = 12V, V_{OUT} = 12V, I_{OUT} = 1.1A; EVAL-LT8333-AZ is Assembled with EMI Filters (SSFM is OFF)

TEST RESULTS



(a) V_{IN} = 5V, V_{OUT} = 12V, I_{OUT} = 0.7A



(b) V_{IN} = 12V, V_{OUT} = 12V, I_{OUT} = 1.1A

Figure 6. EVAL-LT8333-AZ Thermals (JP1 = BURST)

TEST RESULTS

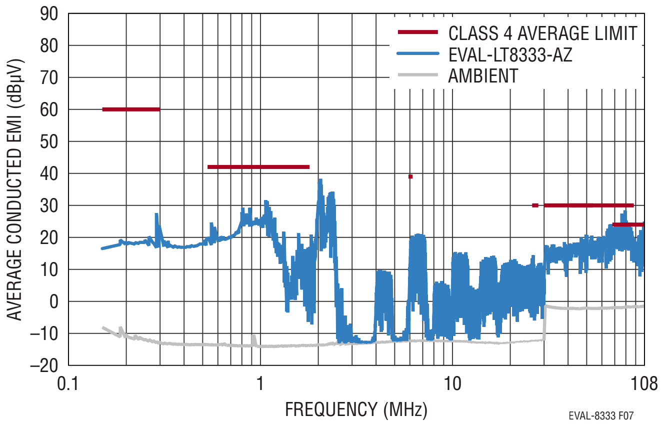


Figure 7. EVAL-LT8333-AZ CISPR25 Voltage Conducted EMI Average Performance with $12V_{IN}$ to $12V_{OUT}$ at 1A, JP1 = BURST + SSFM

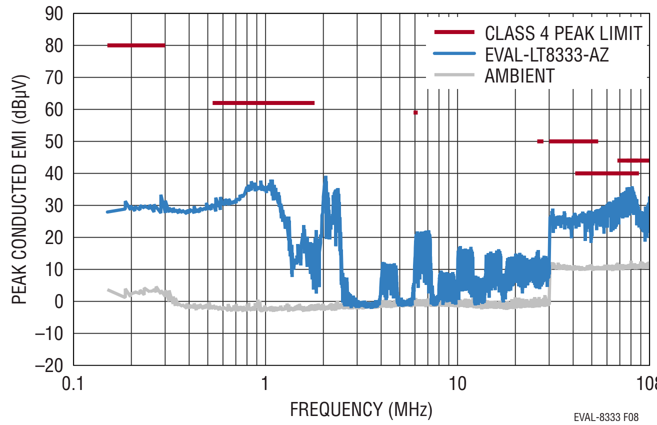


Figure 8. EVAL-LT8333-AZ CISPR25 Voltage Conducted EMI Peak Performance with $12V_{IN}$ to $12V_{OUT}$ at 1A, JP1 = BURST + SSFM

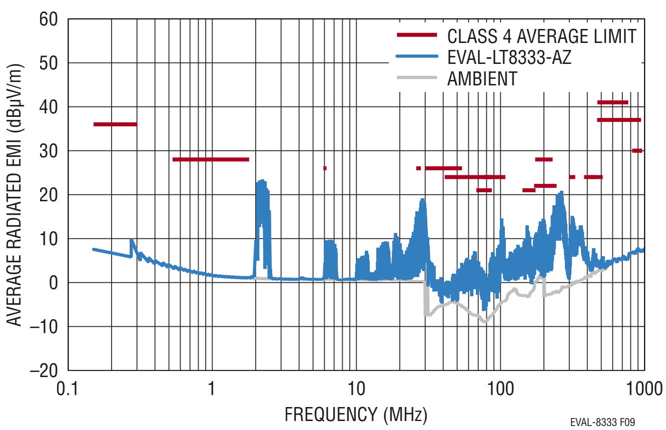


Figure 9. EVAL-LT8333-AZ CISPR25 Radiated EMI Average Performance with $12V_{IN}$ to $12V_{OUT}$ at 1A, JP1 = BURST + SSFM

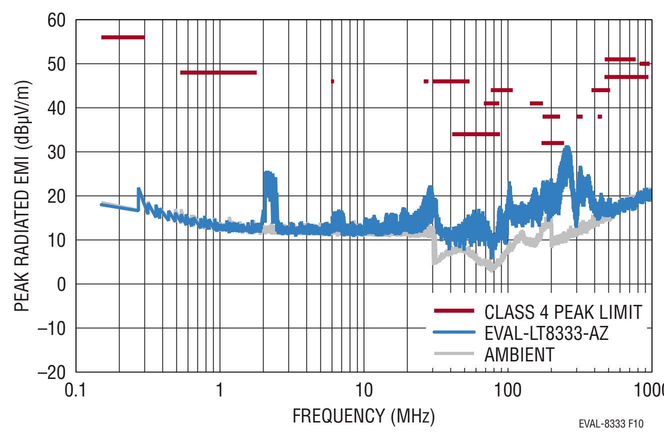
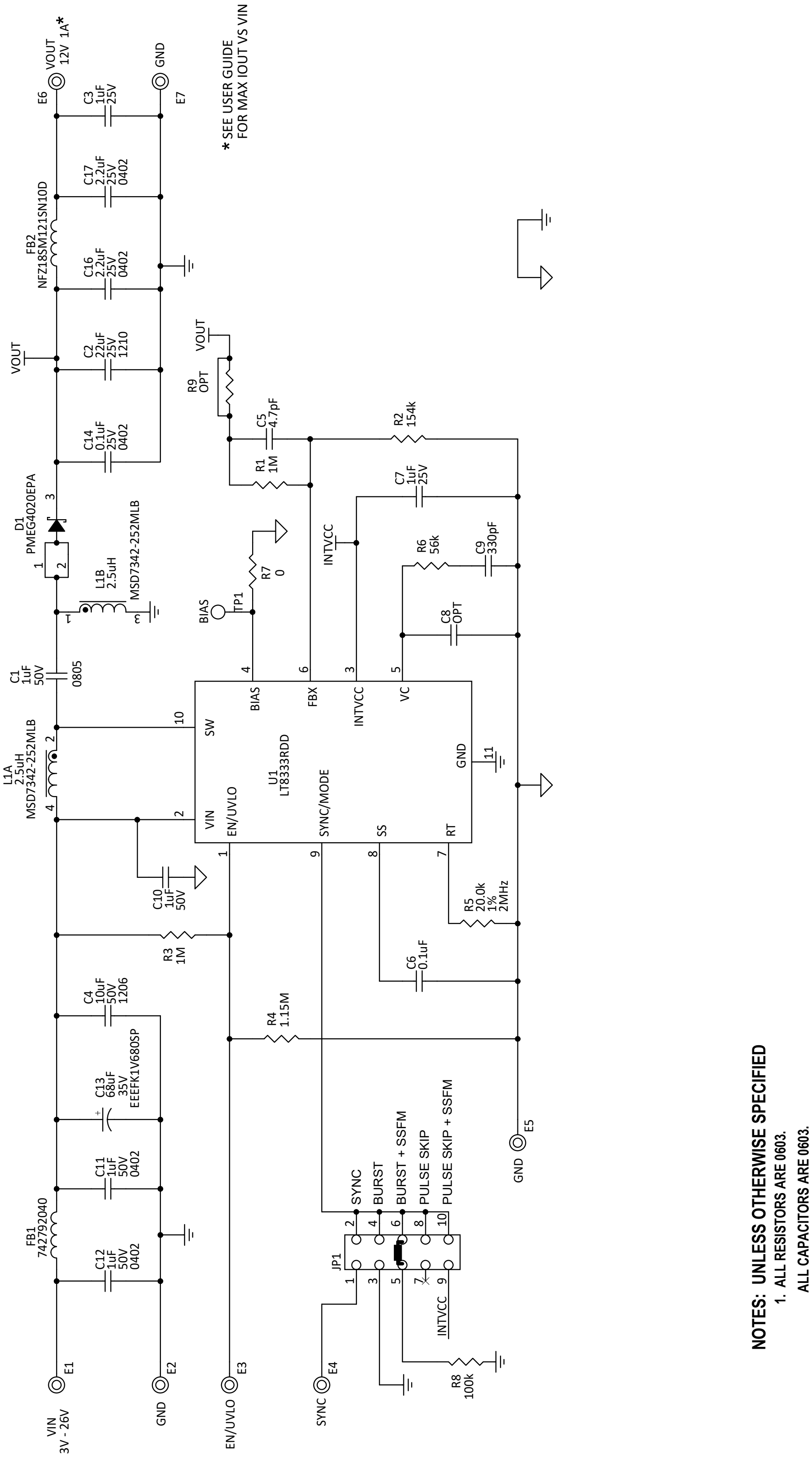


Figure 10. EVAL-LT8333-AZ CISPR25 Radiated EMI Peak Performance with $12V_{IN}$ to $12V_{OUT}$ at 1A, JP1 = BURST + SSFM

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Electrical Components				
1	1	C1	CAP., 1µF, X7R, 50V, 10%, 0805, AEC-Q200	MURATA, GCM21BR71H105KA03L
2	1	C2	CAP., 22µF, X7R, 25V, 20%, 1210, AEC-Q200	TAIYO YUDEN, TMK325B7226MMHP
3	1	C4	CAP., 10µF, X5R, 50V, 10%, 1206, AEC-Q200	MURATA, GRT31CR61H106KE01L
4	1	C5	CAP., 4.7pF, C0G, 25V, ±0.25pF, 0603.AEC-Q200	KEMET, C0603C479C3GACAUTO
5	1	C6	CAP., 0.1µF, X7R, 25V, 10%, 0603, AEC-Q200	SAMSUNG, CL10B104KA8WPNC
6	1	C7	CAP., 1µF, X7R, 25V, 10%, 0603, AEC-Q200	MURATA, GCM188R71E105KA64D
7	1	C9	CAP., 330pF, C0G, 50V, 10%, 0603, AEC-Q200	AVX, 06035A331K4T2A
8	1	C10	CAP., 1µF, X5R, 50V, 10%, 0603, AEC-Q200	TAIYO YUDEN, UMK107ABJ105KAHT
9	2	R1, R3	RES., 1M, 1%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW06031M00FKEA
10	1	R2	RES., 154k, 1%, 1/10W, 0603, AEC-Q200	PANASONIC, ERJ3EKF1543V
11	1	R4	RES., 1.15M, 1%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW06031M15FKEA
12	1	R5	RES., 20k, 1%, 1/10W, 0603, AEC-Q200	PANASONIC, ERJ3EKF2002V
13	1	R6	RES., 56k, 5%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW060356K0JNEA
14	1	D1	DIODE, SCHOTTKY, 40V, 2A, SOT1061, AEC-Q101	NEXPERIA, PMEG4020EPA
15	1	L1	IND., 2.5µH, SHIELDED COUPLED INDUCTORS, 20%, 6.2A, 33mΩ, SMD, 7.5mm × 7.5mm	COILCRAFT, MSD7342-252MLB
16	1	U1	IC, BOOST/SEPIC/INVERTING CONVERTER, 3mm × 3mm, DFN	ANALOG DEVICES, LT8333RDD#PBF
Optional Low EMI Components				
1	1	FB1	IND., 600Ω AT 100MHz, FERRITE BEAD, 25%, 2A, 150mΩ, 0805	WURTH ELEKTRONIK, 742792040
2	1	FB2	IND., 120Ω AT 100MHz, FERRITE BEAD, 25%, 1.25A, 140mΩ, 0603	MURATA, NFZ18SM121SN10D
3	1	C3	CAP., 1µF, X7R, 25V, 10%, 0603, AEC-Q200	MURATA, GCM188R71E105KA64D
4	2	C11, C12	CAP., 1µF, X5R, 50V, 20%, 0402	TAIYO YUDEN, UMK105CBJ105MV-F
5	2	C16, C17	CAP., 2.2µF, X5R, 25V, 10%, 0402, AEC-Q200	MURATA, GRT155R61E225KE13D
6	1	C13	CAP., 68µF, ALUM, 35V, 20%, 6.3mm × 5.8mm, AEC-Q200	PANASONIC, EEEFK1V680SP
7	1	C14	CAP., 0.1µF, X7R, 25V, 10%, 0402, AEC-Q200	MURATA, GCM155R71E104KE02D
Optional Electrical Components				
1	0	C8	CAP., OPTION, 0603	
2	0	R9	RES., OPTION, 0603	
3	1	R8	RES., 100k, 1%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW0603100KFKEA
4	1	R7	RES., 0Ω, 1/10W, 0603, AEC-Q200	VISHAY, CRCW06030000Z0EA
Hardware: For Evaluation Circuit Only				
1	7	E1 - E7	TEST POINT, TURRET, 0.094" MTG. HOLE, PCB 0.062" THK	MILL-MAX, 2501-2-00-80-00-00-07-0
2	1	JP1	CONN., HDR, MALE, 2×5, 2mm, VERT, ST, THT	WURTH ELEKTRONIK, 62001021121
3	1	TP1	TEST POINT, 1-POS, 0.040" MTG. HOLE, 2.54mm DIA × 4.57mm L, THT, BLACK	KEYSTONE, 5001
4	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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