LT8357
60V Low I_Q Boost Controller

DESCRIPTION

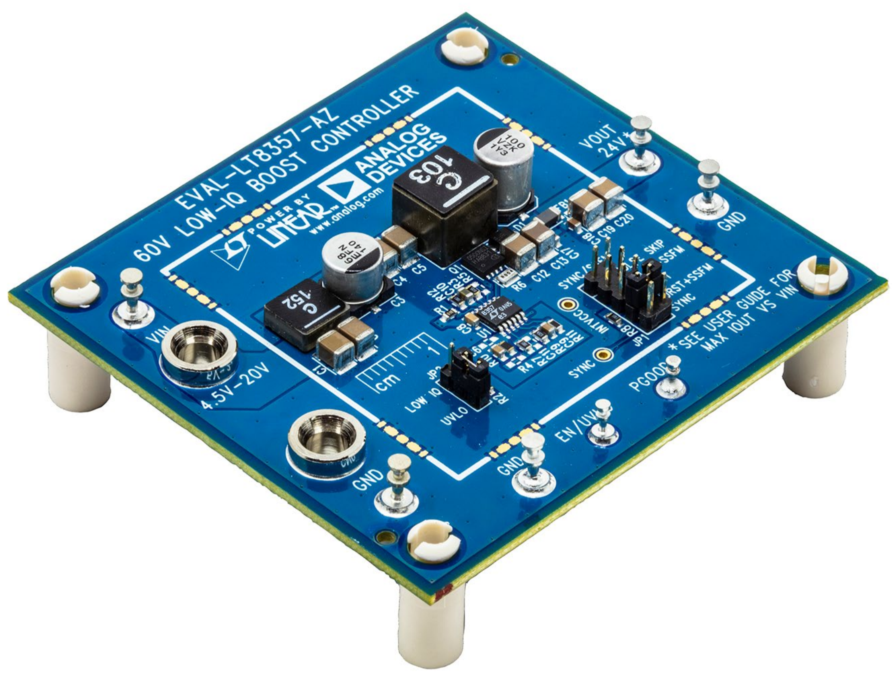
Evaluation circuit EVAL-LT8357-AZ features the LT®8357 as a 200kHz low EMI and low I_Q, boost controller with a 24V output from 4.5V to 20V input. This evaluation circuit features Spread Spectrum Frequency Modulation (SSFM) and EMI filters to provide optimum EMI performance. The board also contains placeholders and an outline to attach clips for an optional EMI Shield attachment. This application circuit can output 2A (see Figure 4 Maximum Output Current vs V_{IN} curve). When placed in shutdown, the converter has very low quiescent current, ideal in automotive and other battery-powered applications. PULSE SKIP and BURST modes are selectable with jumper JP1. Each user-selectable option enables low quiescent current at light load and can also be combined with SSFM operation using JP1.

The LT8357 boost controller IC operates over an input range of 3V to 60V, suitable for automotive, telecom and industrial applications. It exhibits a low quiescent current of 8µA, making it ideal for battery-operated systems. It drives a low side N-channel power MOSFET with a 5V split gate drive. The converter provides adjustable and synchronizable operation from 100kHz to 2MHz with SSFM option. At light load, either PULSE SKIP or low-ripple BURST mode can be selected to improve the efficiency. The LT8357 packs popular features such as soft-start, input undervoltage lockout, adjustable switching frequency and clock synchronization. The Power Good (PGOOD) flag indicates when the output voltage is in regulation.

The LT8357 comes in a thermally enhanced 12-lead plastic MSE package. The LT8357 data sheet gives a complete description of the part, pins, features, operation, and application information. The data sheet must be read in conjunction with this user guide for EVAL-LT8357-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	UNITS
Input Voltage (V_{IN})	$24V_{OUT}$	4.5		20	V
Output Voltage (V_{OUT})	R7 = 10MΩ, R9 = 432kΩ		24		V
Maximum Output Current*	$12V_{OUT}$, $4.5V_{IN}$ $12V_{OUT}$, $8V_{IN}$ to $20V_{IN}$		1 2		A A
Switching Frequency	R11 = 174kΩ, SSFM OFF R11 = 174kΩ, SSFM ON	 200	200 	 238	kHz kHz
Input EN Voltage (Rising)	R1 = 1MΩ, R2 = 374kΩ, JP2 = UVLO		4.5		V
Input UVLO Voltage (Falling)	R1 = 1MΩ, R2 = 374kΩ, JP2 = UVLO		4.3		V
Typical Efficiency (with EMI filters)	$12V_{IN}$, 24V 2.0A Output, JP1 = BURST		95		%
PGOOD (Power Good) Voltage	Power Good Power NOT Good		5.0 0		V V
Zero Load Quiescent Current ($24V_{OUT}$) JP2 = LOW I_Q R7 = 10MΩ, R9 = 432kΩ	$9V_{IN}$, JP1 = PULSE SKIP $9V_{IN}$, JP1 = BURST $12V_{IN}$, JP1 = PULSE SKIP $12V_{IN}$, JP1 = BURST		950 28 870 22		µA µA µA µA

*Please see Figure 4 and Output Voltage and Power section for more details.

QUICK START PROCEDURE

Evaluation circuit EVAL-LT8357-AZ is easy to set up to evaluate the performance of the LT8357. Refer to Figure 1 for proper measurement equipment setup and follow the procedure below:

1. Connect EN/UVLO turret to GND.
2. With power off, connect the input power supply to the board through V_{IN} and GND terminals. Connect the load to the terminals V_{OUT} and GND.
3. Turn on the power at the input. Increase V_{IN} slowly to 12V.

   NOTE: Make sure that the input voltage is always within specification. To operate the board with higher input/output voltage, input and output capacitors with higher voltage ratings might be needed.
4. Disconnect EN/UVLO from GND and the output turns on.
5. Check for the proper output voltage. The output should be regulated at 24V and the PGOOD flag should be high (5V).
6. 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.
7. Set JP1 and JP2 to examine the low I_Q, light load operation of the LT8357. SSFM can be turned on and off with JP1 as well.

   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.

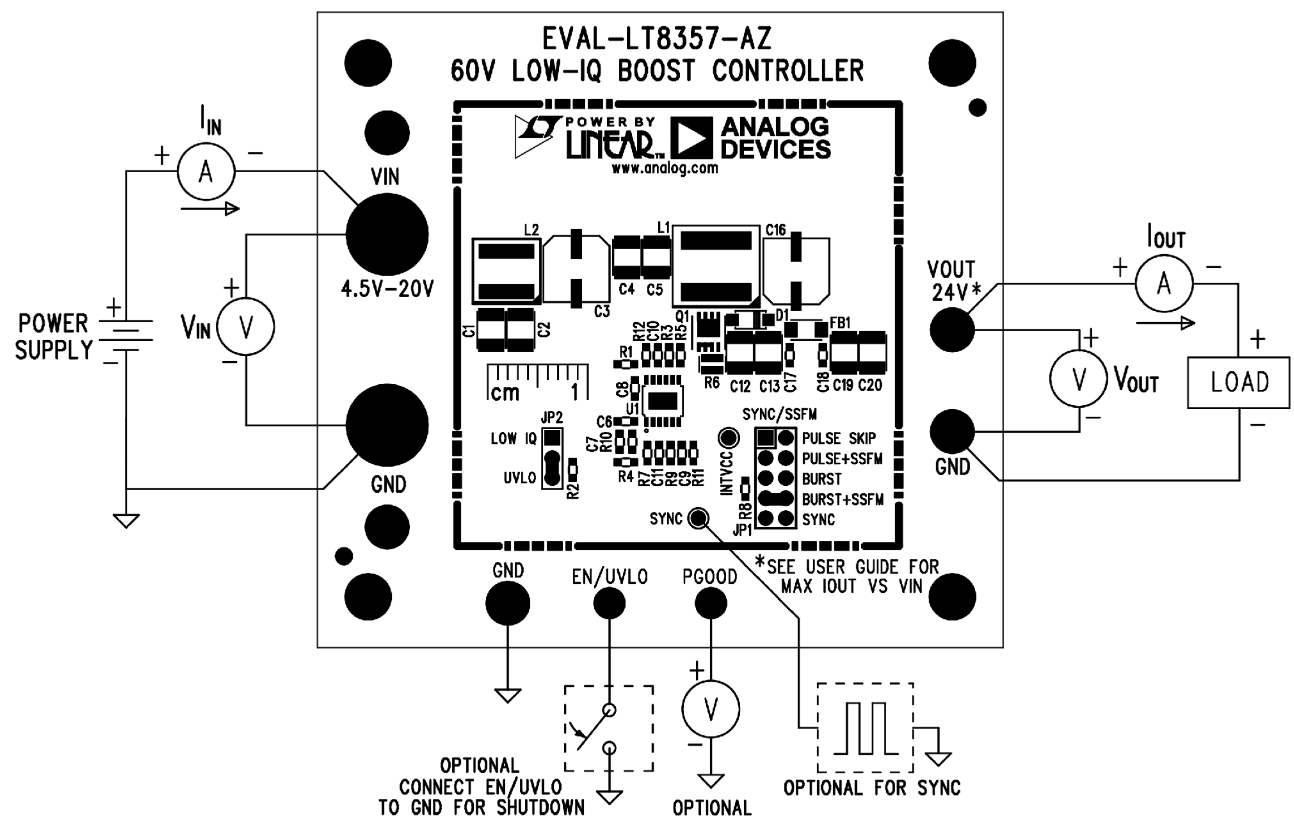


Figure 1. Test Procedure Setup Drawing for EVAL-LT8357-AZ

QUICK START PROCEDURE

OUTPUT VOLTAGE AND POWER

The LT8357 is a low I_Q boost controller. It can boost voltages up with input up to 60V and 5V gate drive MOSFETs. The 5V $INTV_{CC}$ provides the gate drive for the external N-channel power MOSFET. Although EVAL-LT8357-AZ is set for 24V output, the feedback resistors R7 and R9 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, and MOSFET, Q1, must also be able to handle the output voltage. Q1 and D1 are assembled with appropriately rated components for the 24V output application.

The peak switch current limit is 15A, allowing for 2A operation throughout the entire V_{IN} range. However, thermal limitations of some components limit full 2A DC operation below 8V. See Figure 4 to see the full DC operation maximum output current versus V_{IN}. 2A load with transient operation down to 4.5V is allowed. The output ferrite bead limits output current to 2A maximum.

PULSE SKIP, BURST, SSFM, SYNC

The LT8357 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 LT8357. These two features can be explored further in the data sheet of the LT8357. For extremely light load power consumption on EVAL-LT8357-AZ, the feedback resistor R7 is set to 10MΩ, and R9 to 432kΩ resistor.

For even lower no load input current, the JP2 jumper should be set to LOW I_Q. Then the quiescent current of the converter can drop as low as 20µA.

Spread Spectrum Frequency Modulation (SSFM) can be enabled to reduce the emissions of the converter. SSFM spreads the frequency between the R_T frequency and +19% 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.

SPLIT GATE RESISTORS

The LT8357 features split gate drive pins. GATEP pulls the N-channel MOSFET gate high and GATEN pulls the gate low. These rates can be set separately with two different gate resistors. EVAL-LT8357-AZ features a 5.1Ω GATEP resistor R3 and a board shorted (0Ω) GATEN resistor R5. The board user can evaluate different gate speeds for a balance of emissions, efficiency, and thermal performance. If one desires to populate R5 with a resistor, the copper trace on the board must be cut.

EN/UVLO

R1 and R2 set the undervoltage lockout falling and rising thresholds. The LT8357 data sheet gives a formula for calculating these values. EVAL-LT8357-AZ has a falling UVLO threshold of 4.3V and a rising threshold of 4.5V. This threshold can easily be adjusted by changing resistors R1 and R2 according to the data sheet equations.

PGOOD

The Power Good (PGOOD) flag indicates when the output voltage is valid on the LT8357. The PGOOD flag can be monitored with a simple multimeter at the PGOOD turret. A high signal indicates that the output voltage is within range and a low signal indicates that the output voltage is not within its valid range. See data sheet for details. The turret can be left floating when not in use.

TEST RESULTS

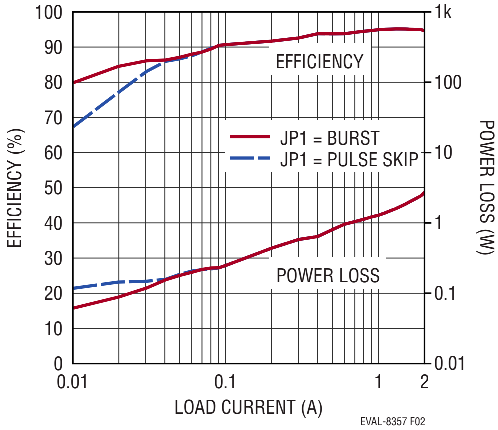


Figure 2. EVAL-LT8357-AZ Efficiency and Power Loss with V_{IN} = 12V to V_{OUT} = 24V. EVAL-LT8357-AZ is Assembled with EMI Filters

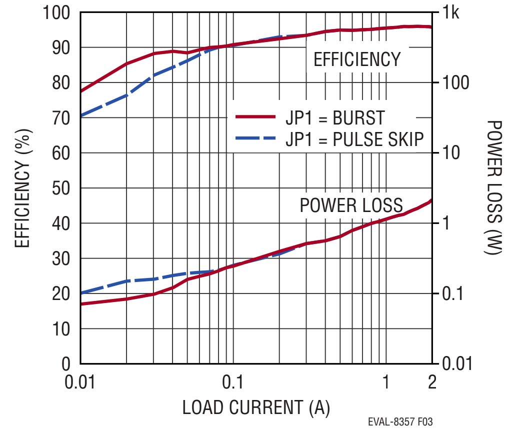


Figure 3. EVAL-LT8357-AZ Efficiency and Power Loss with V_{IN} = 16V to V_{OUT} = 24V. EVAL-LT8357-AZ is Assembled with EMI Filters

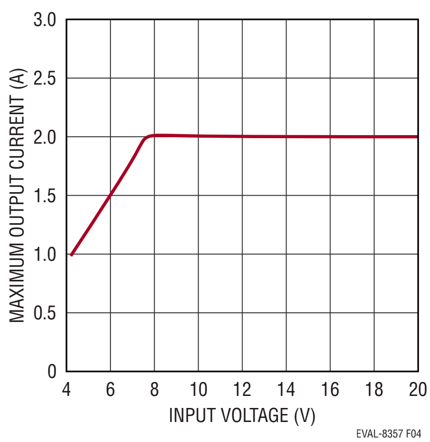


Figure 4. EVAL-LT8357-AZ Steady State Maximum Output Current vs Input Voltage

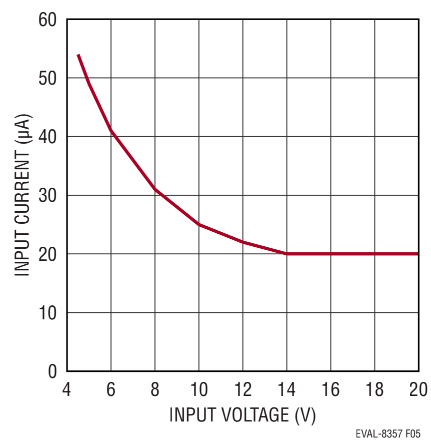


Figure 5. EVAL-LT8357-AZ No Load: Input Current vs Input Voltage with JP1 = BURST, JP2 = LOW I_Q

TEST RESULTS

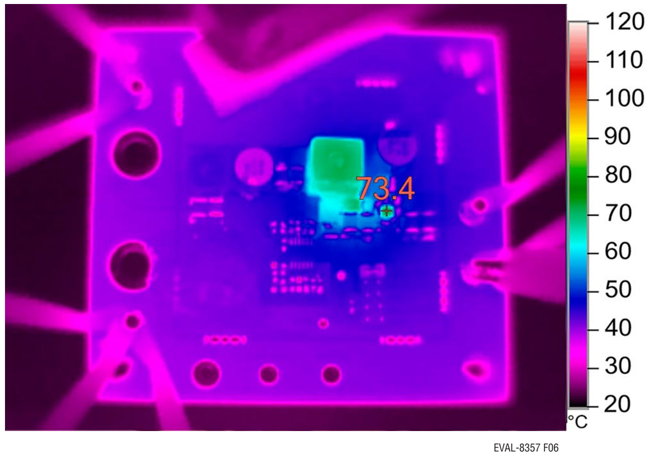


Figure 6. EVAL-LT8357-AZ Thermals $12V_{IN}$ to $24V_{OUT}$ 2A

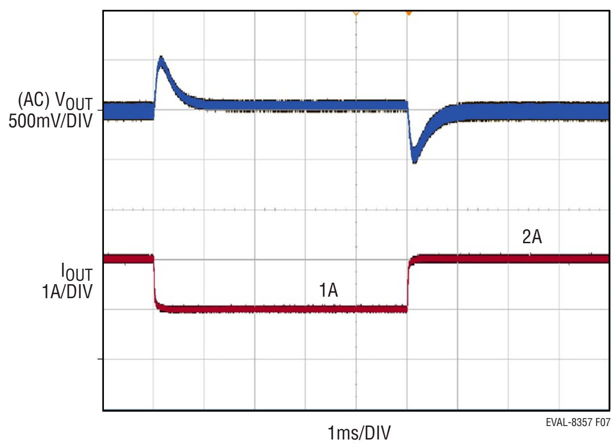


Figure 7. EVAL-LT8357-AZ V_{OUT} Transient Response with JP1 = PULSE SKIP $12V_{IN}$ $24V_{OUT}$ 2A to 1A Transient

TEST RESULTS

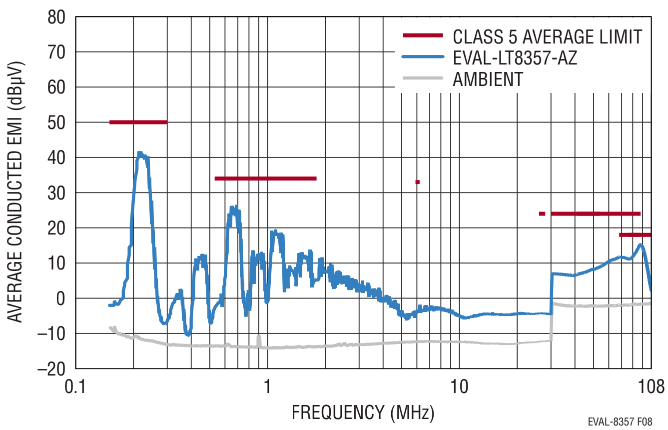


Figure 8. EVAL-LT8357-AZ CISPR25 Voltage Conducted EMI Average Performance with $12V_{IN}$ to $24V_{OUT}$ at 2A, JP1 = BURST + SSFM

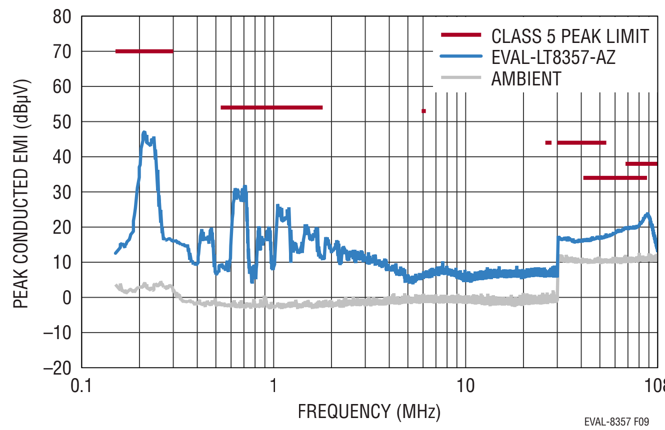


Figure 9. EVAL-LT8357-AZ CISPR25 Voltage Conducted EMI Peak Performance with $12V_{IN}$ to $24V_{OUT}$ at 2A, JP1 = BURST + SSFM

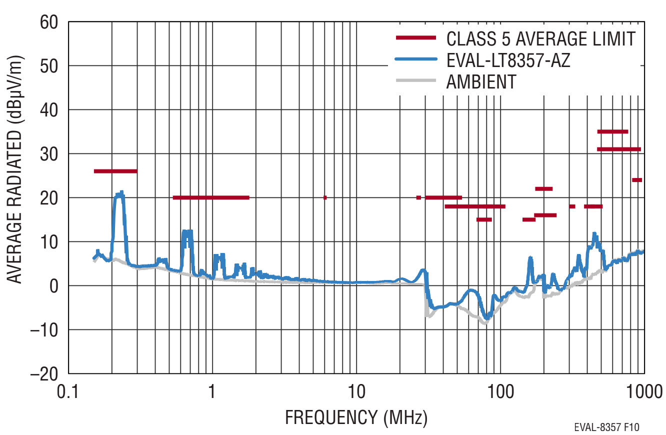


Figure 10. EVAL-LT8357-AZ CISPR25 Radiated EMI Average Performance with $12V_{IN}$ to $24V_{OUT}$ at 2A, JP1 = BURST + SSFM

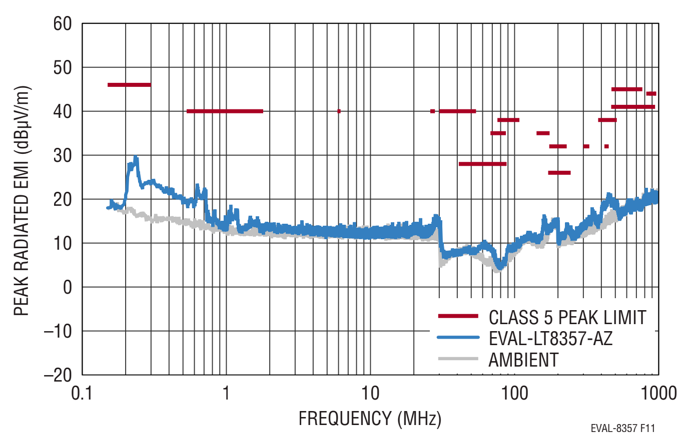


Figure 11. EVAL-LT8357-AZ CISPR25 Radiated EMI Peak Performance with $12V_{IN}$ to $24V_{OUT}$ at 2A, JP1 = BURST + SSFM

EMISSIONS SHIELD (OPTION)

For the ultimate lowest emissions, an EMI shield can be attached to EVAL-LT8357-AZ. The PCB was fabricated with placeholders for eight shield clips which can hold a 44mm × 44mm metal shield. Part numbers for an example shield are provided in the Parts List section under the Hardware. The top silkscreen picture (Figure 12) shows the placeholders for the eight surface mount shield clips. Then the emissions of the board can be tested with and without the removable clip-shield.

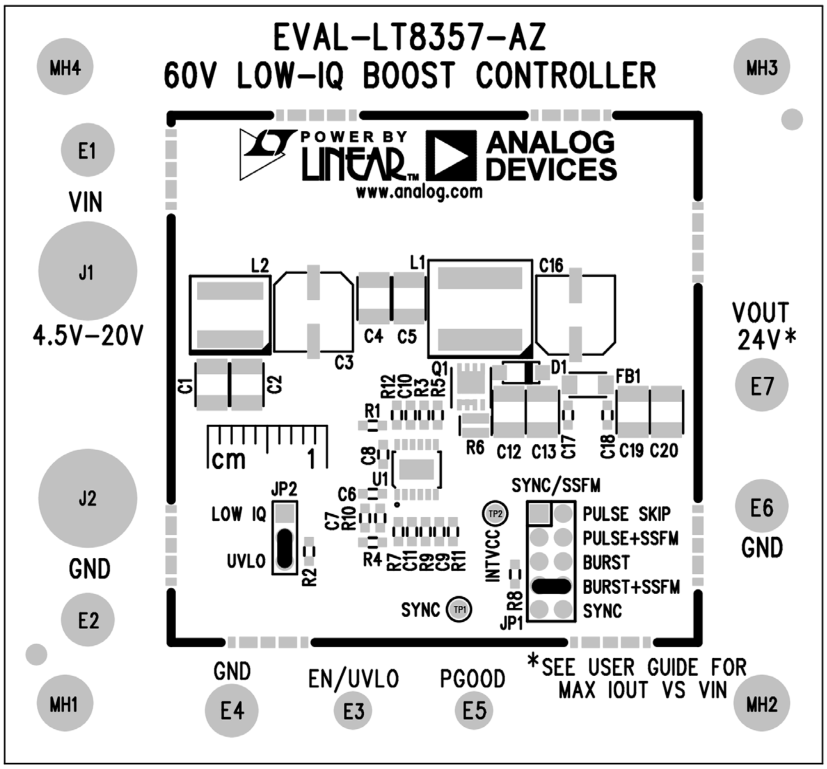


Figure 12. EMI Shield Clips Can Be Soldered to the Eight Placeholders on the PCB. A Square 44mm × 44mm Outline Shows Where the EMI Shield Fits onto the PCB

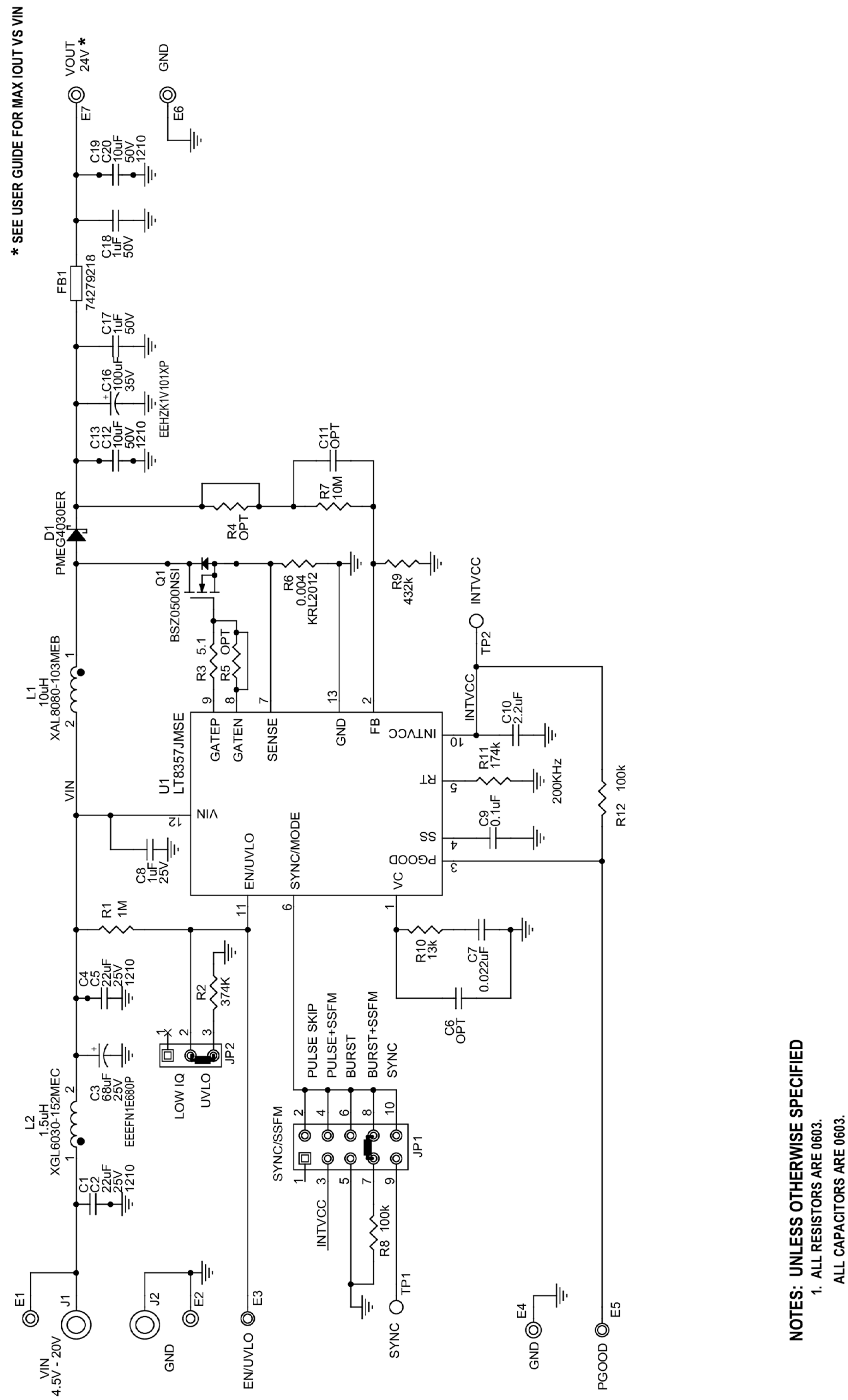
PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Electrical Components				
1	2	C4, C5	CAP., 22µF, X7R, 25V, 20%, 1210, AEC-Q200	TAIYO YUDEN, TMK325B7226MMHP
2	1	C7	CAP., 0.022µF, X7R, 25V, 10%, 0603, AEC-Q200	KEMET, C0603C223K3RACAUTO
3	1	C8	CAP., 1µF, X7R, 25V, 10%, 0603, AEC-Q200	MURATA, GCM188R71E105KA64D
4	1	C9	CAP., 0.1µF, X7R, 50V, 10%, 0603, AEC-Q200	TDK, CGA3E2X7R1H104K
5	1	C10	CAP., 2.2µF, X5R, 50V, 10%, 0603	TAIYO YUDEN, UMK107BBJ225KA-T
6	4	C12, C13, C19, C20	CAP., 10µF, X7S, 50V, 10%, 1210, AEC-Q200	MURATA, GCM32EC71H106KA03L
7	1	C16	CAP., 100µF, ALUM, 35V, 20%, SMD, AEC-Q200	PANASONIC, EEHZK1V101XP
8	1	D1	DIODE, SCHOTTKY, 40V, 3A, SOD-123W, AEC-Q101	NEXPERIA, PMEG4030ER
9	1	L1	IND., 10µH, POWER, 20%, 8.7A, 23.1mΩ, 8.8mm × 8.3mm	COILCRAFT, XAL8080-103MEB
10	1	Q1	XSTR., MOSFET, N-CH, 30V, 40A, TSDSON-8 FL	INFINEON, BSZ0500NSI
11	1	R1	RES., 1M, 1%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW06031M00FKEA
12	1	R2	RES., 374k, 1%, 1/10W, 0603, AEC-Q200	PANASONIC, ERJ3EKF3743V
13	1	R6	RES., 0.004Ω, 1%, 1W, 0508, LONG-SIDE, AEC-Q200-SENSE	SUSUMU, KRL2012E-M-R004-F-T5
14	1	R7	RES., 10M, 1%, 1/10W, 0603, AEC-Q200	PANASONIC, ERJ3EKF1005V
15	1	R9	RES., 432k, 1%, 1/10W, 0603, AEC-Q200	NIC, NRC06F4323TRF
16	1	R10	RES., 13k, 1%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW060313K0FKEA
17	1	R11	RES., 174k, 1%, 1/10W, 0603, AEC-Q200	PANASONIC, ERJ3EKF1743V
18	1	U1	IC, CURRENT MODE, DC/DC CONTROLLER, WIDE INPUT RANGE, MSOP-12	ANALOG DEVICES, LT8357JMSE#PBF
Optional Low EMI Components				
1	2	C1, C2	CAP., 22µF, X7R, 25V, 20%, 1210, AEC-Q200	TAIYO YUDEN, TMK325B7226MMHP
2	1	C3	CAP., 68µF, ALUM ELECT, 25V, 20%, 6.3mm × 5.8mm, RADIAL, SMD, AEC-Q200	PANASONIC, EEEFN1E680P
3	2	C17, C18	CAP., 1µF, X5R, 50V, 10%, 0603, AEC-Q200	TAIYO YUDEN, UMK107ABJ105KAHT
4	1	FB1	IND., 600Ω AT 100MHz, FERRITE BEAD, 25%, 2A, 100mΩ, 1206	WURTH, 74279218
5	1	L2	IND., 1.5µH, SHIELDED PWR, 20%, 10.3A, 6.2mΩ, 6.71mm × 6.51mm, AEC-Q200	COILCRAFT, XGL6030-152MEB
6	1	R3	RES., 5.1Ω, 1%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW06035R10FKEA
7	0	R5	RES., OPTION, 0603	
Optional Electrical Components				
1	0	C6, C11	CAP., OPTION, 0603	
2	0	R4	RES., OPTION, 0603	
3	2	R8, R12	RES., 100k, 1%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW0603100KFKEA

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Hardware: For Evaluation Circuit Only				
1	5	E1, E2, E4, E6, E7	TEST POINT, TURRET, 0.094" MTG. HOLE, PCB 0.062" THK	MILL-MAX, 2501-2-00-80-00-00-07-0
2	2	E3, E5	TEST POINT, TURRET, 0.064" MTG. HOLE, PCB 0.062" THK	MILL-MAX, 2308-2-00-80-00-00-07-0
3	2	J1, J2	CONN., BANANA JACK, FEMALE, THT, NON INSULATED, SWAGE, 0.218"	KEYSTONE, 575-4
4	1	JP1	CONN., HDR, MALE, 2×5, 2mm, VERT, ST, THT	WURTH ELEKTRONIK, 62001021121
5	1	JP2	CONN., HDR., MALE, 1×3, 2mm, VERT, ST, THT	SULLINS CONNECTOR SOLUTIONS, NRPN031PAEN-RC
6	4	MP1, MP2, MP3, MP4	STANDOFF, NYLON, SNAP-ON, 0.50"	KEYSTONE, 8833
7	2	XJP1, XJP2	CONN., SHUNT, FEMALE, 2-POS, 2mm	WURTH ELEKTRONIK, 60800213421
8	0	CL1-CL8	EIGHT EMI SHIELD CLIPS	WURTH ELEKTRONIK, 36900000
9	0	SH1	EMI SHIELD 44mm × 44mm	WURTH ELEKTRONIK, 36907406S

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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