Evaluation Board User Guide

EVAL-LT8350S-AZ

LT8350S 40V_{IN}, 18V_{OUT}, 6A Synchronous Buck-Boost Silent Switcher 2

General Description

The EVAL-LT8350S-AZ Evaluation board is a 40V synchronous buck-boost converter featuring the LT®8350S. It drives up to 2.5A load at 12V output when VIN is between 9V and 40V and will run down to 3VIN with reduced output current. EVAL-LT8350S-AZ runs at 350kHz switching frequency with spread spectrum frequency modulation (SSFM) disabled. When enabled, SSFM spreads the switching frequency of the LT8350S from f_{SW} to f_{SW} + 25% for a reduced electromagnetic interference (EMI) emission.

The LT8350S has an operating input voltage range of 3V to 40V. It has internal, synchronous 42V MOSFETs on the buck side and 20V MOSFETs on the boost side for high efficiency and small size. It has an adjustable switching frequency between 200kHz and 2MHz. The LT8350S can be synchronized to an external source, programmed with SSFM enabled for low EMI, or set to normal operation.

The LT8350S' 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 LT8350S can regulate output current using ISP and ISN. Maximum load current can be limited when LT8350S is used for a constant voltage regulator. It can also be used for an 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.

An Undervoltage lockout can be adjusted on EVAL-LT8350S-AZ with a few simple resistor choices.

Small ceramic input and output capacitors are used to save space and cost. Although LT8350S has in-built high-frequency capacitors(100nF) on the input and output, the board is designed with tiny, high-frequency capacitors placed near the V_{IN} and V_{OUT} pins for added flexibility.

There is an inductor EMI filter and a small ferrite bead EMI filter on the input and output of EVAL-LT8350S-AZ. These filters, combined with proper board layout and SSFM, are effective in reducing EMI to pass CISPR25 class 5 conducted EMI. Follow the recommended layout and four-layer printed circuit board (PCB) thickness of EVAL-LT8350S-AZ for low EMI applications.

The LT8350S data sheet provides a complete description of the part, operation, and applications information. The data sheet must be read in conjunction with this demo manual for EVAL-LT8350S-AZ. The LT8350S 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 at Product Evaluation Boards and Kits | Design Center | Analog Devices.

Features and Benefits

- 3V–40V Operating Input Voltage
- Reduced EMI emissions for CISPR 25 Class 5
  - Spread Spectrum Frequency Modulation
  - Input and Output EMI filter
  - In-built Input and Output high-frequency capacitors
- Adjustable UVLO, V_{OUT}, f_{SW}, Output Current and Limit
- Voltage-Monitoring ($\overline{PGOOD}$) and Current-Monitoring (ISMON)
- Configurable SYNC pin for Forced Continuous Mode (FCM), Discontinuous Conduction Mode (DCM), SSFM, and external Frequency Synchronization
- Feed Forward Function for improved transient response

Ordering Information appears at end of data sheet

One Analog Way, Wilmington, MA 01887-2356, U.S.A. | Tel: 781.329.4700

EVAL-LT8350S-AZ Board Photo

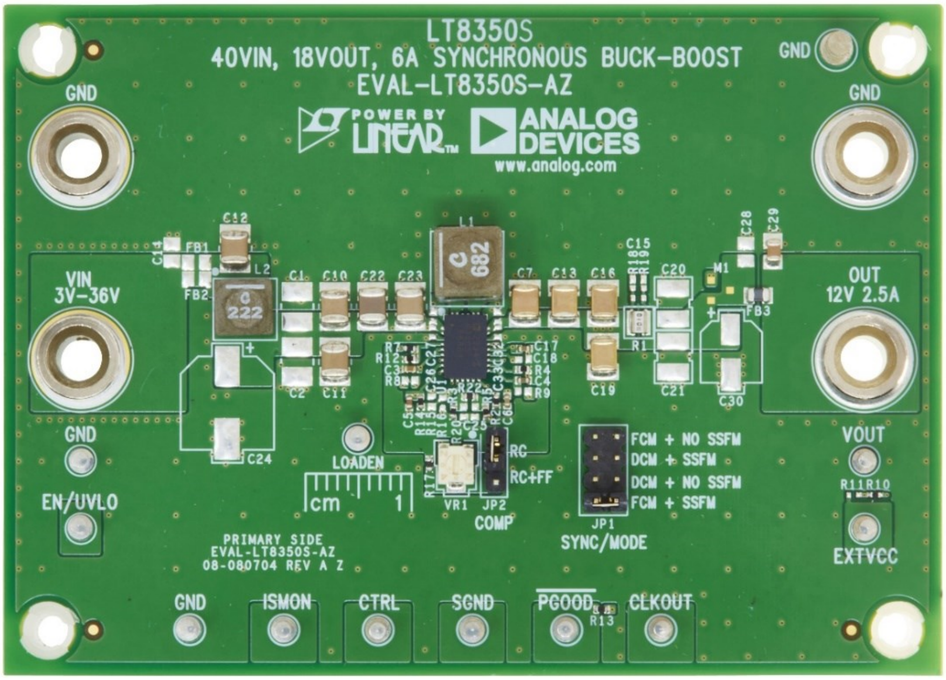


Figure 1. EVAL-LT8350S-AZ Board Photo Front View

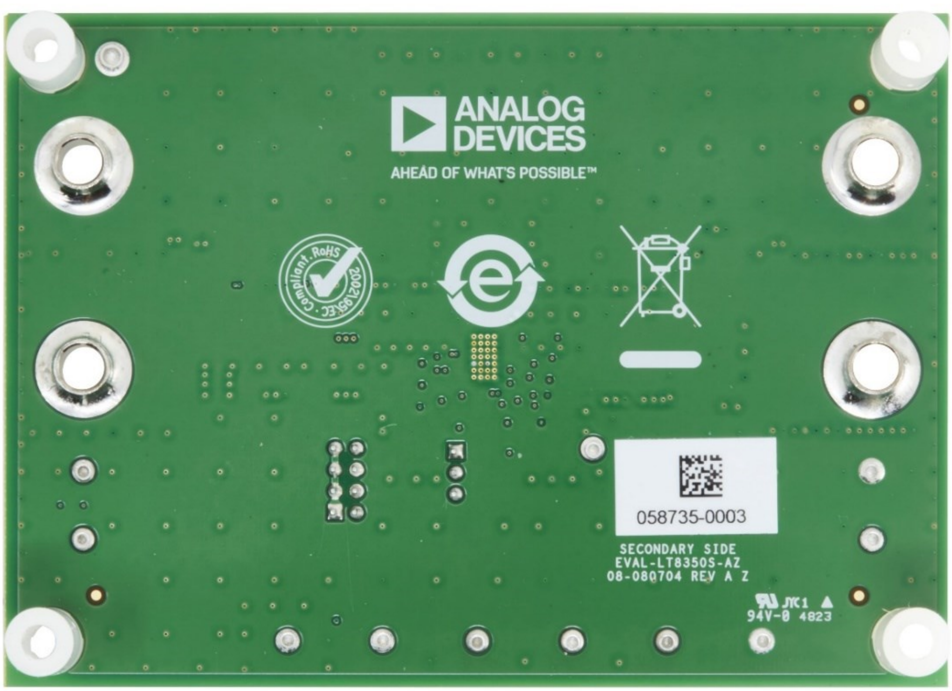


Figure 2. EVAL-LT8350S-AZ Board Photo Back View

Table 1. Performance Summary (Specifications are at T_A = 25°C)

PARAMETER	CONDITIONS/NOTES	MIN	TYP	MAX	UNITS
Input Voltage V_{IN} Range	Operating, R7 = 402kΩ, 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 = 100kΩ, R3 = 10.0kΩ		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, f_{SW} = 350kHz 7.0V < V_{IN} < 40V, V_{OUT} = 12V, f_{SW} = 2MHz	2.5 2.0			A A
Switching Frequency (f_{SW})	R4 = 143kΩ, SSFM = OFF R4 = 143kΩ, SSFM = ON R4 = 14.3kΩ, SSFM = OFF R4 = 14.3kΩ, SSFM = ON		350 350-400 2000 2000-2520		kHz kHz 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 = 110kΩ, R3 = 10.0kΩ		13.2		V
V_{IN} Undervoltage Lockout (UVLO) Falling	R7 = 402kΩ, R12 = 84.5kΩ, I_{OUT} = 2.5A		7.2		V
V_{IN} Enable Turn-On (EN) Rising	R7 = 402kΩ, R12 = 84.5kΩ, I_{OUT} = 2.5A		8.0		V

Quick Start

Required Equipment

- EVAL-LT8350S-AZ
- Power Supply
- Voltmeters
- Ammeters
- Electronic Load

Procedure

EVAL-LT8350S-AZ Evaluation board is easy to set up to evaluate the performance of the LT8350S. See Figure 3 for proper measurement equipment setup and follow the procedure below. Ensure 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 terminal on the PCB, as shown in Figure 3.
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 3.
3. Set JP1 at NO SSFM to disable SSFM and 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 the connections are established, 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 ensure that it is not set too high. 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.

Hardware Set-Up

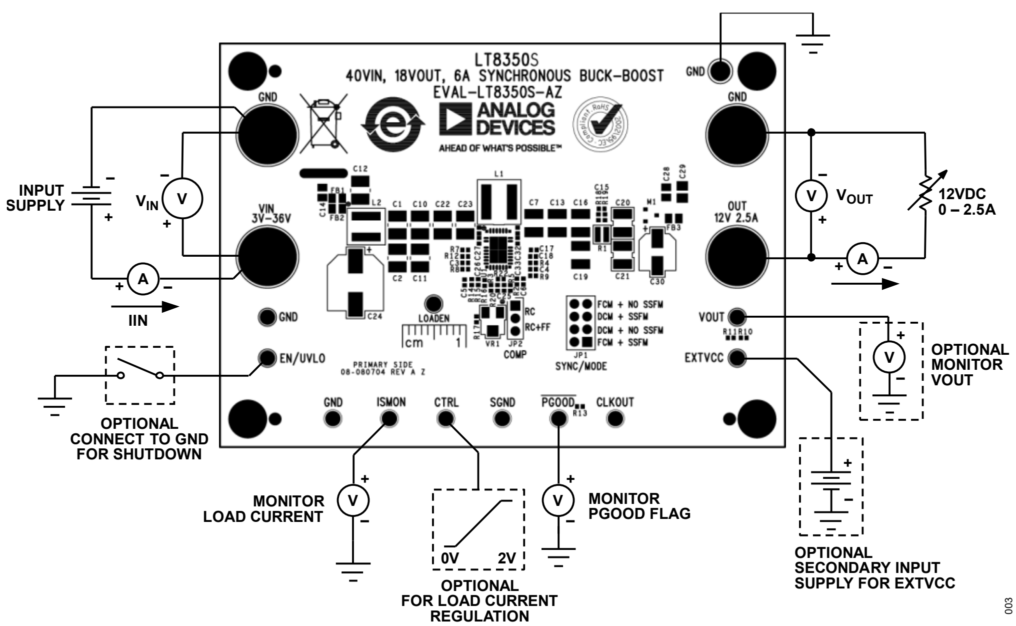


Figure 3. Test Procedure Setup Drawing for EVAL-LT8350S-AZ

Test Results

f_{SW} = 350kHz

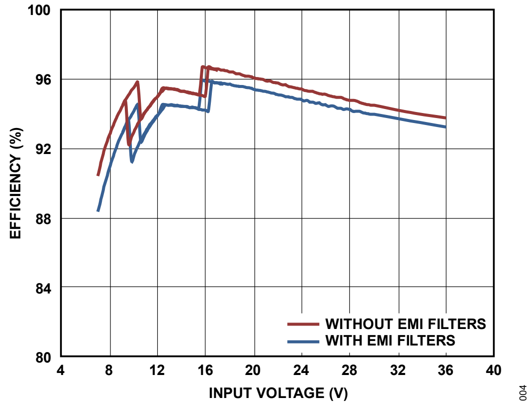


Figure 4. EVAL-LT8350S-AZ Efficiency vs Input Voltage for 2.5A Load with SSFM

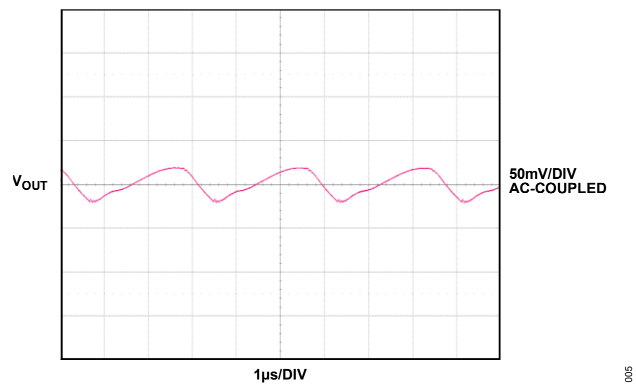


Figure 5. EVAL-LT8350S-AZ Output Voltage Ripple at 12V Input Voltage and 2.5A Load

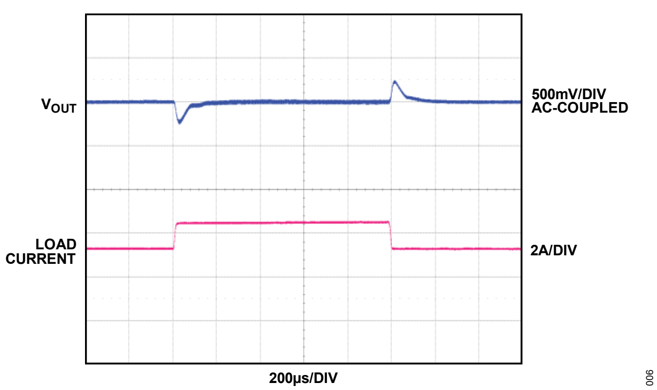


Figure 6. EVAL-LT8350S-AZ Transient Response with JP2 = RC (12V_{IN} and 12V_{OUT} 2.5A to 1.25A)

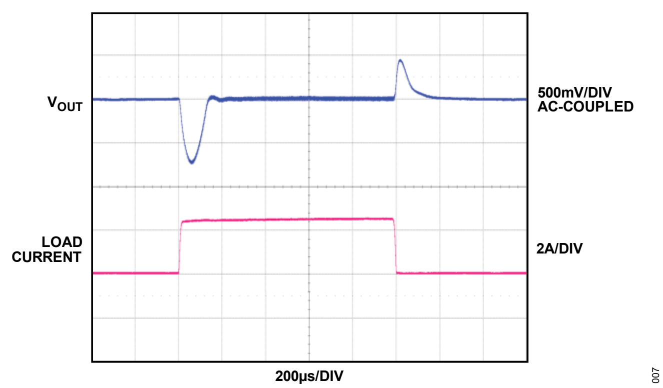


Figure 7. EVAL-LT8350S-AZ Transient Response with JP2 = RC (12V_{IN} and 12V_{OUT} 2.5A to 0A)

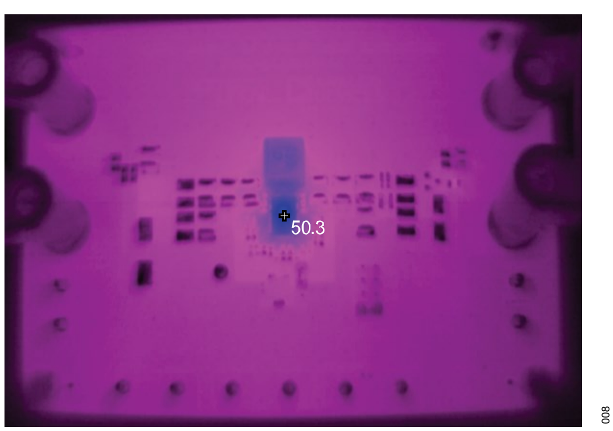


Figure 8. EVAL-LT8350S-AZ Thermals 12V_{IN} to 12V_{OUT} 2.5A with SSFM ON

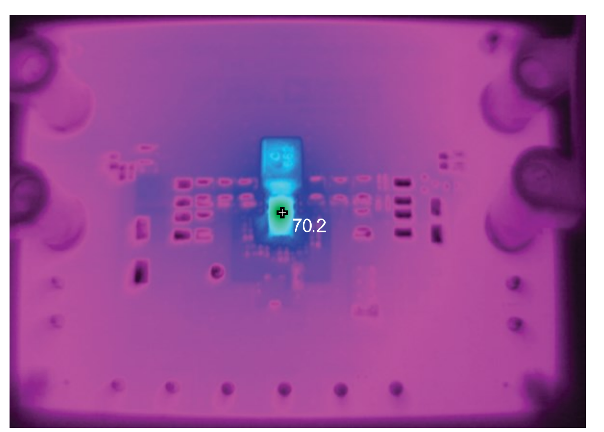


Figure 9. EVAL-LT8350S-AZ Thermals, Worst Case (4-Switch Operation) 9.5V_{IN} to 12V_{OUT} 2.5A with SSFM ON

f_{SW} = 2MHz

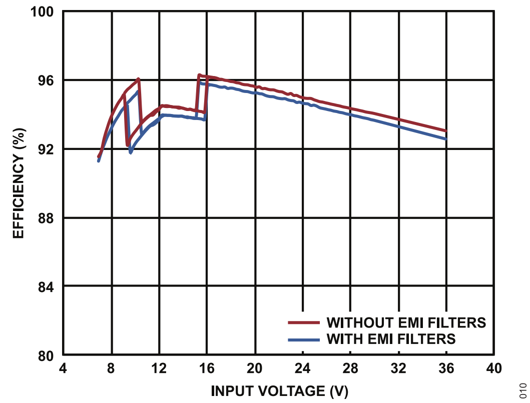


Figure 10. EVAL-LT8350S-AZ Efficiency vs Input Voltage for 2A Load with SSFM

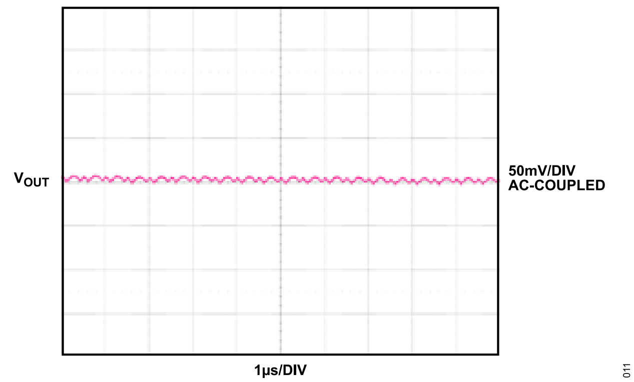


Figure 11. EVAL-LT8350S-AZ Output Voltage Ripple at 12V Input Voltage and 2A Load

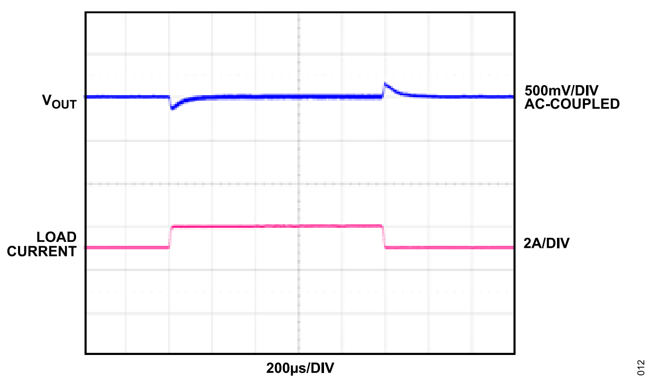


Figure 12. EVAL-LT8350S-AZ Transient Response with JP2 = RC (12V_{IN} and 12V_{OUT} 2A to 1A)

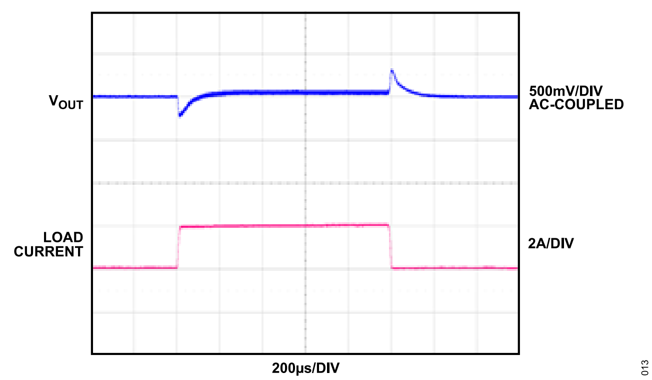


Figure 13. EVAL-LT8350S-AZ Transient Response with JP2 = RC (12V_{IN} and 12V_{OUT} 2A to 0A)

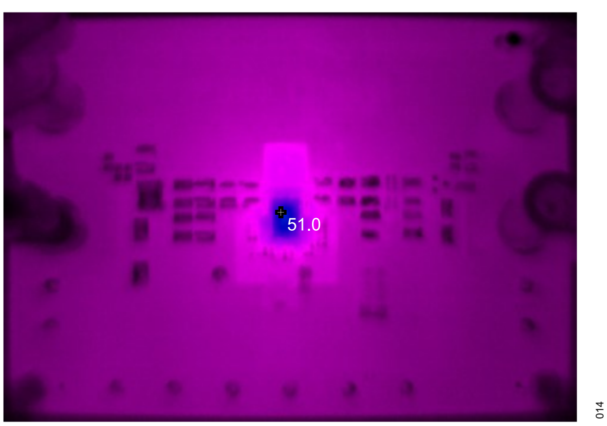


Figure 14. EVAL-LT8350S-AZ Thermals 12V_{IN} to 12V_{OUT} 2A with SSFM ON

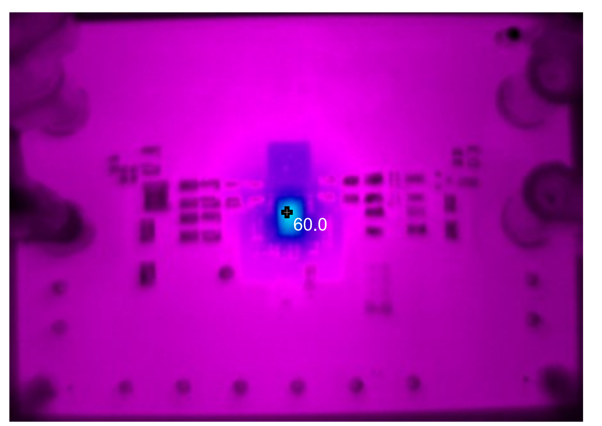


Figure 15. EVAL-LT8350S-AZ Thermals, Worst Case (4-Switch Operation) 9.5V_{IN} to 12V_{OUT} 2A with SSFM ON

Load Current Injection for Faster Load Transient Response

Load transient response can be improved with JP2 = RC + FF, 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, use the following Equation.

$$140 \times \mathrm{R1} \times \frac{\mathrm{R17}}{\mathrm{VR1} + \mathrm{R17}} = 1$$

As EVAL-LT8350S-AZ uses R1 = 10mΩ and R17 = 3.01kΩ, VR1 is determined to 1.2kΩ. Figure 16 and Figure 17 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 6 and Figure 7. With the load current injection, the output voltage drop can be reduced while keeping the same output capacitance, or output capacitance can be reduced while keeping the same output voltage drop.

f_{SW} = 350kHz

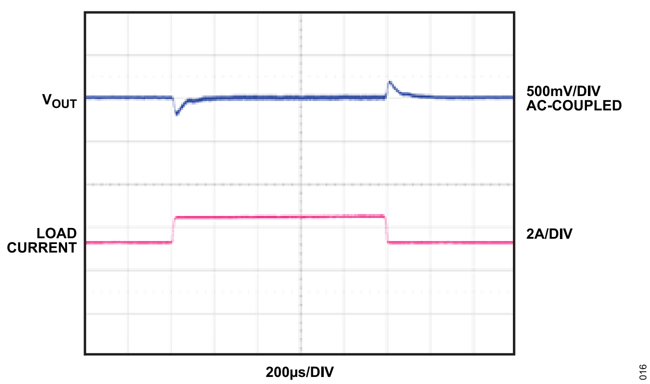


Figure 16. EVAL-LT8350S-AZ Transient Response with JP2 = RC + FF (12V_{IN}, 12V_{OUT}, 2.5A to 1.25A)

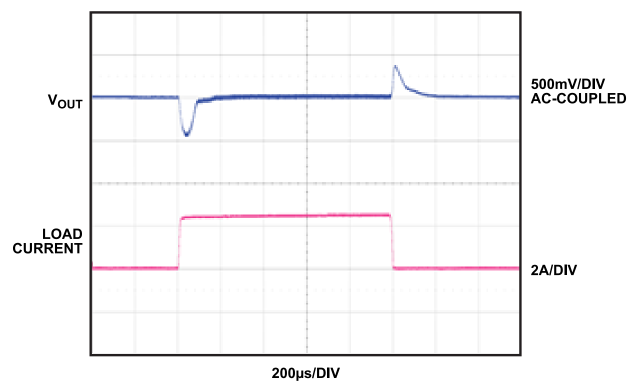


Figure 17. EVAL-LT8350S-AZ Transient Response with JP2 = RC + FF (12V_{IN}, 12V_{OUT}, 2.5A to 0A)

f_{SW} = 2MHz

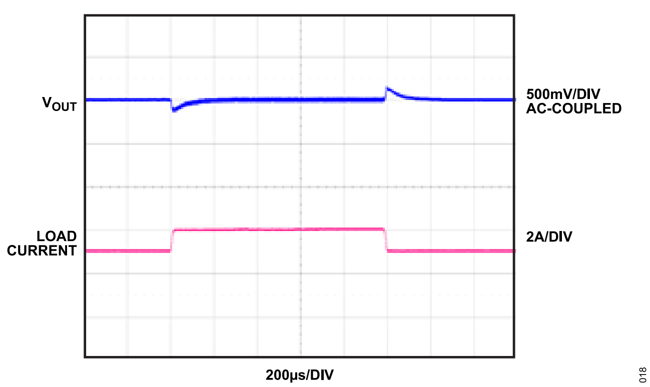


Figure 18. EVAL-LT8350S-AZ Transient Response with JP2 = RC + FF (12V_{IN}, 12V_{OUT}, 2A to 1A)

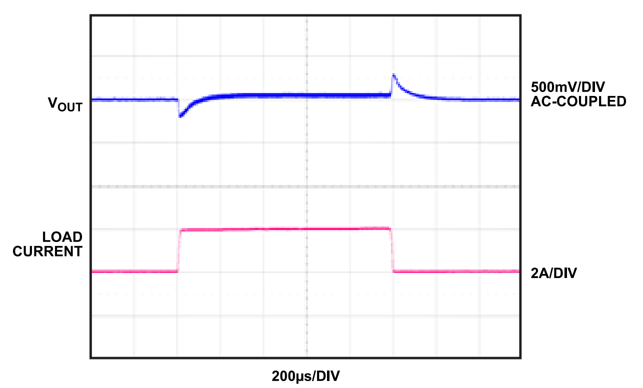
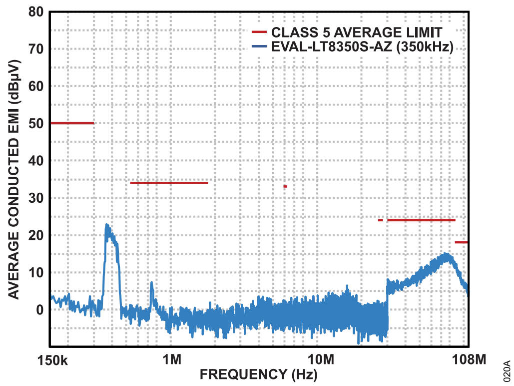


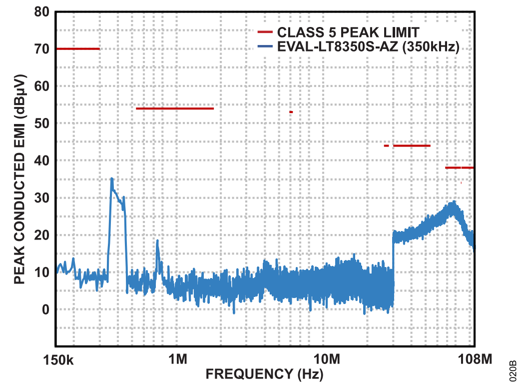
Figure 19. EVAL-LT8350S-AZ Transient Response with JP2 = RC + FF (12V_{IN}, 12V_{OUT}, 2A to 0A)

Electromagnetic Interference Result

f_{SW} = 350kHz

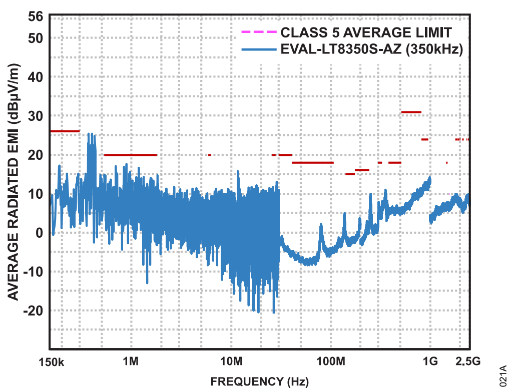


(a) CISPR25 Average, Voltage Method

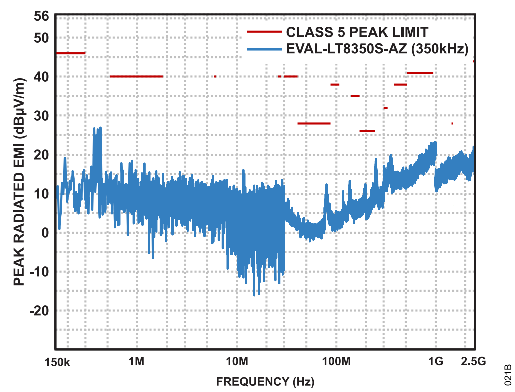


(b) CISPR25 Peak, Voltage Method

Figure 20. EVAL-LT8350S-AZ CISPR25 Voltage Conducted EMI Performance with 12V_{IN} to 12V_{OUT} at 2.5A, JP1 = DCM + SSFM



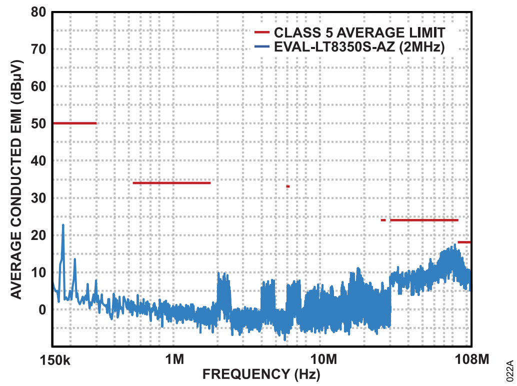
(a) CISPR25 Average, Radiated EMI



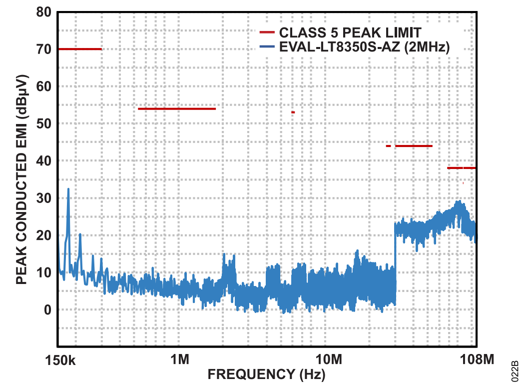
(b) CISPR25 Peak, Radiated EMI

Figure 21. EVAL-LT8350S-AZ CISPR25 Radiated EMI Performance with 12V_{IN} to 12V_{OUT} at 2.5A, JP1 = DCM + SSFM

f_{SW} = 2MHz

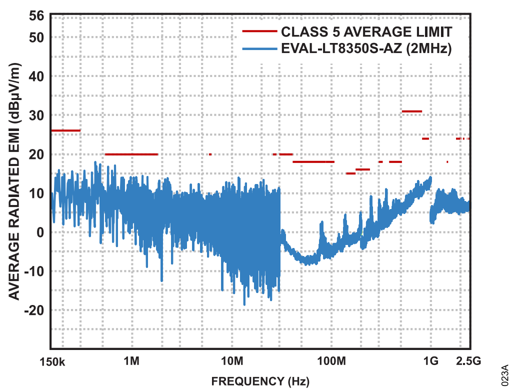


(a) CISPR25 Average, Voltage Method

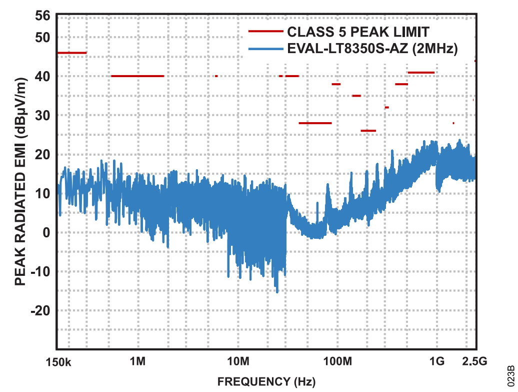


(b) CISPR25 Peak, Voltage Method

Figure 22. EVAL-LT8350S-AZ CISPR25 Voltage Conducted EMI Performance with 12V_{IN} to 12V_{OUT} at 2A, JP1 = DCM + SSFM



(a) CISPR25 Average, Radiated EMI



(b) CISPR25 Peak, Radiated EMI

Figure 23. EVAL-LT8350S-AZ CISPR25 Radiated EMI Performance with 12V_{IN} to 12V_{OUT} at 2.5A, JP1 = DCM + SSFM

Ordering Information

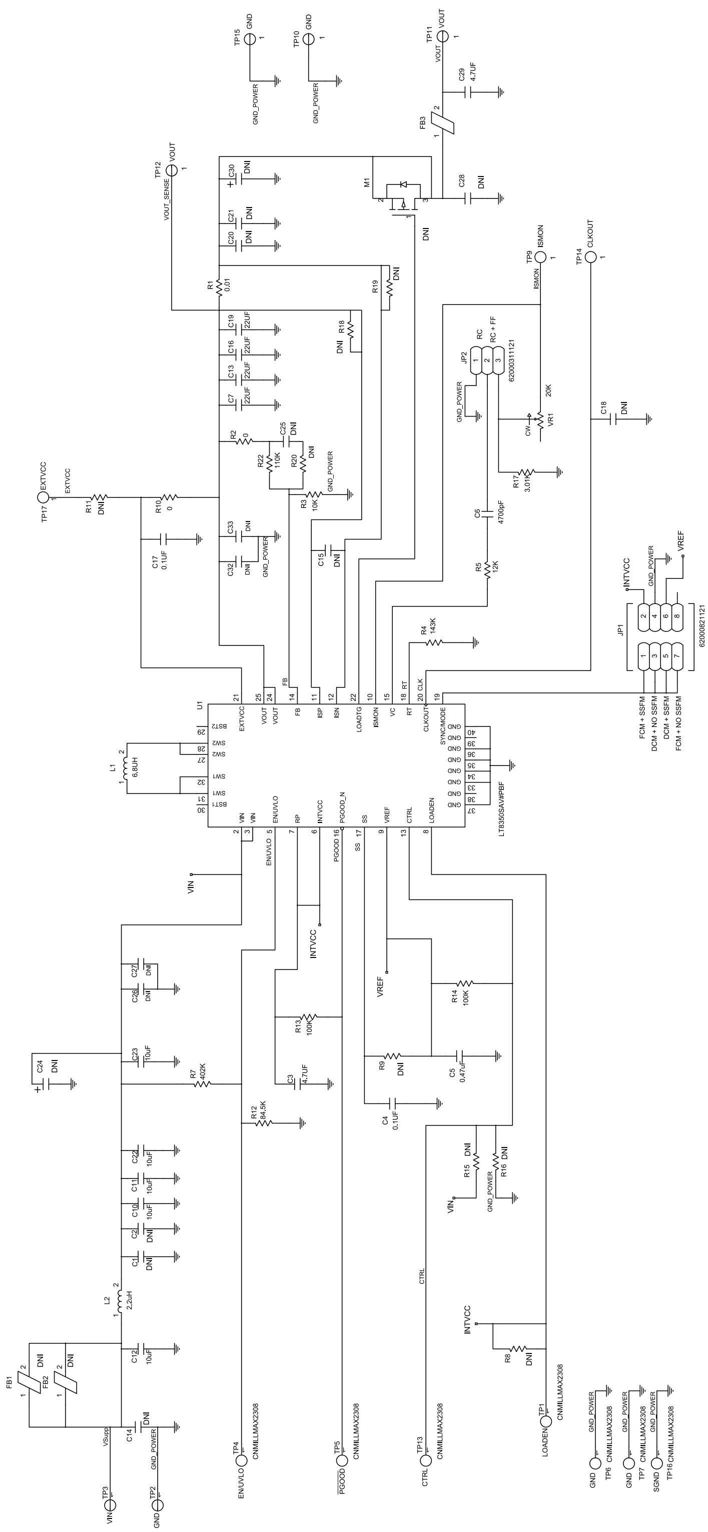
PART	TYPE
EVAL-LT8350S-AZ	Evaluation board

Evaluation Board Bill of Materials

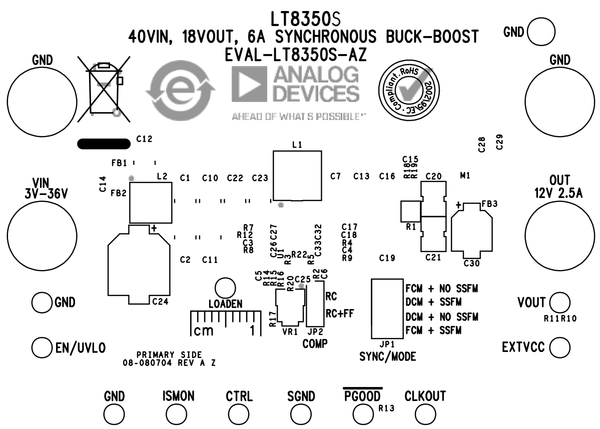
QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
DEFAULT ELECTRICAL COMPONENTS			
2	C4, C17	CAP., 0.1µF, X7R, 50V, 10%, 0402, AEC-Q200	MURATA, GCM155R71H104KE02D
1	C3	CAP., 4.7µF, X5R, 10V, 20%, 0402, AEC-Q200	MURATA, GRT155R61A475ME13D
1	C5	CAP., 0.47µF, X7S, 10V, 10%, 0402, AEC-Q200	MURATA, GCM155C71A474KE36D
1	JP1	CONN., HDR, MALE, 2x4, 2mm, VERT, ST, THT	WURTH ELECTRONIK, 62000821121
1	JP2	CONN., HDR, MALE, 1x3, 2mm, VERT, ST, THT	WURTH ELEKTRONIK, 62000311121
1	R12	RES., 84.5kΩ, 1/16W, 0402, AEC-Q200	VISHAY, CRCW040284K5FKED
2	R13, R14	RES., 100kΩ, 1/16W, 0402, AEC-Q200	VISHAY, CRCW0402100KJNED
1	R22	RES., 110k, 0.5%, 1/16W, 0402, AEC-Q200	PANASONIC, ERJ-2RKD1103X
1	R3	RES., 10k, 1%, 1/10W, 0402, AEC-Q200	PANASONIC, ERJ-2RKF1002X
1	R7	RES., 402k, 1%, 1/10W, 0402, AEC-Q200	PANASONIC, ERJ-2RKF4023X
11	TP1, TP4–TP7, TP9, TP12-TP14, TP16, TP17	TEST POINT, TURRET, 0.064" MTG. HOLE, PCB 0.062" THK	MILL-MAX, 2308-2-00-80-00-00-07-0
4	TP2, TP3, TP10, TP11	TEST POINT, BANANA JACK, 0.312” MTG. HOLE, PCB 0.203” THT	KEYSTONE ELECTRONICS, 575-4
1	TP15	TEST POINT, TURRET, 0.094" MTG. HOLE, PCB 0.062" THK	MILL-MAX, 2501-2-00-80-00-00-07-0
1	U1	IC, BUCK-BOOST VOLTAGE REGULATOR, LQFN-32	ANALOG DEVICES, LT8350SAV#WPBF
1	CONNECTOR	CONN., SHUNT, FEMALE, 2-POS, 2mm	WURTH ELEKTRONIK, 60800213421
1	STAND-OFF	STANDOFF, SELF-RETAINING SPACER, 12.7MM LENGTH	WURTH ELEKTRONIK, 702935000
350kHz APPLICATION COMPONENTS (DEFAULT)			
1	L1	IND., 6.8µH, PWR, SHIELDED, 20%, 9A, 20.80mΩ, 6.56mm x 6.36mm, AEC-Q200, XAL6060	COILCRAFT INC., XAL6060-682MEC
1	R4	RES., 143k, 1%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW0402143KFKED
1	R5	RES., 12k, 1%, 1/10W, 0402, AEC-Q200	PANASONIC, ERJ2RKF1202X
1	C6	CAP., 4700pF, X7R, 50V, 10%, 0402, AEC-Q200	MURATA, GCM155R71H472KA37D
4	C10, C11, C22, C23	CAP., 10µF, X7S, 50V, 10%, 1210, AEC-Q200	MURATA, GCJ32EC71H106KA01
4	C7, C13, C16, C19	CAP., 22µF, X7R, 16V, 20%, 1210, AEC-Q200	TDK, CGA6P1X7R1C226K

2MHz APPLICATION COMPONENTS			
1	L1	IND., 2.2µH, PWR, SHIELDED, 20%, 12.1A, 4.8mΩ, 6.56mm x 6.36mm, AEC-Q200, XAL6060	COILCRAFT INC., XGL6060-222MEC
1	R4	RES., 14.3k, 0.5%, 1/16W, 0402, AEC-Q200	
1	R20	RES., 0, 1/16W, 0402, AEC-Q200	
1	R5	RES., 30k, 1%, 1/16W, 0402, AEC-Q200	
1	C6	CAP., 680pF, X7R, 16V, 10%, 0402, AEC-Q200	
1	C25	CAP., 10pF, X7R, 25V, 10%, 0402, AEC-Q200	
4	C7, C10, C11, C22, C23	CAP., 10µF, X7S, 50V, 10%, 1210, AEC-Q200	MURATA, GCJ32EC71H106KA01
OPTIONAL LOW EMI COMPONENTS			
1	L2	IND., 2.2µH, PWR, SHIELDED, 20%, 9.7A, 14.5mΩ, 5.48mm x 5.28mm, XAL5030, AEC-Q200	COILCRAFT INC., XAL5030-222MEC
1	C12	CAP., 10µF, X7S, 50V, 10%, 1210, AEC-Q200	MURATA, GCJ32EC71H106KA01
1	C29	CAP., 4.7µF, X7R, 16V, 10%, 0805, AEC-Q200	MURATA, GCJ21BR71C475KA01L
1	FB3	IND., 220Ω AT 100MHz, FERRITE BEAD, 25%, 3A, 40mΩ, 0805, AEC-Q200	TDK, MPZ2012S221ATD25
4	C1, C2, C20, C21	CAP., OPTION, 1210	
2	C14, C28	CAP., OPTION, 0805	
2	FB1, FB2	IND., 220Ω AT 100MHz, FERRITE BEAD, 25%, 3A, 40mΩ, 0805, AEC-Q200	TDK, MPZ2012S221ATD25
4	C26, C27, C32, C33	CAP., OPTION, 0402	
OPTIONAL ELECTRICAL COMPONENTS			
1	R1	RES., 0.010Ω, 1%, 1W, 0805 LONG-SIDE, AEC-Q200, CURRENT SENSE	SUSUMU CO, LTD., KRL2012E-M-R010-F-T5
2	R2, R10	RES., 0Ω, 1/16W, 0402, AEC-Q200	VISHAY, CRCW04020000Z0EDHP
1	R17	RES., 3.01k, 1%, 1/10W, 0402, AEC-Q200	PANASONIC, ERJ-2RKF3011X
1	VR1	RES., 20k, 20%, 1/8W, SMD 3mm SQ, 1-TURN, TOP ADJ., TRIMPOT	BOURNS, 3313J-1-203E
8	R8, R9, R11, R15, R16, R18, R19	RES., OPTION, 0402	
1	M1	XSTR., OPTION, MOSFET, P-CH, SOT-23	
3	C15, C18, C25	CAP., OPTION, 0402	
1	C24	CAP., OPTION, ALUM POLY, SMD, 8.0mm × 10.0mm	
1	C30	CAP., OPTION, ALUM POLY, SMD, 5.0mm × 5.8mm, AEC-Q200	

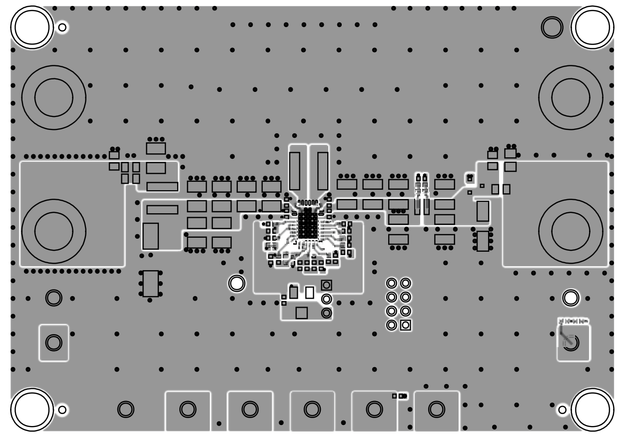
Evaluation Board Schematic



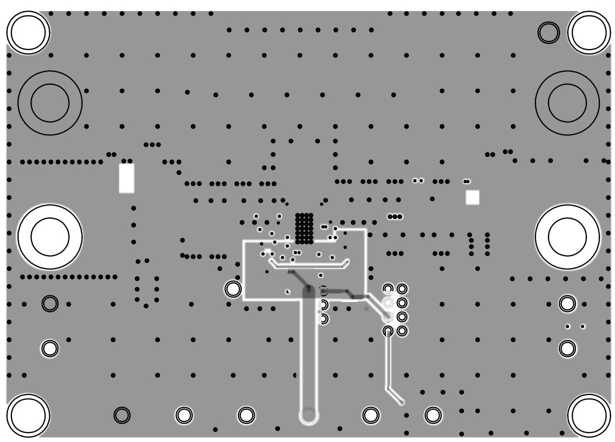
Evaluation Board PCB Layout



EVAL-LT8350S-AZ Component Placement Guide—Top Silkscreen

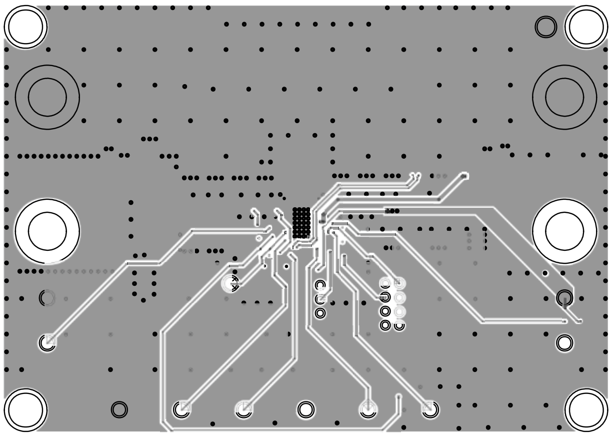


EVAL-LT8350S-AZ PCB Layout—Top View

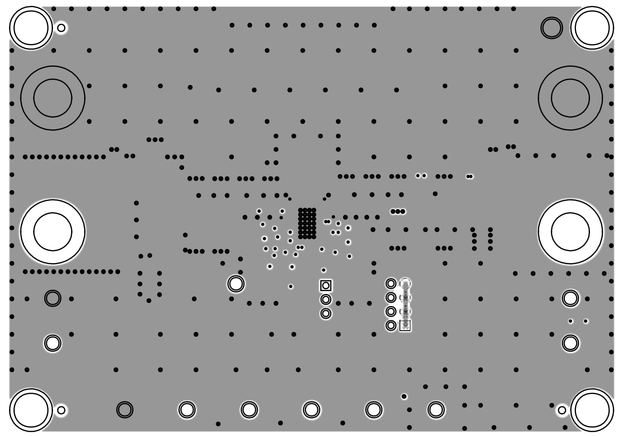


EVAL-LT8350S-AZ PCB Layout—Layer 2

Evaluation Board PCB Layout (continued)



EVAL-LT8350S-AZ PCB Layout—Layer 3



EVAL-LT8350S-AZ PCB Layout—Bottom View

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	04/24	Initial release	—
A	10/25	Updated Evaluation Board Schematic Diagram	12

Notes