Evaluation Board User Guide

EVAL-LT8390A-AZ

60V High-Frequency Synchronous GaN Buck-Boost Controller

General Description

The evaluation circuit EVAL-LT8390A-AZ is a synchronous 4-switch buck-boost controller featuring the LT8390A and 4 EPC GaN FETs. This circuit outputs 24V and maintains tight regulation with up to 5A load current and over an input voltage from 8V to 60V. 2MHz switching frequency provides a small footprint using a single 6mm x 6mm x 6mm inductor while maintaining high efficiency.

The *LT8390A* features a 5V gate driver that is used to safely drive GaNFETs. Additionally, the EVAL-LT8390A-AZ board features external clamping circuitry around the bootstrap capacitors to guarantee that the gate drive of the top FETs is driven under the absolute maximum gate-to-source voltage of the GaNFET. Additionally, Schottky diodes are placed anti-parallel to the synchronous GaNFETs to help with reverse conduction during the LT8390A's 25ns dead time.

The LT8390A has a wide input voltage range from 4V to 60V. It can regulate an output as a boost, a buck, or a 4-switch boost-buck controller. It has an adjustable switching frequency between 600kHz and 2MHz. It has an option for external frequency synchronization or spread spectrum frequency modulation. Its high switching frequency is unique to buck-boost controller ICs. Because of this, it can be used for high power when the input may be above, below, or equal to the output.

The *LT8390A* 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. The LT8390AJUFD is assembled in a 28-lead 4mm x 5mm plastic QFN package with a thermally enhanced ground pad. LT8390A is also available in a 28-Lead plastic TSSOP (FE) package. Proper board layout is essential for maximum thermal performance. Refer to the data sheet PC Board Layout Checklist section for more details.

Design files for this circuit board are available at *Product Evaluation Boards and Kits | Design Center | Analog Devices*.

Performance Summary (T_A = 25°C)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage Range	I_{OUT} = 0A - 5A Heatsink + 400LFM Airflow Maximum Board Temperature < 105°C after 10 minutes	8		60	V
	I_{OUT} = 0A - 5A, Heatsink Maximum Board Temperature < 105°C after 10 minutes	12		43	
	I_{OUT} = 0A - 5A, No Heatsink or Airflow Maximum Board Temperature < 115°C after 10 minutes	14.5		32	V
Output Voltage	V_{IN} = 8V - 60V		24		V
EN/UVLO Threshold (Rising Turn-On)			8.9		V
EN/UVLO Falling Threshold			7.9		V
Switching Frequency	JP2 = Disable SS (SSFM Off)		2		MHz
	JP2 = Enable SS (SSFM On)	2		2.5	MHz
Typical Efficiency	V_{IN} = 12V, I_{OUT} = 5A		94		%
	V_{IN} = 24V, I_{OUT} = 5A		93		%
	V_{IN} = 48V, I_{OUT} = 5A		92		%

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Quick Start Procedure

Evaluation circuit EVAL-LT8390A-AZ is easy to set up to evaluate the performance of the LT8390A. For a proper measurement equipment setup, see *Figure 1* and follow the procedure below.

1. Set the input power supply to a voltage between 9V and 60V. Disable the power supply. An input of 8V can be achieved after start up.

   NOTE: Make sure that the input voltage V_{IN} does not exceed 60V.

   NOTE: Without a heatsink or airflow, we recommend operating with an input of 14.5V to 32V if operating at 5A load. See *Figure 4* for more details.

2. Connect the positive terminal of the power supply to V_{IN} and the negative terminal to GND.
3. Connect the load (< 5A) between V_{OUT} and GND.
4. Verify that the output voltage is 24V on the DMM connected to V_{OUT}. If there is no output, temporarily disconnect the load to make sure that the load is not set too high.
5. Once the proper output voltage is established, adjust the load 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 minimize the length of the oscilloscope probe ground lead. Measure the input or output voltage ripple by connecting the probe tip directly across the V_{IN} or V_{OUT} and GND terminals, preferably across the input or output capacitors.

The EVAL-LT8390A-AZ is a fully assembled and tested board that demonstrates the performance of the LT8390A. The evaluation circuit is designed to deliver 24V output at a load current of up to 5A from an 8V to 60V input supply. The board is programmed at a 2MHz switching frequency for optimum efficiency and component size.

Adjusting the Output Voltage

The LT8390A supports an adjustable output voltage range, from 1V to 60V. To change the output voltage from the programmed 24V, change R5 and R6. Refer to the Programming the Output Voltage section on the data sheet for calculating the V_{FB} resistor divider values for the desired output voltage. All the corresponding power components must also be changed to meet the desired output voltage.

Setting the Switching Frequency

Selecting the switching frequency is a trade-off between efficiency and component size. A switching frequency of 2MHz is chosen for this board for optimal space saving. R23 programs the desired switching frequency. The switching frequency is set using the RT pin. Refer to the Switching Frequency Selection section in the datasheet for more details.

EN/UVLO

The EN/UVLO turret of the evaluation circuit serves as an external on/off control for the controller. The EVAL-LT8390A-AZ includes a resistive voltage divider (R7 and R8) connected between the V_{IN} and GND pins to turn on the device at the required input voltage. The EVAL-LT8390A-AZ is designed to turn on LT8390A at around 8.9V. However, this threshold can be easily adjusted by changing R7 and R8. Short EN/UVLO turret to GND to turn off the device.

Spread Spectrum and External Frequency Synchronization (SYNC/SSFM, JP1)

The LT8390A features spread-spectrum mode operation to improve EMI. This mode varies the switching frequency within the typical boundaries of the frequency set by the FREQ pin and +25%. Spread-spectrum operation is enabled by tying the SYNC pin to $INTV_{CC}$. The EVAL-LT8390A-AZ includes a jumper (JP1) to conveniently enable or disable the spread-spectrum operation.

The LT8390A also features a phase-locked loop to synchronize the internal oscillator to an external clock source. The EVAL-LT8390A-AZ provides a SYNC turret to connect an external clock source to synchronize with the device switching. Keep the jumper (JP1) in the SYNC position when the external clock signal is applied. Refer to the datasheet for more details about external clock synchronization. See *Table 1* to configure JP1.

Open-Drain $\overline{\text{PGOOD}}$ Output ($\overline{\text{PGOOD}}$)

The EVAL-LT8390A-AZ provides a $\overline{\text{PGOOD}}$ turret to monitor the status of the $\overline{\text{PGOOD}}$ output. $\overline{\text{PGOOD}}$ is low when V_{FB} voltage is within ±10% of the 1.00V reference. $\overline{\text{PGOOD}}$ is high when V_{FB} voltage is not within 1.00V ± 10%. The voltage on the $\overline{\text{PGOOD}}$ pin should not exceed 6V.

CTRL and ISMON

The EVAL-LT8390A-AZ provides a resistive divider (R9 and R10) to set the CTRL pin. The default resistive divider to CTRL pin voltage is set to control the maximum voltage threshold of ISP-ISN to 50mV. With the 8mΩ resistor at R2, the maximum output current threshold is set to 6.25A. These resistors can be changed to fit any output current desired. ISMON is a representation of the output current read at ISP-ISN. Please see the datasheet for more information.

LOADEN and External Load Switch

The LT8390A can drive an external high-side PMOS as a load switch. The LOADEN pin is used to control this load switch. The EVAL-LT8390A-AZ is not equipped with an external load switch. If an external load switch is required, R25 should be installed with a short, and the copper trace for the external FET on the bottom side of the board must be cut to install the external switch. Refer to the datasheet for more information.

Thermal Performance

The EVAL-LT8390A-AZ features excellent thermal performance due to the high efficiency of the synchronous GaN FET controller circuitry. The component temperatures of EVAL-LT8390A-AZ with a typical 24V input and 5A load are shown in *Figure 5*. The four-layer PCB layout features solid copper planes that provide adequate heat spreading across the whole board. With a heatsink, EVAL-LT8390A-AZ can achieve very high power, see *Figure 4*.

The board can operate with an input voltage from 14.5V-32V at 5A without a heatsink or forced air under transient conditions. If the input voltage below 14.5V or above 32V for over a minute is required, the circuit will require a heatsink and/or forced air flow to keep the maximum temperature of the board under 105°C at room temperature. With a heatsink and airflow, the board can operate at the full V_{IN} range and load at a steady state.

Heatsink

The EVAL-LT8390A-AZ features space for a heatsink to extend the power and thermal capabilities significantly. The board is designed for the Wakefield-Vette 567-45AB heatsink and is to be used in conjunction with thermal pads and Wurth Elektronik 9774010243R spacers. The spacers should be soldered onto P1, P2, P3, and P4, and a thermal pad placed between the heatsink and the GaN FETs. Properly screw in the heatsink to fully extend the power capabilities of the board.

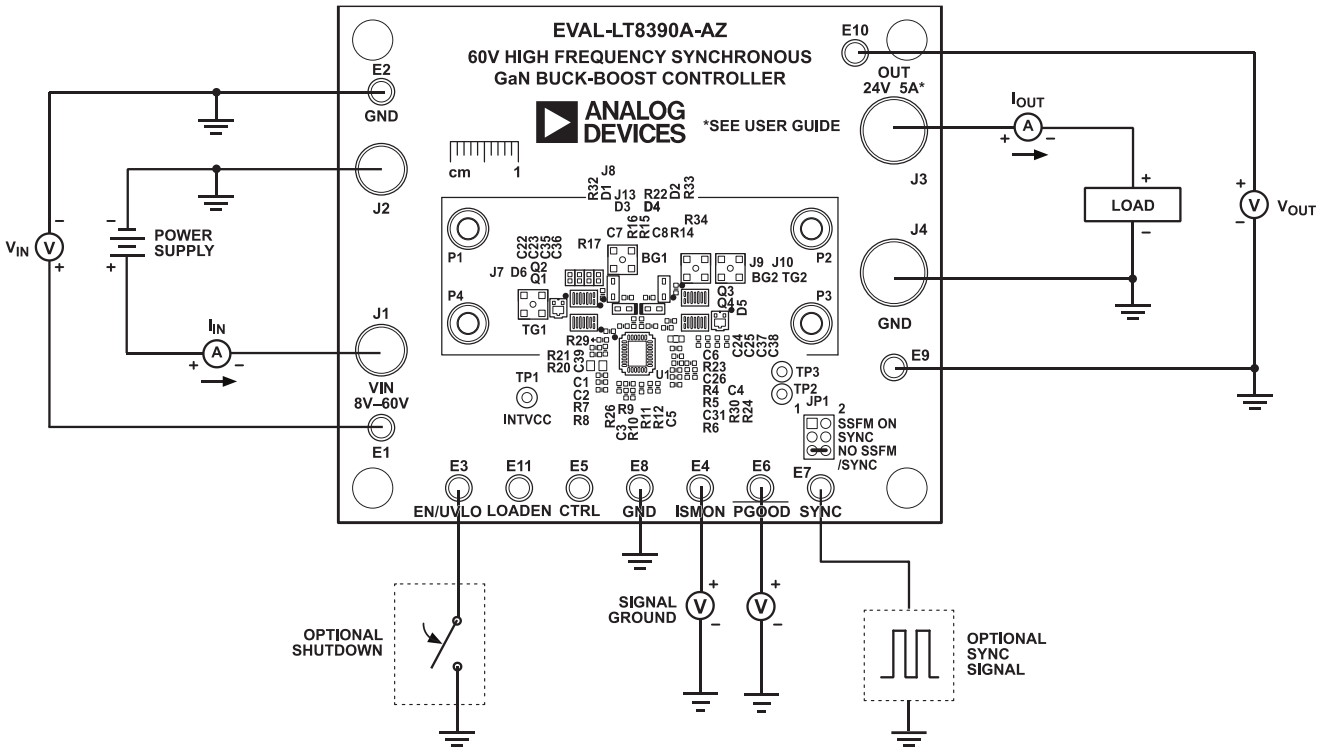

Figure 1. EVAL-LT8390A-AZ Board Connections

Table 1. SYNC/SPRD Selection Jumper (JP1) Settings

SHUNT POSITION	MODE PIN	MODE
1-2	Connected to $INTV_{CC}$	Spread Spectrum (SSFM) ON
3-4	Connected to SYNC Turret	Enables external clock synchronization
5-6*	Connected to GND	Spread Spectrum (SSFM) OFF

**Default position*

Performance

(V_{IN} = 24V, V_{OUT} = 24V, I_{OUT} = 5A, f_{SW} = 2MHz, T_A = +25°C, unless otherwise noted.)

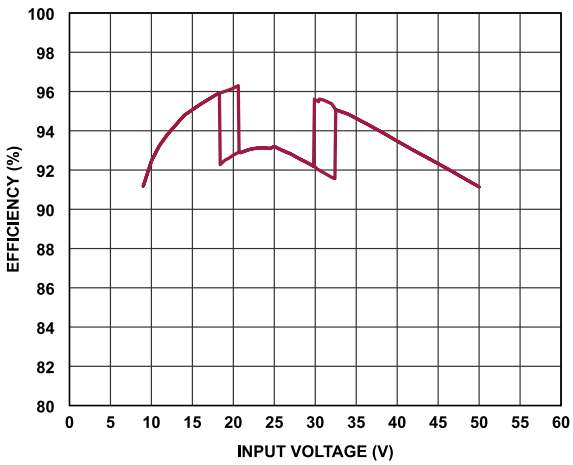

Figure 2. Efficiency vs. Input Voltage at I_{LOAD} = 5A. While sweeping V_{IN}, the efficiency stays around 92%-96% even at high frequency and high output voltage.

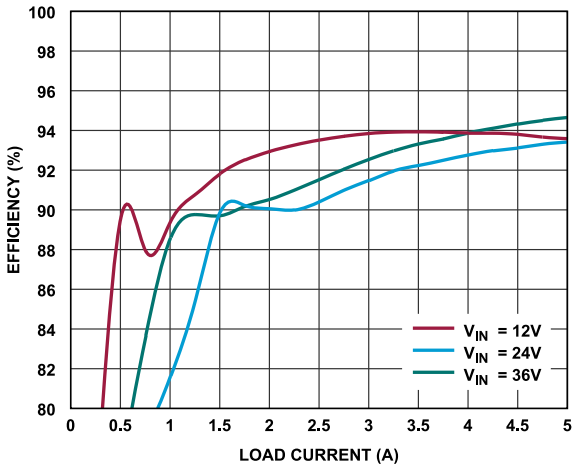

Figure 3. Efficiency vs. Load Current. GaN FETs lower switching losses allowing for great efficiency even at 2MHz switching.

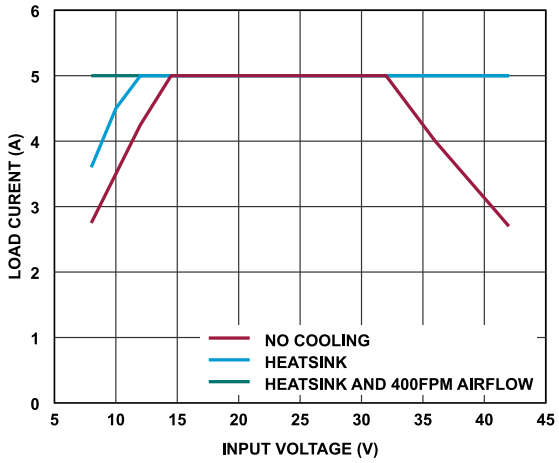

Figure 4. Maximum Load Current vs. Input Voltage. With a Heatsink and airflow, the board can operate at 120W for all V_{IN}.

Figure 5. Thermal Image of Top Layer at V_{IN} = 24V, V_{OUT} = 24V, I_{OUT} = 5A. Without airflow or heatsinks, the EVAL-LT8390A-AZ has great thermal performance.

Bill of Materials

ITEM	QTY	DESIGNATOR	DESCRIPTION	MANUFACTURER, PART NUMBER
REQUIRED CIRCUIT COMPONENTS				
1	1	C1	CAP CER 1UF 100V 10% X7S 0805	MURATA, GRJ21BC72A105KE11L
2	1	C10	CAP ALUM POLY 100UF 63V 20% 10X12.6MM 1000H	PANASONIC, 63SXV100M
3	2	C12, C32	CAP CER 10UF 100V 10% X7S 1210	MURATA, GRM32EC72A106KE05L
4	4	C14, C20, C21, C45	CAP CER 10uF 50V 10% X7R 1210	MURATA, GRM32ER71H106KA12L
5	1	C2	CAP CER 4.7uF 10V 10% X5R 0402 LOW ESR	TDK, C1005X5R1A475K050BC
6	4	C22, C23, C35, C36	CAP CER 0.1uF 100V 10% X5R 0402	MURATA, GRM155R62A104KE14D
7	4	C24, C25, C37, C38	CAP CER 0.1uF 50V 10% X5R 0402 AEC-Q200	TAIYO YUDEN, UMK105BJ104KVHF
8	1	C27	CAP CER 1uF 16V 10% 0402 LOW ESR	TDK, C1005X6S1C105K050BC
9	1	C3	CAP CER 0.47UF 16V 10% X7S 0402 AEC-Q200 LOW ESR	TDK, CGA2B1X7S1C474K050BC
10	2	C4, C39	CAP CER 1000pF 50V 1% C0G 0402	MURATA, GRM1555C1H102FA01D
11	1	C5	CAP CER 100NF 25V 10% X5R 0402	TDK, C1005X5R1E104K050BC
12	1	C6	CAP CER 1uF 50V 10% X7R 0603	TAIYO YUDEN, UMK107AB7105KA-T
13	2	C7, C8	CAP CER 0.1uF 25V 10% X7R 0402	AVX CORPORATION, 04023C104KAT2A
14	2	D1, D2	DIODE SCHOTTKY SINGLE BARRIER	NXP SEMICONDUCTORS, BAT46WJ,115
15	2	D3, D4	DIO ZNR 5.1V 5% SOD523	CENTRAL SEMICONDUCTOR, CMOZ5L1 TR PBFREE
16	2	D5, D6	DIO SCHOTTKY BARRIER RECTIFIER, 2A	NEXPERIA, PMEG6020EPA,115
17	1	L1	IND POWER SHIELDED/MOLDED WIREWOUND 0.68UH 20% 1MHZ COMPOSITE 22.7A 0.0023OHM DCR AEC-Q200	COILCRAFT INC., XGL6060-681MEC
18	4	Q1, Q2, Q3, Q4	TRAN MOSFET N-CH GAN 100V 60A	EFFICIENT POWER CONVERSION CORPORATION, EPC2218
19	1	R1	RES SMD 0.002 OHM 2% 1W 1206 AEC-Q200	SUSUMU CO, LTD, KRL3216-M-R002-G-T1
20	1	R10	RES SMD 75K Ohm 1% 1/10W 0402 AEC-Q200	PANASONIC, ERJ-2RKF7502X
21	1	R11	RES SMD 100K Ohm 5% 1/16W 0402 AEC-Q200	VISHAY, CRCW0402100KJNED
22	2	R13, R22	RES SMD 10 Ohm 1% 1/10W 0402 AEC-Q200	PANASONIC, ERJ-2RKF10R0X
23	4	R14, R16, R24, R26	RES SMD 0 Ohm JUMPER 1/10W 0402 AEC-Q200	PANASONIC, ERJ-2GE0R00X
24	1	R15	RES SMD 6.2 OHM 1% 1/16W 0402 AEC-Q200	STACKPOLE ELECTRONICS, INC., RMCF0402FT6R20
25	1	R17	RES SMD 3.3 Ohm 1% 1/16W 0402	YAGEO, RC0402FR-073R3L
26	2	R18, R19	RES SMD 10 OHM 5% 1/10W 0402 AEC-Q200	PANASONIC, ERJ-2GEJ100X
27	1	R2	RES SMD 0.008 OHM 1% 1/2W 0805 AEC-Q200 CURRENT SENSE ULTRA-LOW OHMIC CHIP	ROHM, PMR10EZPFU8L00
28	2	R20, R21	RES SMD 47 Ohm 1% 1/10W 0402 AEC-Q200	PANASONIC, ERJ-2RKF47R0X
29	1	R23	RES SMD 59K Ohm 1% 1/10W 0402 AEC-Q200	PANASONIC, ERJ-2RKF5902X
30	1	R4	RES SMD 18K Ohm 1% 1/16W 0402	YAGEO, RC0402FR-0718KL

ITEM	QTY	DESIGNATOR	DESCRIPTION	MANUFACTURER, PART NUMBER
31	1	R5	RES SMD 232K Ohm 1% 1/10W 0402 AEC-Q200	PANASONIC, ERJ-2RKF2323X
32	1	R6	RES SMD 10K Ohm 1% 1/10W 0402 AEC-Q200	PANASONIC, ERJ-2RKF1002X
33	1	R7	RES SMD 357K Ohm 1% 1/10W 0402 AEC-Q200	PANASONIC, ERJ-2RKF3573X
34	1	R8	RES SMD 64.9K Ohm 1% 1/10W 0402 AEC-Q200	PANASONIC, ERJ-2RKF6492X
35	1	R9	RES SMD 124K Ohm 1% 1/16W 0402	YAGEO, RC0402FR-07124KL
36	1	U1	IC-ADI 60V 2MHZ SYNCHRONOUS 4-SWITCH BUCK-BOOST CONTROLLER WITH SPREAD SPECTRUM	ANALOG DEVICES, LT8390AJUFD#PBF
HARDWARE – FOR EVALUATION BOARD ONLY				
1	1		SHUNT, 2MM JUMPER WITH TEST POINT	WURTH ELEKTRONIK, 60800213421
2	2		WASHER, #10 FLAT STEEL	KEYSTONE, 4703
3	2		CONNECTOR RING LUG TERMINAL, 10 CRIMP, NON-INSULATED	KEYSTONE, 8205
4	4		STANDOFF, BRD SPT SNAP FIT 15.9MM LENGTH	KEYSTONE, 8834
5	4		NUT, HEX STEEL, 10-32 THREAD, 9.27MM OUT DIA	KEYSTONE, 4705
6	10	E1, E2, E3, E4, E5, E6, E7, E8, E9, E10	CONN-PCB SOLDER TERMINAL TEST POINT TURRET 0.094" MTG. HOLE PCB 0.062 INCH THK	MILL-MAX, 2501-2-00-80-00-00-07-0
7	2	J1, J2	CONN-PCB THREADED BROACHING STUD, 625MIL LENGTH	PENN ENGINEERING, KFH-032-10ET
8	2	J3, J4	CONN-PCB BANANA JACK	KEYSTONE ELECTRONICS, 575-4
9	1	JP1	CONN-PCB 6POS UNSHROUDED HEADER VERT 2MM PITCH	SAMTEC INC., TMM-103-02-L-D
OPTIONAL ELECTRICAL AND HARDWARE COMPONENTS				
1	1		HEATSINK 1/8 BRICK 55X20.7X11.4M	WAKEFIELD-VETTE, 567-45AB
2	0		THERM PAD 10MMX10MM GRAY	T-GLOBAL TECHNOLOGY, TG-TG-A1780-10-10-0.5
3	4	C26, C31, C34, C44	OPT, 0402	OPT, 0402
4	1	E11	CONN-PCB SOLDER TERMINAL TEST POINT TURRET 0.094" MTG. HOLE PCB 0.062 INCH THK	MILL-MAX, 2501-2-00-80-00-00-07-0
5	6	FB1, FB2, FB3, FB4, FB5, FB6	OPT, 1206	OPT, 1206
6	4	J7, J8, J9, J10	CONN-PCB MMCX JACK STR 50OHM 0-6GHZ	MOLEX, 734152063
7	4	P1, P2, P3, P4	CONN-PCB 1POS STEEL SPACER WITH M2X0.4 THD	WURTH ELEKTRONIK, 9774010243R
8	1	Q5	OPT, TRAN P-CHANNEL MOSFET 100V 10.8A	VISHAY, SI7113ADN-T1-GE3
9	9	R12, R25, R28, R29, R30, R31, R32, R33, R34	OPT, 0402	OPT, 0402
10	3	TP1, TP2, TP3	CONN-PCB TST PNT BLK	KEYSTONE ELECTRONICS, 5001

Evaluation Board Schematic

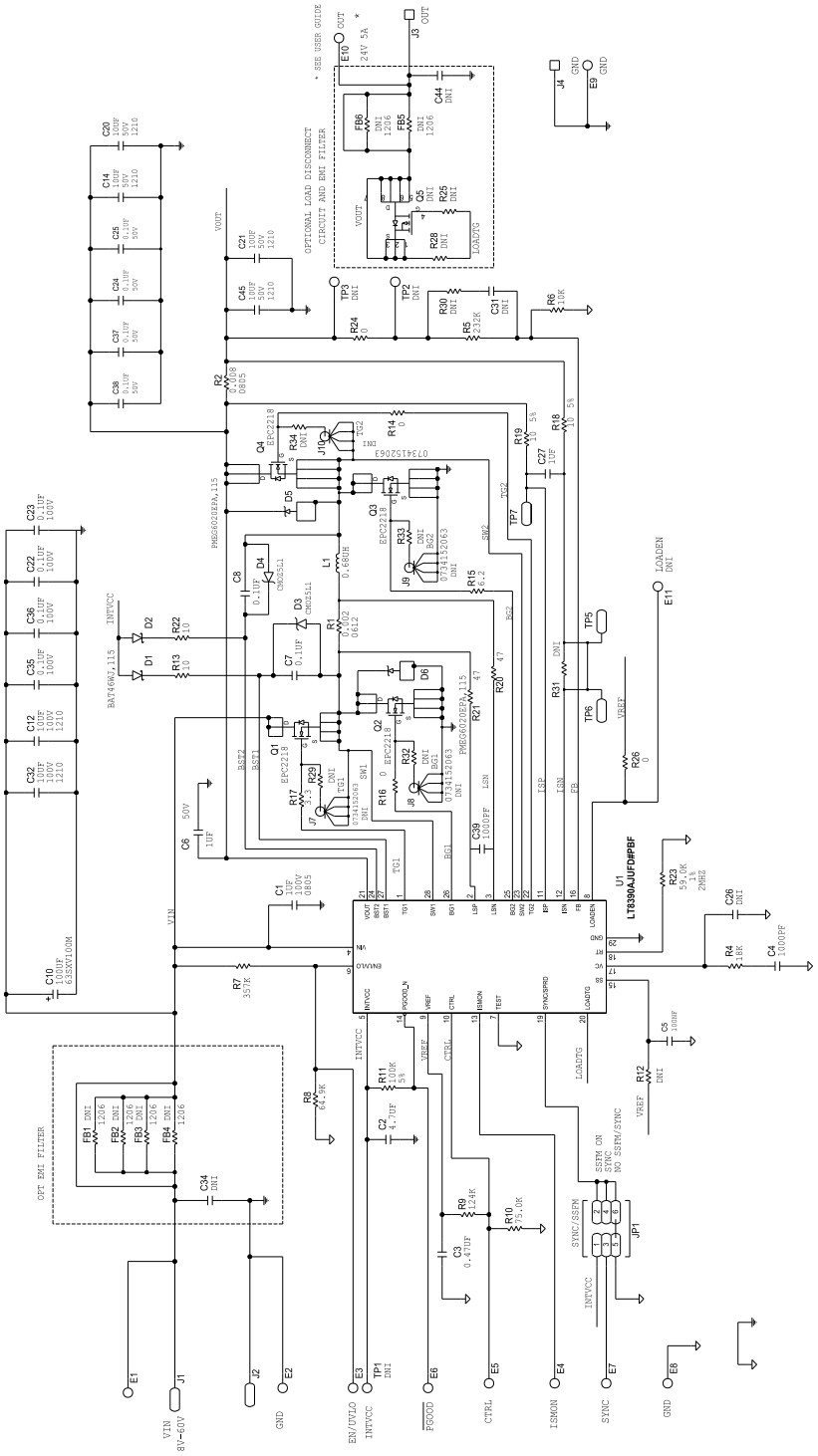

Figure 6. EVAL-LT8390A-AZ Evaluation Board Schematic

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	12/23	Initial Release	—