LT8390

High Power Synchronous 4-Switch Buck-Boost Regulator with Spread Spectrum

DESCRIPTION

Demonstration circuit 2431A is a 4-switch synchronous buck-boost regulator that demonstrates the high power capability of the LT®8390. The output is 12V and the maximum output current is 25A for up to 300W power delivery. The switching frequency is 150kHz and efficiency can go higher than 98%.

The operating input voltage range of DC2431A is from 9V to 36V. The output voltage and EN/UVLO are all programmed by resistor dividers. EN/UVLO is set so the circuit will turn off when the input voltage falls below 9V and will turn on when the input voltage rises above 10V.

DC2431A features MOSFETs that complement the 5V gate drive of the LT8390 to achieve high efficiency. 40V MOSFETs are used on the input side of the four-switch topology while 25V MOSFETs are used on the output side. Ceramic capacitors are used at both the circuit input and output because of their small size and high ripple current capability. In addition to ceramic capacitors, there are four bulk aluminum polymer capacitors on the output. The input has four aluminum polymer capacitors.

The PCB has large copper planes and extensive vias for excellent high power thermal performance. There are four mounting holes on the board for optional heat sink and fan, which can push the output power of DC2431A up to 480W. For more details, please consult the factory for assistance.

The CTRL input is pulled up to the V_{REF} pin through a 0Ω resistor to set the output current limit to its maximum, and an external voltage on CTRL can be used to lower the current limit if the resistor is removed. A capacitor at the SS pin programs soft-start.

To improve the EMI performance, the LT8390 has spread spectrum frequency modulation. With the SYNC/SPRD pin tied to $INTV_{CC}$, LT8390 starts to spread its switching frequency ±15% around the programmed oscillator frequency.

The $\overline{PGOOD}$ status flag indicates when output voltage is within ±10% of final regulation voltage.

The LT8390's proprietary peak current mode buck-boost architecture ensures DC2431A runs either in discontinuous conduction mode (DCM) or pulse-skipping mode (PSM) without reversed inductor current. Both of them enhance the light load efficiency.

The demo circuit is designed to be easily reconfigured to many other applications, including the example schematics in the data sheet. Consult the factory for assistance.

High power operation, 4-switch buck-boost topology, proprietary peak current mode architecture, fault protection and full monitoring make the LT8390 attractive for high power voltage regulator circuits and also circuits that require output current regulation such as battery chargers. The LT8390EFE is available in a thermally enhanced 28-lead TSSOP package. The LT8390 data sheet must be read in conjunction with this demo manual to properly use or modify demo circuit DC2431A.

Design files for this circuit board are available at http://www.linear.com/demo/DC2431A

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PERFORMANCE SUMMARY Specifications are at T_A = 25°C

PARAMETER	CONDITIONS	MIN	TYP	MAX
Input Voltage Range (V_{IN})	V_{OUT} = 12V, I_{OUT} ≤ 25A	$9V_{DC}$		$36V_{DC}$
Output Voltage (V_{OUT})	R7 = 110k, R8 = 10k	$11.5V_{DC}$	$12.0V_{DC}$	$12.5V_{DC}$
Maximum Output Current	9V ≤ V_{IN} ≤ 36V, V_{OUT} = 12V	25A		
Switching Frequency	R5 = 309k		150kHz	
Efficiency	V_{IN} = 12V, V_{OUT} = 12V, I_{OUT} =10A		98%	
Input EN Voltage	R9 = 365k, R10 = 56.2k		$10V_{DC}$	
Input UVLO Voltage	R9 = 365k, R10 = 56.2k		$9V_{DC}$	
Output Current Limit	R3 = R4 = 6mΩ		33A	

LINEAR TECHNOLOGY
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QUICK START PROCEDURE

The DC2431A is easy to set up to evaluate the performance of the LT8390EFE. 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. Set JP1 at NO SSFM/SYNC to disable SSFM, or at SSFM ON to enable SSFM, or at EXT SYNC and tie EXT SYNC to external oscillator.
2. Connect the EN/UVLO terminal to ground with a clip-on lead. Connect the power supply (with power off), load, and meters as shown.
3. After all connections are made, turn on the input power and verify that the input voltage is between 9V and 36V.
4. 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.
5. 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.

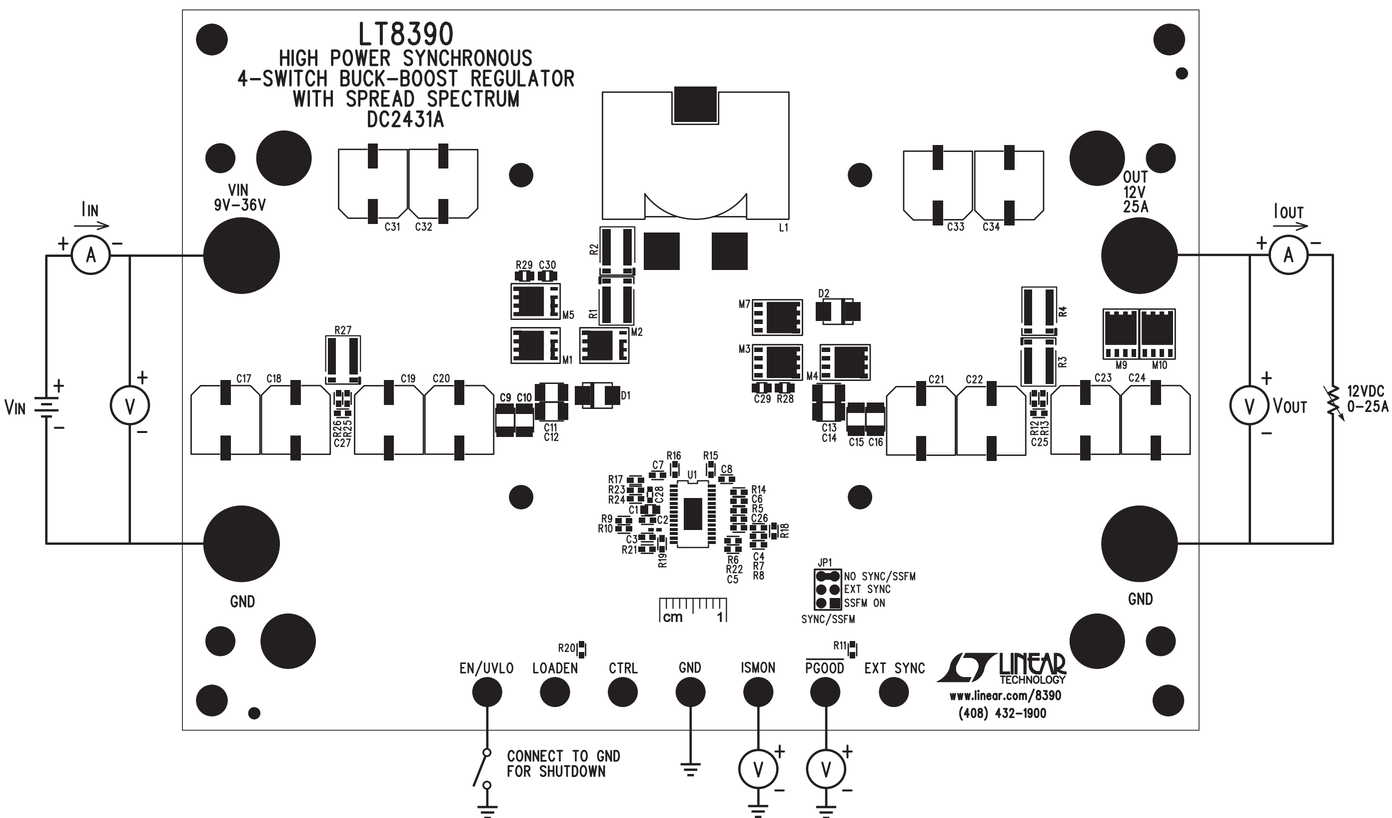

Figure 1. Test Procedure Setup Drawing for DC2431A

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TEST RESULTS

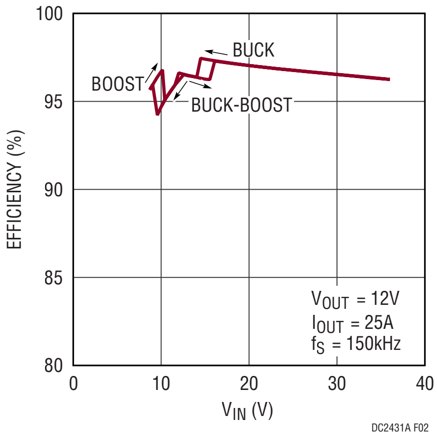

Figure 2. Efficiency vs V_{IN} at Full Load

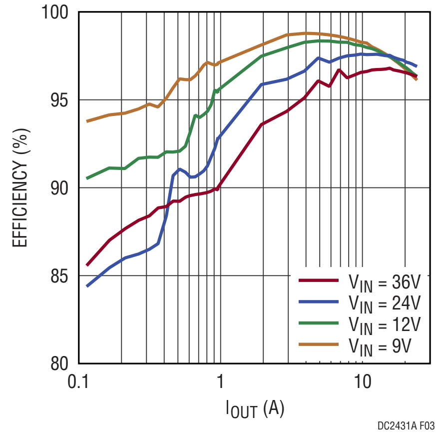

Figure 3. Efficiency vs I_{OUT} at Different V_{IN}

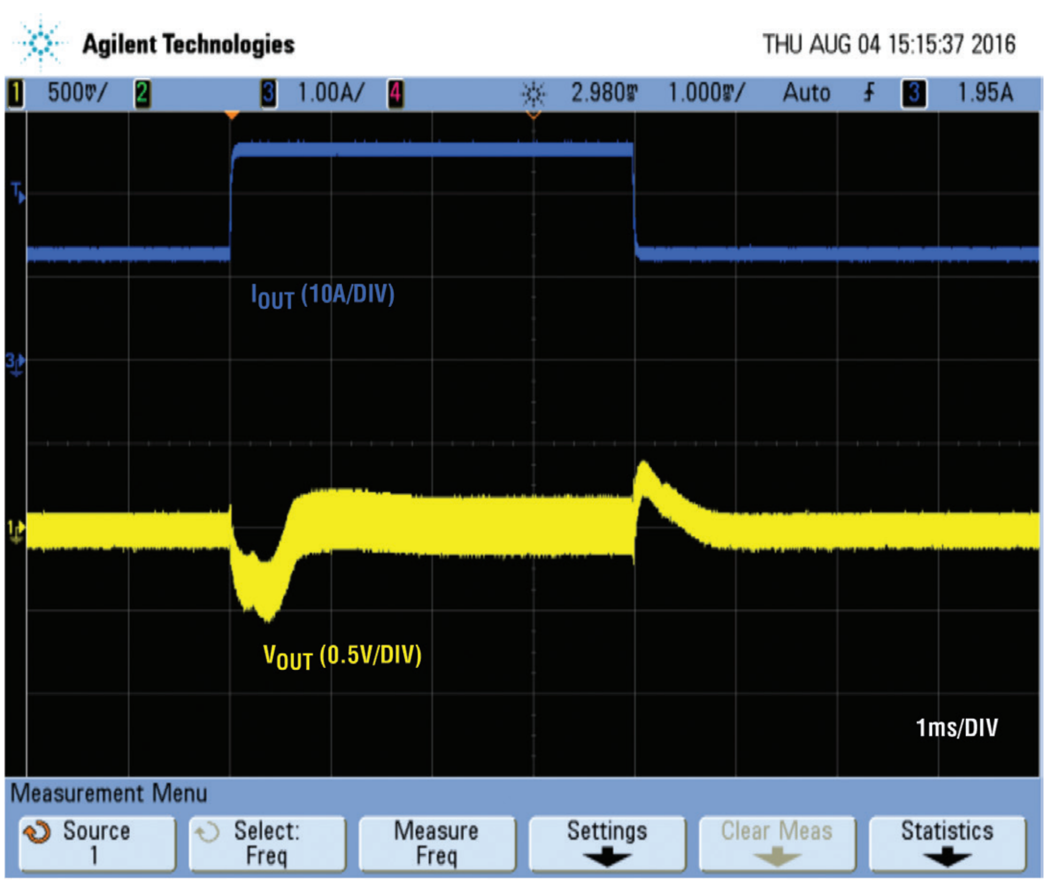

Figure 4. Output Voltage Load Transient Response, V_{IN} = 12V, V_{OUT} = 12V, I_{OUT} = 12.5A to 25A to 12.5A

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THERMAL IMAGE

An example thermal image shows the temperature distribution on the DC2431A. The test is done in still air at room temperature (25°C) at worst case (lowest V_{IN} at 4-switch buck-boost region). The highest temp is below 100°C, around power inductor winding, at V_{IN} = 9.5V, V_{OUT} = 12V, and 25A load current.

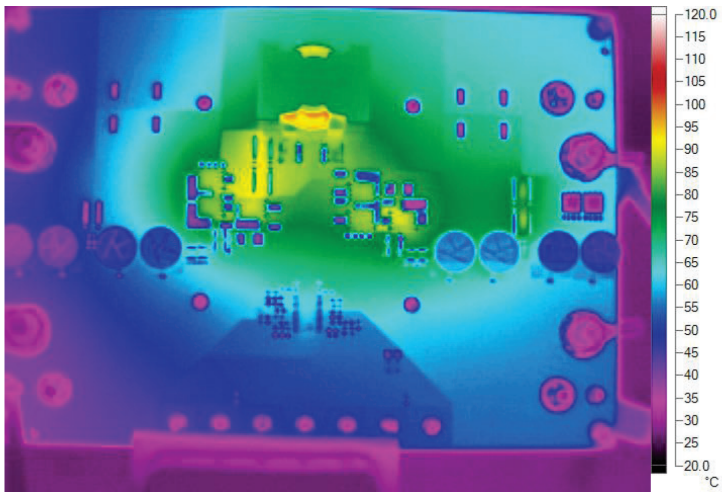

Figure 5. Temperature Rise at Worst Case (V_{IN} = 9.5V, V_{OUT} = 12V, I_{OUT} = 25A)

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	1	C1	CAP., 1µF, X7S, 100V, 10%, 0805	MURATA, GRJ21BC72A105KE11L
2	1	C2	CAP., 4.7µF, X5R, 10V, 10%, 0603	MURATA, GRM188R61A475KE15D
3	1	C3	CAP., 0.47µF, X7R, 16V, 10%, 0603	MURATA, GRM188R71C474KA88D
4	1	C4	CAP., 0.015µF, X7R, 16V, 10%, 0603	MURATA, GRM188R71C153KA01D
5	3	C5, C7, C8	CAP., 0.1µF, X7R, 16V, 10%, 0603	MURATA, GRM188R71C104KA01D
6	2	C6, C25	CAP., 1µF, X7R, 25V, 10%, 0603	MURATA, GRM188R71E105KA12D
7	4	C9, C10, C11, C12	CAP., 10µF, X7R, 50V, 10%, 1210	MURATA, GRM32ER71H106MA12L
8	4	C13, C14, C15, C16	CAP., 47µF, X5R, 16V, 10%, 1210	MURATA, GRM32ER61C476KE15K
9	4	C17, C18, C19, C20	CAP., ALUM, 180µF, 50V, 20%, 10mm × 12.7mm	NICHICON, PCR1H181MCL1GS
10	4	C21, C22, C23, C24	CAP., ALUM, 560µF, 16V, 20%, 10mm × 12.5mm	SUNCON ELECTRONIC, 16HVH560M
23	1	L1	IND., 3.3µH	COILCRAFT, SER2915L-332KL
24	2	M1, M5	XSTR., MOSFET, N-CH, 40V, TDSON-8	INFINEON, BSC014N04LSI
25	1	M2	XSTR., MOSFET, N-CH, 40V, TDSON-8	INFINEON, BSC010N04LSI
26	2	M3, M7	XSTR., MOSFET, N-CH, 25V, TDSON-8	INFINEON, BSC015NE2LS5I
27	1	M4	XSTR., MOSFET, N-CH, 25V, TDSON-8	INFINEON, BSC009NE2LS5I
29	2	R1, R2	RES., SENSE, 0.002Ω, 3W, 2%, 1225	SUSUMU, KRL6432E-M-R002-G-T1
30	2	R3, R4	RES., SENSE, 0.006Ω, 3W, 2%, 1225	SUSUMU, KRL6432E-M-R006-G-T1

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PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
31	1	R5	RES., 309k, 1/10W, 1%, 0603	VISHAY, CRCW0603309KFKEA
32	1	R6	RES., 15k, 1/10W, 1%, 0603	VISHAY, CRCW060315K0FKEA
33	1	R7	RES., 110k, 1/10W, 1%, 0603	VISHAY, CRCW0603110KFKEA
34	1	R8	RES., 10k, 1/10W, 1%, 0603	VISHAY, CRCW060310K0FKEA
35	1	R9	RES., 365k, 1/10W, 1%, 0603	VISHAY, CRCW0603365KFKEA
36	1	R10	RES., 56.2k, 1/10W, 1%, 0603	VISHAY, CRCW060356K2FKEA
37	1	R11	RES., 100k, 1/10W, 1%, 0603	VISHAY, CRCW0603100KFKEA
38	2	R12, R13	RES., 10Ω, 1/10W, 1%, 0603	VISHAY, CRCW060310R0FKEA
43	1	U1	I.C., VOLTAGE REGULATOR, 28-TSSOP	LINEAR TECH., LT8390EFE#PBF
Optional Electronic Components				
39	7	R14, R15, R16, R17, R18, R19, R20	RES., 0Ω, 1/10W, 0603	VISHAY, CRCW06030000Z0EA
40	0	R21, R22, R23, R24, R25, R26 (OPT)	RES., OPTION, 0603	
41	0	R27 (OPT)	RES., OPTION, 1225	
42	0	R28, R29 (OPT)	RES., OPTION, 0805	
11	0	C26, C27, C28 (OPT)	CAP., OPTION, 0603	
12	0	C29, C30 (OPT)	CAP., OPTION, 0805	
13	0	C31, C32, C33, C34 (OPT)	CAP., OPTION, ALUM	
28	0	M9, M10 (OPT)	XSTR., MOSFET, OPTION, TDSON-8	
14	0	D1, D2 (OPT)	DIODE., OPTION, SMB	
Hardware				
15	11	E1, E2, E3, E4, E5, E6, E7, E8, E9, E10, E11	TEST POINT, TURRET, .094 MTG. HOLE	MILL-MAX, 2501-2-00-80-00-00-07-0
16	1	JP1	CONN., HEADER, 2 × 3, 2mm	WURTH ELEKTRONIK, 62000621121
17	1	XJP1	SHUNT, 2mm	WURTH ELEKTRONIK, 60800213421
18	4	J1, J2, J3, J4	CONN., JACK, BANANA, 0.218	KEYSTONE, KEY-575-4
19	4	J5, J6, J7, J8	STUD, TEST PIN	PEM KFH-032-10
20	8	(J5, J6, J7, J8)	NUT, BRASS NUTS # 10-32	ANY #10-32
21	4	(J5, J6, J7, J8)	RING, LUG RING # 10	KEYSTONE #10
22	4	(J5, J6, J7, J8)	WASHER, TIN PLATED BRASS	ANY #10

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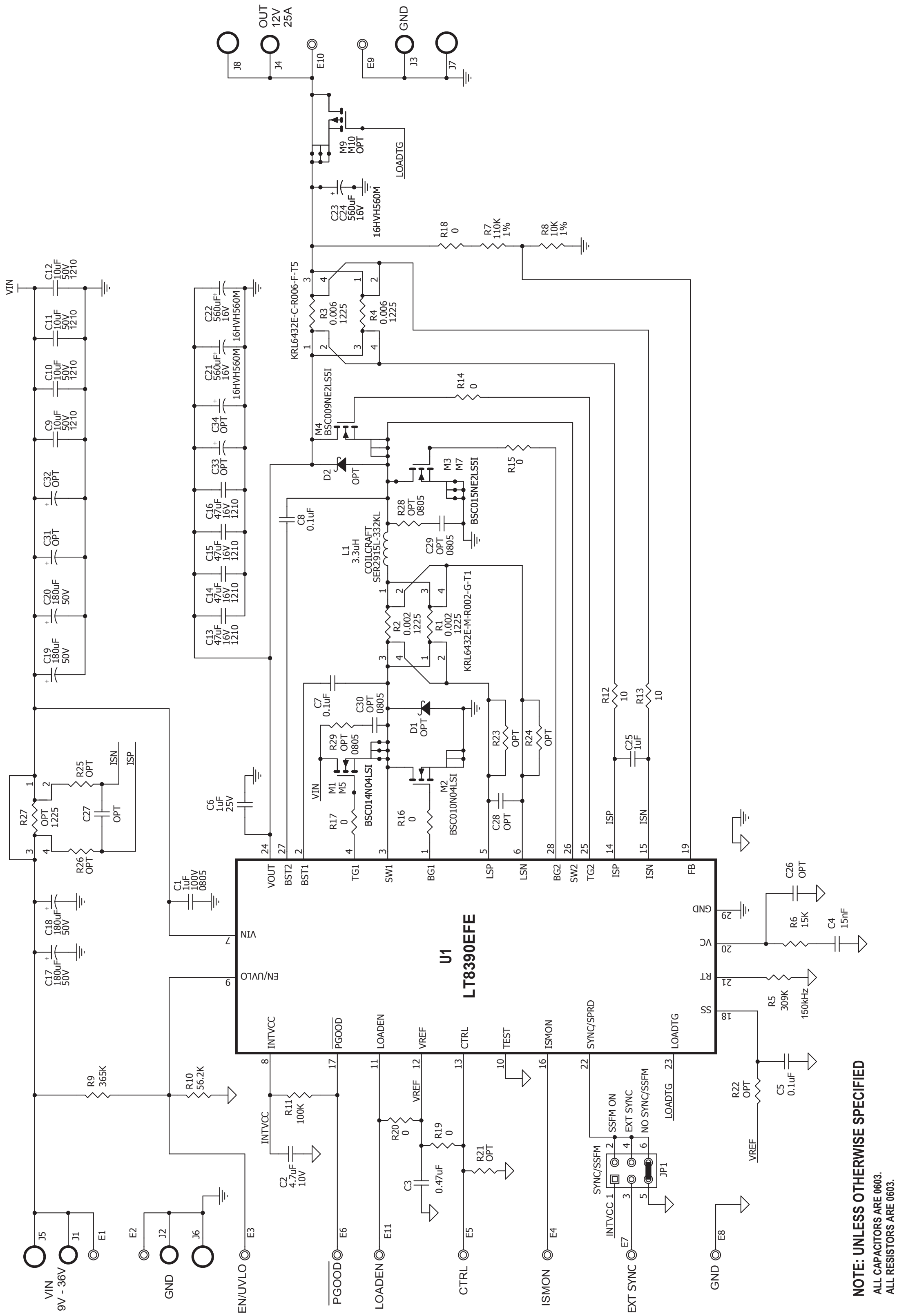
SCHEMATIC DIAGRAM



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Mailing Address:

Linear Technology

1630 McCarthy Blvd.

Milpitas, CA 95035

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Linear Technology Corporation
1630 McCarthy Blvd., Milpitas, CA 95035-7417
(408) 432-1900 ● FAX: (408) 434-0507 ● www.linear.com

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