LTC3789EGN 300W 2-Phase Interleaved Synchronous Buck-Boost Converter

DESCRIPTION

Demonstration circuit 2253A is a high power, high efficiency, 2-phase interleaved synchronous buck-boost converter with a 6V to 36V input range. It can supply a 25A maximum load current with a 12V output. This demo board features 2x LTC3789EGN controllers.

The LTC®3789 is a high performance current-mode buck-boost switching regulator controller that operates from input voltages above, below or equal to the output voltage, while an output current feedback loop provides support for output current limit and battery charging. With a wide 4V to 38V (40V maximum) input and output range and seamless, low noise transitions between operating regions, the LTC3789 is ideal for automotive, telecom and battery-powered systems.

The light load operating mode of the controller is determined through the MODE/PLLIN pin. By default, the forced continuous mode (CCM) operation is pre-selected on this demo board. Switching frequency is preset at about 200kHz. Two paralleling schemes are available for this demo board and by default the method of shared I_{TH} pins is adopted. Please refer to the Quick Start Procedure section for the optional Master-Slave paralleling scheme. To shut down the converter, force the RUN pin below 1.2V (JP1: OFF) Please refer to LTC3789 data sheet for more detailed information.

Design files for this circuit board are available at http://www.linear.com/demo/DC2253A

PERFORMANCE SUMMARY

Specifications are at T_A = 25°C

PARAMETER	CONDITION	VALUE
Input Voltage Range		6V to 36V
Output Voltage, V_{OUT}	V_{IN} = 6V to 36V, I_{OUT} = 0A to 25A	12V ±2%
Maximum Output Current, I_{OUT}	V_{IN} = 6V to 36V, V_{OUT} = 12V	25A
Typical Output Ripple	V_{IN} = 36V, I_{OUT} = 25A (20MHz BW) V_{IN} = 12V, I_{OUT} = 25A (20MHz BW) V_{IN} = 6V, I_{OUT} = 25A (20MHz BW)	$36mV_{P-P}$ $200mV_{P-P}$ $380mV_{P-P}$
Typical Efficiency	V_{IN} = 12V, V_{OUT} = 12V, I_{OUT} = 25A, see Figure 3	97.8%
Typical Switching Frequency		200kHz

QUICK START PROCEDURE

Demonstration circuit 2253A is easy to set up to evaluate the performance of the LTC3789EGN. Refer to Figure 1 for the proper measurement equipment setup and follow the procedure below:

1. With power off, connect the input power supply to V_{IN} (6V to 36V) and GND (input return).
2. Connect the 12V output load between V_{OUT} and GND (Initial load: no load).
3. Connect the DVMs to the input and output. Set the default jumper position, JP1: ON.
4. Turn on the input power supply and check for the proper output voltages. V_{OUT} should be 12V ±2%.
5. Once the proper output voltages are established, adjust the loads within the operating range and observe the output voltage regulation, ripple voltage and other parameters.

Note: When measuring the output or input voltage ripple, do not use the long ground lead on the oscilloscope probe. See Figure 2 for the proper scope probe technique. Short, stiff leads need to be soldered to the (+) and (–) terminals of an output capacitor. The probe's ground ring needs to touch the (–) lead and the probe tip needs to touch the (+) lead.

Optional Master-Slave Paralleling Scheme

Besides the default paralleling scheme by tying the I_{TH} pins together, another optional Master-Slave scheme can be achieved on the demo board to obtain a better sharing of the inductor currents and output currents between phases. Please refer to the schematic in Page 8. To implement it,

1. Remove R67, R69 and R70.
2. Populate R68, R71 with 0Ω.
3. Set R_{FB3} 5~10% higher than R_{FB1} and set $R_{FB4} = R_{FB2}$.
4. Choose the current reference divider R65 and R66 so that when the Vout is regulated, the voltage drop on R65 is equal to V_{ILIM}, where V_{ILIM} is the output current limit threshold voltage. For example, when I_{LIM} pin is grounded, V_{ILIM} = 50mV. For V_{OUT} = 12V, select R65 = 100Ω and R66 = 24kΩ and then the voltage drop on R65 will be 50mV.

QUICK START PROCEDURE

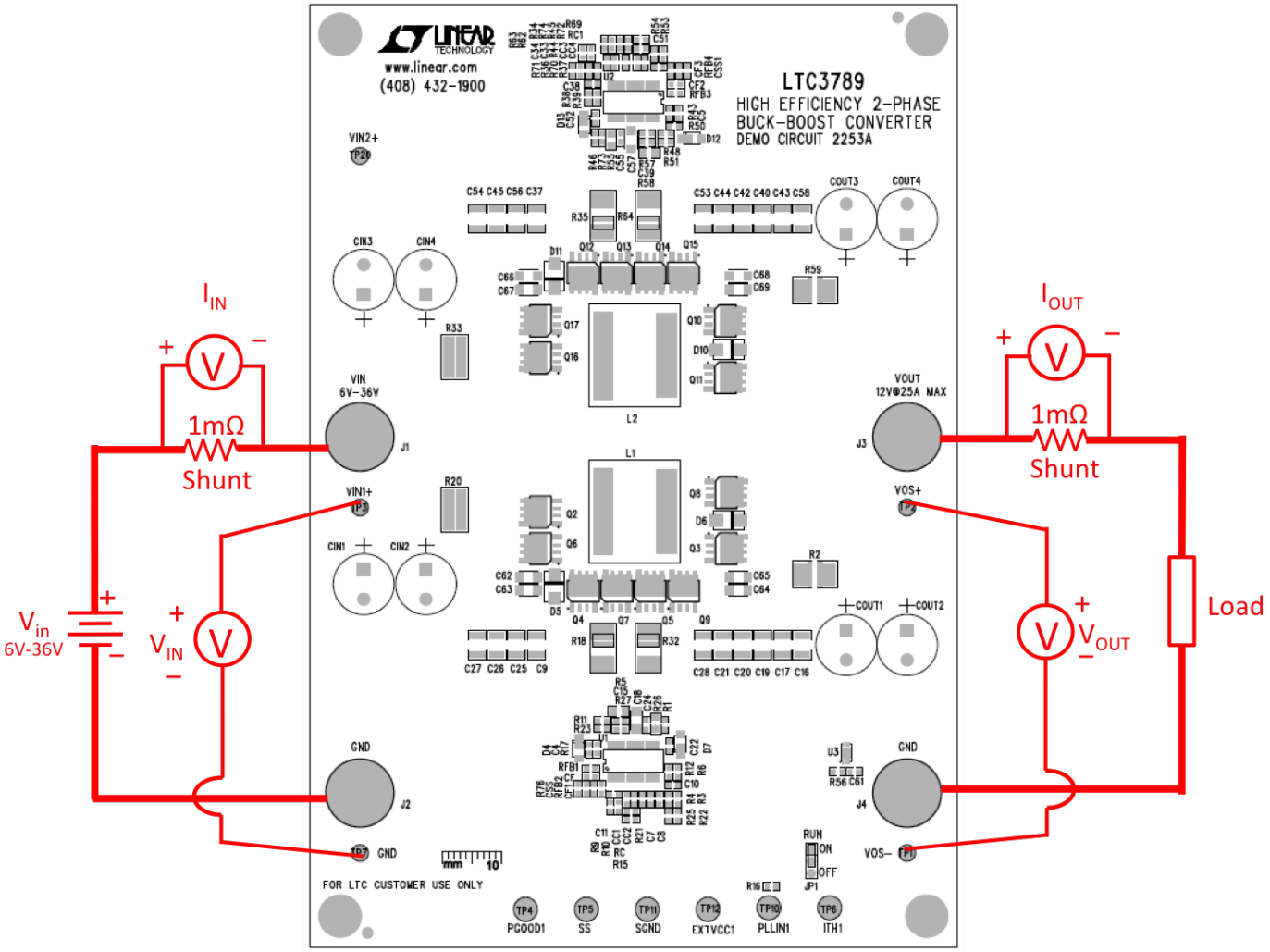


Figure 1. Proper Measurement Equipment Setup

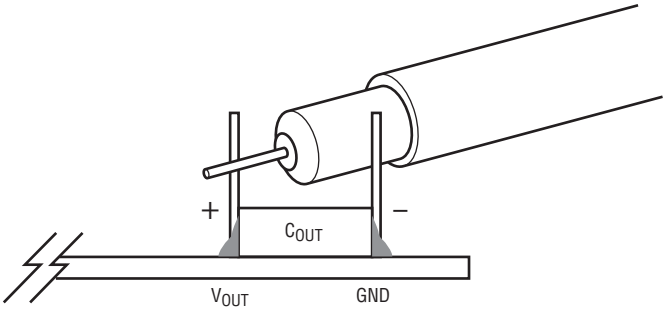


Figure 2. Measuring Output Voltage Ripple

QUICK START PROCEDURE

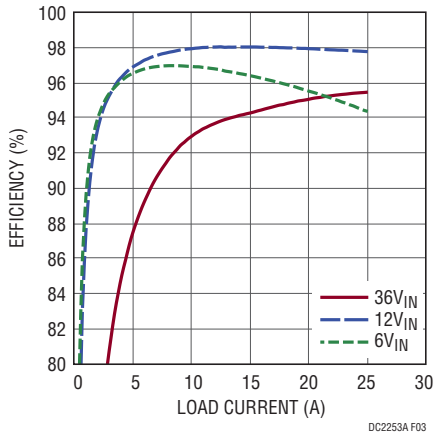


Figure 3. Efficiency vs Load Current (V_{OUT} = 12V, CCM)

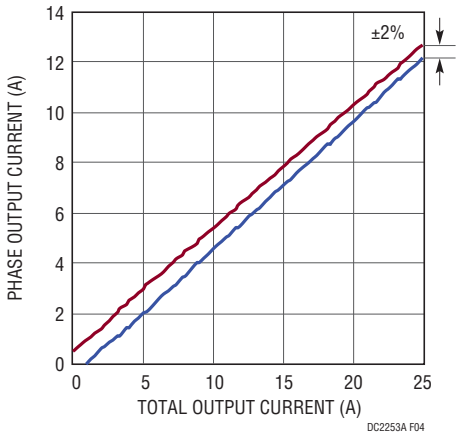


Figure 4. Output Current Sharing (V_{IN} = 6V, V_{OUT} = 12V)

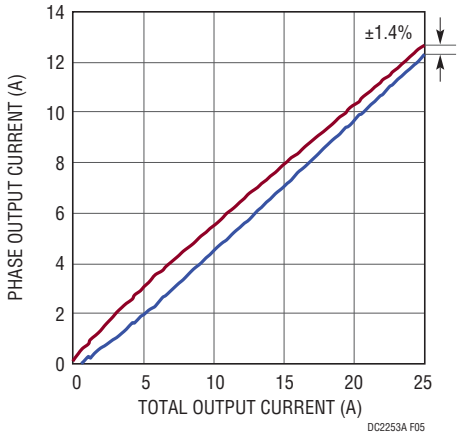


Figure 5. Output Current Sharing (V_{IN} = 12V, V_{OUT} = 12V)

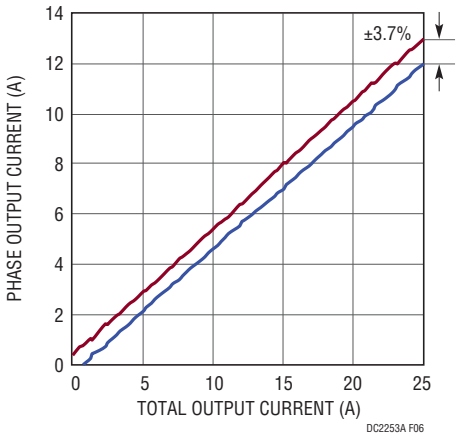


Figure 6. Output Current Sharing (V_{IN} = 36V, V_{OUT} = 12V)

QUICK START PROCEDURE

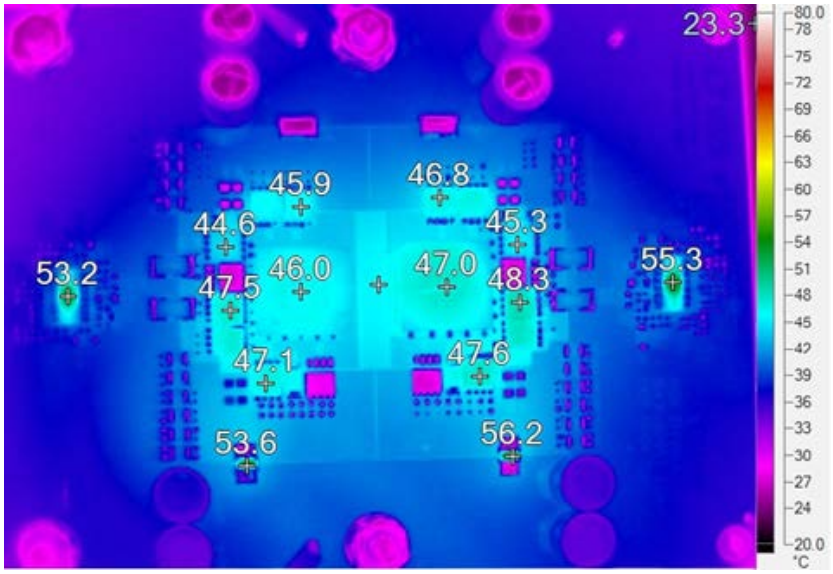


Figure 7. Thermal Performance (V_{IN} = 12V, V_{OUT} = 12V, 25A Load, No Air Flow)

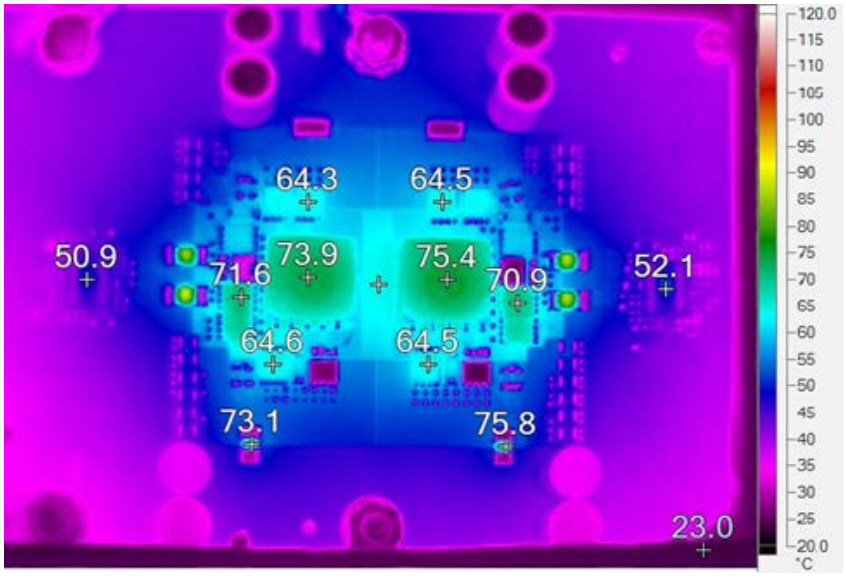


Figure 8. Thermal Performance (V_{IN} = 6V, V_{OUT} = 12V, 25A Load, 200LFM)

QUICK START PROCEDURE

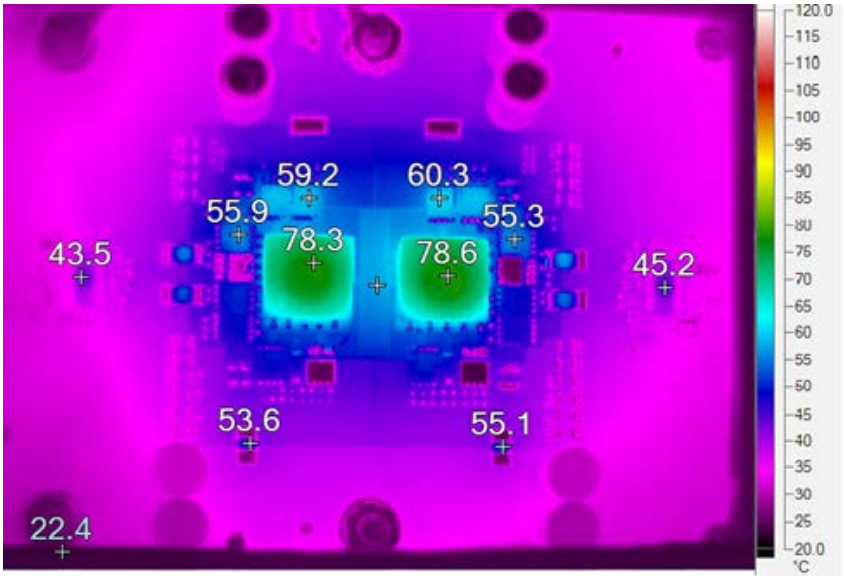


Figure 9. Thermal Performance (V_{IN} = 36V, V_{OUT} = 12V, 25A Load, 200LFM)

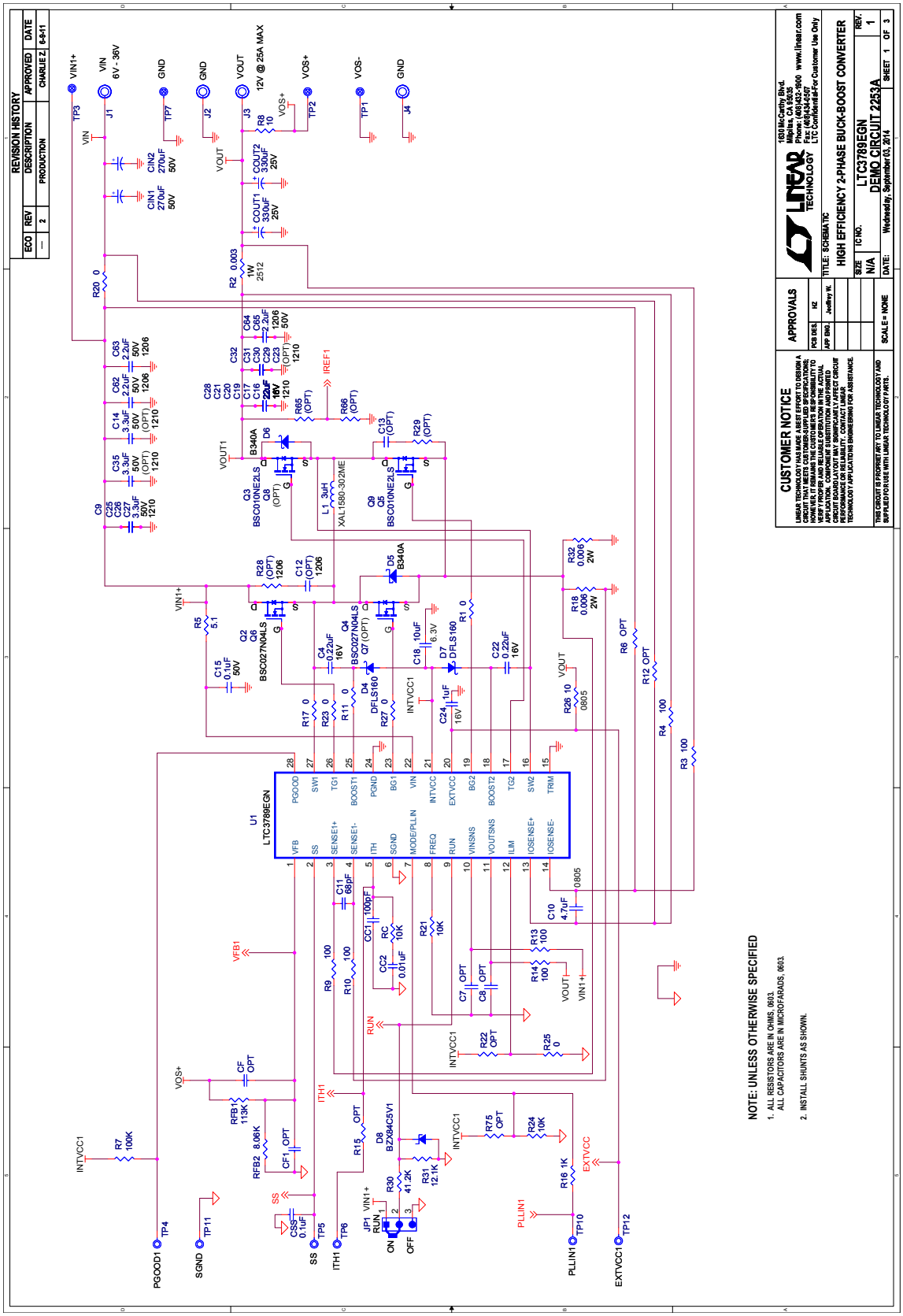
PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
1	2	CC1, CC4	CAP., C0G, 100pF, 50V, 10% 0603	AVX, 06035A101KAT2A
2	2	CC2, CC3	CAP., X7R, 0.01µF, 50V, 10% 0603	AVX, 06035C103KAT2A
3	5	CSS1, C15, C39, C61, CSS	CAP., X7R, 0.1µF, 50V, 10% 0603	AVX, 06035C104KAT2A
4	0	CF1, CF2, CF3, C7, C8, CF, C23	CAP., 0603 OPTIONAL	
5		C29, C30, C31-C34		
6		C12, C13, C59, C60	CAP., 1206 OPTIONAL	
7		C14, C35, C36, C41, C46-C50	CAP., 1210 OPTIONAL	
8	4	C62, C63, C66, C67	CAP., X7R, 2.2µF, 50V, 10% 1206	KEMET C1206C225K5RACTU
9	4	C64, C65, C68, C69	CAP., X7R, 2.2µF, 25V, 10% 1206	AVX 12063C225KAT2A
10	2	C11, C51	CAP., NPO, 68pF, 50V, 10% 0603	AVX, 06035A680KAT2A
11	2	C10, C38	CAP., X5R, 4.7µF, 10V, 10% 0603	AVX, 0603ZD475KAT2A
12	2	C24, C55	CAP., X7R, 1µF, 16V, 20% 0603	AVX, 0603YC105MAT2A
13	4	CIN1, CIN2, CIN3, CIN4	CAP., ALUM, 270µF, 50V, 20%	SUN ELECTRONICS, 50ME270WX+T
14	4	COUT1, COUT2, COUT3, COUT4	CAP., OS-CON, 330µF, 25V, 20%	SANYO, 25SEPF330M
15	12	C16, C17, C19, C20, C21, C28	CAP., X7R, 22µF, 16V, 20% 1210	AVX, 1210YC226MAT2A
16		C40, C42, C43, C44, C53, C58		
17	4	C4, C5, C22, C52	CAP., X7R, 0.22µF, 16V, 20% 0603	AVX, 0603YC224MAT2A
18	8	C9, C25, C26, C27	CAP., X7R, 3.3µF, 50V, 20% 1210	AVX, 12105C335MAT2A
19		C37, C45, C54, C56		
20	2	C18, C57	CAP., X5R, 10µF, 6.3V, 20% 1206	AVX, 12066D106MAT2A
21	4	D4, D7, D12, D13	DIODE, SCHOTTKY 1A 60V POWERDI123	DIODE INC., DFLS160-7
22	4	D5, D6, D10, D11	DIODE, SCHOTTKY 3A 40V SMA	DIODE INC., B340A-13-F
23	1	D8	DIODE, ZENER 5.1V 350MW SOT23-3	DIODE INC., BZX84C5V1-7-F
24	1	JP1	HEADER, 3 PIN 0.079 SINGLE ROW	SAMTEC, TMM-103-02-L-S
25	1	XJP1	SHUNT, .079" CENTER	SAMTEC, 2SN-BK-G
26	4	J2, J4, J5, J6	STUD, TESTPIN	PEM KFH-032-10
27	8	J1, J2, J3, J4 (x2)	NUT, BRASS 10-32	ANY #10-32
28	4	J1, J2, J3, J4	RING, LUG #10	KEYSTONE, 8205, #10
29	4	J1, J2, J3, J4	WASHER, TIN PLATED BRASS	ANY #10, #10EXT BZ TN
30	2	L1, L2	INDUCTOR, 3µH	COILCRAFT LNC. XAL1580-302ME
31	6	Q2, Q4, Q6, Q16, Q17, Q12	MOSFET N-CHANNEL	INFINEON, BSC027N04LS
32	6	Q3, Q5, Q10, Q15, Q9, Q14	MOSFET N-CHANNEL	INFINEON, BSC010NE2LS
33	0	Q7, Q8, Q11, Q13 OPT		
34	1	RFB1	RES., CHIP., 113k, 0.1W, 1% 0603	YAGEO, RC0603FR-07113KL
35	1	RFB2	RES., CHIP., 8.06k, 0.1W, 1% 0603	YAGEO, RC0603FR-078K06L
36	4	R18, R32, R35, R64	RES., CHIP., 0.006Ω, 2W, 1% 2512	SUSUMU., KRL3264E-C-R006
37	2	R2, R59	Sense RES 0.003Ω 1W 1% 2512 SMD	YAGEO, PR2512FKF070R003L
38	12	R3, R4, R9, R10, R13, R14, R36	RES., CHIP., 100Ω, 0.1W, 1% 0603	YAGEO, RC0603FR-07100RL
39		R37, R40, R41, R53, R54		
40	2	R5, R58	RES., CHIP, 5.1Ω, 0.1W, 5% 0805	YAGEO, RC0805JR-075R1L
41	0	R6, R12, R15, R22, R28, R29, R38, R39	RES., 0603, OPTIONAL	
42		R63, R68, R71, R74, R75, R65, R66, R73		

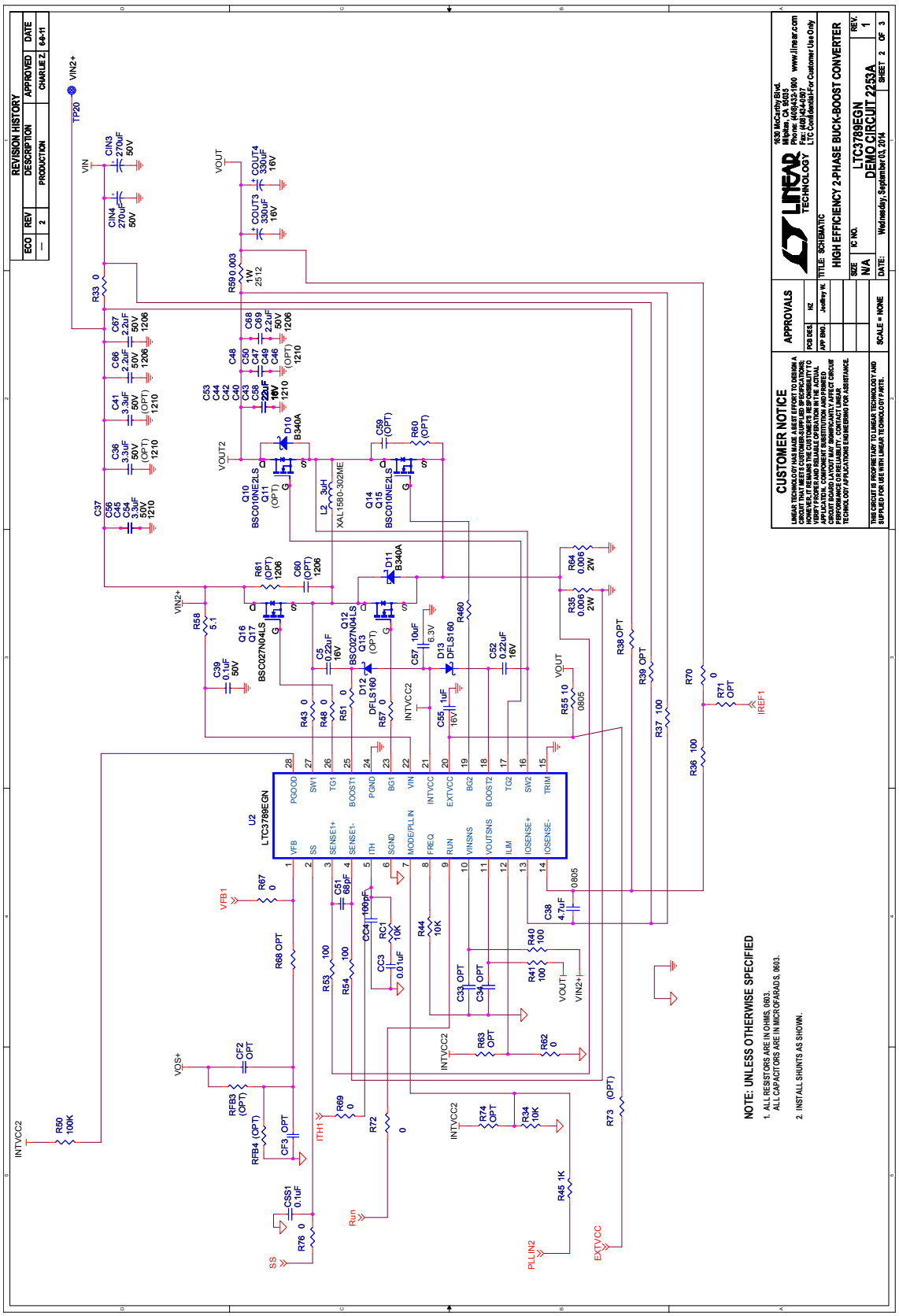
PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
43		RFB3, RFB4		
44		R28, R29, R60, R61	RES., 1206, OPTIONAL	
45	2	R7, R50	RES., CHIP., 100k, 0.1W, 1% 0603	YAGEO, RC0603FR-07100KL
46	1	R8	RES., CHIP., 10Ω, 0.1W, 5% 0603	YAGEO, RC0603JR-0710RL
47	2	R26, R55	RES., CHIP., 10Ω, 0.1W, 5% 0805	YAGEO, RC0805JR-0710RL
48	17	R1, R11, R17, R23, R25	RES., CHIP., 0Ω 1% 0603	YAGEO, RC0603FR-070RL
49		R27, R43, R46, R48, R51, R76		
50		R57, R62, R67, R69, R70, R72		
51	1	R20, R33	RES., CHIP., 0Ω 2512	TEPRO, RN5326
52	2	R16, R45	RES., CHIP., 1k, 0.1W, 1% 0603	YAGEO, RC0603FR-071KL
53	6	RC1, R21, R24, R34, R44, RC	RES., CHIP., 10k, 0.1W, 1% 0603	YAGEO, RC0603FR-0710KL
54	1	R30	RES., CHIP., 41.2k, 0.1W, 1% 0603	YAGEO, RC0603FR-0741K2L
55	1	R31	RES., CHIP., 12.1k, 0.1W, 1% 0603	YAGEO, RC0603FR-0712K1L
56	1	R56	RES., CHIP., 499k, 0.1W, 1% 0603	YAGEO, RC0603FR-07499KL
57	5	TP1, TP2, TP3, TP7, TP20	TESTPOINT, TURRET, .061" PBF	MILL-MAX, 2308-2-00-80-00-00-07-0
58	6	TP4, TP5, TP6, TP10-TP12	TESTPOINT, TURRET, .094" PBF	MILL-MAX, 2501-2-00-80-00-00-07-0
59	2	U1, U2	I.C.,LTC3789EGN SSOP N	LINEAR TECH., LTC3789EGN#PBF
60	1	U3	I.C.,LTC6908CDCB-1 2mm × 3mm	LINEAR TECH., LTC6908CDCB-1
61	4	MTGS AT 4 CORNERS	STAND-OFF, NYLON 0.5"	KEYSTONE, 8833 (SNAP ON)
62	1		FAB, PRINTED CIRCUIT BOARD	DEMO CIRCUIT FT228A
63	2	STENCILS	STENCIL BOTH SIDES	STENCIL FT228A

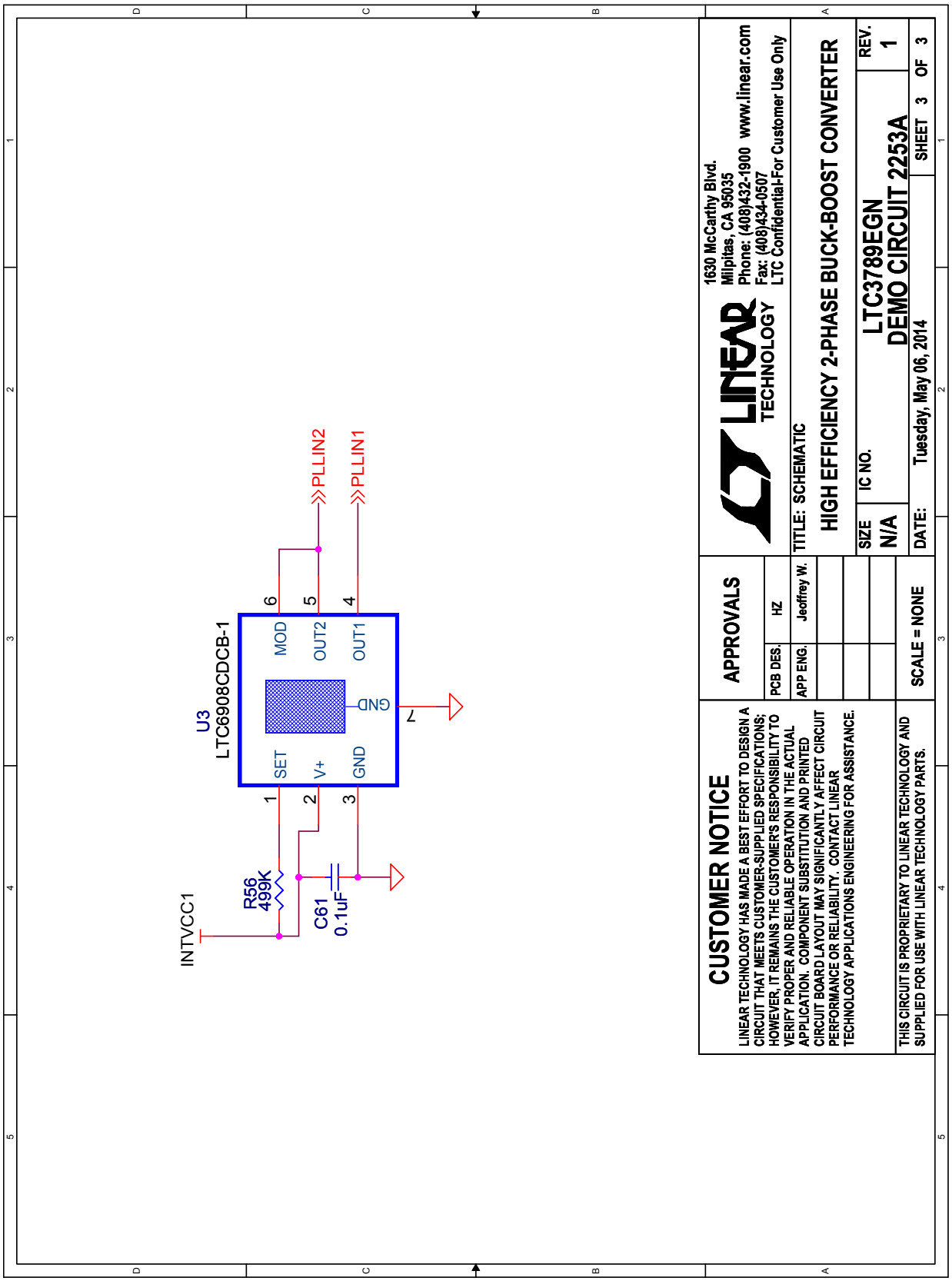
SCHEMATIC DIAGRAM



SCHEMATIC DIAGRAM



SCHEMATIC DIAGRAM



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