LTC3774EUHE
High Efficiency Dual Output Step-Down Converter with Very Low DCR Inductor

DESCRIPTION

Demonstration circuit DC2002A is a dual output synchronous buck converter featuring the LTC3774EUHE. The demo board supplies two rails of 1.5V / 30A and 1.2V / 30A.

The power stage for each rail consists of a 0.33µH 0.32mΩ DCR inductor with a 11mm × 11mm footprint and a 6mm × 6mm DrMOS driven by the PWM outputs of the LTC3774EUHE at a switching frequency of 400kHz. The inductor, DrMOS and the local ceramic input and output capacitors forms the core converter which occupies a 1.1″ × 1.1″ area on the top layer. The control circuit is directly underneath on the bottom layer and occupies an area of 0.9″×1.1″. The result is a two sided core converter with a current density of 50A per square inch and a full load efficiency of 91.1% for the 1.5V rail and 90.0% for the 1.2V rail.

Additional features of this demo board include:

- Remote Sensing for Each Output
- PLLIN and CLKOUT Pins
- PGOOD, RUN and TRK/SS Pins for Each Output
- Optional Resistors to Tie the Two Outputs Together
- Optional Footprint for Hot Swap™ FET on the Input of Each Phase for MOSFET Failure Protection
- Optional Footprint for an LTC4449 Gate Driver and Discrete MOSFETs
- Optional Footprint for a Dual Phase Delta Power Block

Design files for this circuit board are available at http://www.linear.com/demo/DC2002A

PERFORMANCE SUMMARY

Specifications are at T_A = 25°C, No Airflow

PARAMETER	CONDITIONS	VALUE
Minimum Input Voltage		7V
Maximum Input Voltage		14V
Output Voltage V_{OUT1}	I_{OUT1} = 0A TO 30A, V_{IN} = 7V to 14V	1.5V ±2%
Output Voltage V_{OUT2}	I_{OUT2} = 0A TO 30A, V_{IN} = 7V to 14V	1.2V ±2%
V_{OUT1} Maximum Output Current, I_{OUT1}	V_{IN} = 7V to 14V, V_{OUT1} = 1.5V	30A
V_{OUT2} Maximum Output Current, I_{OUT2}	V_{IN} = 7V to 14V, V_{OUT2} = 1.2V	30A
Nominal Switching Frequency		400kHz
Efficiency See Figures 2 and 3	V_{OUT1} = 1.5V, I_{OUT1} = 30A, V_{IN} = 12V	91.1% Typical
	V_{OUT2} = 1.2V, I_{OUT2} = 30A, V_{IN} = 12V	90.0% Typical

QUICK START PROCEDURE

Demonstration circuit 2002A is easy to set up to evaluate the performance of the LTC3774EUHE. Please refer to Figure 1 for proper measurement equipment setup and follow the procedure below.

1. With power off, connect the input supply, load and meters as shown in Figure 1. Preset the load to 0A and V_{IN} supply to be 0V. For both assemblies, place the jumpers in the following positions:

JP1	RUN1	ON
JP2	RUN2	ON
JP5	MODE	CCM

2. Adjust the input voltage to be between 7V and 14V. V_{OUT1} should be 1.5V ±2%.

   V_{OUT2} should be 1.2V ±2%.

3. Next, apply 30A load to each output and re-measure V_{OUT}.

4. Once the DC regulation is confirmed, observe the output voltage ripple, load step response, efficiency and other parameters.

   Note 1. Use the BNC connectors labeled V_{OUT1} or V_{OUT2} to measure the output voltage ripple.

   Note 2. Do not connect load from the V_{OS1}^+ turret to the V_{OS1}^- turret or from the V_{OS2}^+ turret to the V_{OS2}^- turret. This could damage the converter. Only apply load across the stud connectors on the edge of the board.

Dynamic Load Circuit (Optional)

Demonstration circuit 2002A provides a simple load step circuit consisting of a MOSFET and sense resistor for each rail. To apply a load step, follow the steps below.

1. Pre-set the amplitude of a pulse generator to 0.0V and the duty cycle to 5% or less.

2. Connect the scope to the V_{OUT1}/V_{OUT2} BNC connectors for the rail under test with a coax cable. To monitor the load step current, connect the scope probe across the ISTEP± turrets for that rail.

3. Connect the output of the pulse generator to the PULSE GEN turret for the rail under test and connect the return to the adjacent GND turret.

4. With the converter running, slowly increase the amplitude of the pulse generator output to provide the desired load step pulse height. The scaling for the load step signal is 5mV/Amp.

Single Output/Dual Phase Operation

A single output/dual phase converter may be preferred for higher output current applications. The optional components required to tie the phases together are found on the lower left of the 1st sheet. To tie the two outputs together, make the following modifications:

1. Tie the two V_{OUT} shapes together with a piece of copper or a 0mΩ jumper at R47 and R36. One part to consider is Tepro RN5326.

2. Tie V_{OSNS1} to V_{OSNS2} by stuffing a 0Ω resistor at R53 and tie V_{OS1}^- to V_{OS2}^- by stuffing a 0Ω resistor at R92.

3. Tie ITH1 to ITH2 by stuffing a 0Ω resistor at R68.

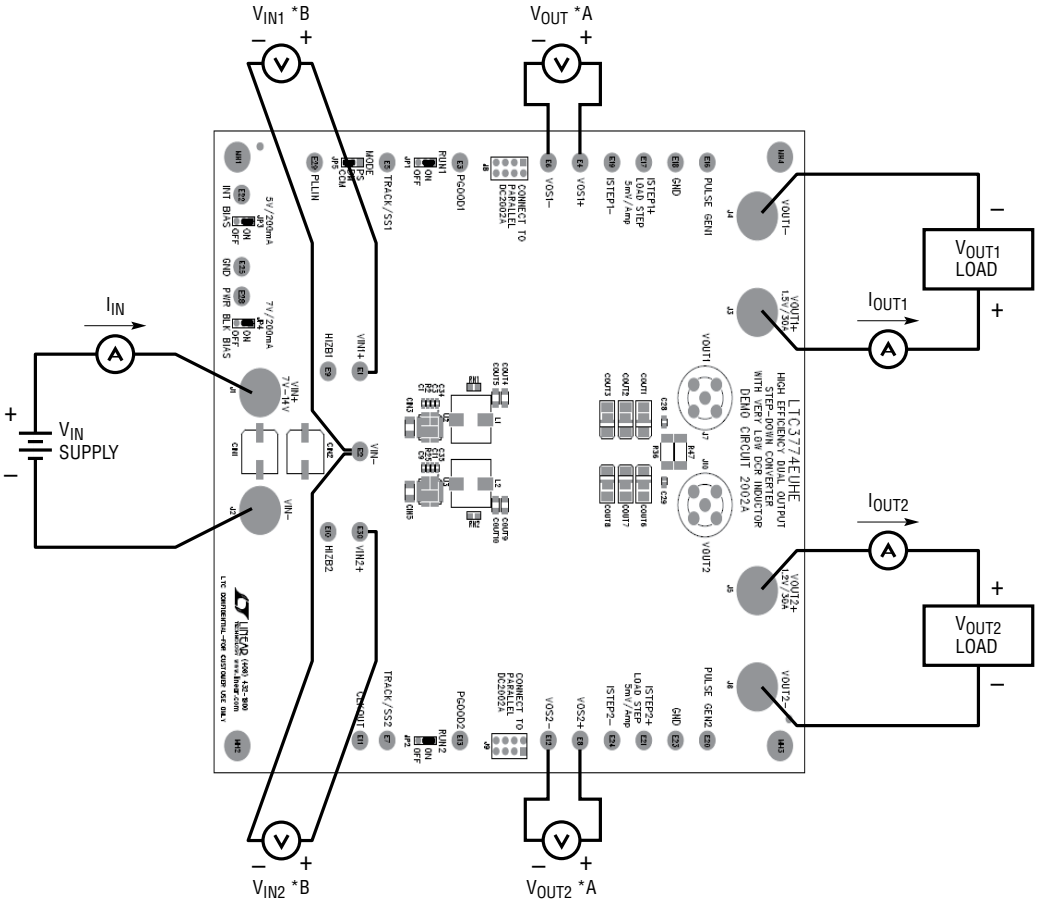
4. Tie RUN1 to RUN2 by stuffing a 0Ω resistor at R54.

5. Tie TK/SS1 to TK/SS2 by stuffing a 0Ω resistor at R48.

Paralleling Boards

Up to 6 DC2002A demo boards can be paralleled to produce a single output, 12 phase converter. To connect two or more DC2002A boards together, first tie the two phases together as described in the Single Output/Dual Phase Operation section. Next, place the boards side by side such that header J8 of one board mates with socket J9 of the other. This will connect the common control signals together which are the V_{OSNS}, V_{OS}^-, ITH, RUN and TK/SS signals. It will also tie the CLKOUT signal of one phase to the PLLIN input of the other phase. Next, tie the V_{OUT}, V_{IN} and GND of the boards together using the exposed copper on the edges of the board. Figure 6 shows how to tie 2 boards together for a single output, 4 phase converter.

QUICK START PROCEDURE



*A MONITOR THE OUTPUT VOLTAGE ACROSS EITHER COUT4 OR COUT9 FOR ACCURATE EFFICIENCY MEASUREMENTS.
*B MONITOR THE VOLTAGE AT VIN1 WHEN MEASURING THE EFFICIENCY OF PHASE 1 AND VIN2 WHEN MEASURING THE EFFICIENCY OF PHASE 2.

Figure 1. Proper Measurement Equipment Setup

QUICK START PROCEDURE

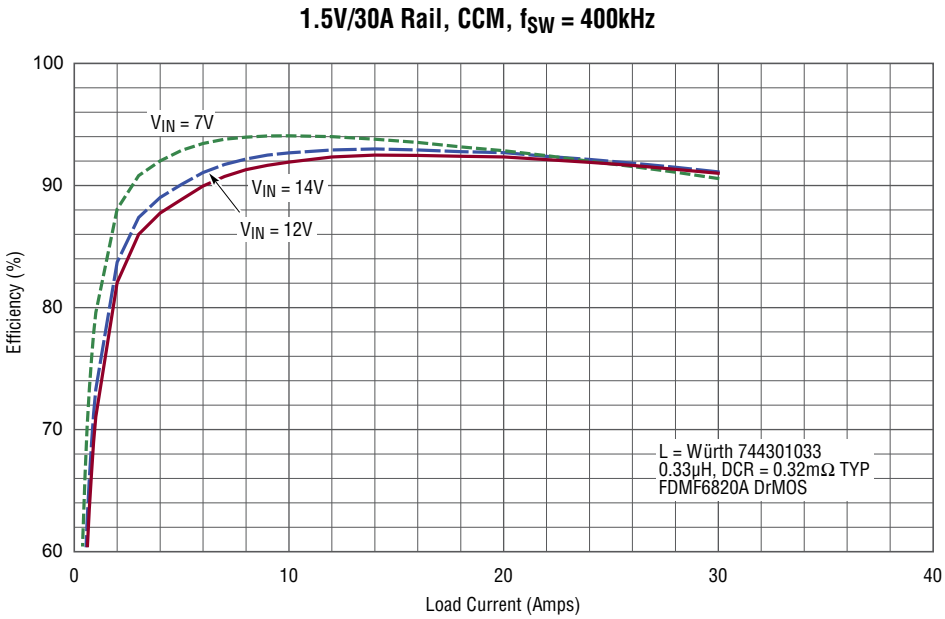


Figure 2. Efficiency Curves for the 1.5V Rail at V_{IN} = 12V, 14V and 7V in CCM.

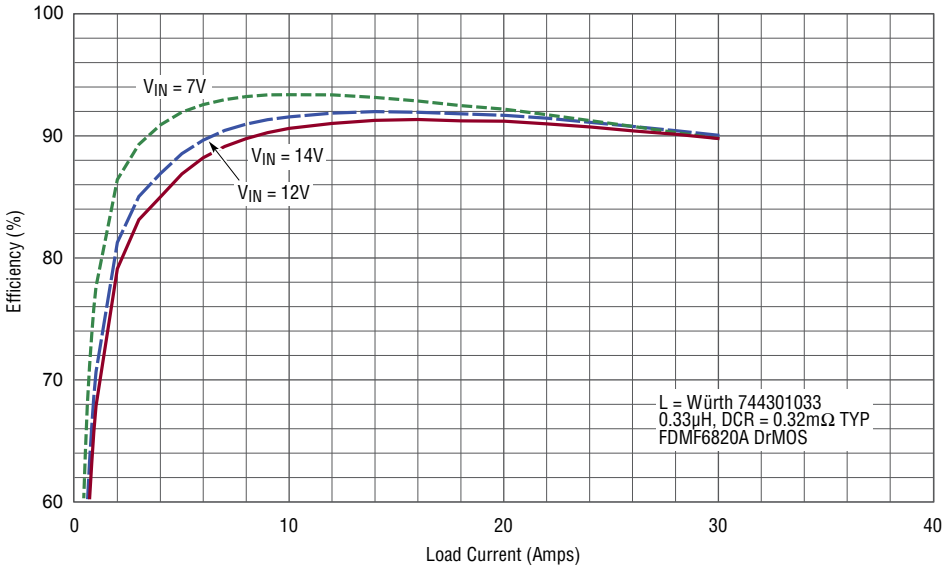


Figure 3. Efficiency Curves for the 1.2V Rail at V_{IN} = 12V, 14V and 7V in CCM.

QUICK START PROCEDURE

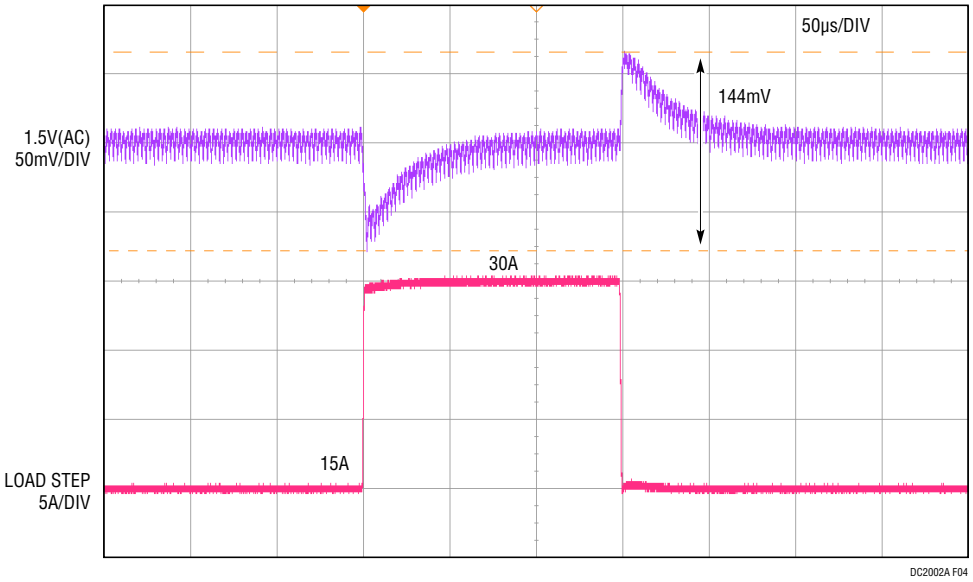


Figure 4. 50% to 100% to 50% Load Step Response of the 1.5V Rail. C_{OUT} = 3× Sanyo 2R5TPE330M9 || 2× 100µF X5R 1206, L = Würth 744301033 (0.33µH), f_{SW} = 400kHz.

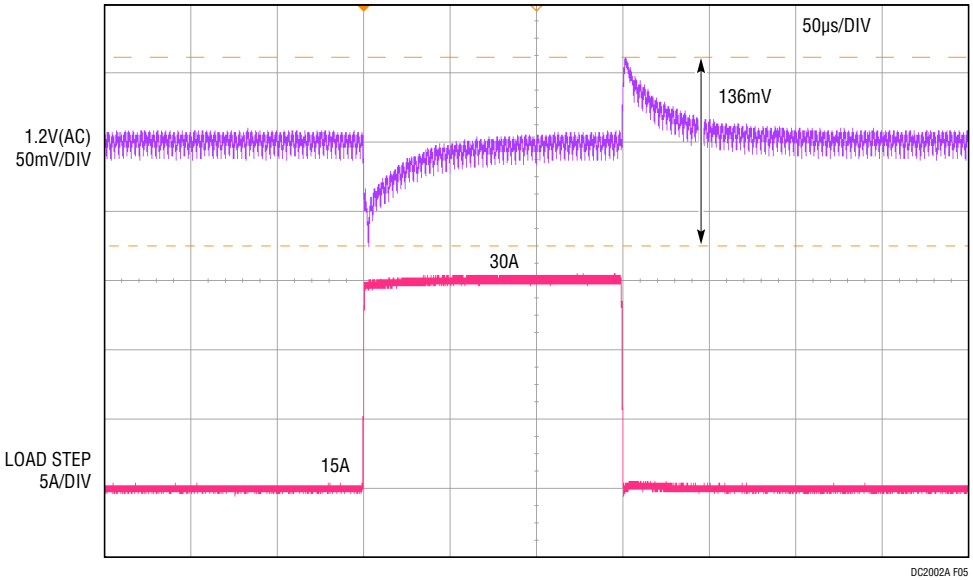


Figure 5. 50% to 100% to 50% Load Step Response of the 1.2V Rail. C_{OUT} = 3× Sanyo 2R5TPE330M9 || 2× 100µF X5R 1206, L = Würth 744301033 (0.33µH), f_{SW} = 400kHz.

QUICK START PROCEDURE

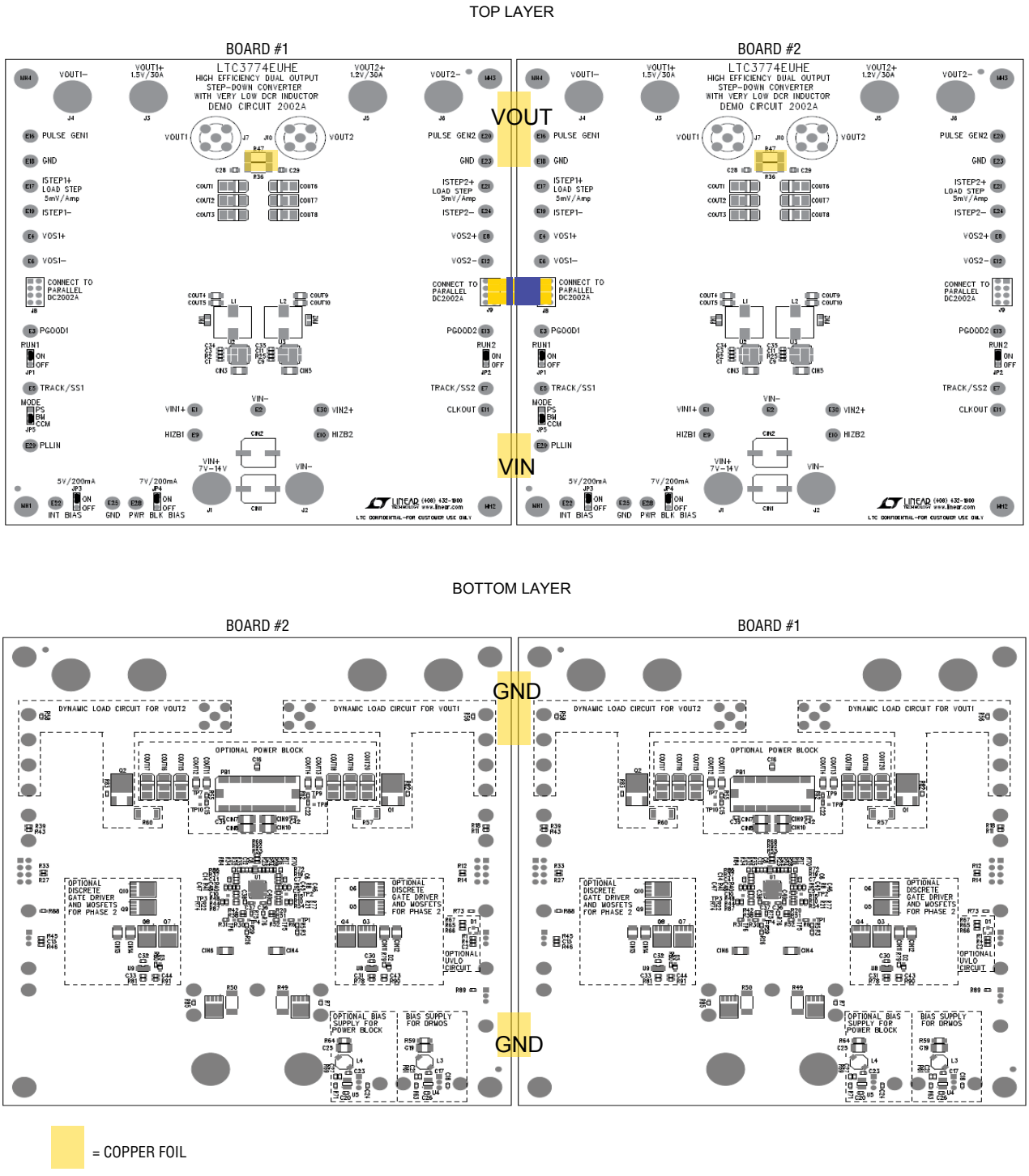


Figure 6. How to Parallel Two Boards for a Single Output, 4 Phase Converter

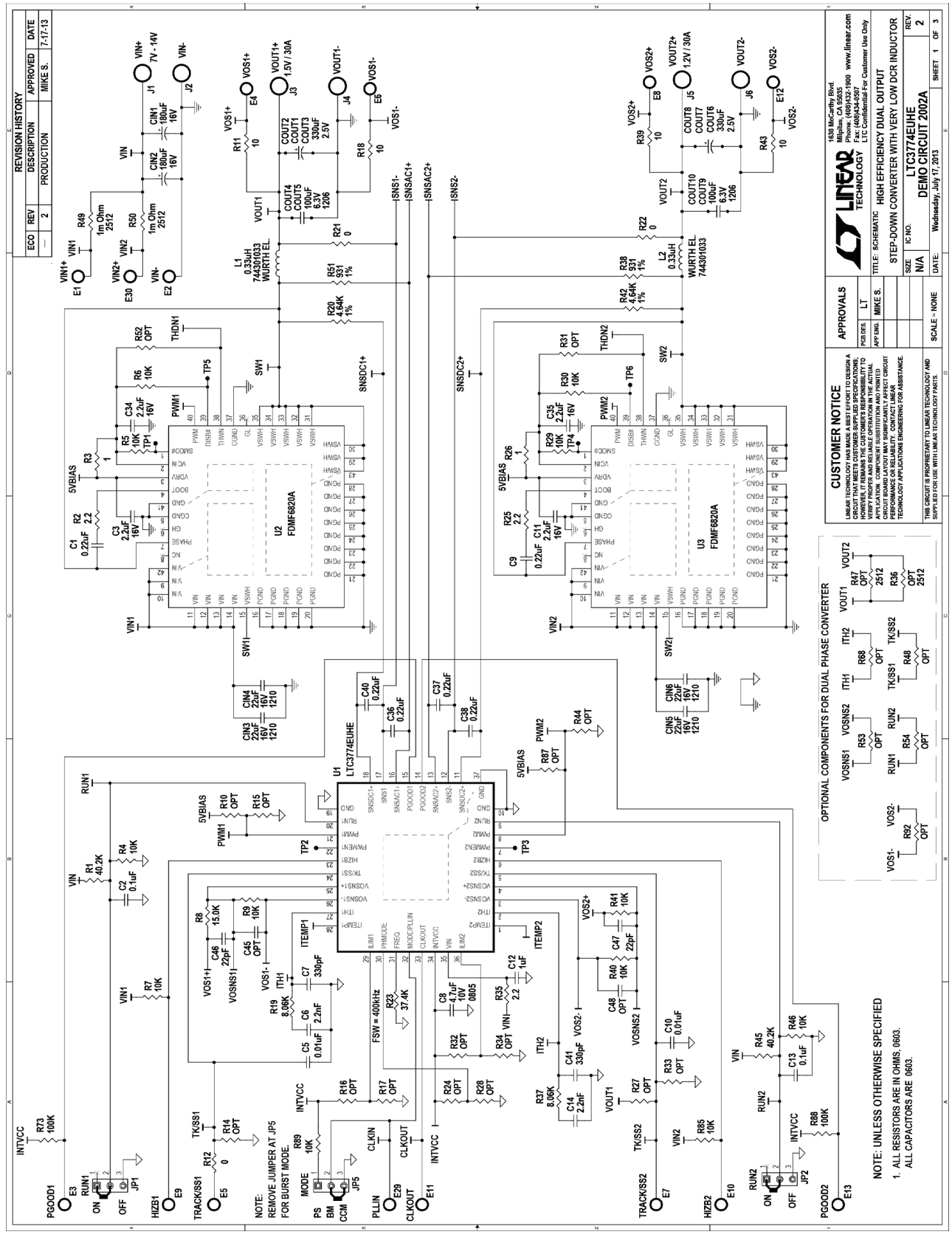
PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	2	C_{IN1}, C_{IN2}	CAP, 180µF, 20%, 16V, OSCON	SANYO, 16SVP180MX
2	4	C_{IN3}, C_{IN4}, C_{IN5}, C_{IN6}	CAP, 22µF, 20%, 16V, X5R 1210	MURATA, GRM32ER61C226KE20L
3	6	C_{OUT1}-C_{OUT3}, C_{OUT6}-C_{OUT8}	CAP, 330µF, 20%, 2.5V, 7343	SANYO, 2R5TPE330M9
4	4	C_{OUT4}, C_{OUT5}, C_{OUT9}, C_{OUT10}	CAP, 100µF, 20%, 6.3V, X5R 1206	MURATA, GRM31CR60J107ME39L
5	6	C1, C9, C36, C37, C38, C40	CAP, 0.22µF, 10%, 25V, X7R 0603	AVX, 06033C224KAT2A
6	2	C2, C13	CAP, 0.1µF, 10%, 25V, X7R 0603	AVX, 06033C104KAT2A
7	4	C3, C11, C34, C35	CAP, 2.2µF, 10%, 16V, X7R 0603	MURATA, GRM188R61C225KE15D
8	2	C5, C10	CAP, 0.01µF, 10%, 25V, X7R 0603	AVX, 06033C103KAT2A
9	2	C6, C14	CAP, 2200pF, 5%, 25V, X7R 0603	AVX 06033C222JAT2A
10	2	C7, C41	CAP, 330pF, 10%, 50V, NPO 0603	AVX 06035A331KAT
11	1	C8	CAP, 4.7µF, 10%, 16V, X7R 0805	AVX, 0805YC475KAT2A
12	1	C12	CAP, 1µF, 20%, 25V, X5R 0603	AVX, 06033D105MAT2A
13	2	C46, C47	CAP, 22pF, 10%, 25V, NPO 0603	AVX, 06033A220KAT2A
14	2	C28, C29	CAP, 10µF, 20%, 6.3V, X5R 0805	AVX, 08056D106MAT2A
15	2	L1, L2	IND., 0.33µH, 0.325mΩ, DCR 20%	WÜRTH, 744301033
16	2	R1, R45	RES, 40.2k, 1%, 1/10W, 0603	VISHAY, CRCW060340K2FKEA
17	3	R2, R25, R35	RES, 2.2Ω, 1%, 1/10W, 0603	VISHAY, CRCW06032R20FKEA
18	2	R3, R26	RES, 1Ω, 1%, 1/10W, 0603	VISHAY, CRCW06031R00FKEA
19	12	R4-R7, R9, R29, R30, R40, R41, R46, R85, R89	RES, 10k, 1%, 1/10W, 0603	VISHAY, CRCW060310K0FKEA
20	1	R8	RES, 15k, 1%, 1/10W, 0603	VISHAY, CRCW060315K0FKEA
21	4	R11, R18, R39, R43	RES, 10Ω, 1%, 1/10W, 0603	VISHAY, CRCW060310R0FKEA
22	3	R12, R21, R22	RES, 0Ω, JUMPER 0603	VISHAY, CRCW06030000Z0EA
23	2	R20, R42	RES, 4.64k, 1%, 1/10W, 0603	VISHAY, CRCW06034K64FKEA
24	1	R23	RES, 37.4k, 1%, 1/10W, 0603	VISHAY, CRCW060337K4FKEA
25	2	R38, R51	RES, 931Ω, 1%, 1/10W, 0603	VISHAY, CRCW0603931RFKEA
26	2	R49, R50	RES, 0.001Ω, 2512, 5%	PANASONIC ERJM1WTJMOU
27	2	R73, R88	RES, 100K 1% 1/10W 0603	VISHAY, CRCW0603100KFKEA
28	1	U1	LTC3774EUHE	LINEAR TECH., LTC3774EUHE#PBF
29	2	U2, U3	MOSFET, DrMOS DC/DC 3.3V PWM	FAIRCHILD, FDMF6820A
30	2	R19, R37	RES, 8.06k, 1%, 1/16W, 0603	VISHAY, CRCW06038K06FKEA
5V BIAS (for DrMOS)				
1	1	R59	RES, 0Ω, JUMPER 1206	VISHAY, CRCW12060000Z0EA
2	1	U4	I.C., BUCK REGULATOR LT3470ETS8	LINEAR TECH., LT3470ETS8#PBF
3	1	C17	CAP, 0.22µF, 10%, 25V, X7R 0603	AVX, 06033C224KAT2A
4	2	C18, C26	CAP, 1µF, 20%, 25V, X5R 0603	AVX, 06033D105MAT2A
5	1	L3	IND., 33µH, -53DLC	TOKO, A914BYW-330M=P3
6	1	C19	CAP, 22µF, 20%, 16V, X5R 1210	MURATA, GRM32ER61C226KE20L
7	1	C21	CAP, 22pF, 10%, 25V, NPO 0603	AVX, 06033A220KAT2A
8	1	R61	RES, 604k, 1%, 1/10W, 0603	VISHAY, CRCW0603604KFKEA
9	1	R63	RES, 200k, 1%, 1/10W, 0603	VISHAY, CRCW0603200KFKEA

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Dynamic Load Circuits				
1	2	R56, R58	RES, 10k, 1%, 1/10W, 0603	VISHAY, CRCW060310K0FKEA
2	2	Q1, Q2	MOSFET, N-Channel 30-V	VISHAY, SUD50N03-12P-E3
3	2	R57, R60	RES 0.005Ω, 1%, 0.5W, 2010	VISHAY, WSL20105L000FEA
Additional Components				
1	0	C_{IN7}-C_{IN12}, C_{IN13}, C_{IN14}, C25	CAP, 1210	OPT
2	0	C_{OUT15}-C_{OUT20} (OPT)	CAP, 7343	OPT
3	0	C_{OUT11}-C_{OUT14}	CAP, 1206	OPT
4	0	C16	CAP, 0805	OPT
5	0	C15, C20, C22-C24, C27, C30-C33, C39, C42, C43, C44-C48	CAP, 0603	OPT
6	0	D1	DIODE SOT23	OPT
7	0	D2, D3	DIODE SOD-323	OPT
8	0	L4	IND, -53DLC	OPT
9	0	PB1	POWER BLOCK, D12S1R845A	OPT
10	0	Q3, Q4, Q5, Q6, Q7, Q8, Q9, Q10	MOSFET, PG-TDSON-8	OPT
11	0	RN1, RN2	RES, NTC, 0805	OPT
12	0	R10, R14, R15, R24, R27, R28, R31, R33, R44, R48, R52-R55, R62, R65-R72, R74-R84, R86, R87, R90, R91, R92	RES, 0603	OPT
13	0	R16, R32, R17, R34	RES, 0603	OPT
14	0	R36, R47	RES, 2512	OPT
15	0	R64	RES, 1206	OPT
16	0	U5	OPT, BUCK REGULATOR LT3470ETS8	OPT
17	0	U8, U9	GATE DRIVER, LTC4449EDCB	OPT
18	0	E28	OPT, TESTPOINT, TURRET, .095"	OPT
19	0	JP4	HEADER, 3 PIN, 0.079 SINGLE ROW	OPT
Hardware				
1	25	E1-E13, E16-E25, E29, E30	TESTPOINT, TURRET, .095"	MILL MAX, 2501-2-00-80-00-00-07-0
2	4	JP1, JP2, JP3, JP5	HEADER, 3 PIN 0.079 SINGLE ROW	SULLINS, NRPN031PAEN-RC
3	4	XJP1, XJP2, XJP3, XJP5	SHUNT, .079" CENTER	SAMTEC, 2SN-BK-G
4	6	J1, J2, J3, J4, J5, J6	STUD, TEST PIN	PEM, KFH-032-10
5	12	(J1, J2, J3, J4, J5, J6)x2	NUT, BRASS PL #10-32	ANY, 10-32M/S BR PL
6	6	J1, J2, J3, J4, J5, J6	RING, LUG #10	KEYSTONE, 8205
7	6	J1, J2, J3, J4, J5, J6	WASHER, TIN PLATED BRASS	ANY, #10EXT BZ TN
8	2	J7, J10	CON, BNC, 5 PINS	CONNEX, 112404, 7 Trays
9	1	J8	Header, Dbl Row, RT Angle, 2 × 4, 8 Pin	MILL-MAX, 802-10-008-20-001000
10	1	J9	Socket, Dbl Row, RT Angle, 2 × 4, 8 Pin	MILL-MAX, 803-43-008-20-001000

SCHEMATIC DIAGRAM



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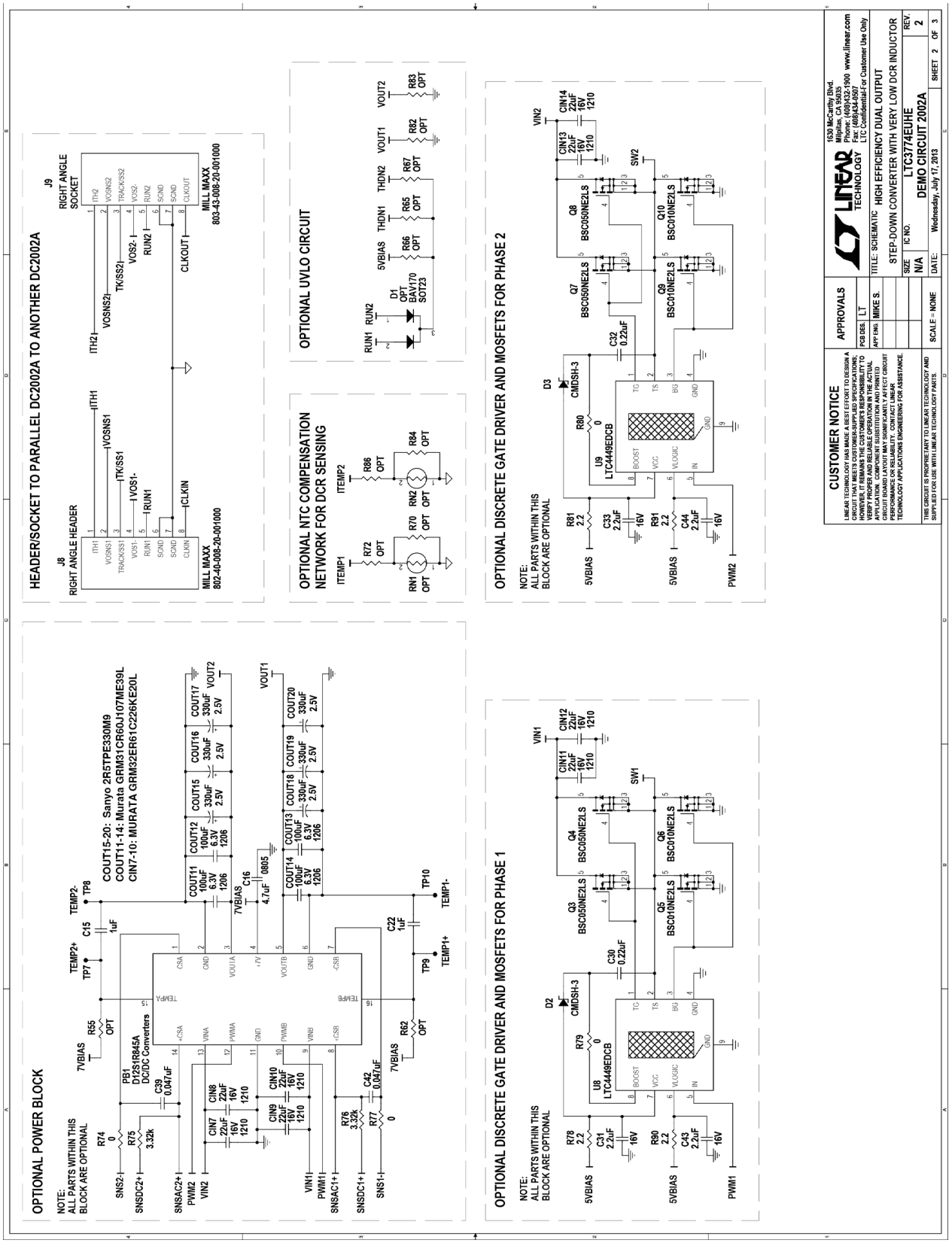

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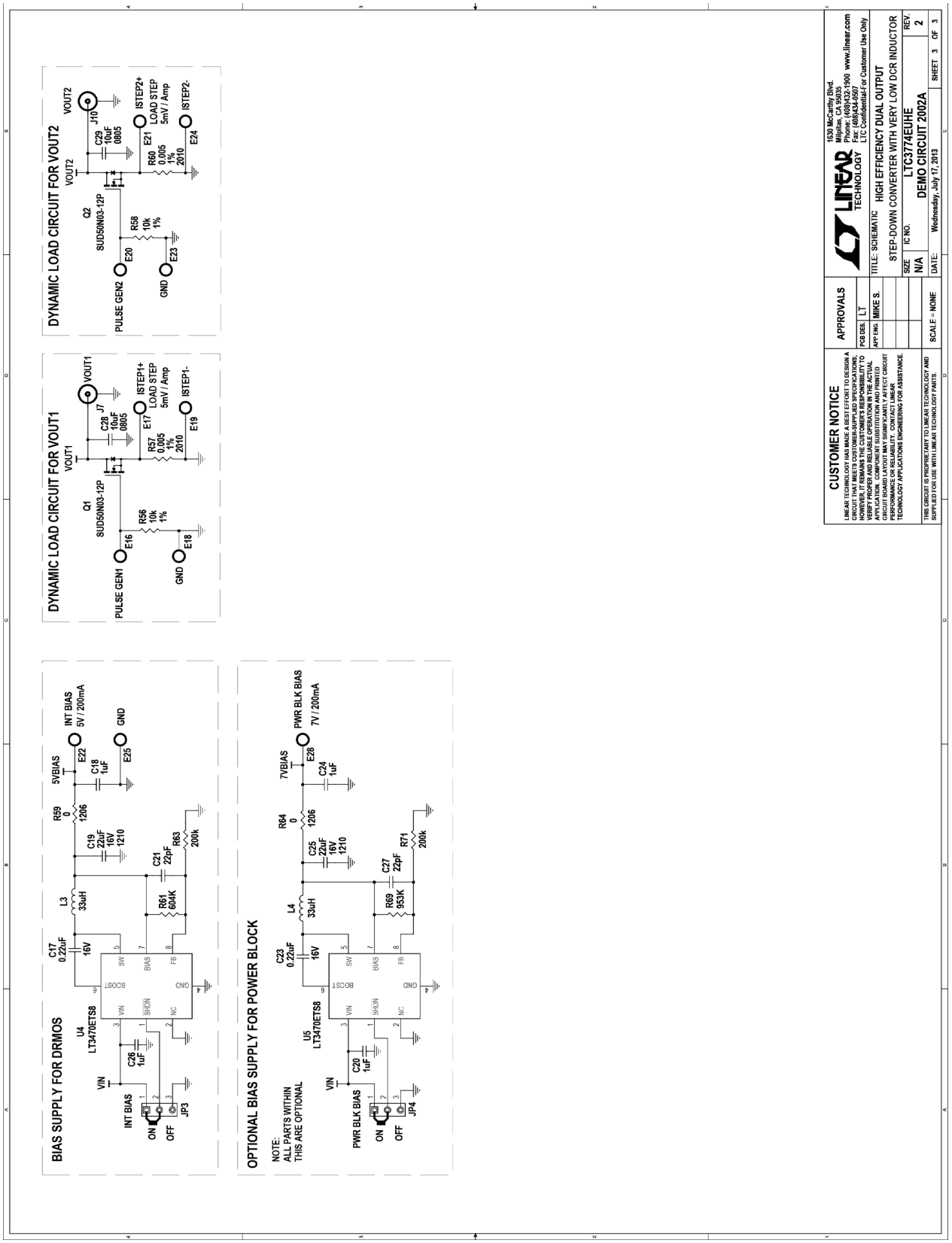

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