

LTC3860EUH

Wide Input Range, High Efficiency Step-Down DC/DC Converter

DESCRIPTION

Demonstration circuit DC1755A provides the user with two high current dual phase synchronous buck converters driven by the LTC3860. These buck converters provide outputs of 1.5V/50A and 1.2V/50A over an input voltage range of 6V to 14V and a switching frequency of 500kHz. The board can be easily modified for a 4-phase, single V_O , 100A supply. The power stage for each phase consists of the tri-state PWM compatible 6mm $\times$ 6mm Fairchild DrMOS module and a 0.47 μ H 13.2mm $\times$ 12.8mm iron powder type inductor from Würth. A high density, two sided drop-in layout is used. The entire converter, excluding the bulk output and input capacitors, fits within a 2.25" $\times$ 1.38" area on the board.

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The main features of the board are listed below:

- High efficiency and high current density.
- Remote sensing for each output.
- Optional resistors to tie the two outputs together.
- Connector and header to tie two or more boards together for up to 12-phase operation.
- RUN, PGOOD and TRACK/SS pins for each output.
- CLKIN and CLKOUT pins.
- Onboard bias voltage regulator.
- BNC connectors to monitor each output voltage.

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

PERFORMANCE SUMMARY ($T_A = 25^\circ\text{C}$), no airflow.

PARAMETER	CONDITIONS	VALUE
Minimum Input Voltage		6V
Maximum Input Voltage		14V
Output Voltage V_{OUTA}	$I_{OUTA} = 0\text{A to } 50\text{A}$, $V_{IN} = 6\text{V to } 14\text{V}$	$1.5\text{V} \pm 2\%$
Output Voltage V_{OUTB}	$I_{OUTB} = 0\text{A to } 50\text{A}$, $V_{IN} = 6\text{V to } 14\text{V}$	$1.2\text{V} \pm 2\%$
V_{OUTA} Maximum Output Current, I_{OUTA}	$V_{IN} = 6\text{V to } 14\text{V}$, $V_{OUTA} = 1.5\text{V}$	50A
V_{OUTB} Maximum Output Current, I_{OUTB}	$V_{IN} = 6\text{V to } 14\text{V}$, $V_{OUTB} = 1.2\text{V}$	50A
Nominal Switching Frequency		500kHz
Efficiency	$V_{OUTA} = 1.5\text{V}$, $I_{OUTA} = 50\text{A}$, $V_{IN} = 12\text{V}$	90.2% Typical
See Figures 2 and 3	$V_{OUTB} = 1.2\text{V}$, $I_{OUTB} = 50\text{A}$, $V_{IN} = 12\text{V}$	89.2% Typical

QUICK START PROCEDURE

Demonstration circuit 1755A is easy to set up to evaluate the performance of the LTC3860EUH. 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. Place jumpers in the following positions:

JP1	RUNA	ON
JP2	RUNB	ON
JP3	INT PWR BLK BIAS	ON

- 2) Adjust the input voltage to be between 6V to 14V. V_{OUTA} should $1.5V \pm 2\%$.

V_{OUTB} should $1.2V \pm 2\%$.

- 3) Next, apply 50A load to each output and remeasure V_{OUT} .
- 4) Once the DC regulation is confirmed, observe the output voltage ripple, load step response, efficiency and other parameters.

Note 1. No airflow is required at room temperature with 50A on both outputs. But for ambient temperatures higher than 30°C, a cooling fan is recommended.

Note 2. Use the BNC connectors labeled V_{OUTA} or V_{OUTB} to measure the output voltage ripple.

Note 3. Do not apply the load from the $VOSA^+$ turret to the $VOSA^-$ turret or from the $VOSB^+$ turret to the $VOSB^-$ turret. These turrets are only intended to monitor the voltage across COUT3 and COUT13 respectively. Heavy load currents applied across these turrets may damage the converter.

DYNAMIC LOAD CIRCUIT (OPTIONAL)

Demonstration circuit 1755A 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) Preset the amplitude of a pulse generator to 0.0V and the duty cycle to 5% or less.
- 2) Connect the scope to the VOUT BNC connectors for the rail under test with a coax cable. To monitor the load step current, connect the scope probe across the I_{STEP}^{+-} 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 one of the GND turrets.
- 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 10mV/A.

QUICK START PROCEDURE

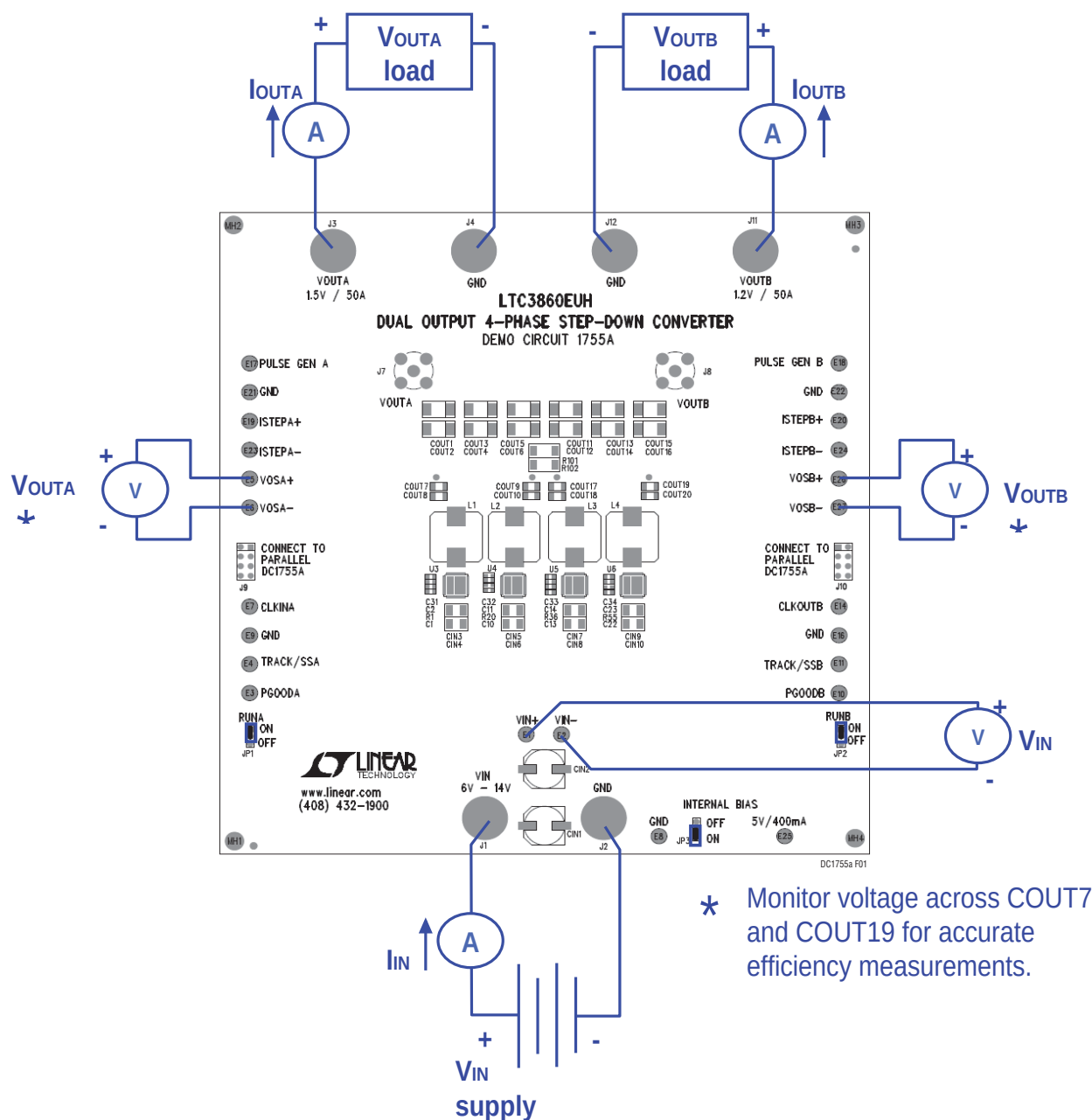


Figure 1. Proper Measurement Equipment Setup

QUICK START PROCEDURE

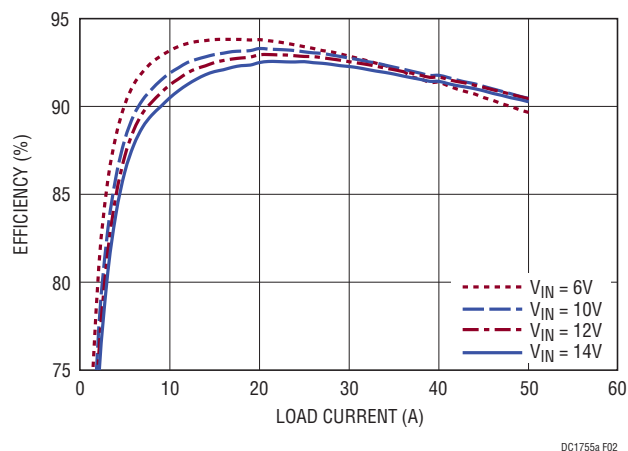


Figure 2. Efficiency Curves for the 1.5V Rail of the DC1755A

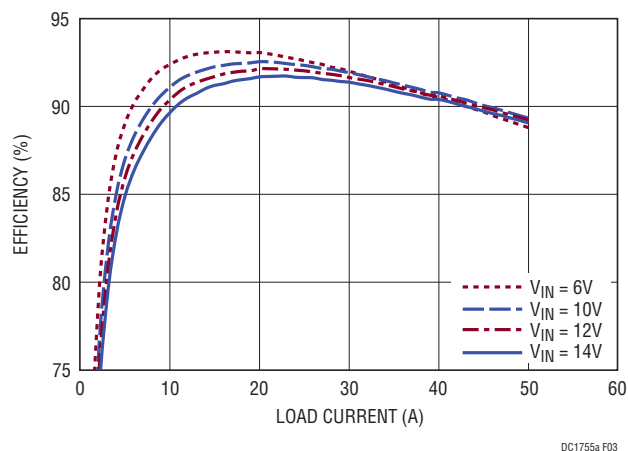


Figure 3. Efficiency Curves for the 1.2V Rail of the DC1755A

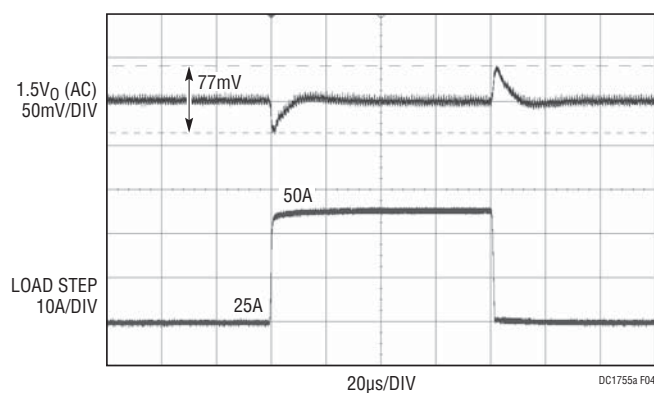


Figure 4. Load Step Response of the 1.5V Rail

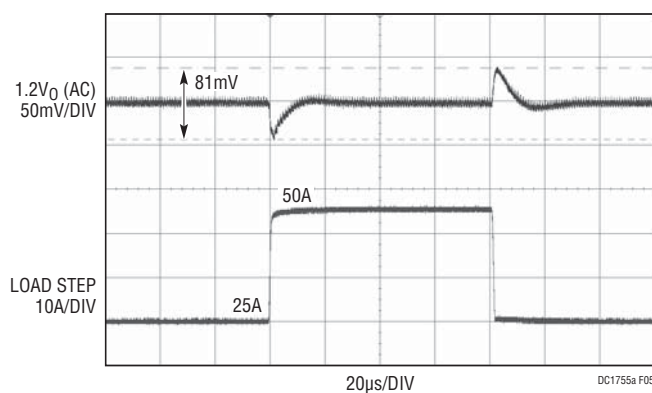


Figure 5. Load Step Response of the 1.2V Rail

SINGLE OUTPUT/4-PHASE OPERATION

A single output/4-phase converter may be preferred for higher output current applications. The optional components required to tie the phases together are found on sheet 3 of the schematic in the lower right hand corner. To tie the two outputs together, make the following modifications:

- 1) Select one rail to be the master.
 - a) If VOUTA is the master, then stuff 0Ω at R103 to disable the error amplifier for VOUTB.
 - b) If VOUTB is the master, then stuff 0Ω at R104 to disable the error amplifier for VOUTA.

- 2) Stuff 0Ω at R87, R88, R89 and R91 to tie the IAVG, COMP, TRACK/SS and RUN signals together.
- 3) Remove the redundant compensation components.

6-PHASE AND 12-PHASE OPERATION

Two or more boards may be tied together for up to 12-phase operation. To parallel two or more boards, place the boards side by side. Connect J9 of one board to J10 of the adjacent board (see sheet 3 of the schematic, lower right hand corner). This will tie the IAVG, COMP, TRACK/SS and

QUICK START PROCEDURE

RUN signals of the adjacent boards together. Next, locate the exposed copper shapes on the four corners of the board on the top and bottom layers. Use these shapes to tie the VOUT, VIN and GND planes of the adjacent boards. Next, select which phases will be the master or the slave.

Figure 6 shows the typical setup for a 6-phase + 2-phase converter. Figure 7 shows the typical setup for a 12-phase converter. For additional help and support, contact your local LTC sales office.

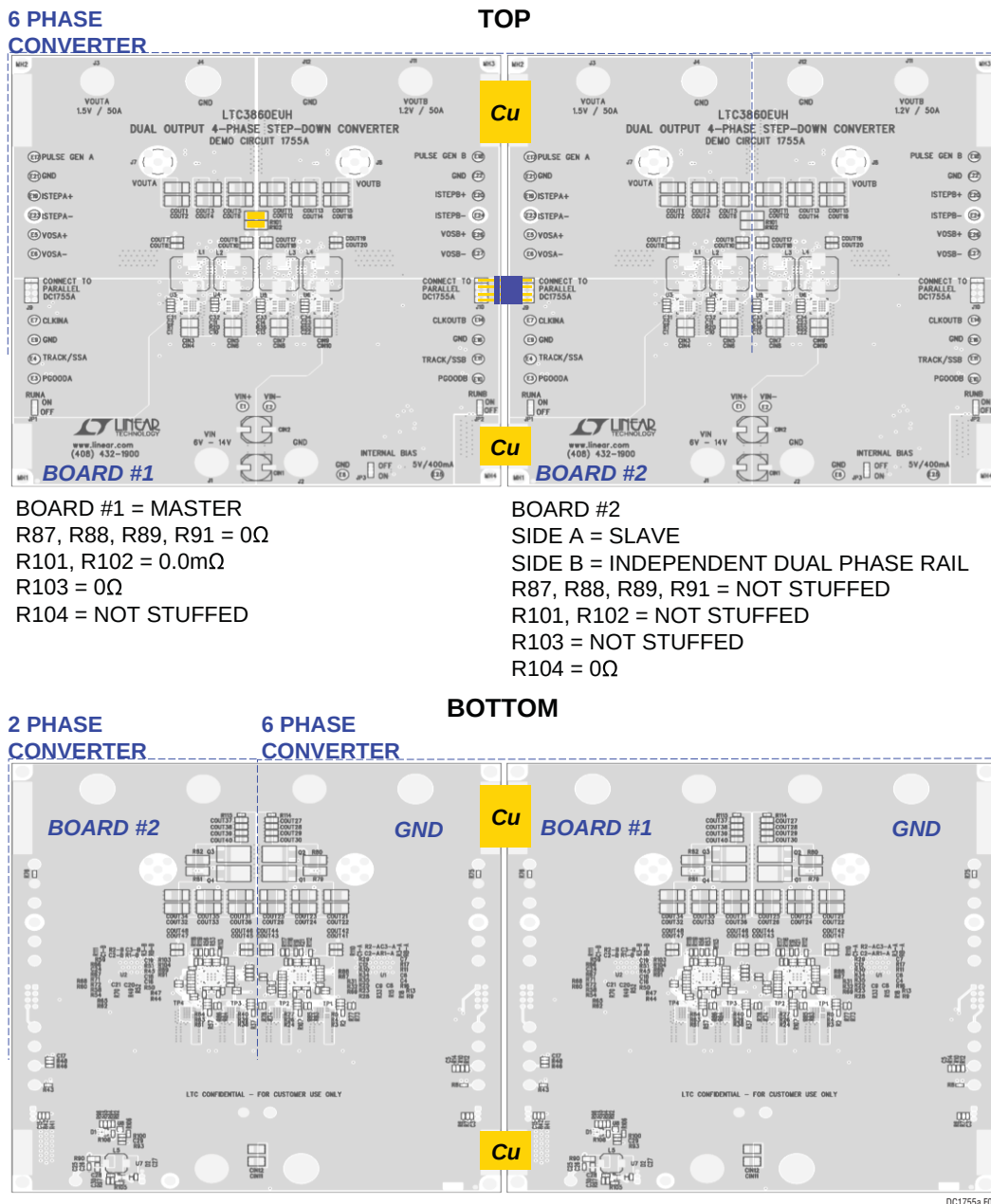


Figure 6. Typical Setup for a 6-Phase + 2-Phase Converter

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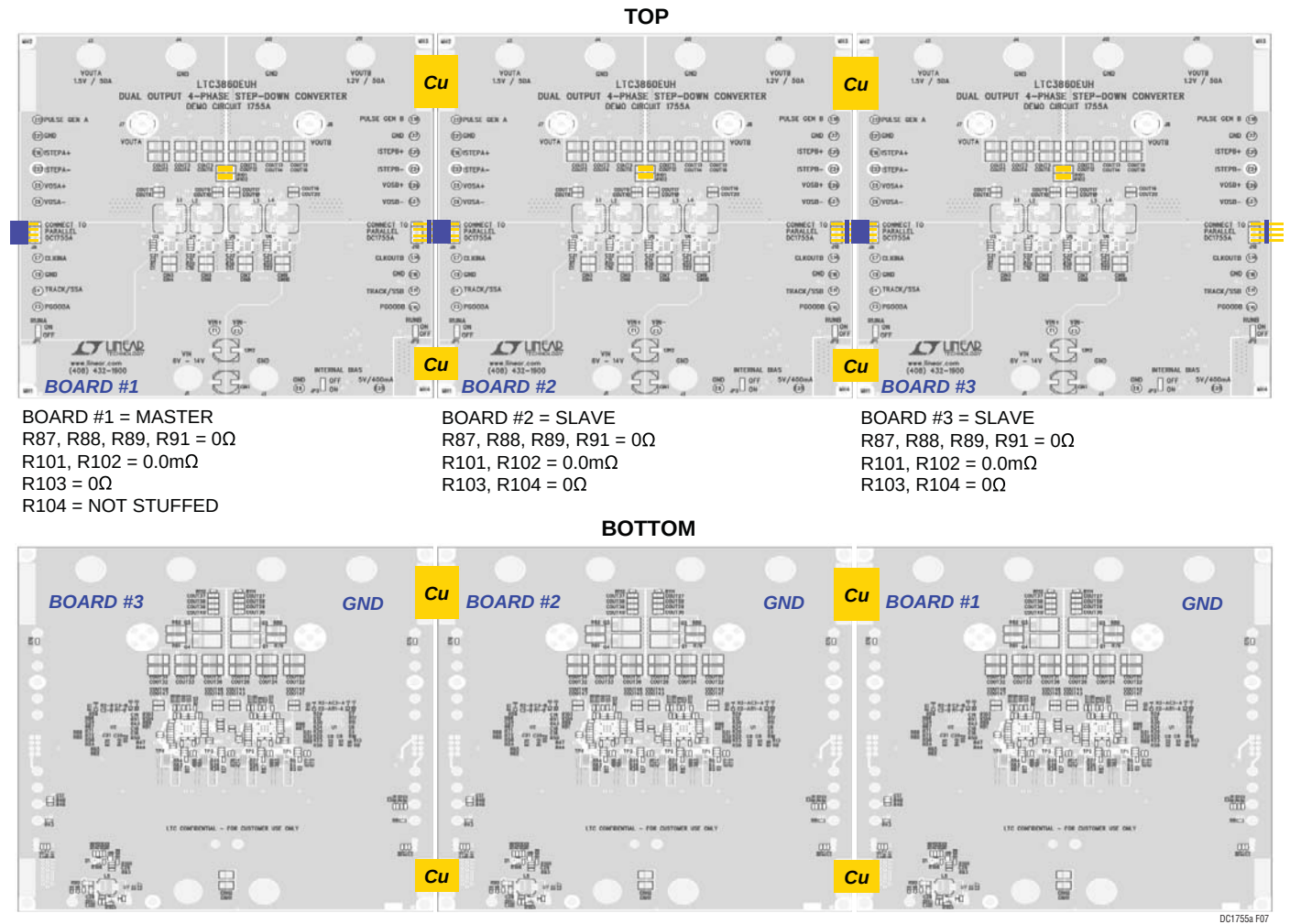


Figure 7. Typical Setup for a 12-Phase Converter

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	1	CIN1	CAP, 180 μ F 20% 16V OSCON	SANYO 16SVP180MX
2	4	CIN3, CIN5, CIN7, CIN9	CAP, 1210 22 μ F 20% 16V X5R	TDK C3225X5R1C226M
3	12	COUT1 to COUT3, COUT4 to COUT6, COUT11 to COUT13, COUT14 to COUT16	CAP, 7343 330 μ F 20% 2.5V POSCAP	SANYO 2R5TPE330M9L
4	8	COUT7 to COUT10, COUT17 to COUT20	CAP, 1206 100 μ F 20% 6.3V X5R	MURATA GRM31CR60J107ME39L
5	2	C1 to A, C1 to B	CAP, 0603 470pF 10% 25V NPO	AVX 06033A471KAT2A
6	8	C1, C8, C9, C10, C13, C20, C21, C22	CAP, 0603 0.22 μ F 10% 25V X7R	TDK C1608X7R1E224K
7	8	C2, C11, C14, C23, C31, C32, C33, C34	CAP, 0603 2.2 μ F 10% 16V X7R	MURATA GRM188R61C225KE15
8	2	C4, C16	CAP, 0603 100pF 5% 25V NPO	AVX 06033A101JAT2A
9	2	C2 to A, C2 to B	CAP, 0603 68pF 5% 25V NPO	AVX 06033A680JAT2A
10	2	C3 to A, C3 to B	CAP, 0603 2200pF 25V X7R	MURATA GRM188R71E222MA01
11	3	C7, C19, C28	CAP, 0603 1 μ F 20% 25V X5R	AVX 06033D105MAT2A
12	4	L1, L2, L3, L4	IND, 0.47 μ H 20%	WÜRTH 744355147
13	1	RB to A	RES, 0603 13.3k 1% 1/10W	VISHAY CRCW060313K3FKEA
14	1	RB to B	RES, 0603 20k 1% 1/10W	NIC NRC06F2002TRF
15	19	R1, R11, R12, R16, R20, R25, R36, R45, R46, R50, R54, R55, R59, R62, R69, R112, R113, R116, R118	RES, 0603 0 Ω JUMPER	VISHAY CRCW06030000Z0EA
16	2	R1 to A, R1 to B	RES, 0603 20k 1% 1/10W	NIC NRC06F2002TRF
17	6	R2, R17, R37, R51, R57, R107	RES, 0603 1 Ω 5% 1/10W	VISHAY CRCW06031R00JNEA
18	2	R2 to A, R2 to B	RES, 0603 6.8k 1% 1/10W	VISHAY CRCW06036K80FKEA
19	2	R3 to A, R3 to B	RES, 0603 523 Ω 1% 1/10W	VISHAY CRCW0603523RFKEA
20	9	R3, R4, R24, R26, R31, R38, R39, R61, R63	RES, 0603 10k 1% 1/10W	VISHAY CRCW060310K0FKEA
21	2	R8, R43	RES, 0603 100k 5% 1/10W	YAGEO RC0603JR-07100KL
22	4	R15, R33, R49, R70	RES, 0603 2.87k 1% 1/10W	VISHAY CRCW06032K87FKEA
23	2	R18, R52	RES, 0603 59.0k 1% 1/10W	VISHAY CRCW060359K0FKEA
24	4	R19, R21, R53, R56	RES, 0603 10 Ω 1% 1/10W	NIC NRC06F10R0TRF
25	2	R30, R67	RES, 0603 40.2k 1% 1/10W	VISHAY CRCW060340K2FKEA
26	2	U1, U2	IC, DUAL OUTPUT BUCK CONVERTER	LINEAR TECHNOLOGY LTC3860EUH
27	4	U3, U4, U5, U6	INTEGRATED MOSFET, DC/DC CONVERTER	FAIRCHILD FDMF6707B
Bias Supply and UVLO Circuit				
1	1	C29	CAP, 0603 2.2 μ F 10% 16V X7R	MURATA GRM188R61C225KE15
2	1	C25	CAP, 0603 1 μ F 20% 25V X5R	AVX 06033D105MAT2A
3	1	C26	CAP, 0805 10 μ F 10% 25V NPO	AVX 08053D106MAT2A
4	1	C27	CAP, 0603 0.1 μ F 10% 16V X7R	AVX 0603YC104KAT2A
5	1	C30	CAP, 0603 10pF 5% 50V NPO	MURATA GQM1885C1H100JB01
6	1	D1	DIODE, BAV170 SOT23	DIODES INC., BAV170
7	1	D2	DIODE SHOTTKY SOD326	NXP PMEG2005AEA
8	1	L5	INDUCTOR 27 μ H 20%	WÜRTH 7447789127
9	1	R105	RES, 0603 20k 1% 1/10W	NIC NRC06F2002TRF
10	1	R106	RES, 0603 10k 1% 1/10W	VISHAY CRCW060310K0FKEA

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PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
11	1	R90	RES, 1206 0Ω JUMPER	VISHAY CRCW12060000Z0EA
12	1	R93	RES, 0603 100Ω 5% 1/10W	VISHAY CRCW0603100RFKEA
13	1	R97	RES, 0603 105k 1% 1/10W	VISHAY CRCW0603105KFKEA
14	1	R100	RES, 0603 127k 1% 1/10W	VISHAY CRCW0603127KFKEA
15	1	U7	IC, STEP DOWN REGULATOR, DFN	LINEAR TECHNOLOGY LT3502EDC
16	1	U8	IC, VOLTAGE MONITOR, DC-3	LINEAR TECHNOLOGY LT6703IDC-3

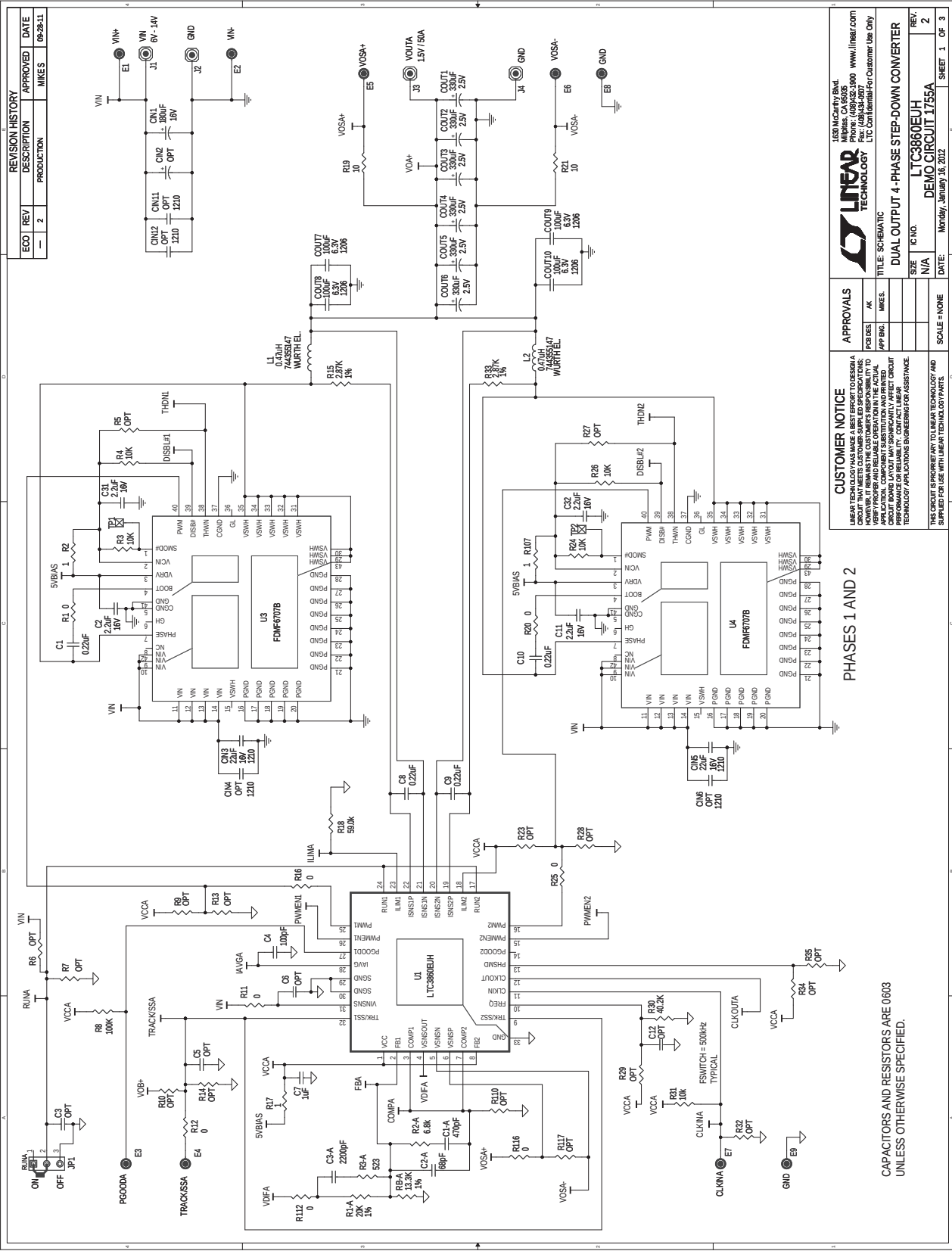
Additional Circuit Components

1	0	CIN2	CAP, SANYO SVP-F8	OPTIONAL
2	0	CIN4, CIN6, CIN8, CIN10 to CIN12	CAP, 1210	OPTIONAL
3	0	COUT21 to COUT26, COUT31 to COUT36	CAP, 7343H	OPTIONAL
4	0	COUT27 to COUT30, COUT37 to COUT48	CAP, 1206	OPTIONAL
5	0	R5, R6, R7, R9, R10, R13, R14, R23, R27, R28, R29, R32, R34, R35, R40, R41, R42, R44, R47, R48, R58, R60, R64, R65, R66, R68, R71, R72, R87, R88, R89, R91, R92, R94, R95, R96, R103, R104, R108, R110, R111, R114, R115, R117, R119	RES, 0603	OPTIONAL
6	0	C3, C5, C6, C12, C15, C17, C18, C24	CAP, 0603	OPTIONAL
7	0	Q2, Q3	MOSFET, TO-252	OPTIONAL
8	0	R73, R74, R77, R78, R83, R84, R85, R86	RES, 0603	OPTIONAL
9	0	R80, R82, R101, R102	RES, 2010	OPTIONAL
10	2	Q1, Q4	MOSFET, TO-252	VISHAY SUD50N03-09P
11	2	R75, R76	RES, 0603 10k 1% 1/10W	VISHAY CRCW060310K0FKEA
12	2	R79, R81	RES, 2010 0.010Ω 2% 1W	IRC LRC-LRF2010LF-01-R010-F

Hardware/Components (For Demo Board Only)

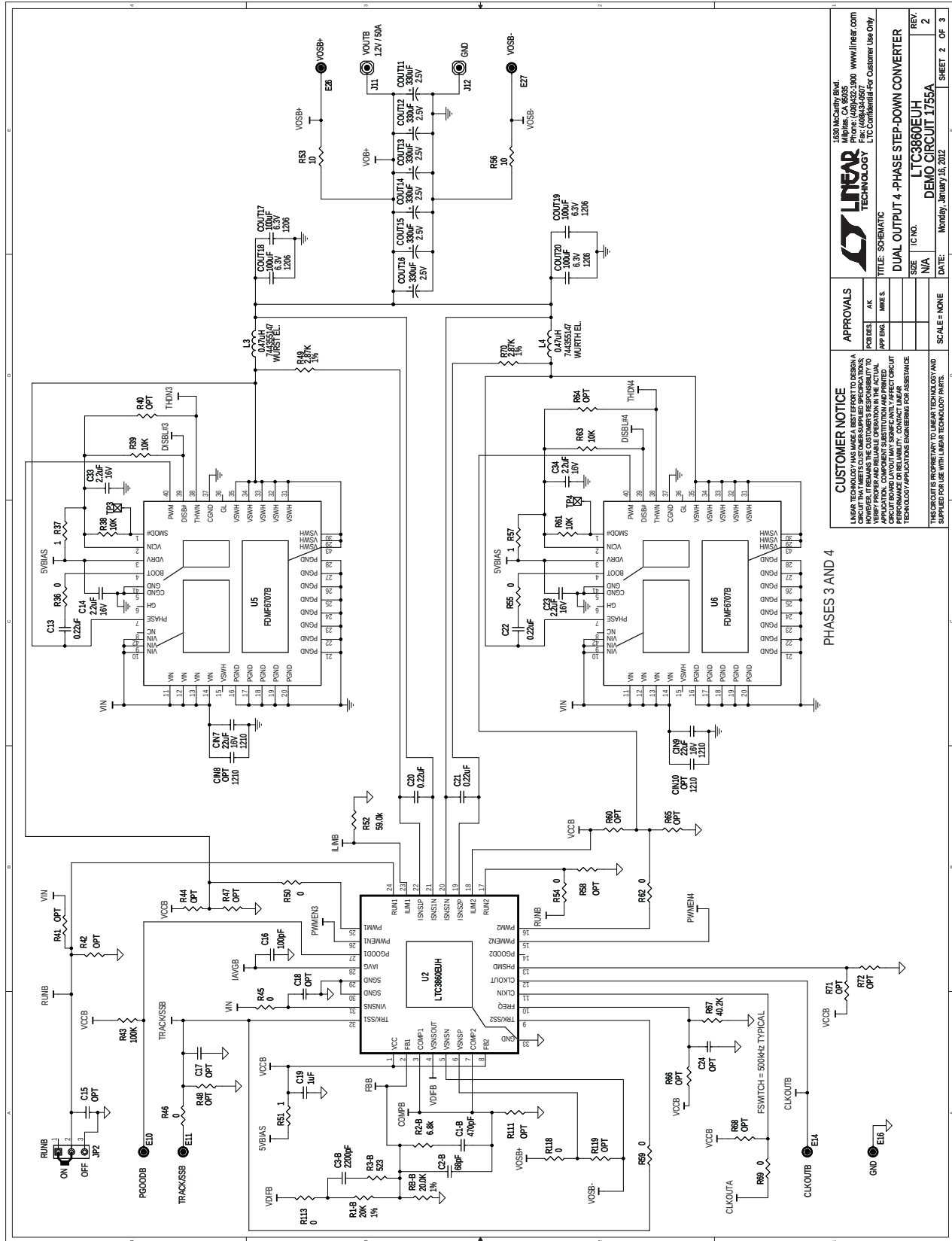
1	4		STANDOFF, SNAP ON	KEystone 8831
2	12		NUT, BRASS #10-32	ANY
3	6		RING, LUG #10	KEystone 8205
4	6		WASHER, TIN, PLATED BRASS	ANY
5	24	E1 to E11, E14, E16, E17 to E27	TURRET	MILL MAX 2501-2-00-80-00-00-07-0
6	3	JP1 to JP3	HEADER, 3 PIN	SAMTEC TMM-103-02-L-S
7	3	XJP1 to XJP3	SHUNT, 2mm CTRS	SAMTEC 2SN-BK-G
8	6	J1 to J4, J11, J12	STUD, TEST PIN	PEM KFH-032-10
9	2	J7, J8	CON, BNC, 5 PINS	CONNEX 112404
10	1	J9	HEADER, DOUBLE ROW, RIGHT ANGLE	MILL-MAX 802-40-008-20-001000
11	1	J10	SOCKET, DOUBLE ROW	MILL-MAX 803-43-008-20-001000

SCHEMATIC DIAGRAM



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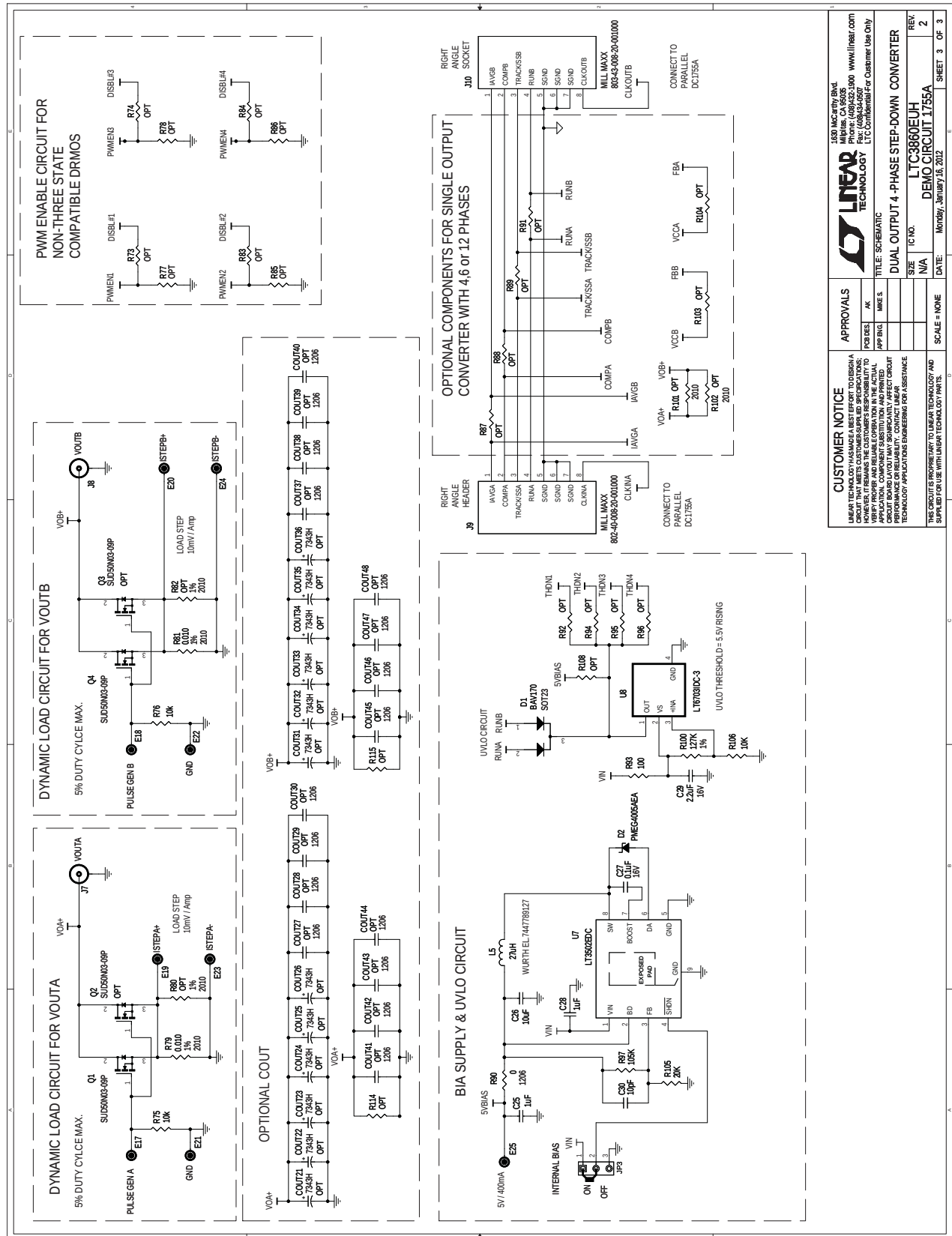
SCHEMATIC DIAGRAM



PHASES 3 AND 4

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LINEAR TECHNOLOGY 1630 McCarty Blvd. Milpitas, CA 95035 Tel: (408) 255-0000 Fax: (408) 255-0001 L.T.C. Confidential - For Customer Use Only		TITLE: SCHEMATIC DUAL OUTPUT 4-PHASE STEP-DOWN CONVERTER	
SCALE: NONE		REV: 2	
DATE: Monday, January 16, 2012		SHEET 2 OF 3	

SCHEMATIC DIAGRAM



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