LTC3765/LTC3766
300W Isolated Forward Converter with Synchronous Rectification

DESCRIPTION

Demonstration circuit 2199B-C is a 300W isolated forward converter with synchronous rectification featuring the LTC3765/LTC3766 chip-set. It produces a regulated 56V, 5.4A output from an input voltage range of 36V to 60V.

This circuit was designed to demonstrate the high levels of performance, efficiency, and small solution size attainable using these parts in an active-clamp-reset forward converter power supply, suitable for telecom, industrial, and other applications. It has a 4.7in^2 solution footprint area. Synchronous rectification helps to attain an efficiency approaching 96%. Secondary-side control eliminates complex opto-coupler feedback, providing fast transient response with minimum output capacitance. For other output requirements, see the LTC3766 data sheet or contact the LTC sales.

Design files for this circuit board are available at http://www.linear.com/demo/DC2199B-C

PERFORMANCE SUMMARY

Specifications are at T_A = 25°C

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{IN}	Input Supply Range		36		60	V
V_{OUT}	Output Voltage			56.0		V
I_{OUT}	Output Current Range, Continuous	200LFM	0		5.4	A
f_{SW}	Switching (Clock) Frequency			200		kHz
$V_{OUT(P-P)}$	Output Ripple	V_{IN} = 48V, I_{OUT} = 30A (20MHz BW)		100		mV_{P-P}
I_{REG}	Output Regulation	Line and Load (36V_{IN} to 60V_{IN}, 0A_{OUT} to 5.4A_{OUT})		±0.02		%
P_{OUT}/P_{IN}	Efficiency (See Figure 3)	V_{IN} =48V, I_{OUT} = 5.4A		95.2		%
	Isolation	Basic		1500		VDC
	Approximate Solution Size	Component Area × Top Component Height		4.7in^2 × 0.6		Inches

OPERATING PRINCIPLES

The LTC3765 active clamp forward controller and gate driver is used on the primary and provides start-up, gate drive, and protection functions. Once start-up is accomplished, the LTC3766 high efficiency, secondary-side synchronous forward controller takes over, and provides the LTC3765 with timing information and bias power through a small pulse transformer.

When input voltage is applied, the LTC3765 commences soft-start of the output voltage. When the output reaches the RUN threshold, the LTC3766 comes alive and takes control by sending encoded PWM gate pulses to the LTC3765 through T2. These pulses also provide primary bias power efficiently over a wide input voltage range.

The transition from primary to secondary control occurs at some fraction of the nominal output voltage. From then on, operation and design is reduced to that of a simple buck converter. Secondary control eliminates delays, tames large-signal overshoot, and reduces output capacitance needed to meet transient response requirements.

An optional LC filter stage on the input lowers RMS input current. The filter must have output impedance that is less than the converter input impedance to assure stability. This may require a damping impedance, which is provided by R1. (See Linear Technology Application Note 19 for a discussion of input filter stability.) R1 is coupled through a tiny 2mm × 2mm inductor L1, and provides damping with arbitrarily low source impedance. For bench testing, an electrolytic capacitor has been added at the input terminals to provide suitable ripple current capability. The values selected have a filter resonant frequency that is below the converter switching frequency, thus avoiding high circulating currents in the filter.

QUICK START PROCEDURE

Demonstration circuit 2199B-C is easy to set up to evaluate the performance of the LTC3765/LTC3766. Refer to Figure 1 for proper measurement equipment setup and follow the procedure below:

NOTE: When measuring the output voltage ripple, care must be taken to avoid a long ground lead on the oscilloscope probe. Measure the output voltage ripple by touching the probe tip and ground ring directly across the last output capacitor as shown in Figure 1.

1. Set an input power supply that is capable of 36V to 60V to 36V. Then turn off the supply.
2. Direct an airflow of 200LFM across the unit for sustained operation at full load.
3. With power off, connect the supply to the input terminals $+V_{IN}$ and $-V_{IN}$.
   a. Input voltages lower than 36V can keep the converter from turning on due to the undervoltage lockout feature of the LTC3765/LTC3766.
   b. If efficiency measurements are desired, an ammeter capable of measuring 10ADC or a resistor shunt can be put in series with the input supply in order to measure the DC2199B-C's input current.
   c. A voltmeter with a capability of measuring at least 60V can be placed across the input terminals in order to get an accurate input voltage measurement.
4. Turn on the power at the input.

   NOTE: Make sure that the input voltage never exceeds 60V.
5. Check for the proper output voltage of 56V. Turn off the power at the input.
6. Once the proper output voltages are established, connect a variable load capable of sinking 5.4A at 56V to the output terminals $+V_{OUT}$ and $-V_{OUT}$. Set the current for 0A.
   a. If efficiency measurements are desired, an ammeter or a resistor shunt that is capable of handling 5.4ADC can be put in series with the output load in order to measure the DC2199B-C's output current.

QUICK START PROCEDURE

b. A voltmeter with a capability of measuring at least 56V can be placed across the output terminals in order to get an accurate output voltage measurement.

7. Turn on the power at the input.

   NOTE. If there is no output, temporarily disconnect the load to make sure that the load is not set too high.

8. Once the proper output voltage is again established, adjust the load within the operating range and observe the output voltage regulation, ripple voltage, efficiency and other desired parameters.

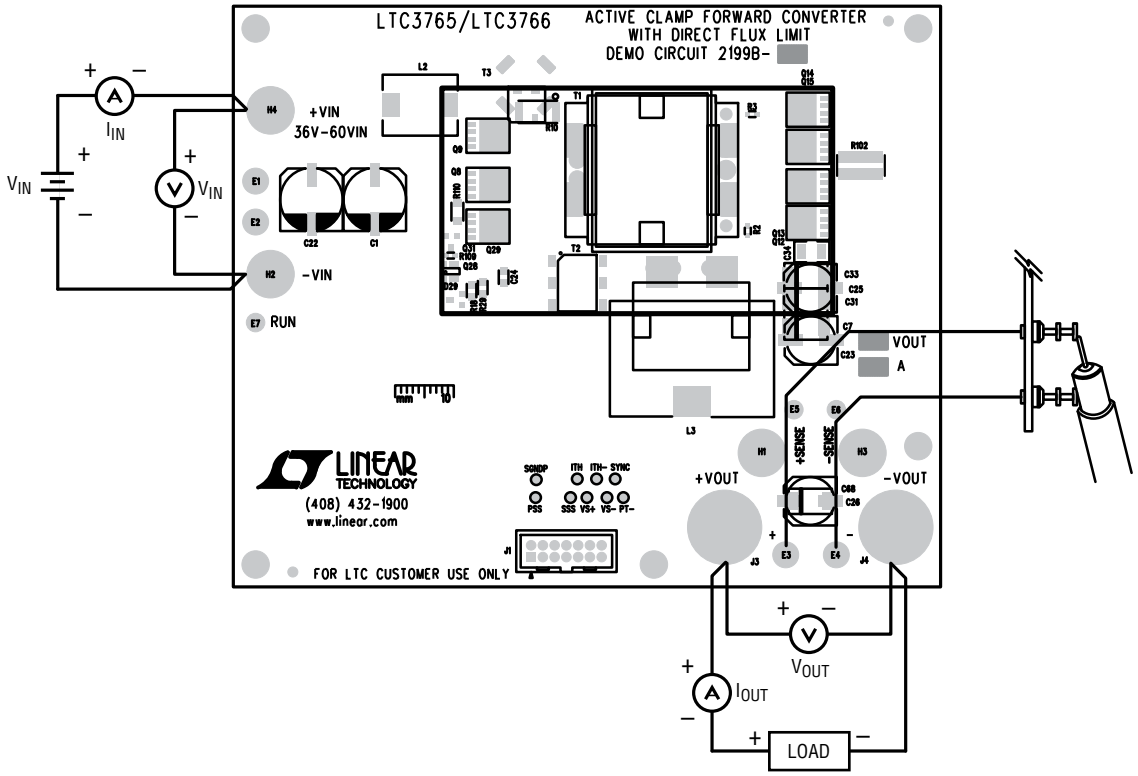


Figure 1. Proper Measurement Equipment Setup

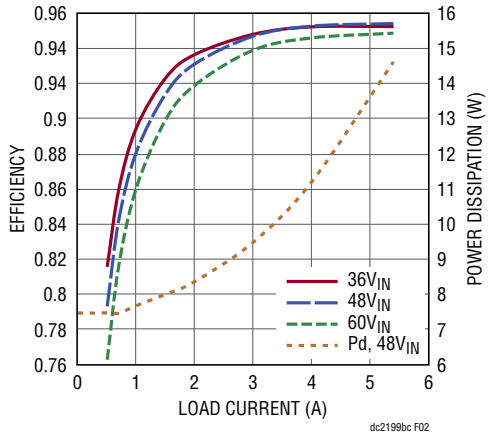


Figure 2. Efficiency and Power Dissipation

QUICK START PROCEDURE

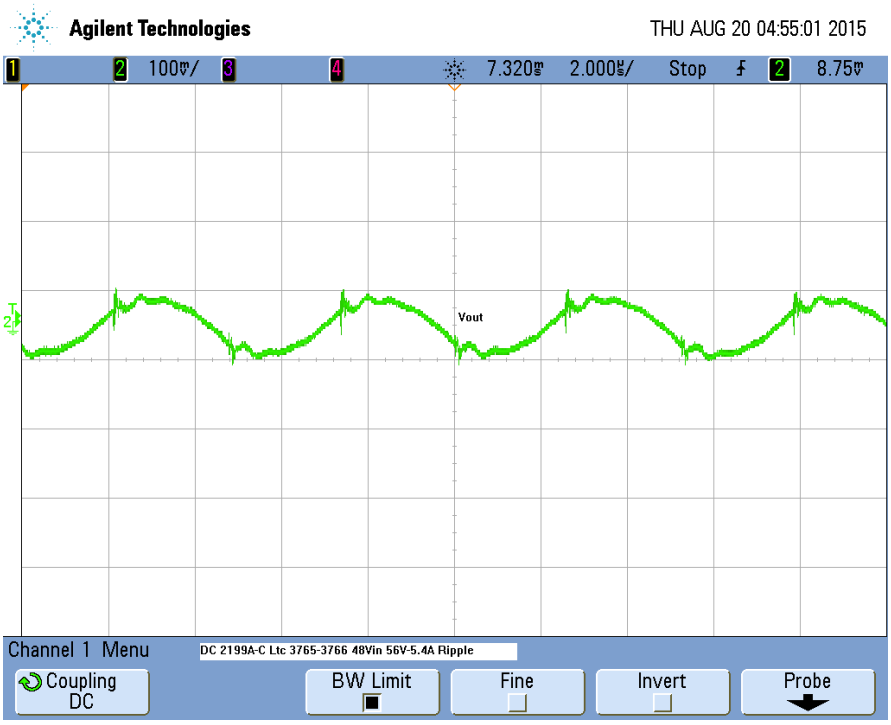


Figure 3. Output Ripple at $48V_{IN}$ and $5.4A_{OUT}$ (100mV, 2µs/DIV, 20MHz)

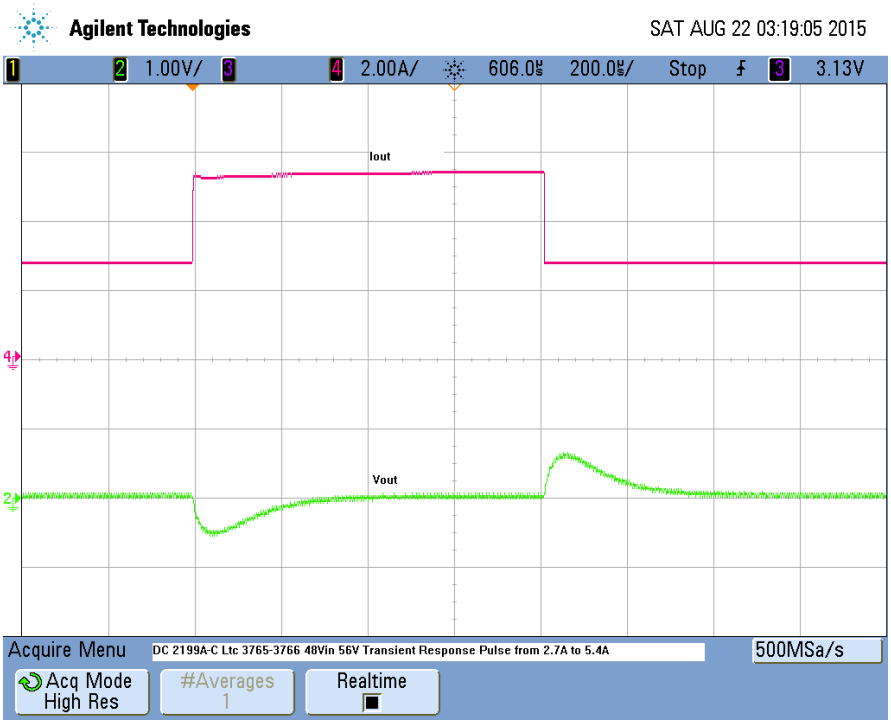


Figure 4. Transient Response Waveform at $48V_{IN}$ and 2.7A to 5.4A to $2.7A_{OUT}$ (2A, 1V, 200µs/DIV)

QUICK START PROCEDURE

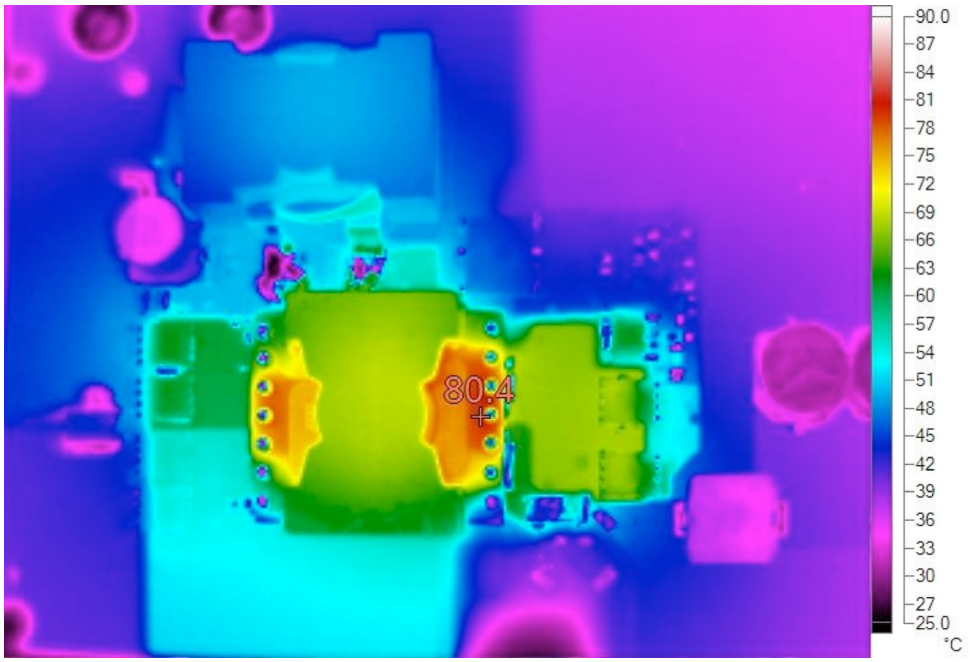


Figure 5. Thermal Map, Front Side at $48V_{IN}$ and $5.4A_{OUT}$ (T_A = 25°C, 200LFM)

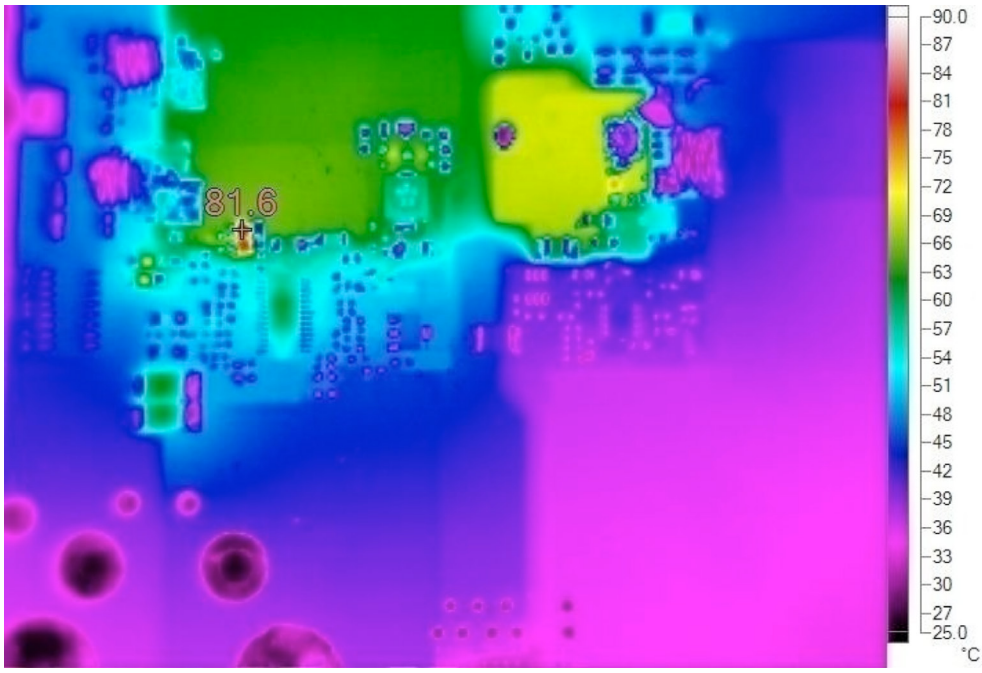


Figure 6. Thermal Map, Back Side at $48V_{IN}$ and $5.4A_{OUT}$ (T_A = 25°C, 200LFM)

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	2	C1, C22	Cap., Alum., Elect., 33µF, 80V, CAP-10x10	PANASONIC, EEHZA1K330P
2	5	C2, C3, C4, C5, C6, C34	CAP., X7R, 4.7µF, 100V, 10%,1210	MURATA, GRM32DC72A475KE01L
3	1	C10	CAP., X7R, 4.7nF, 630V, 10%,1206	MURATA, GRM31A7U2J472KW31
4	1	C11	CAP., X7R, 0.015µF, 25V, 10%, 0603	AVX, 06033C153KAT2A
5	2	C24, C71	CAP., X7R, 1.0µF, 16V, 10%, 0805	MURATA, GRM21BR71C105KA01
6	2	C25, C26	Cap., Alum., Elect., 33µF, 63V, CAP-8x10	PANASONIC, EEHZA1J330P
7	1	C30	CAP., X7R, 2200pF, 250V, 10%,1812	MURATA, GA343QR7GD222KW01L
8	1	C51	CAP., C0G, 220pF, 630V, 5%,1206	MURATA, GRM31A5C2J221JW01
9	4	C55, C73, C80, C119	CAP., X7R, 1nF, 25V, 10%, 0603	MURATA, GRM188R71E102KA01
10	1	C66	CAP., X7R, 0.047µF, 200V, X7R, 10%, 1206	MURATA, GRM31CR72D473KW03
11	2	C72, C102	CAP., X7R, 0.1µF, 25V, 10%, 0805	AVX, 08053C104KAT2A
12	1	C75	CAP., NPO, 100pF, 25V, 5%, 0603	AVX, 06033A101JAT2A
13	1	C76	CAP., X7R, 3.3nF, 25V, 10%, 0603	AVX, 06033C332KAT2A
14	1	C77	CAP., X7R, 10µF, 25V, 10%, 1206	AVX, 12063C106KAT2A
15	1	C78	CAP., NPO, 0.033µF, 25V, 5%, 0805	TDK, TDK, C2012C0G1E333J125AA
16	1	C79	CAP., X7R, 4.7nF, 25V, 10%, 0603	MURATA, GRM188R71E472KA01
17	1	C101	CAP., NPO, 220pF, 25V, 5%, 0603	AVX, 06033A221JAT2A
18	1	C103	CAP., NPO, 1000pF, 25V, 5%, 0603	AVX, 06033A102JAT2A
19	1	C105	CAP., X7R, 0.22µF, 16V, 10%, 0603	MURATA, GRM188R71C224KA01
20	1	C106	CAP., COG, 150pF, 250V, 5%, 0603	TDK, C1608C0G2E151J080AA
21	1	C111	CAP., X7R, 0.22µF,50V, 10%, 0805	AVX, 08055C224KAT2A
22	1	C112	CAP., X7R, 0.22µF, 250V, 10%, 1206/1210	TDK C3225X7R2E224K
23	1	C113	CAP., X7R, 0.033µF, 25V, 10%, 0603	AVX, 06033C333KAT2A
24	1	C116	CAP., X7R, 4.7µF, 25V,10%,1206	AVX, 12063C475KAT2A
25	1	C118	CAP., NPO, 470pF, 5%, 0603	AVX, 06033A471JAT2A
26	2	D1,D34	DIODE ULTRA FAST 1A 200V SMP	VISHAY, ES1PD-M3 / 84A
27	2	D29, D30	DIODE SCHOTTKY 60V 0.5A, SOT23	DIODES INC, ZHCS506TA
28	2	D37, D38	Diode, BAS21, SOT23	DIODES INC., BAS21-13-F
29	1	D40	DIODE, 1N4148WS, SOD323	VISHAY, 1N4148WS-E3-08
30	1	D41	DIODE, TVS,170V, SMB	FAIRCHILD, SMBJ170A
31	1	D42	DIODE, ZENER, 27V, SOD323	DIODES INC., BZT52C27S-7-F
32	1	L1	INDUCTOR, 1.0µH, 20%	COILCRAFT, XPL2010-102ML
33	1	L2	INDUCTOR, 2.0µH, 20%	VISHAY, IHLP4040DZER2R0M11
34	1	L3	INDUCTOR, 33µH, 10%	Wurth, 7443643300
35	1	L4	INDUCTOR, 680µH, DO1606T	COILTRONICS, SD25-681
36	2	Q8, Q9	MOSFET, N-CH 150V, POWERPAK-SO-8	INFINEON, BSC190N15NS3 G
37	2	Q12, Q13	MOSFET, N-CH, 120V, POWERPAK-SO-8	VISHAY, Si7190DP
38	2	Q14, Q15	MOSFET, N-CH, 120V, POWERPAK-SO-8	VISHAY, Si7172DP
39	1	Q27	TRANS., NPN, 60V, 1A, SOT-89	DIODES INC., FCX491TA
40	1	Q28	MOSFET, N-CH, SUPER, SOT-6	FAIRCHILD, FDC2512-NL
41	1	Q29	MOSFET, P-CH, IRF6217, POWERPAK-SO-8	IR, IRF6217TRPBF

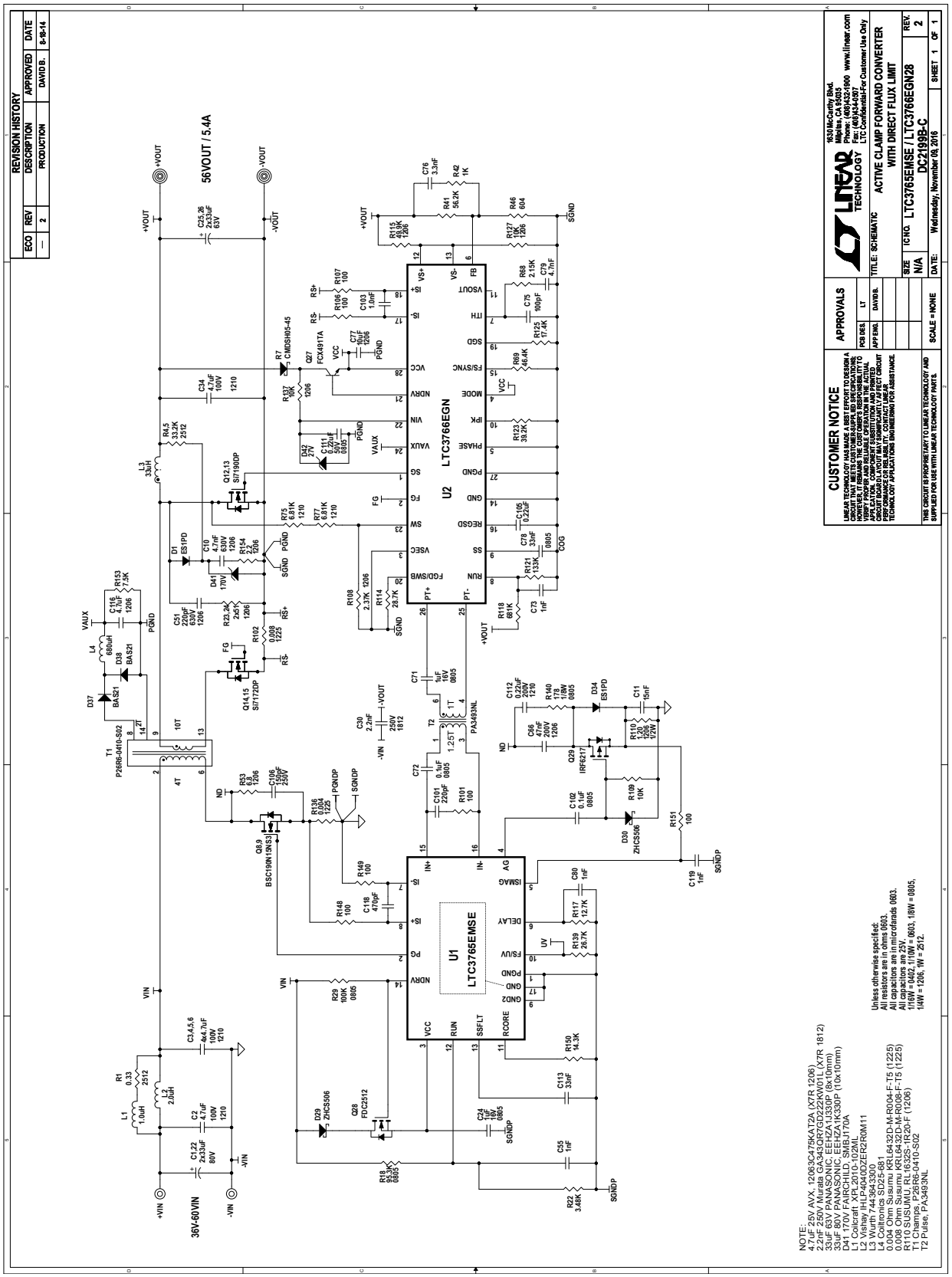
PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
42	1	R1	RES., CHIP, 0.33, 1/4W, 5%, 2512	PANASONIC, ERJ-1TRQJR33U
43	1	R7	DIODE SCHOTTKY 45V 0.5A, SOD323	CENTRAL SEMI., CMDSH05-45
44	2	R4, R5	RES., CHIP, 33.2K, 1W, 1%, 2512	PANASONIC, ERJ-1TYF3322U
45	1	R18	RES., 95.3K, 1/8W, 1%, 0805	VISHAY, CRCW080595K3FKEA
46	1	R22	RES., 3.48K, 1/16W, 1%, 0603	VISHAY, CRCW06033K48FKEA
47	2	R23, R24	RES., CHIP, 51, 1/4W, 5%, 1206	VISHAY, CRCW120651R0JKEA
48	1	R29	RES., CHIP, 100K, 1/8W, 5%, 0805	VISHAY, CRCW0805100KJNEA
49	1	R41	RES., CHIP, 56.2K, 1/16W, 1%, 0603	VISHAY, CRCW060356K2FKEA
50	1	R42	RES., CHIP, 1K, 1/16W, 1%, 0603	VISHAY, CRCW06031K00FKEA
51	1	R46	RES., CHIP, 604, 1/16W, 1%, 0603	VISHAY, CRCW0603604RFKEA
52	1	R53	RES., CHIP, 6.8, 1/2W, 1%, 1206	PANASONIC, ERJ-8RQF6R8V
53	1	R68	RES., CHIP, 2.15K, 1/16W, 1%, 0603	VISHAY, CRCW06032K15FKEA
54	1	R69	RES., CHIP, 46.4K, 1/16W, 1%, 0603	VISHAY, CRCW060346K4FKEA
55	2	R75, R77	RES., CHIP, 6.81K, 1/2W, 1%, 1210	VISHAY, CRCW12106K81FKEA
56	6	R101, R106, R107, R148, R149, R151	RES., CHIP, 100, 1/16W, 1%, 0603	VISHAY, CRCW0603100RFKEA
57	1	R102	RES., CHIP, 0.008, 3W, 1%, 1225	SUSUMU, KRL6432D-M-R008-F-T5
58	1	R108	RES., CHIP, 2.37K, 1/4W, 1%, 1206	VISHAY, CRCW12062K37FKEA
59	1	R109	RES., CHIP, 10K, 1/16W, 1%, 0603	VISHAY, CRCW060310K0FKEA
60	1	R110	RES., CHIP, 1.20, 1/2W, 1%, 1206	SUSUMU, RL1632S-1R20-F
61	1	R114	RES., CHIP, 28.7K, 1/16W, 1%, 0603	VISHAY, CRCW060328K7FKEA
62	1	R115	RES., CHIP, 49.9K, 1/4W, 1%,1206	VISHAY, CRCW120649K9FKEA
63	1	R117	RES., CHIP, 12.7K, 1/16W, 1%, 0603	VISHAY, CRCW060312K7FKEA
64	1	R118	RES., CHIP, 681K, 1/16W, 1%, 0603	VISHAY, CRCW0603681KFKEA
65	1	R121	RES., CHIP, 133K, 1/16W, 1%, 0603	VISHAY, CRCW0603133KFKEA
66	1	R123	RES., CHIP, 39.2K, 1/16W, 1%, 0603	VISHAY, CRCW060339K2FKEA
67	1	R125	RES., CHIP, 17.4K, 1/16W, 1%, 0603	VISHAY, CRCW060317K4FKEA
68	1	R127	RES., CHIP, 10K, 1/4W, 1%, 1206	VISHAY, CRCW120610K0FKEA
69	1	R136	RES., CHIP, 0.004, 1W, 1%, 1225	SUSUMU, KRL6432D-M-R004-F-T5
70	1	R137	RES., CHIP, 10K, 1/4W, 5%, 1206	VISHAY, CRCW120610K0JKEA
71	1	R139	RES., CHIP, 26.7K, 1/16W, 1%, 0603	VISHAY, CRCW060326K7FKEA
72	1	R140	RES., CHIP, 178, 1/8W, 1%, 0805	PANASONIC, ERJ-6ENF1780V
73	1	R150	RES., CHIP, 14.3K, 1/16W, 1%, 0603	VISHAY, CRCW060314K3FKEA
74	1	R153	RES., CHIP, 7.5K, 1/16W, 5%, 0603	VISHAY, CRCW06037K50JKEA
75	1	R154	RES., CHIP, 2.2, 1/4W, 5%, 1206	VISHAY, CRCW12062R20JKEA
76	1	T1	TRANSFORMER, 4T:4T:2T	CHAMPS TECH., P26R6-0410-S02
77	1	T2	TRANSFORMER, 1.25:1	PULSE, PA3493NL
78	1	U1	I.C. LTC3765EMSE, MSOP-16 PIN	LINEAR TECH., LTC3765EMSE#PBF
79	1	U2	I.C. LTC3766EGN, SSOP-GN28	LINEAR TECH., LTC3766EGN#PBF

PARTS LIST

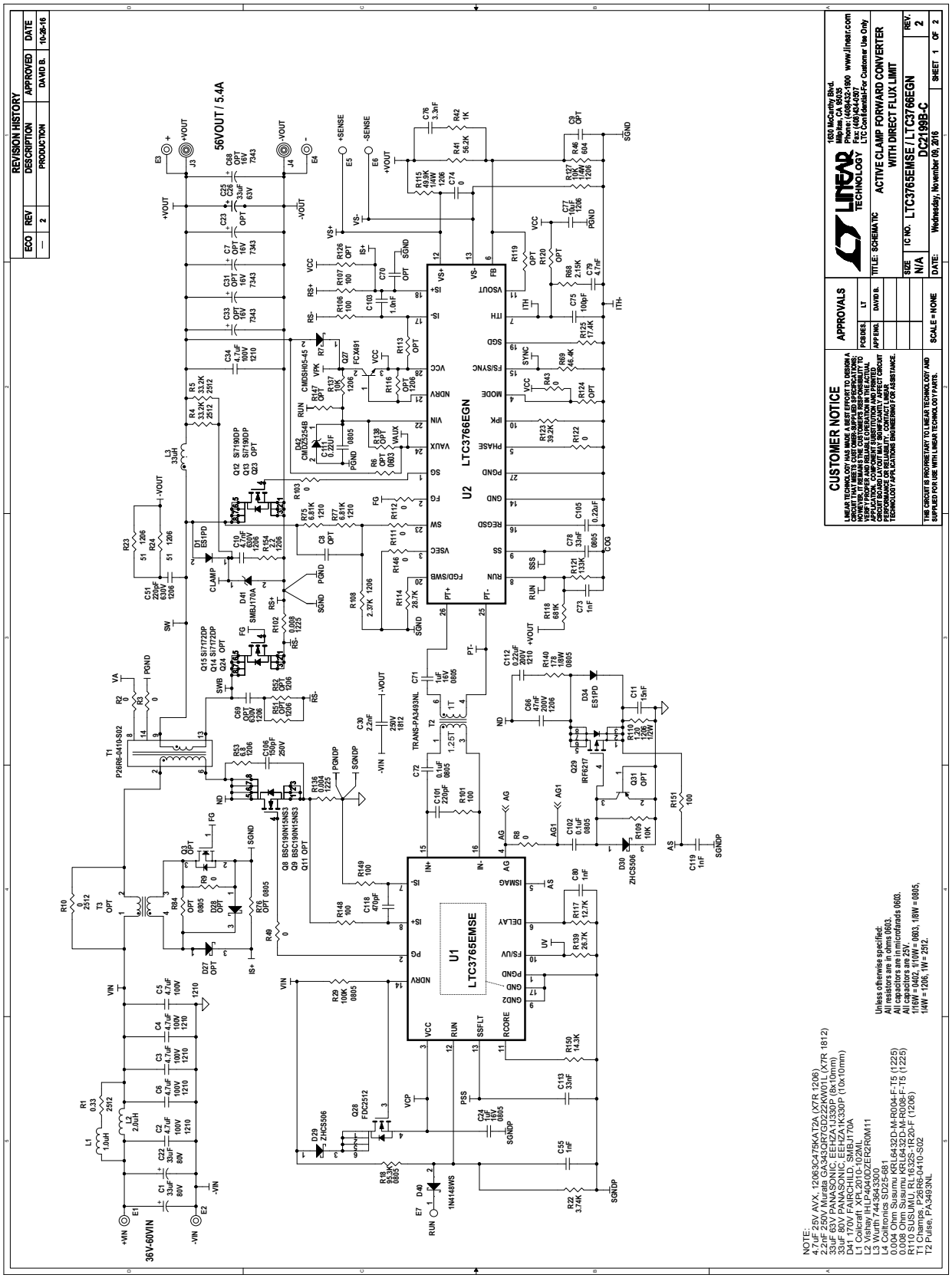
ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Additional Demo Board Circuit Components				
1	0	C7, C31, C33, C68	CAP., OPT, 7343	OPT
2	0	C8, C9, C18, C19, C12, C13, C14, C16, C20, C70	CAP., OPT, 0603	OPT
3	0	C17, C69	CAP., OPT,1206	OPT
4	0	C21, C15, C114	CAP., OPT, 0805	OPT
5	0	C23	CAP., OPT, CAP-SVPF-E12	OPT
6	1	C74	CAP, 0 0HM, JUMPER, 0603	VISHAY, CRCW06030000Z0EA
7	0	D2, D4, D35	DIODE, OPT, SOD323	OPT
8	0	D27, D28	DIODE, OPT, SOT23	OPT
9	0	Q1, Q2	MOSFET, OPT, SOT23-6	OPT
10	0	Q3	MOSFET, OPT, SOT23	OPT
11	0	Q4	MOSFET, OPT, D-PAK	OPT
12	0	Q31	TRANS, OPT, SOT23	OPT
13	0	Q11, Q23, Q24	MOSFET, OPT, POWERPAK-SO-8	OPT
15	7	R2, R3, R8, R43, R49, R103, R111, R112, R122, R146	RES., CHIP, 0 OHM, 0603	VISHAY, CRCW06030000Z0EA
14	0	R6, R9, R11, R12, R19, R25, R26, R27, R28, R30, R31, R32, R33, R34, R35, R113, R119, R120, R124, R126, R138, R147	RES., OPT, 0603	OPT
17	1	R10	RES., CHIP, 0.00 OHM, 1225	TEPRO, RN5326
16	0	R13, R14, R15	RES., OPT, 2512	OPT
18	0	R17, R51, R52, R116	RES., OPT,1206	OPT
19	0	R76, R84, R152	RES., OPT, 0805	OPT
20	0	T3	TRANSFORMER, 1:100, CT02-100	OPT
21	0	U3	I.C. OPT, SO16	OPT
Hardware: For Demo Board Only				
1	4	E1, E2, E3, E4	TESTPOINT, TURRET, .094"	MILL-MAX, 2501-2-00-80-00-00-07-0
2	3	E5, E6, E7	TESTPOINT, TURRET, .061"	MILL-MAX, 2308-2-00-80-00-00-07-0
3	0	J1	HEADER, OPT, 2X7PIN, 0.079CC	OPT, MOLEX, 87331-1420
4	2	J3, J4	STUD, TEST PIN	PEM, KFH-032-10
5	4	J3, J4 (2 EACH)	NUT, BRASS, #10-32	ANY #10-32
6	2	J3, J4	WASHER, STAR #10 BRASS NICKEL	ANY, #10EXT BZ TN
7	2	J3, J4	Ring, Lug Ring # 10	KEYSTONE, 8205
8	4	(STAND-OFF)	STAND-OFF, NYLON 0.25" (SNAP ON)	KEYSTONE, 8831

SCHEMATIC DIAGRAM



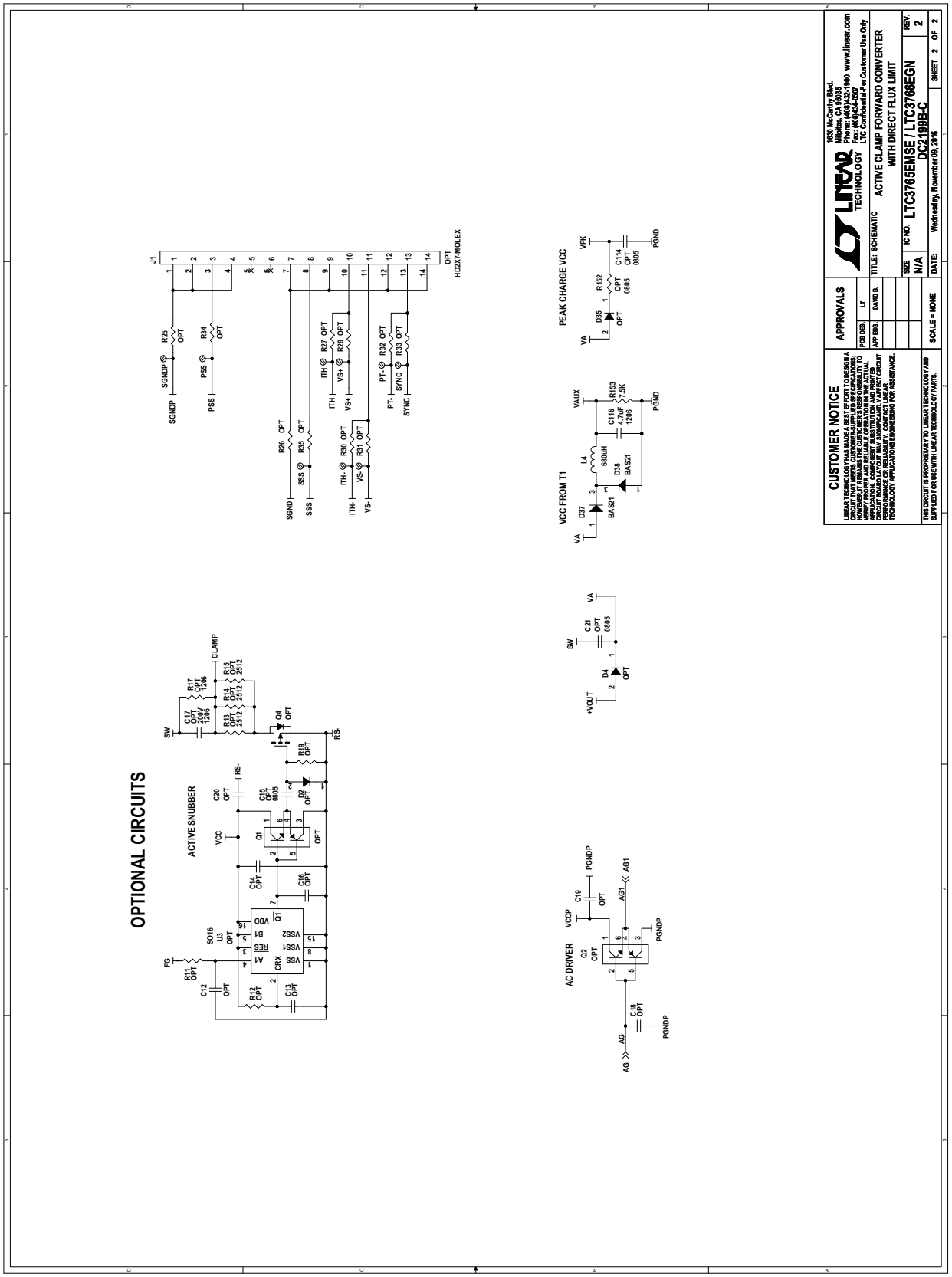
Simplified Schematic (without Unneeded Components)

SCHEMATIC DIAGRAM



Full Schematic, Page 1

SCHEMATIC DIAGRAM



Full Schematic, page 2

DEMONSTRATION BOARD IMPORTANT NOTICE

Linear Technology Corporation (LTC) provides the enclosed product(s) under the following **AS IS** conditions:

This demonstration board (DEMO BOARD) kit being sold or provided by Linear Technology is intended for use for **ENGINEERING DEVELOPMENT OR EVALUATION PURPOSES ONLY** and is not provided by LTC for commercial use. As such, the DEMO BOARD herein may not be complete in terms of required design-, marketing-, and/or manufacturing-related protective considerations, including but not limited to product safety measures typically found in finished commercial goods. As a prototype, this product does not fall within the scope of the European Union directive on electromagnetic compatibility and therefore may or may not meet the technical requirements of the directive, or other regulations.

If this evaluation kit does not meet the specifications recited in the DEMO BOARD manual the kit may be returned within 30 days from the date of delivery for a full refund. THE FOREGOING WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY THE SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. EXCEPT TO THE EXTENT OF THIS INDEMNITY, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user releases LTC from all claims arising from the handling or use of the goods. Due to the open construction of the product, it is the user's responsibility to take any and all appropriate precautions with regard to electrostatic discharge. Also be aware that the products herein may not be regulatory compliant or agency certified (FCC, UL, CE, etc.).

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LTC currently services a variety of customers for products around the world, and therefore this transaction **is not exclusive**.

Please read the DEMO BOARD manual prior to handling the product. Persons handling this product must have electronics training and observe good laboratory practice standards. **Common sense is encouraged**.

This notice contains important safety information about temperatures and voltages. For further safety concerns, please contact a LTC application engineer.

Mailing Address:

Linear Technology
1630 McCarthy Blvd.
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LifeElectronics
Живое партнерство

ООО «ЛайфЭлектроникс» **“LifeElectronics” LLC**

ИНН 7805602321 КПП 780501001 Р/С 40702810122510004610 ФАКБ "АБСОЛЮТ БАНК" (ЗАО) в г.Санкт-Петербурге К/С 30101810900000000703 БИК 044030703

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- *Конкурентоспособные цены и скидки постоянным клиентам.*
- *Специальные условия для постоянных клиентов.*
- *Подбор аналогов.*
- *Поставку компонентов в любых объемах, удовлетворяющих вашим потребностям.*

- *Приемлемые сроки поставки, возможна ускоренная поставка.*
- *Доставку товара в любую точку России и стран СНГ.*
- *Комплексную поставку.*
- *Работу по проектам и поставку образцов.*
- *Формирование склада под заказчика.*

- *Сертификаты соответствия на поставляемую продукцию (по желанию клиента).*
- *Тестирование поставляемой продукции.*
- *Поставку компонентов, требующих военную и космическую приемку.*
- *Входной контроль качества.*
- *Наличие сертификата ISO.*

В составе нашей компании организован Конструкторский отдел, призванный помогать разработчикам, и инженерам.

Конструкторский отдел помогает осуществить:

- *Регистрацию проекта у производителя компонентов.*
- *Техническую поддержку проекта.*
- *Защиту от снятия компонента с производства.*
- *Оценку стоимости проекта по компонентам.*
- *Изготовление тестовой платы монтаж и пусконаладочные работы.*

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