



LT3752-1/LT8311

200W Active Clamp Forward Converter with Input Voltage 150V to 400V

DESCRIPTION

Demonstration circuit 1929A is a 200W active clamp forward converter featuring the LT[®]3752-1/LT8311 chipset. It operates at about 100kHz and produces a regulated 12V output from an input voltage ranging from 150V to 400V, making it well suited for automotive, industrial, and other applications. Table 1 summarizes the performance of the demo board.

The LT3752-1 is a current mode PWM controller optimized for a forward converter with high-side active clamp transformer reset. An accurate, programmable volt-second clamp allows primary switch duty cycles above 50% for better utilization of switch, transformer and rectifier. The AOUT control signal can be used to power a gate drive transformer, level-shift driver, or opto-coupler driver for the high-side N-channel FET. The SOUT controls the secondary side synchronous rectification. The integrated housekeeping flyback controller brings great convenience for both primary and secondary bias circuits. During its soft-start and soft-stop, LT3752-1 folds back switching

frequency and duty-ratio clamp, thus reduces the electrical stresses over the output inductor, and transformer.

The LT3752-1 features a set of safety protections including undervoltage, overvoltage and overcurrent protections. Its precise overcurrent protection allows for continuous reliable operation under short-circuit conditions. The LT8311 controls the secondary side synchronous rectification, with enhanced regulation of the output voltage during startup, shutdown or recovery from a fault.

The LT3752-1 and LT8311 data sheets give complete descriptions of the parts, operation and application information. The data sheet must be read in conjunction with this quick start guide for Demo Circuit 1929A.

Design files for this circuit board are available at
<http://www.linear.com/demo/DC1929A>

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PERFORMANCE SUMMARY

Specifications are at $T_A = 25^\circ\text{C}$

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage Range (V_{IN})		150	250	400	V
Startup Voltage		150			V
UVLO Shutdown Voltage		147			V
OVLO Shutdown Voltage		416			V
Output Voltage (V_{OUT})	$V_{IN} = 150\text{V to } 400\text{V}$	11.76	12	12.24	V
Rated Output Current Continuous (I_{OUT})	300LFM	16.7			A
Short-term Output Current (I_{MAX})	300LFM, 1 Minute		20		A
Switching Frequency (f_{SW})		100			kHz
Output Voltage Ripple (Peak_to_Peak)		120			mV _{P-P}
No Load Current	$I_{OUT} = 0\text{A}, V_{IN} = 400\text{V}$	18			mA
Efficiency	$V_{IN} = 250\text{V}, I_{OUT} = 16.7\text{A}, 300LFM$	93.9			%
Isolation (Primary and Secondary)		1500			V

DEMO MANUAL DC1929A

QUICK START PROCEDURE

IMPORTANT NOTE TO CUSTOMERS:

HAZARDOUS HIGH VOLTAGES ARE PRESENTED ON THE DEMO CIRCUIT. IMPROPER OR UNSAFE HANDLING OF THIS DEMO BOARD CAN LEAD TO LETHAL INJURIES TO HUMAN BODY. ONLY QUALIFIED PERSONNEL SHOULD OPERATE IT. YOU ARE STRONGLY RECOMMENDED TO USE SAFETY GLASSES AND AN ISOLATION TRANSFORMER. IMPROPER COMPONENTS REPLACEMENT ON THE DEMO CIRCUIT CAN CAUSE PERFORMANCE DETERIORATIONS, CIRCUIT MALFUNCTION, PROPERTY DAMAGE, AND EVEN LIFE-THREATENING INJURIES. CONTACT LINEAR TECHNOLOGY APPLICATIONS ENGINEERS FOR PROPER COMPONENT REPLACEMENT AND CIRCUIT MODIFICATION.

Demonstration circuit 1929A must be set up as follows to evaluate the performance of the LT3752-1/LT8311. Refer to Figure 1 for proper equipment setup and follow the procedure below.

NOTE. Do not operate DC1929A unless you have the appropriate safety precautions in place on your bench to guarantee safety. Always remove power before touching, servicing, or attaching probes to the demo board. Never leave the DC1929A unattended when under power.

1. With power off, connect the input power supply to the board. The power supply should be adjustable over 100V ~ 450V range, and at least 3A current capability. An ammeter capable of measuring 3ADC can be put in series with the input supply to measure the input current. Connect the load to the terminals V_{OUT}^+ (J1) and V_{OUT}^- (J2) on the board. The load should be adjustable up to 20A. If efficiency measurements are desired, an ammeter capable of measuring 20ADC or a resistor shunt can be put in series with the load to measure the output current. A voltmeter can be placed across the output terminals (E4, E5) in order to get an accurate output voltage measurement.
2. Direct airflow of 300LFM across the demo circuit for sustained operation at full load. Refer to Figure 1 for proper airflow direction.

3. Turn on the power at the input. Increase V_{IN} slowly to 150V.

NOTE. Make sure that the input voltage does not exceed 400V. Make sure the load current does not exceed the specifications.

NOTE. Check the standby current without any load applied and it should be less or around 25mA at 150V input, or 20mA at 400V input. Any cross-conduction of the primary-secondary switches will significantly increase the standby current.

4. Check for the proper output voltages. The output should be regulated at 12.0V ($\pm 2\%$).

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

NOTE. By removing the resistor R2, and applying the V_{IN} between V_B and $-V_{IN}$, the main power circuit is disconnected from the control/bias circuits, and the control/bias circuit can be debugged separately. The standby current of the control/bias circuit should be less than 2mA.

NOTE. By removing R37 and R40, and adjusting R25 to 107k, the feedback loop is disabled, and the circuit runs in no-opto bus converter mode.

5. Once the proper output voltage is established, adjust the input voltage and load current within the operating range and observe the output voltage regulation, ripple voltage, efficiency and other parameters.

NOTE. When measuring the output voltage ripples, care must be taken to avoid a long ground lead on the oscilloscope probe. See Figure 2 for proper scope probe technique.

NOTE. Airflow should be directed to the demo circuit according to the direction shown in Figure 1. Running the circuit at full load without airflow could overheat the power components, and lead to damage of the board. Overload operation of the demo circuit is feasible for short-term only. Long term overcurrent operation is not recommended, unless enhanced cooling methods are used.

6. Turn off the load at the output, the power at the input, and then turn off the airflow.

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QUICK START PROCEDURE

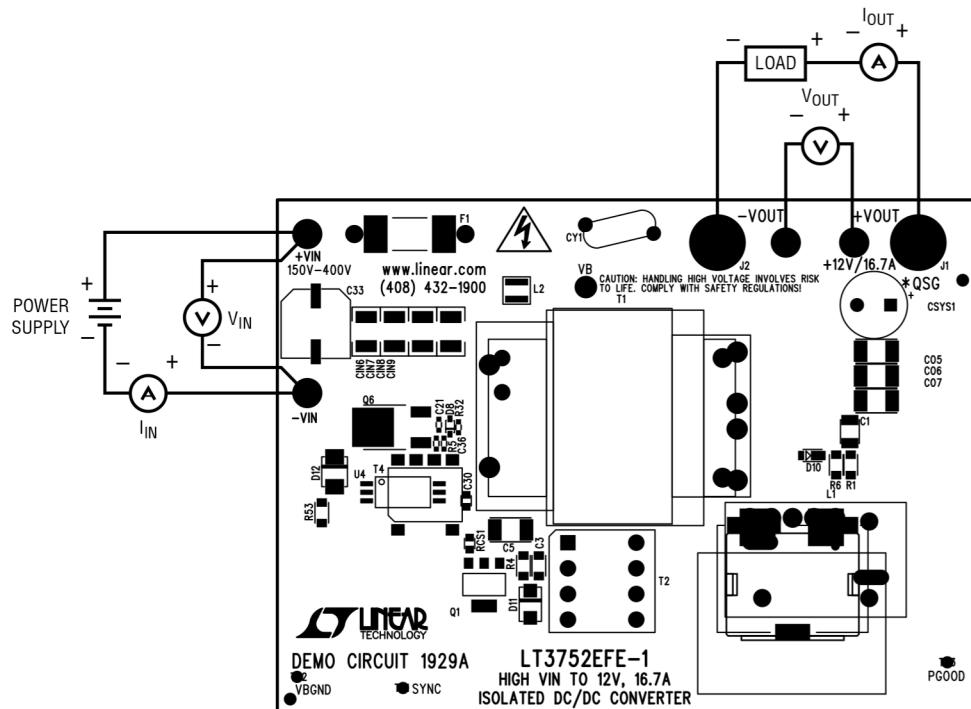


Figure 1. Proper Measurement Equipment Setup

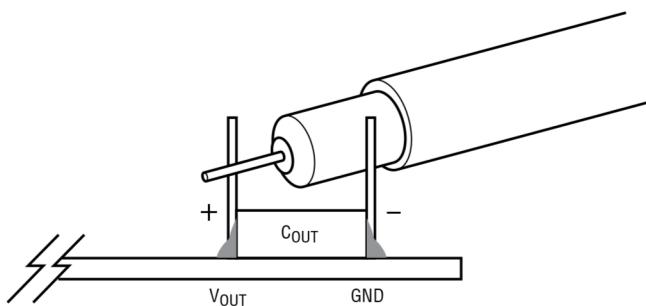


Figure 2. Proper Scope Probe Placement for Measuring Output Ripple

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QUICK START PROCEDURE

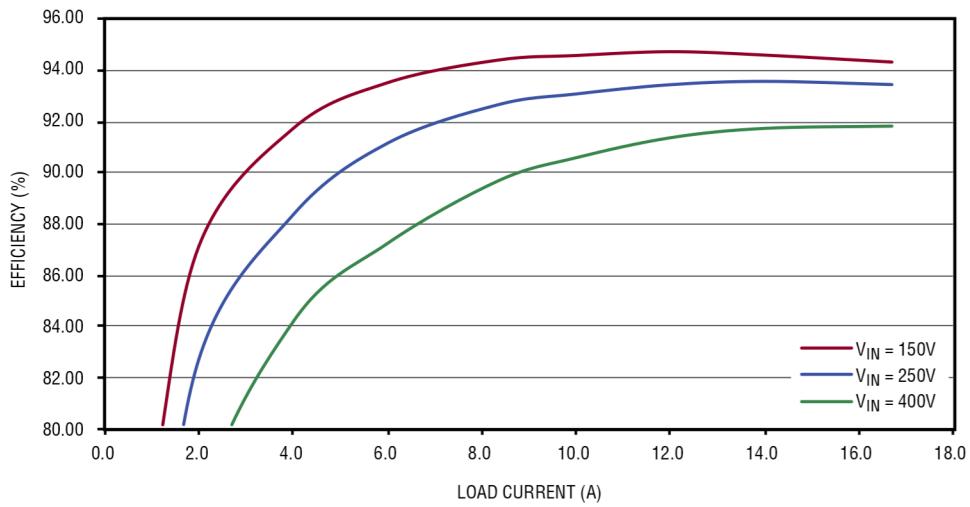


Figure 3. Typical Efficiency Curve, (300LFM, $T_A = 25^\circ\text{C}$)

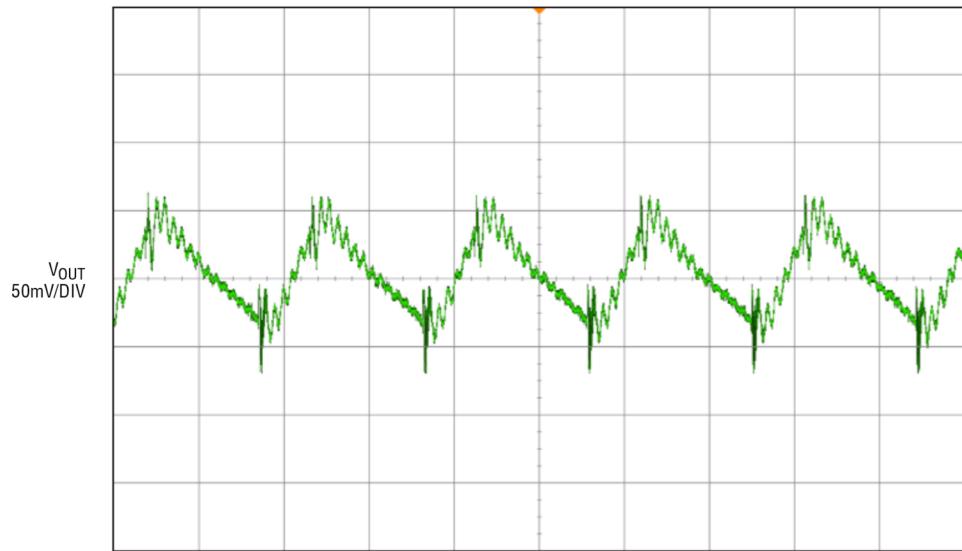


Figure 4. Output Ripple at $250V_{IN}$ at $16.7A_{OUT}$

QUICK START PROCEDURE

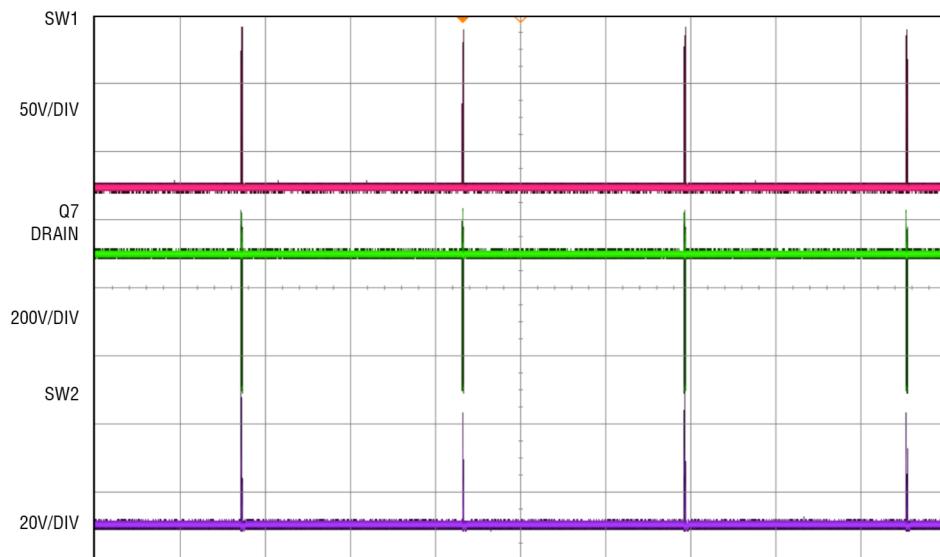


Figure 5. Short-Circuit at Output at $V_{IN} = 400V$

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PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	9	CIN1-CIN9	CAP., X7T, 0.22µF, 630V, 10% 1812	TDK, C4532X7T2J224K
2	4	C01, C02, C03, C04	CAP., X7R, 33µF, 16V, 20%, 1812	TDK, C4532X7R1C336M
3	1	CSYS1	CAP., ALUM, 1000µF, 16V, SEPF SERIES	PANASONIC, 16SEPF1000M
4	1	CY1	CAP., CER, 2200pF, 500VAC, 20% RADIAL	VISHAY, VY1222M47Y5UG63V0
5	1	C1	CAP., X7R, 10nF, 250V, 10% 1210	AVX, 1210PC103KAT1A
6	1	C4	CAP., X7R, 4.7µF, 25V, 10%, 1206	TDK, C3216X7R1E475K
7	2	C5, C8	CAP., X7R, 47nF, 630V, 10%, 1812	AVX, 1812CC473KAT1A
8	1	C6	CAP., X7R, 22µF, 25V, 10%, 1210	MURATA, GRM32ER71E226K
9	1	C7	CAP., CH, 10nF, 630V, 10%, 1210	TDK, C3225CH2J103J125AA
10	1	C10	CAP., X7R, 10µF, 25V, 10%, 1210	AVX, 12103C106KAT2A
11	2	C11, C27	CAP., X7R, 22nF, 50V, 10%, 0603	AVX, 06035C223KAT2A
12	1	C12	CAP., COG, 220pF, 25V, 5%, 0603	AVX, 06033A221JAT2A
13	2	C13, C21	CAP., COG, 470pF, 25V, 5%, 0603	AVX, 06033A471JAT2A
14	1	C14	CAP., X7R, 1nF, 25V, 10%, 0603	AVX, 06033C102KAT2A
15	2	C22, C26	CAP., X5R, 4.7µF, 25V, 10%, 0805	AVX, 08053D475KAT2A
16	1	C23	CAP., X7R, 0.47µF, 16V, 10%, 0603	TDK, C1608X7R1C474K
17	1	C24	CAP., X7R, 0.22µF, 25V, 10%, 0603	AVX, 06033C224KAT2A
18	2	C25, C31	CAP., X5R, 2.2µF, 16V, 10%, 0603	AVX, 06033YD225KAT2A
19	1	C28	CAP., COG, 68pF, 50V, 5%, 0603	AVX, 06035A680JAT2A
20	1	C29	CAP., X7R, 1µF, 25V, 10%, 0603	AVX, 06033C105KAT2A
21	1	C30	CAP., X7R, 0.22µF, 50V, 10%, 0805	AVX, 08055C224KAT2A
22	1	C32	CAP., COG, 10pF, 50V, 5%, 0603	AVX, 06035A100JAT2A
23	1	C33	CAP., Alum. Electro. 2.2µF, 450V, G13 size	Panasonic, EEVEB2W2R2Q
24	2	D1, D2	Schottky Barrier Rec., POWER-DI-123	DIODE INC., DFLS1200-7
25	4	D4, D5	Diode, High-Speed Diode, SOD-523	NXP/Phillips Semi. BAS516
26	1	D10	Schottky Barrier Rec., SOD-123	CENTRAL SEMI., CMMR1U-02
27	1	D12	Rectifier, 1000V, 1A, SMB	CENTRAL SEMI., CMR1U-10
28	1	F1	FUSE, 600V, 2.5A, 485 SERIES	Littelfuse, 048502.5DR
29	1	L1	IND., 15µH	Coilcraft, AGP2923-153KL
30	1	L2	IND., 4.7µH, XAL40xx SERIES	Coilcraft, XAL4030-472ME
31	1	Q1	N-Chan. BSP300, SOT-223	infineon, BSP300
32	3	Q2, Q3, Q8	FET, N-CH, POWER 56	Fairchild, FDMS86200
33	2	Q4, Q5	FET, N-CH, LFPAK	RENESAS, RJK0653DPB-00#J5
34	1	Q6	Power Transistor, 600V, DPAK	Infineon, IPD60R1K4C6
35	1	Q7	Power Transistor, 650V, DPAK	Infineon, IPD65R250C6
36	1	Q9	NPN/PNP Transistor, SC-74	NXP SEMI., PBSS4140DPN
37	1	RCS1	RES., CHIP., 0.2, 1/8W, 1% 0805	VISHAY, WSL0805R200FEA
38	1	RCS2	RES., CHIP., 0.039, 1W, 1%, PRL1632	SUSUMU, PRL1632-R039-F-T1
39	1	RCS3	RES., CHIP., 0.002, 1W, 2%, PML18	ROHM, PML18EZPGV2L00
40	2	R1,R6	RES., CHIP., 20k, 1/4W, 1%, 1206	VISHAY, CRCW120620K0FKEA
41	1	R2	RES., CHIP., 2, 1/4W, 1%, 1206	VISHAY, CRCW12062R00FKEA

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PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
42	1	R5	RES., CHIP., 3.3, 1/10W, 1%, 0603	VISHAY, CRCW06033R30FKEA
43	2	R7, R14	RES., CHIP., 374k, 1/4W, 1%, 1206	VISHAY, CRCW1206374KFKEA
44	1	R8	RES., CHIP., 402, 1/4W, 1%, 1210	VISHAY, CRCW1210402RFKEA
45	2	R9, R17	RES., CHIP., 499k, 1/4W, 1%, 1206	VISHAY, CRCW1206499KFKEA
46	1	R10	RES., CHIP., 232, 1/10W, 1%, 0603	VISHAY, CRCW0603232RFKEA
47	1	R11	RES., CHIP., 499, 1/10W, 1%, 0603	VISHAY, CRCW0603499RFKEA
48	1	R15	RES., CHIP., 806, 1/10W, 1%, 0603	VISHAY, CRCW0603806RFKEA
49	1	R16	RES., CHIP., 2.80k, 1/10W, 1%, 0603	VISHAY, CRCW06032K80FKEA
50	1	R18	RES., CHIP., 5.76k, 1/10W, 1%, 0603	VISHAY, CRCW06035K76FKEA
51	1	R19	RES., CHIP., 200, 1/10W, 5%, 0603	VISHAY, CRCW0603200RJKEA
52	1	R22	RES., CHIP., 2.94k, 1/10W, 1%, 0603	VISHAY, CRCW06032K94FKEA
53	1	R23	RES., CHIP., 1.5k, 1/10W, 1%, 0603	VISHAY, CRCW06031K50FKEA
54	3	R3, R24, R31	RES., CHIP., 10, 1/10W, 5%, 0603	VISHAY, CRCW060310R0JKEA
55	1	R25	RES., CHIP., 124k, 1/10W, 1%, 0603	VISHAY, CRCW0603124KFKEA
56	1	R28	RES., CHIP., 124k, 1/10W, 1%, 0603	VISHAY, CRCW0603124KFKEA
57	1	R29	RES., CHIP., 20k, 1/10W, 1%, 0603	VISHAY, CRCW060320K0FKEA
58	1	R30	RES., CHIP., 40.2k, 1/10W, 1%, 0603	VISHAY, CRCW060340K2FKEA
59	3	R12, R32, R46	RES., CHIP., 10k, 1/10W, 5%, 0603	VISHAY, CRCW060310K0JNEA
60	1	R33	RES., CHIP., 75k, 1/10W, 1%, 0603	VISHAY, CRCW060375K0FKEA
61	1	R34	RES., CHIP., 154, 1/10W, 1%, 0603	VISHAY, CRCW0603154RFKEA
62	4	R35, R36, R41, R63	RES., CHIP., 100k, 1/10W, 1%, 0603	VISHAY, CRCW0603100KFKEA
63	1	R37	RES., CHIP., 100, 1/10W, 5%, 0603	VISHAY, CRCW0603100RJNEA
64	1	R38	RES., CHIP., 5.62k, 1/10W, 1%, 0603	VISHAY, CRCW06035K62FKEA
65	1	R39	RES., CHIP., 78.7k, 1/10W, 1%, 0603	VISHAY, CRCW060378K7FKEA
66	1	R40	RES., CHIP., 3.16k, 1/10W, 1%, 0603	VISHAY, CRCW06033K16FKEA
67	3	R42, R55, R62	RES., CHIP., 1k, 1/10W, 1%, 0603	VISHAY, CRCW06031K00FKEA
68	1	R43	RES., CHIP., 12.7k, 1/10W, 1%, 0603	VISHAY, CRCW060312K7FKEA
69	1	R49	RES., CHIP., 1.13k, 1/10W, 1%, 0603	VISHAY, CRCW06031K13FKEA
70	5	R50, R56, R59-R61	RES., CHIP., 0, 1%, 0603	VISHAY, CRCW06030000Z0EA
71	1	R51	RES., CHIP., 309, 1/10W, 1%, 0603	VISHAY, CRCW0603309RFKEA
72	1	R53	RES., CHIP., 4.42, 1/4W, 1%, 1206	VISHAY, CRCW12064R42FKEA
73	1	R54	RES., CHIP., 523k, 1/10W, 1%, 0603	VISHAY, CRCW0603523KFKEA
74	1	R65	RES., CHIP., 10, 1/8W, 5%, 0805	VISHAY, CRCW080510R0JNEA
75	1	T1	Transformer, LT80R2-12AC-3124005 REV 01	CHAMPS, LT80R2-12AC-3124005 REV 01
76	1	T2	Transformer, WE750817020 REV 1	WE., 750817020 REV 1
77	1	T3	Transformer, PE-68386NL	PULSE ENG., PE-68386NL
78	1	U1	I.C., Synch. Reg. TSSOP-38(331)	Linear Tech., LT3752EFE-1#PBF
79	1	U2	I.C., LT8311EFE TSSOP-20(16)	Linear Tech., LT8311EFE#PBF
80	1	U3	I.C., PS2801C-1	NEC, PS2801C-1
81	1	U4	I.C., ACPL-W346	AVAGO, ACPL-W346

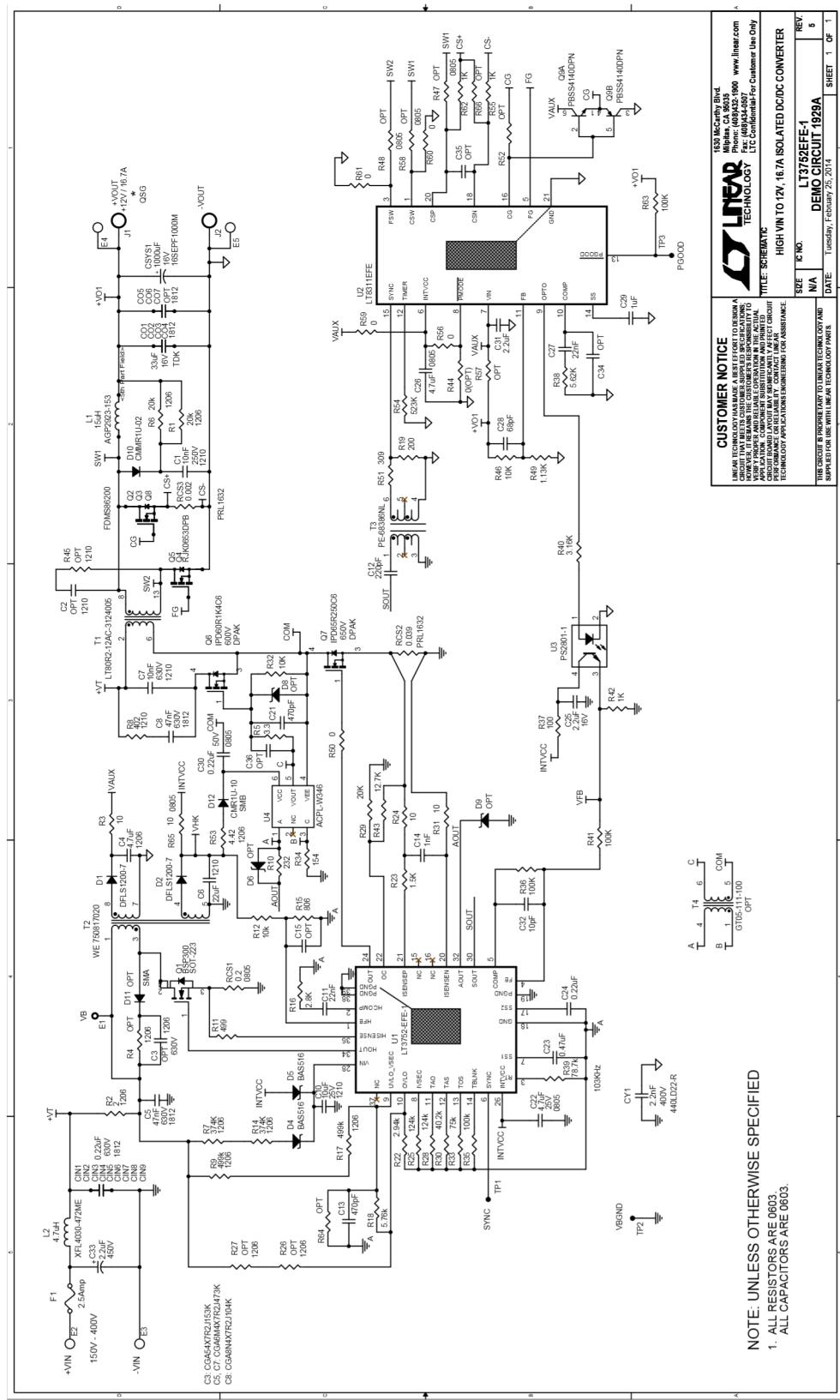
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PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Additional Demo Board Circuit Components				
1	0	C05, C06 (OPT)	CAP., X7R, 1812	
2	0	C2 (OPT)	CAP., 1210	
3	0	C3 (OPT)	CAP., 1206	
4	0	C15, C34-C36 (OPT)	CAP., 0603	
5	0	D6 (OPT)	Diode, SOD-523	
6	0	D8, D9 (OPT)	Diode, SOD323	
7	0	D11 (OPT)	Rectifier, SMA	
8	0	R4, R26, R27 (OPT)	RES., CHIP., 1206	
9	0	R44, R52, R57, R64, R66 (OPT)	RES., 0603	
10	0	R45 (OPT)	RES., 1210	
11	0	R47, R48, R58 (OPT)	RES., 0805	
12	0	T4 (OPT)	Transformer., GT05-111-100	ICE, GT05-111-100
Hardware: For Demo Board Only				
1	1	E1	TESTPOINT, TURRET, .061" pbf	MILL-MAX, 2308-2-00-80-00-00-07-0
2	4	E2-E5	TESTPOINT, TURRET, .094" pbf	MILL-MAX, 2501-2-00-80-00-00-07-0
3	2	J1, J2	JACK BANANA	KEYSTONE, 575-4

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SCHEMATIC DIAGRAM



Information furnished by Linear Technology Corporation is believed to be accurate and reliable. However, no responsibility is assumed for its use. Linear Technology Corporation makes no representation that the interconnection of its circuits as described herein will not infringe on existing patent rights.



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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.**

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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.

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