

LTC3765/LTC3766

120W Isolated Forward Converter with Synchronous Rectification

DESCRIPTION

Demonstration circuit 1739B-C is a 120W isolated forward converter with synchronous rectification featuring the [LTC®3765/LTC3766](#) chip set.

This circuit was designed to demonstrate the high level of performance, efficiency, and small solution size attainable using this chip set in an active-clamp-reset forward converter power supply. It operates at 240kHz and produces a regulated 12V, 10A output from an input voltage range of 9V to 36V: suitable for telecom, industrial, and other applications. It has an eighth-brick footprint area. Synchrono-

nous rectification helps to attain efficiency exceeding 94%. 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 factory.

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

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PERFORMANCE SUMMARY

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

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{IN}	Input Supply Range		9		36	V
V_{OUT}	Output Voltage			12.0		V
I_{OUT}	Output Current Range, Continuous	200LFM	0		10	A
f_{SW}	Switching (Clock) Frequency			240		kHz
$V_{OUT(P-P)}$	Output Ripple	$V_{IN} = 24V$, $I_{OUT} = 10A$ (20MHz BW)		40		mV _{P-P}
I_{REG}	Output Regulation	Line and Load ($9V_{IN}$ to $36V_{IN}$, $0A_{OUT}$ to $10A_{OUT}$)		± 0.27		%
P_{OUT}/P_{IN}	Efficiency (See Figure 3)	$V_{IN} = 24V$, $I_{OUT} = 10A$		92.7		%
	Isolation	Basic	1500			VDC
	Approximate Size	Component Area $\times$ Top Component Height		$2.3 \times 0.9 \times 0.47$		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 secondary bias source reaches the undervoltage threshold, the LTC3766 comes alive and takes control by sending encoded PWM gate pulses to the LTC3765 through T3. 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 simplified 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. (See Linear Technology Application Note 19 for a discussion of input filter stability.) A source with a 170m Ω or higher ESR at the filter resonant frequency (~35kHz) is one way of providing damping for the filter elements provided on the DC1739B-C. For bench testing, an electrolytic capacitor has been added at the input terminals to provide suitable damping and 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 1739B-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 9V to 36V to 9V. 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 +VIN and -VIN.
 - a. Input voltages lower than 9V 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 DC1739B-C's input current.
- c. A voltmeter with a capability of measuring at least 36V 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 36V.

5. Check for the proper output voltage of 12V. Turn off the power at the input.
6. Once the proper output voltages are established, connect a variable load capable of sinking 10A at 12V to the output terminals +VOUT and -VOUT. Set the current for 0A.

QUICK START PROCEDURE

- If efficiency measurements are desired, an ammeter or a resistor shunt that is capable of handling 10ADC can be put in series with the output load in order to measure the DC1739B-C's output current.
- A voltmeter with a capability of measuring at least 12V can be placed across the output terminals in order to get an accurate output voltage measurement.

- 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.

- 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.

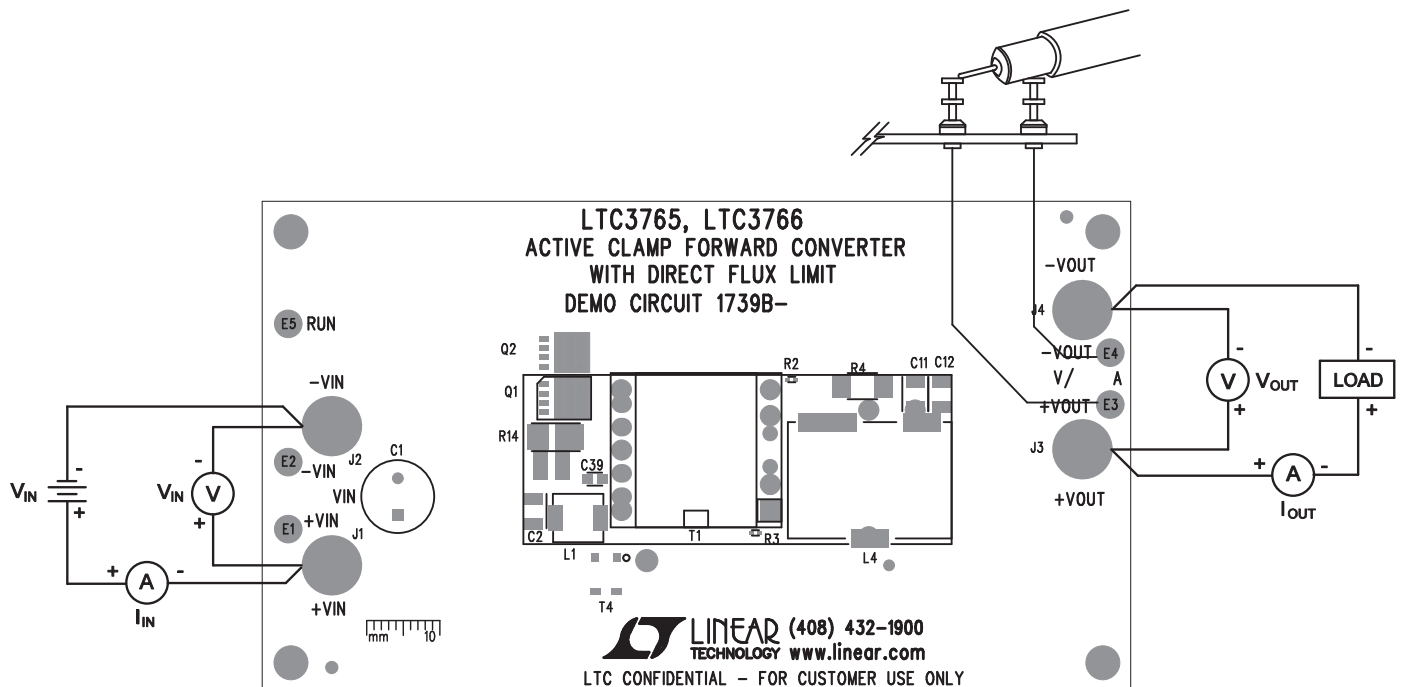


Figure 1. Proper Measurement Equipment Setup

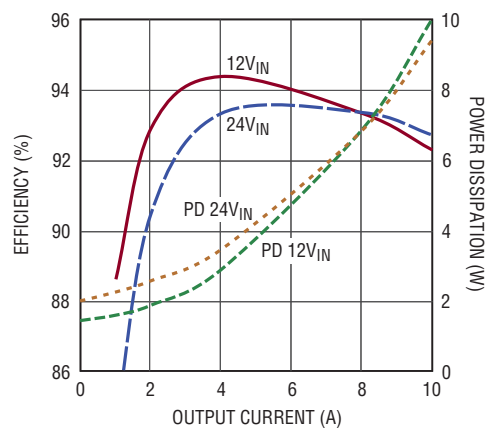


Figure 2. Efficiency and Power Dissipation

QUICK START PROCEDURE

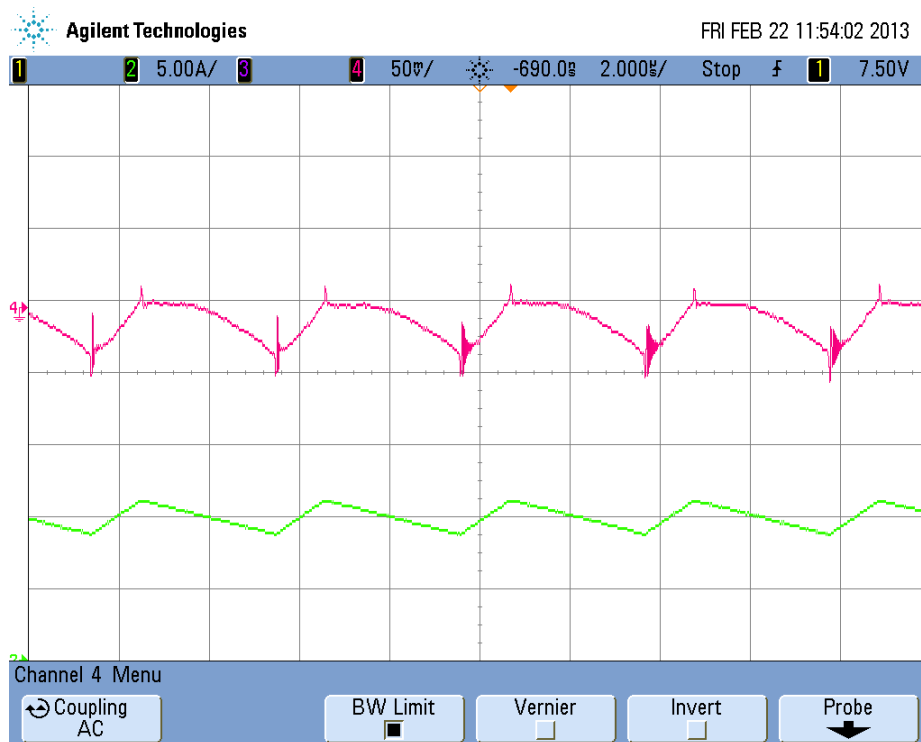


Figure 3. Output Ripple at 24V_{IN} and 10A_{OUT} (50mV, 5A, 2μs/Div, 20MHz)



Figure 4. Transient Response Waveform at 24V_{IN} and 5A – 7.5A – 5A_{OUT} (5A, 100mV, 100μs/Div)

dc1739bcf

QUICK START PROCEDURE



Figure 5. Thermal Map, Front Side at 24V_{IN} and 10A_{OUT} (T_A = 25°C, 200LFM)



Figure 6. Thermal Map, Back Side at 24V_{IN} and 10A_{OUT} (T_A = 25°C, 200LFM)

DEMO MANUAL DC1739B-C

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	1	C1	CAP., AL., TH, 100uF, 50V, ME-PX SERIES	SUNCON, 50ME100PX
2	4	C2, C3, C4, C5	CAP., X7R, 10uF, 50V, 10%, 1210	MURATA, GRM32ER71H106KA12
3	1	C6	CAP., COG, 47pF, 200V, 5%, 1206	AVX, 12062A470JAT2A
4	1	C7	CAP., COG, 15pF, 200V, 5%, 0805	AVX, 08052A150JAT2A
5	2	C8, C9	CAP., POSCAP, 68uF, 16V, 20%, 7343	SANYO, 16TQC68M
6	1	C10	CAP., X7R, 2.2nF, 630V, 5%, 1206	MURATA, GRM31A7U2J222JW31
7	2	C12, C27	CAP., X7R, 10uF, 16V, 20%, 1206	MURATA, GRM31CR71C106MA12
8	1	C13	CAP., X7R, 1.0uF, 100V, 10%, 1206	MURATA, GRM31CR72A105KA01
9	1	C14	CAP., X7R, 0.1uF, 250V, 10%, 1206	MURATA, GRM31CR72E104KW03
10	1	C16	CAP., COG, 1000pF, 25V, 5%, 0402	TDK, C1005C0G1E102J
11	3	C17, C20, C35	CAP., X7R, 0.1uF, 25V, 10%, 0603	AVX, 06033C104KAT2A
12	1	C18, C33	CAP., COG, 2200pF, 50V, 5%, 0603	MURATA, GRM1885C1H222JA01D
13	1	C19	CAP., X7R, 12nF, 50V, 10%, 0805	AVX, 08055C123KAT2A
14	2	C21, C23	CAP., X7R, 1.0uF, 16V, 10%, 0805	MURATA, GRM21BR71C105KA01L
15	2	C22	CAP., COG, 220pF, 25V, 5%, 0603	AVX, 06033A221JAT2A
16	1	C24	CAP., X7R, 2200pF, 250V, 10%, 1812	MURATA, GA343QR7GD222KW01L
17	1	C25	CAP., COG, 0.033uF, 25V, 5%, 0805	TDK, C2012C0G1E333J
18	1	C28	CAP., X7R, 0.010uF, 50V, 10%, 0603	AVX, 06035C103KAT2A
19	1	C29	CAP., X7R, 0.033uF, 25V, 10%, 0603	AVX, 06033C333KAT2A
20	1	C32	CAP., COG, 47pF, 25V, 5%, 0603	AVX, 06033A470JAT2A
21	2	C37, C44	CAP., COG, 1000pF, 25V, 5%, 0603	AVX, 06033A102JAT2A
22	1	C36	CAP., X7R, 1500pF, 50V, 10%, 0402	AVX, 04025C152KAT2A
23	1	C39	CAP., X7R, 1.0uF, 50V, 10%, 0805	MURATA, GRM21BR71H105KA12
24	1	D1	DIODE ULTRA FAST 1A 200V SMP	VISHAY, ES1PD-M3 / 84A
25	2	D3, D5	DIODE SCHOTTKY 40V 0.4A SOD323	DIODES INC., ZHCS400TA
26	1	L1	INDUCTOR, 0.56uH 20%	VISHAY, IHLP2525EZERR56M01
27	1	L4	INDUCTOR, 16uH	CHAMPS PQA2050-16-LTC
28	1	Q1	MOSFET N-CH 60V POWERPAK-SO-8	INFINEON, BSC028N06NS
29	1	Q3	MOSFET N-CH POWERPAK-SO-8	INFINEON, BSC057N08NS3G
29	1	Q4	MOSFET N-CH 150V POWERPAK-SO-8	INFINEON, BSC190N15NS3
30	1	Q5	MOSFET, P-CH, IRF6217, SO-8	IR, IRF6217TR
31	1	Q6	MOSFET, N-CH, SUPER SOT23	FAIRCHILD, 2N7002
32	1	R1	RES., CHIP, 12.4Ω, 1/4W, 1%, 1206	VISHAY, CRCW120612R4FKEA
33	2	R4	RES., CHIP, 15k, 1W 2512	VISHAY, CRCW251215KJNEG
34	1	R7, R37	RES., CHIP, 909Ω, 1/8W, 1%, 0805	VISHAY, CRCW0805909RFKEA
35	1	R10	RES., CHIP, 0.005Ω, 1W, 1%, 2512	PANASONIC, ERJ-M1WTF5M0U
36	1	R11	RES., CHIP, 51.1Ω, 1/8W, 1%, 0805	VISHAY, CRCW080551R1FKEA
37	1	R14	RES., CHIP, 0.004Ω, 3W, 5%, 1225	SUSUMU, KRL6432D-C-R004-F-T5
38	1	R17	RES., CHIP, 28.7k, 1/8W, 1%, 0805	VISHAY, CRCW080528K7FKEA
39	1	R18	RES., CHIP, 100k, 1/8W, 5%, 0805	VISHAY, CRCW0805100KJNEA
40	4	R19, R20, R23, R24	RES., CHIP, 100Ω, 1/16W, 1%, 0402	VISHAY, CRCW0402100RFKEA
41	1	R22	RES., CHIP, 1.82k, 1/4W, 1%, 1206	VISHAY, CRCW12061K82FKEA
42	1	R25	RES., CHIP, 10k, 1/10W, 1%, 0603	VISHAY, CRCW060310K0FKEA
43	1	R26	RES., CHIP, 2.21k, 1/10W, 1%, 0603	VISHAY, CRCW06032K21FKEA

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PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
44	1	R27	RES., CHIP, 0.750Ω, 1/3W, 1%, 0805	SUSUMU, RL1220S-R75-F
45	1	R29	RES., CHIP, 20.0k, 1/10W, 1%, 0603	VISHAY, CRCW060320K0FKEA
46	1	R35	RES., CHIP, 1.82k, 1/10W, 1%, 0603	VISHAY, CRCW06031K82FKEA
47	1	R36	RES., CHIP, 11.5k, 1/10W, 1%, 0603	VISHAY, CRCW060311K5FKEA
48	1	R38, R39, R56	RES., CHIP, 100Ω, 1/10W, 1%, 0603	VISHAY, CRCW0603100RFKEA
48	1	R40	RES., CHIP, 464k, 1/10W, 1%, 0603	VISHAY, CRCW0603464KFKEA
49	1	R41	RES., CHIP, 14.7k, 1/10W, 1%, 0603	VISHAY, CRCW060314K7FKEA
49	1	R42	RES., CHIP, 78.7k, 1/10W, 1%, 0603	VISHAY, CRCW060378K7FKEA
50	1	R44	RES., CHIP, 102k, 1/10W, 1%, 0603	VISHAY, CRCW0603102KFKEA
51	1	R46	RES., CHIP, 60.4k, 1/10W, 1%, 0603	VISHAY, CRCW060360K4FKEA
52	1	R47	RES., CHIP, 15.0k, 1/10W, 1%, 0603	VISHAY, CRCW060315K0FKEA
53	1	R48	RES., CHIP, 4.99k, 1/10W, 1%, 0603	VISHAY, CRCW06034K99FKEA
54	1	R49	RES., CHIP, 1.87k, 1/10W, 1%, 0603	VISHAY, CRCW06031K87FKEA
55	1	R50	RES., CHIP, 604Ω, 1/10W, 1%, 0603	VISHAY, CRCW0603604RFKEA
56	1	R51	RES., CHIP, 16.2k, 1/10W, 1%, 0603	VISHAY, CRCW060316K2FKEA
57	1	R52	RES., CHIP, 21.5k, 1/10W, 1%, 0603	VISHAY, CRCW060321K5FNEA
58	1	R53	RES., CHIP, 8.25k, 1/10W, 1%, 0603	VISHAY, CRCW06038K25FKEA
49	1	T1	TRANSFORMER, 3T:6T	CHAMPS, G45R2-0603-xx
50	1	T3	TRANSFORMER, 1.25T:1T	COILCRAFT, CT8281-BL
51	1	U1	I.C. LTC3765EMSE, MSOP-16PIN	LINEAR TECH., LTC3765EMSE
52	1	U2	I.C. LTC3766EGN28, SSOP-GN28	LINEAR TECH., LTC3766EGN

Additional Demo Board Circuit Components

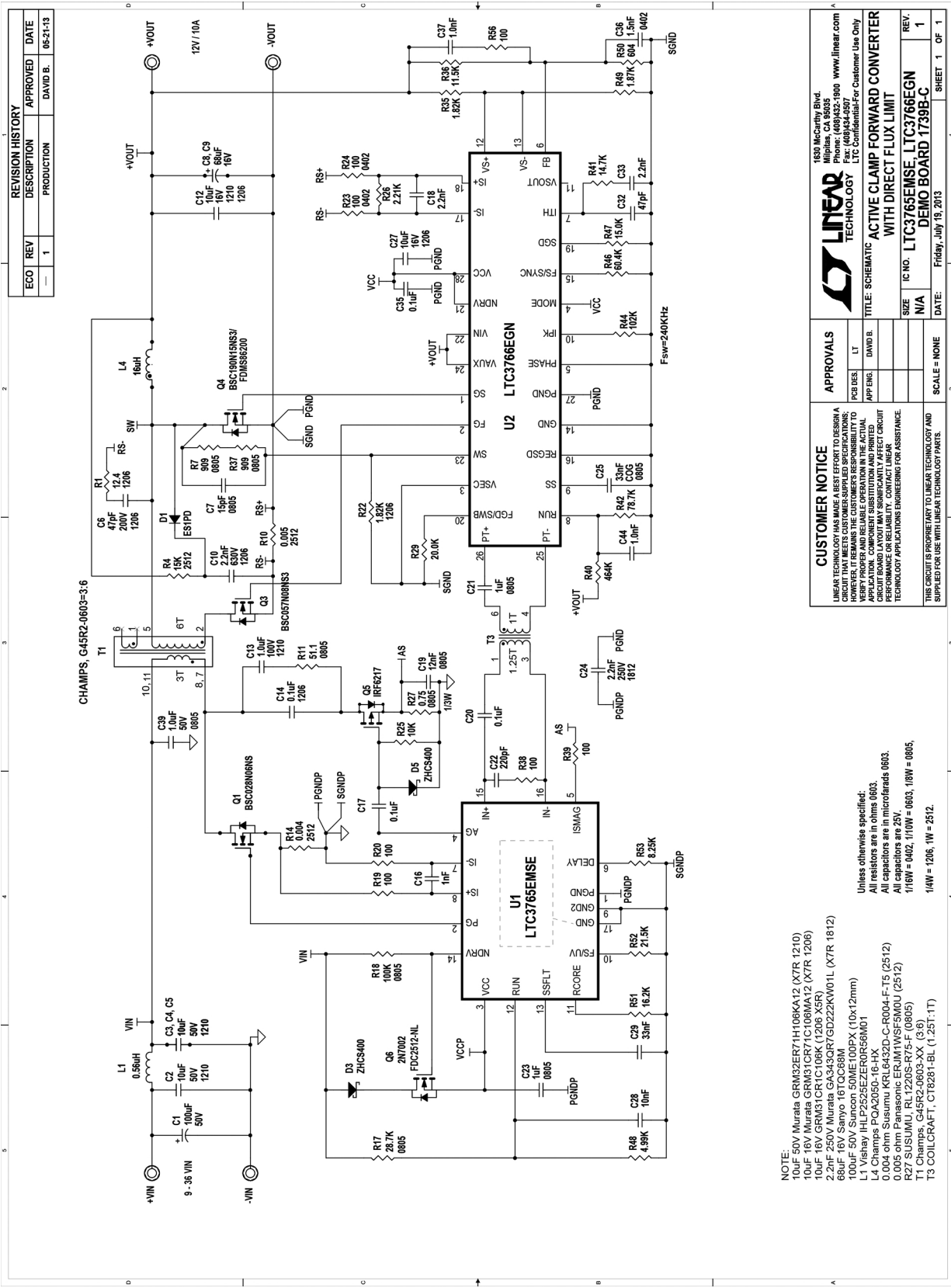
53	0	C42, C43	CAP., OPT, 0402	OPT
54	0	C15, C30, C31, C41	CAP., OPT, 0603	OPT
55	0	C38, C40	CAP., OPT, 0805	OPT
56	1	C26	0Ω JUMPER 0603	VISHAY, CRCW06030000Z0EA
57	0	C11, C34	CAP., OPT, 1206	OPT
58	1	D2	DIODE 4148 SOD323	DIODES INC., 1N4148WS
59	0	D4	DIODE OPT 220AA	OPT
60	0	D7, D8, D9, D10	DIODE OPT SOD323	OPT
61	0	D11	DIODE OPT SOT23	OPT
62	0	L5	INDUCTOR, OPT 1608	OPT
63	0	Q2	MOSFET OPT POWERPAK-SO-8	OPT
64	0	Q7, Q9	TRANSISTOR, NPN, OPT SOT23	OPT
65	0	Q8	TRANSISTOR, NPN/PNP, OPT SOT23-6	OPT
66	12	R8, R9, R21, R28, R30-R34, R45, R54, R59	0Ω JUMBER 0402	VISHAY, CRCW04020000Z0ED
67	1	R6	0Ω JUMBER 0603	VISHAY, CRCW06030000Z0ED
68	0	R2, R3, R12, R43, R58	RES., OPT, 0402	OPT
69	0	R55, R57, R60	RES., OPT, 0805	OPT
70	0	T4	TRANSFORMER, OPT	OPT

Hardware For Demo Board Only

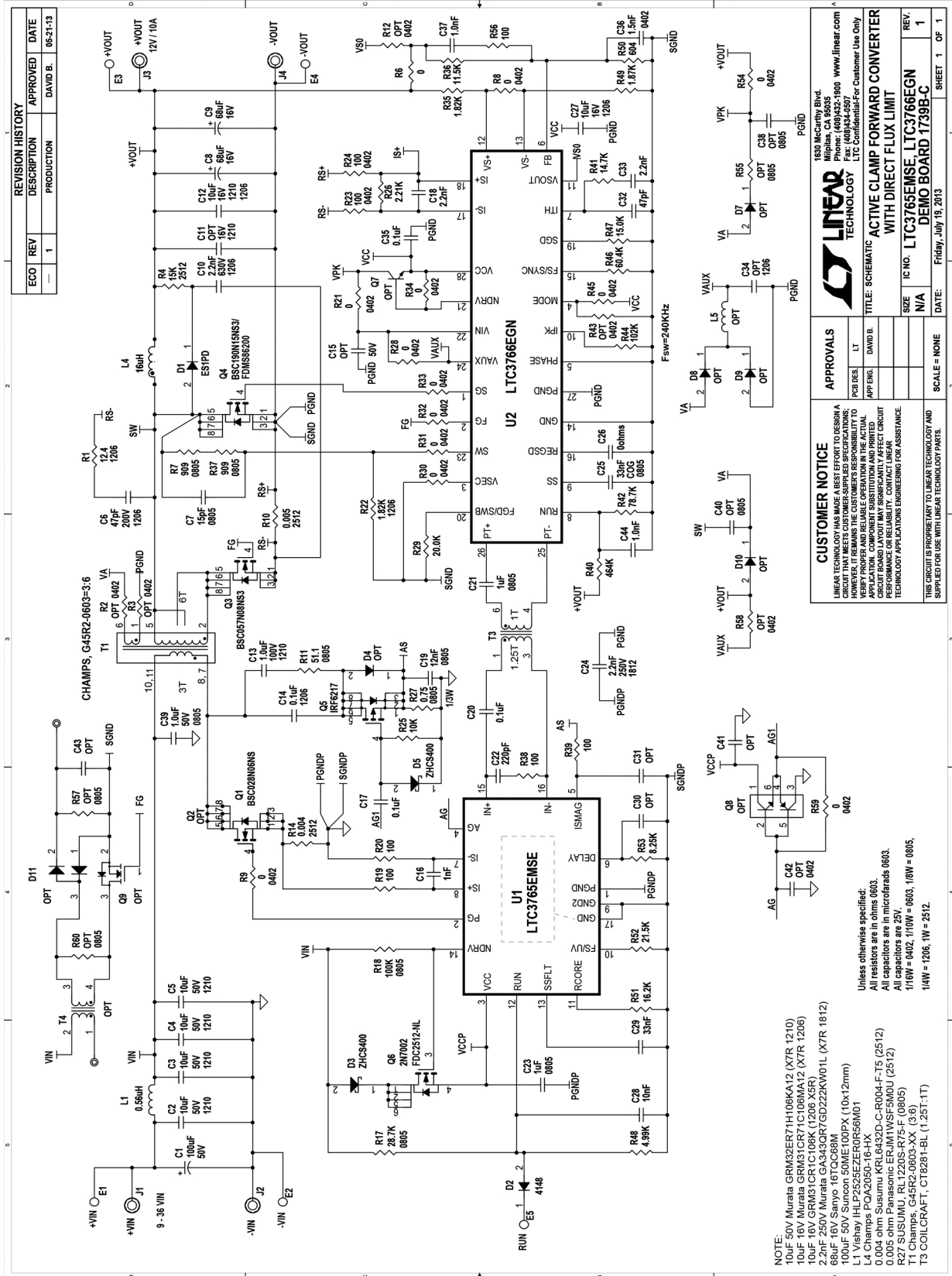
71	5	E1, E2, E3, E4, E5	TESTPOINT, TURRET, 0.090" PBF	MILL-MAX, 2501-2-00-80-00-00-07-0
72	4	J1, J2, J3, J4	CONNECTOR, BANANA JACK	Keystone, 575-4
73	4	MTGS AT 4 CORNERS	STANDOFF, NYLON 0.5 1/2"	KEYSTONE, 8833(SNAP-ON)

DEMO MANUAL DC1739B-C

SCHEMATIC DIAGRAM



SCHEMATIC DIAGRAM-COMPLETE PCB



DEMO MANUAL DC1739B-C

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

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