

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. Synchron-

ous 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°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 × Top Component Height | | 2.3 × 0.9 × 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 170mΩ 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

- a. 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.
- b. 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.

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.

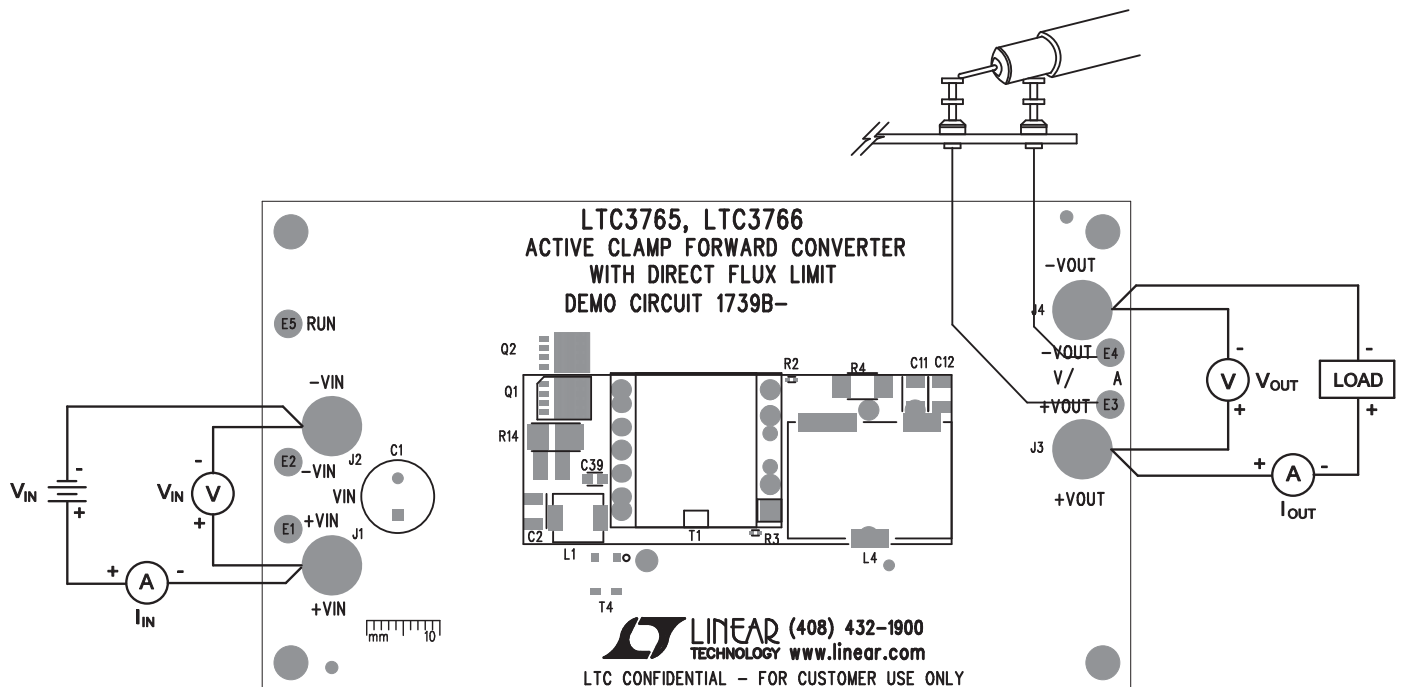


Figure 1. Proper Measurement Equipment Setup

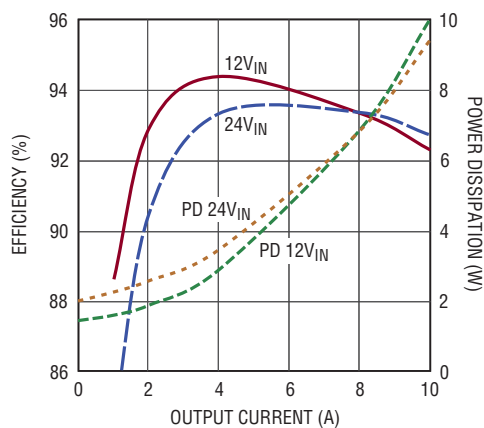


Figure 2. Efficiency and Power Dissipation

QUICK START PROCEDURE

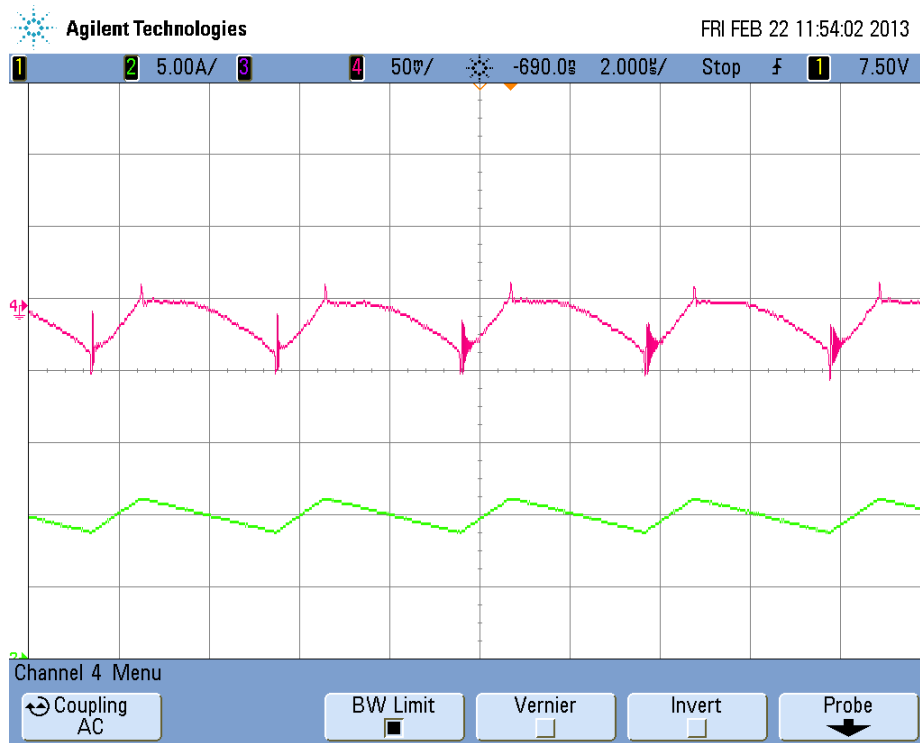


Figure 3. Output Ripple at 24V_{IN} and 10A_{OUT} (50mV, 5A, 2µs/Div, 20MHz)



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

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, 10µF, 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, 68µF, 16V, 20%, 7343 | SANYO, 16TQC68M |
| 6 | 1 | C10 | CAP., X7R, 2.2nF, 630V, 5%, 1206 | MURATA, GRM31A7U2J222JW31 |
| 7 | 2 | C12, C27 | CAP., X7R, 10µF, 16V, 20%, 1206 | MURATA, GRM31CR71C106MA12 |
| 8 | 1 | C13 | CAP., X7R, 1.0µF, 100V, 10%, 1206 | MURATA, GRM31CR72A105KA01 |
| 9 | 1 | C14 | CAP., X7R, 0.1µF, 250V, 10%, 1206 | MURATA, GRM31CR72E104KW03 |
| 10 | 1 | C16 | CAP., COG, 1000pF, 25V, 5%, 0402 | TDK, C1005C0G1E102J |
| 11 | 3 | C17, C20, C35 | CAP., X7R, 0.1µF, 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, 1.0µF, 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, 0.010µF, 50V, 10%, 0603 | AVX, 06035C103KAT2A |
| 19 | 1 | C29 | CAP., X7R, 0.033µF, 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, 0.56µH 20% | VISHAY, IHLP2525EZERR56M01 |
| 27 | 1 | L4 | INDUCTOR, 16µH | CHAMPS PGA2050-16-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 |

dc1739bfc

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

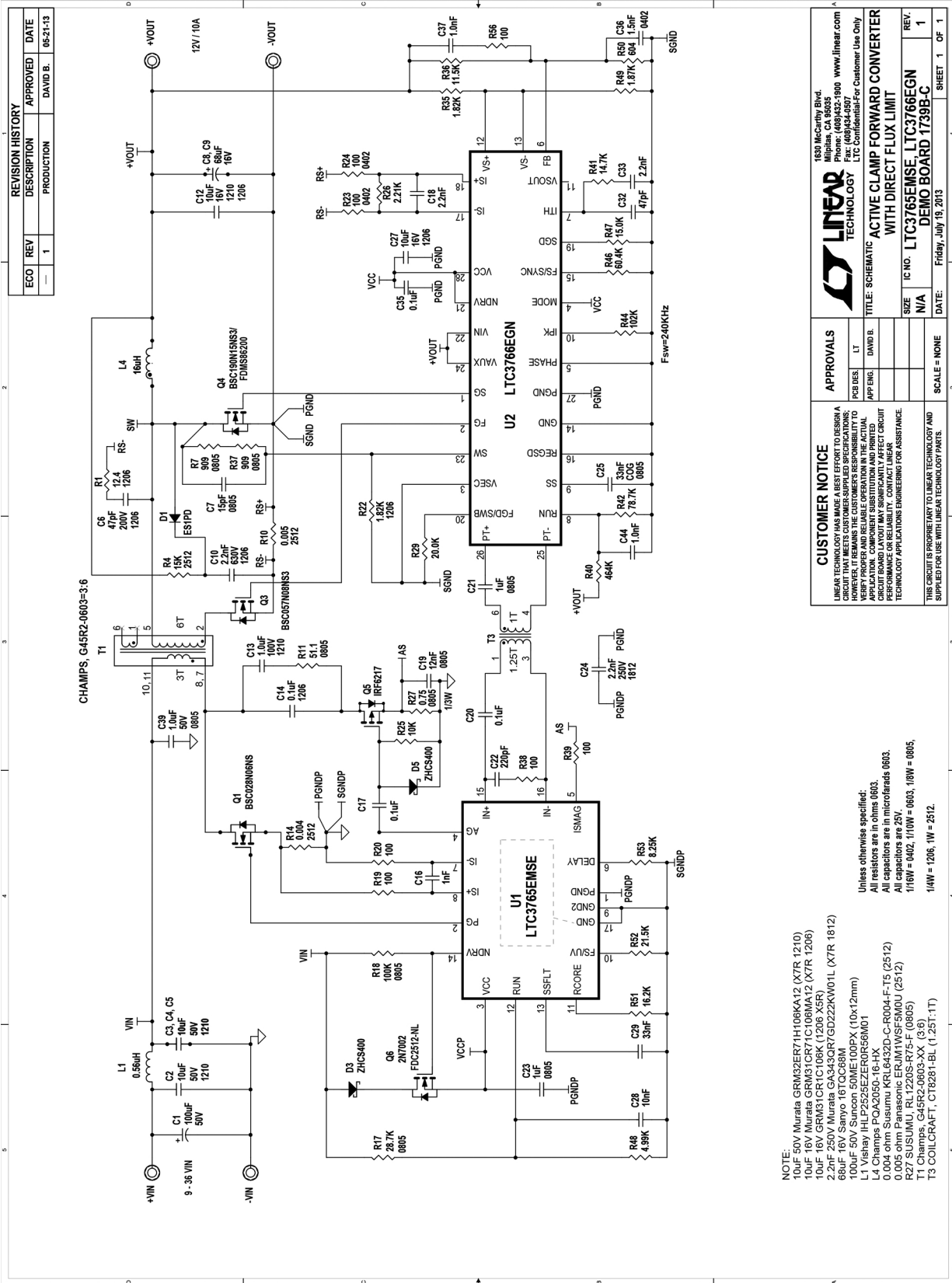
| | | | | |
|----|----|--|----------------------------------|--------------------------|
| 53 | 0 | C42, C43 | CAP., OPT, 0402 | OPT |
| 54 | 0 | C15, C30, C31, C41 | CAP., OPT, 0603 | OPT |
| 55 | 0 | C38, C40 | CAP., OPT, 0805 | OPT |
| 56 | 1 | C26 | 0Ω JUMPER 0603 | VISHAY, CRCW06030000Z0EA |
| 57 | 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

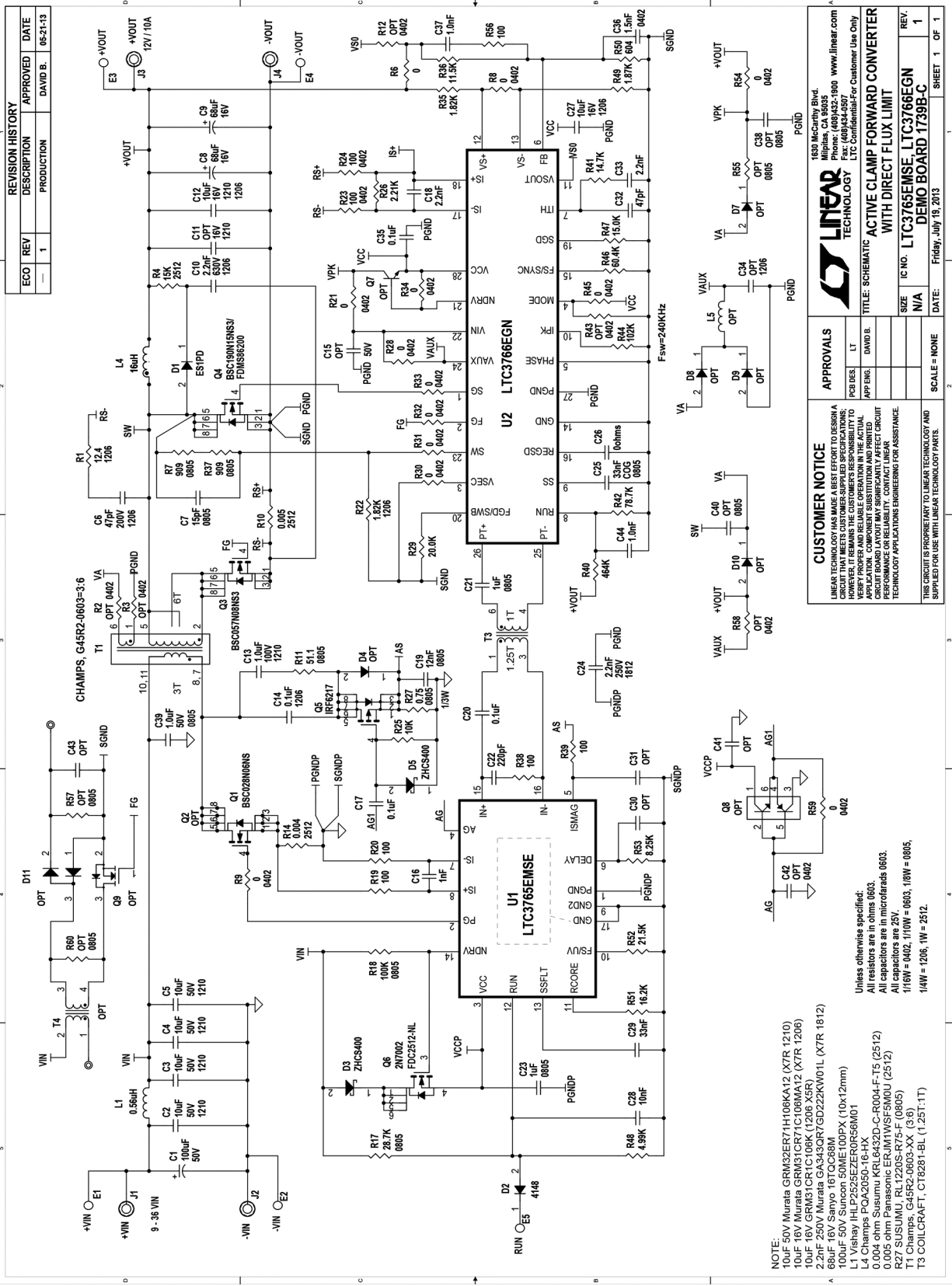
| | | | | |
|----|---|--------------------|-------------------------------|-----------------------------------|
| 71 | 5 | E1, E2, E3, E4, E5 | TESTPOINT, TURRET, 0.090" PBF | MILL-MAX, 2501-2-00-80-00-00-07-0 |
| 72 | 4 | J1, J2, J3, J4 | CONNECTOR, BANANA JACK | Keystone, 575-4 |
| 73 | 4 | MTGS AT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

DEMO MANUAL DC1739B-C

SCHEMATIC DIAGRAM



SCHEMATIC DIAGRAM-COMPLETE PCB



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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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