

High Efficiency PolyPhase® Synchronous Boost Converter

DESCRIPTION

Demonstration circuit DC2061 is a DC/DC synchronous boost converter featuring the LTC®3784 constant frequency current mode synchronous boost controller. The DC2061A operates over a 6V to 60V input, develops a 48V output and provides 3A to 12A of output current as shown in Figure 3. The 150kHz ($2 \cdot 150\text{kHz}$ at the output) constant frequency operation results in a small and efficient circuit. The converter provides high output voltage accuracy (typically $\pm 3\%$) over wide load range with no minimum load requirement. The

demonstration circuit can be easily modified to generate different output voltages.

The DC2061 has a small circuit footprint. It is a high performance and cost effective solution for telecom, automotive and Power over Ethernet applications.

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

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PERFORMANCE SUMMARY

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

| PARAMETER | CONDITION | VALUE |
|---------------------------------|------------------------------------------------------------------------|----------------------|
| Minimum Input Voltage | $I_{OUT} = 0\text{A to } 3\text{A}$ | 6V |
| Maximum Input Voltage | $I_{OUT} = 0\text{A to } 12\text{A}$ | 60V |
| V_{OUT} | $V_{IN} = 6\text{V to } 47\text{V}, I_{OUT} = 0\text{A to } 3\text{A}$ | 48V $\pm 3\%$ |
| Typical Output Ripple V_{OUT} | $V_{IN} = 6\text{V to } 47\text{V}, I_{OUT} = 3\text{A}$ | 200mV _{P-P} |
| Nominal Switching Frequency | | 150kHz |

QUICK START PROCEDURE

Demonstration circuit DC2061 is easy to set up to evaluate the performance of the LTC3784. For proper measurement equipment setup refer to Figure 1 and follow the procedure below:

Note: When measuring the input or output voltage ripple, care must be taken to minimize the length of oscilloscope probe ground lead. Measure the input or output voltage ripple by connecting the probe tip directly across the VIN or VOUT and GND terminals as shown in Figure 2.

1. With power off, connect the input power supply to VIN and GND.
2. Keep the load set to 0A or disconnected.
3. Turn the input power source on and slowly increase the input voltage. Be careful not to exceed 60V.

Note: Make sure that the input voltage, V_{IN} , does not exceed 60V. If higher operating voltage is required, power components with higher voltage ratings should be used. When the input voltage is set higher than 48V the output voltage will follow the input voltage.

4. Set the input voltage to 6V and check for the proper output voltage of 48V. Set the output load to 2A. If there is no output, temporarily disconnect the load to make sure that the load is not set too high.
5. Once the proper output voltage is established, adjust the load and observe the output voltage regulation, ripple voltage, efficiency and other parameters.

QUICK START PROCEDURE

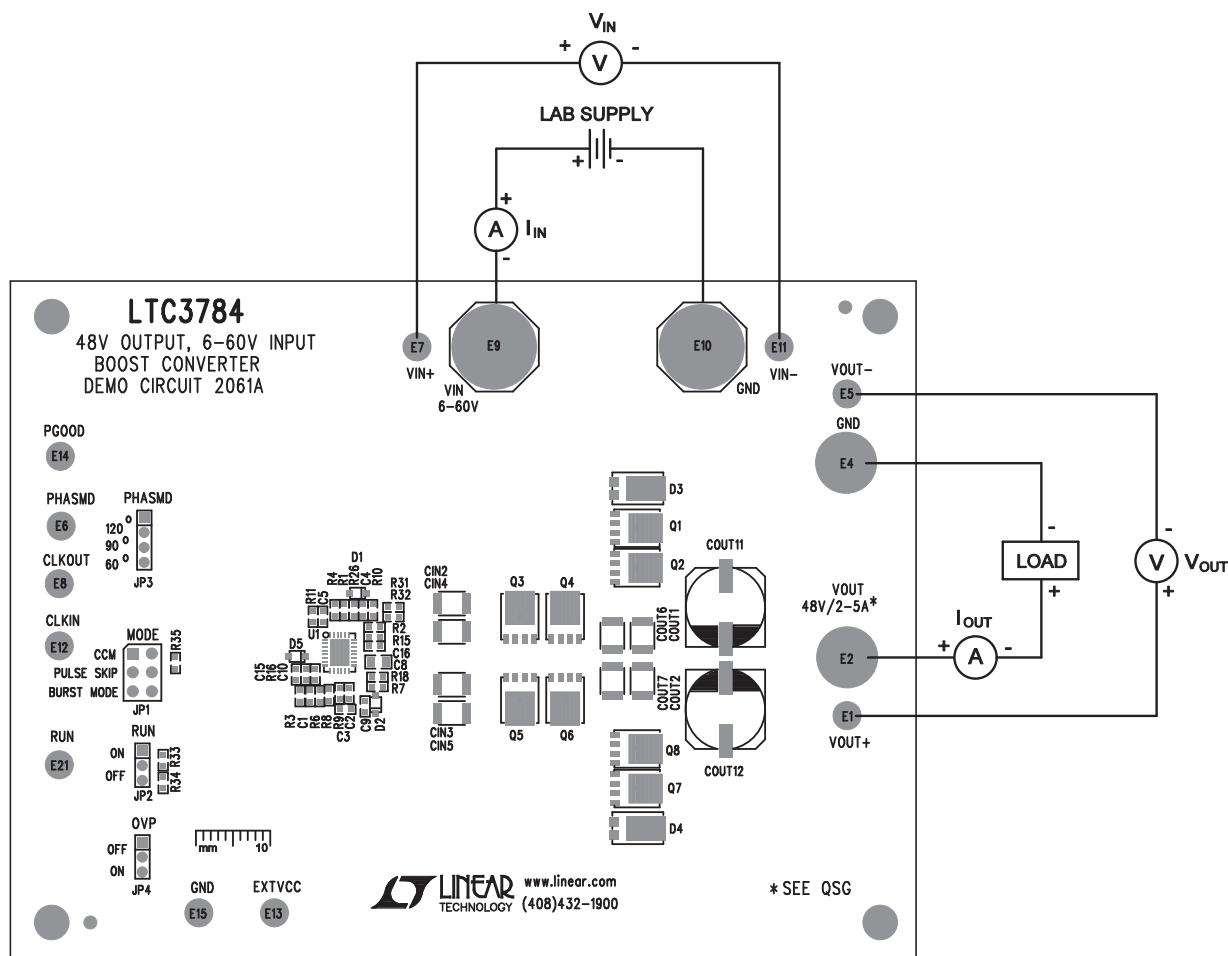


Figure 1. Proper Measurement Equipment Setup

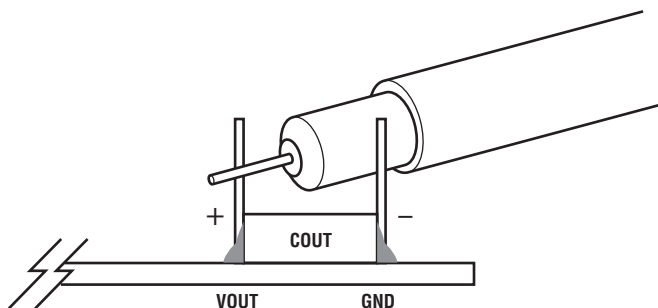


Figure 2. Measuring Input or Output Ripple

QUICK START PROCEDURE

Changing The Output Voltage

To set the output voltage lower than 48V, change the bottom voltage divider resistors connected to LTC3784 FB pin (see the Schematic Diagram). To get higher than a 48V output voltage, MOSFETs and capacitors with higher voltage ratings may be required.

Note that the output voltage will start following the input voltage when input voltage is greater than the voltage set by the voltage divider. In this mode (**wire mode**) the synchronous output rectifier MOSFET is turned continuously ON. The only losses in this mode are due to the current sense resistors, inductors and output MOSFETs DC resistance.

Converter Efficiency And Output Current

The DC2061 output current capability depends on the input voltage and proper cooling. Typical performance of DC2061A is shown in Figure 3. As can be seen from Figure 3, the output current capability depends on the input voltage. Also, when input voltage is equal to, or higher than the output voltage setting (wire mode) the efficiency is very high (99%) since the converter is not really running and the output MOSFET is shorting VIN to VOUT.

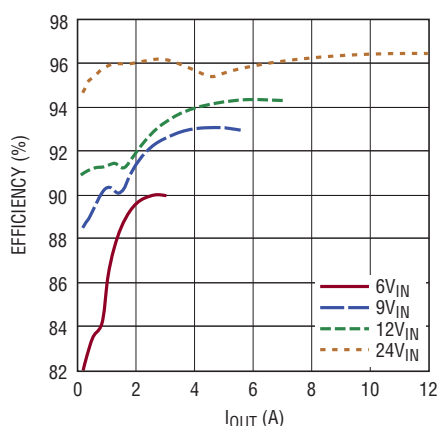


Figure 3. High Efficiency of DC2061 Allows the Board to Be Used in Thermally Critical Applications with Outputs Over 3A

Output Load Step Response

The load step response of DC2061A is very good even though relatively small amount of output capacitance is present at the output. If higher load steps need to be handled more output capacitance can be added in order to keep the voltage transients at the desired level. The load step transients are shown in Figure 4. Also, note that the load step response even from 0% load is excellent thanks to synchronous rectification.

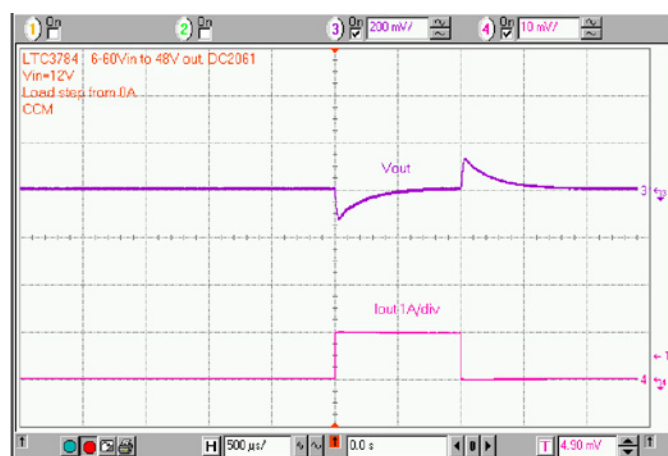


Figure 4. Fast Transient Response of DC2061 is Achieved with a Small Amount of Output Capacitance

Soft-Start Function

The DC2061 features soft-start circuit that controls the inrush current and output voltage ramp at start-up. The capacitor C15 (Figure 6) controls the start-up period. The start-up waveforms are shown in Figure 5. Please note the small output voltage step at about -2ms mark. The step is resulting from synchronous MOSFET being turned on. When the synchronous MOSFET is turned on the voltage drop across the synchronous MOSFET (body diode) is reduced from about 0.7V to $I_{OUT} \cdot R_{DS(ON)}$. While the synchronous MOSFET is in off state (prior to -2ms mark) the synchronous MOSFET body diodes are dissipating about $0.7V \cdot I_{OUT}$ or about 2.1W with 3A load. Please refer to the LTC3784 data sheet for details about proper handling of synchronous MOSFETs in your application.

QUICK START PROCEDURE

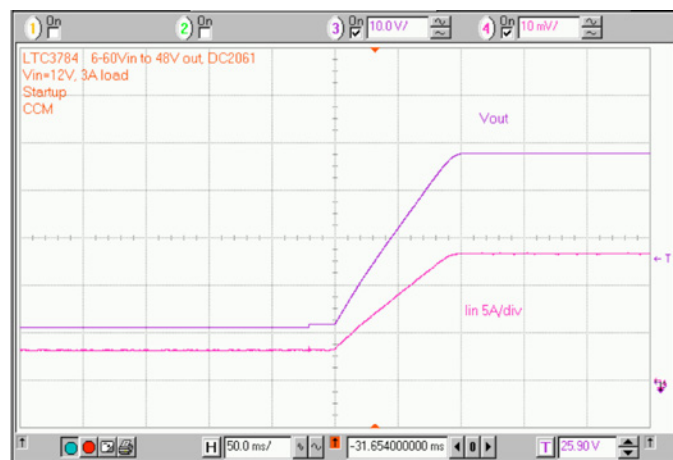


Figure 5. The DC2061 Ramps the Output Slowly at Start-Up without Generating an Input Current Surge

Bias Circuit

The LTC3784 can operate with input voltages up to 65V. However, depending on input voltage, operating frequency and MOSFETs that are used the power dissipation in the part may become too high. In order to provide bias power at high input voltage the DC2061 circuit is equipped with high efficiency bias circuit LTC3630A.

If the circuit is to be used with limited input voltage the bias power can be derived directly from input power source.

Options to power the LTC3784 from VIN or VOUT are provided on DC2061. Please remove the LTC3630A circuit in order to use these options. Also, refer to the data sheet for more information about bias power.

PARTS LIST

| ITEM | QTY | REFERENCE | PART DESCRIPTION | MANUFACTURER/PART NUMBER |
|------------------------------------|-----|--------------------------------------------------------------------------------|--------------------------------------------|------------------------------|
| Required Circuit Components | | | | |
| 1 | 5 | CIN1, COUT5, COUT10, COUT11, COUT12 | CAP., 33 μ F, 63V, EP-CAP | SUN ELECTRONICS, 63HVH33M |
| 2 | 12 | COUT1, COUT2, CIN2, COUT3, CIN3, COUT4, CIN4, CIN5, COUT6, COUT7, COUT8, COUT9 | CAP., X7S, 4.7 μ F 100V, 20% 3225/1210 | TDK, C3225X7S2A475M |
| 3 | 1 | C2 | CAP., NPO, 100pF, 25V, 10%, 0603 | AVX, 06033A101KAT |
| 4 | 1 | C3 | CAP., X7R, 15nF, 25V, 10%, 0603 | AVX, 06033C153KAT |
| 5 | 5 | C4, C9, C16, C17 | CAP., X5R, 0.1 μ F, 25V, 10%, 0603 | AVX, 06033D104KAT2A |
| 6 | 2 | C5, C10 | CAP., NPO, 1000pF, 25V, 10%, 0603 | AVX, 06033A102KAT |
| 7 | 1 | C8 | CAP., X5R, 4.7 μ F, 25V, 10%, 0805 | TAIYO YUDEN, TMK212BJ475KG-T |
| 8 | 1 | C12 | CAP., X7R, 0.1 μ F, 100V, 10%, 1206 | AVX, 12061C104KAT |
| 9 | 1 | C13 | CAP., X7R, 47nF, 25V, 10%, 0603 | AVX, 06033C473KAT |
| 10 | 1 | C14 | CAP., X5R, 22 μ F, 16V, 10%, 1206 | AVX, 1206YD226KAT2A |
| 11 | 1 | C15 | CAP., X5R, 1 μ F, 10V, 10%, 0603 | AVX, 06033D104KAT2A |
| 12 | 3 | D1, D2 | DIODE, BAS170W SOD323 | INFINEON, BAS170W |
| 13 | 1 | D5 | DIODE, PDZ6.8B SOD323 | NXP, PDZ6.8B |
| 14 | 2 | L1, L2 | IND, 10 μ H | COILCRAFT, SER2918H-103KL |
| 15 | 1 | L3 | IND, 220 μ H IND-744775222 | WURTH ELEC., 744775222 |
| 16 | 4 | Q2, Q4, Q6, Q8 | MOSFET, N-Channel, LPAK | INFINEON, BSC028N06LS3 |
| 17 | 4 | RSNS1, RSNS2, RSNS3, RSNS4 | RES., Chip, 0.006 Ω , 1%, 2010 | VISHAY, WSL20106L000FEA |
| 18 | 7 | R2, R3, R7, R13, R15, R18, R21 | RES., Chip, 0 Ω , 1%, 0603 | VISHAY, CRCW06030000Z0EA |
| 19 | 1 | R5 | RES., Chip, 30.1k, 1%, 0603 | VISHAY, CRCW060330K1FKEA |
| 20 | 1 | R6 | RES., Chip, 475k, 1%, 0603 | VISHAY, CRCW0603475KFEA |
| 21 | 2 | R8 | RES., Chip, 12.1k, 1%, 0603 | VISHAY, CRCW060312K1FKEA |
| 22 | 1 | R9 | RES., Chip, 15k, 1%, 0603 | VISHAY, CRCW060315K0FKEA |

PARTS LIST

| ITEM | QTY | REFERENCE | PART DESCRIPTION | MANUFACTURER/PART NUMBER |
|------|-----|-----------|------------------------------------|-------------------------------|
| 23 | 2 | R17, R23 | RES., Chip, 10 Ω , 1%, 0603 | VISHAY, CRCW060310R0FKEA |
| 24 | 2 | R26, R35 | RES., Chip, 100k, 1%, 0603 | VISHAY, CRCW0603100KFKEA |
| 25 | 1 | R29 | RES., Chip, 47k, 1%, 0603 | VISHAY, CRCW060347K0FKEA |
| 26 | 1 | R30 | RES., Chip, 523k, 1%, 0603 | VISHAY, CRCW0603523KFKEA |
| 27 | 1 | R33 | RES., Chip, 150k, 1%, 0603 | VISHAY, CRCW0603150KFKEA |
| 28 | 1 | R34 | RES., Chip, 38.3k, 1%, 0603 | VISHAY, CRCW060338K3FKEA |
| 29 | 1 | R36 | RES., Chip, 80.6k, 1%, 0603 | VISHAY, CRCW060380K6FKEA |
| 30 | 1 | U1 | I.C. LTC3784IUFD QFN28–4 x 5 | LINEAR TECH., LTC3784IUFD#PBF |
| 31 | 1 | U2 | I.C. LTC3630AEMSE | LINEAR TECH., LTC3630AEMSE |

Additional Demo Board Circuit Components

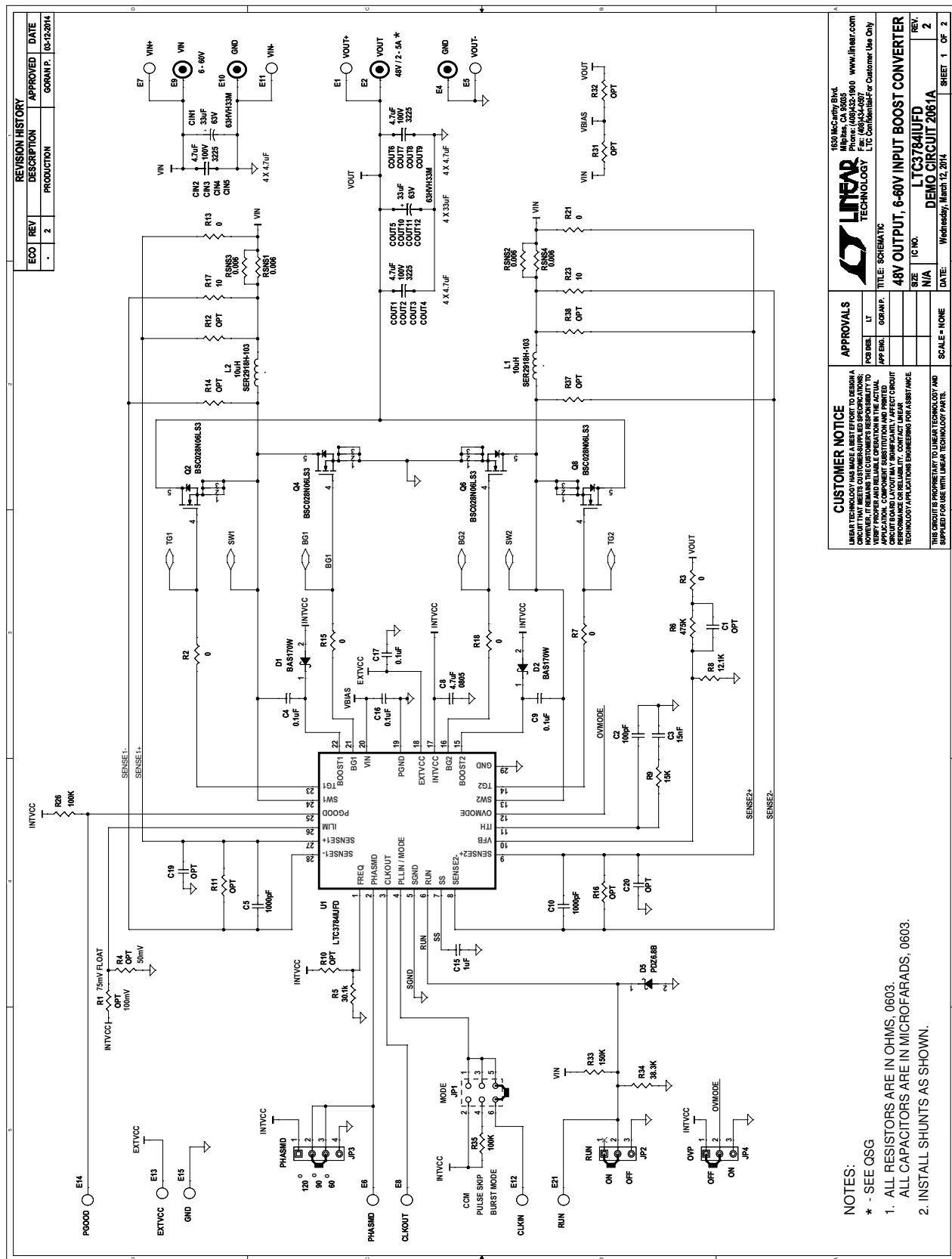
| | | | | |
|---|---|---------------------------------------------------------------|-------------------------------|-----|
| 1 | 0 | C1, C19, C20 | OPT, 0603 | OPT |
| 2 | 0 | D3, D4 | DIODE, OPT PDS760 POWERID5-2P | OPT |
| 3 | 0 | D6 | DIODE, OPT SOD123 | OPT |
| 4 | 0 | Q1, Q3, Q5, Q7 | OPT, LPAK | OPT |
| 5 | 0 | R1, R4, R10, R11, R12, R14, R16, R27, R28, R31, R32, R37, R38 | OPT, 0603 | OPT |

Hardware-For Demo Board Only

| | | | | |
|----|----|-------------------------|--------------------------------|-----------------------------------|
| 1 | 11 | E1, E5-E8, E11-E15, E21 | TURRET, TESTPOINT, .091" | MILL-MAX, 2501-2-00-80-00-00-07-0 |
| 2 | 2 | E2, E4 | JACK BANANA | KEYSTONE, 575-4 |
| 3 | 2 | E9, E10 | STUD, TEST PIN | PEM, KFH-032-10 |
| 4 | 4 | (E9, E10) x 2 | NUT, BRASS NUTS # 10-32 | ANY, #10-32 |
| 5 | 2 | E9, E10 | RING, LUG RING # 10 | KEYSTONE, 8205 |
| 6 | 2 | E9, E10 | WASHER, #10, TIN PLATED BRASS | ANY, #10 EXT BZ TN |
| 7 | 1 | JP1 | HEADER, 6 PINS 2 x 3 100 Ctrs. | SAMTEC, TSW-106-07-L-D |
| 8 | 2 | JP2, JP4 | HEADER, 3 Pins 2mm CTRS. | SULLINS, NRPN031PAEN-RC |
| 9 | 1 | JP3 | HEADER, 4 Pins 2mm CTRS. | SULLINS, NRPN041PAEN-RC |
| 10 | 3 | XJP2, XJP3, XJP4 | SHUNT, 2mm CTRS. | SAMTEC, 2SN-BK-G |
| 11 | 1 | XJP1 | SHUNT, 100 CTRS. | SAMTEC SNT-100-BK-G |
| 12 | 4 | MTGS | HEX STANDOFF 6-32 NYLON 3/4" | KEYSTONE, 1903D |
| 13 | 4 | MTGS | SCREW, PAN PHILLIPS 6-32 | B & F, PMSSS 632 0038 PH |
| 14 | 1 | | FAB, PRINTED CIRCUIT BOARD | DEMO CIRCUIT 2061A |
| 15 | 2 | | STENCILS TOP AND BOTTOM | STENCIL DC2061A |

DEMO MANUAL DC2061A

SCHEMATIC DIAGRAM





DEMO MANUAL DC2061A

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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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