# LTM4607EV
# High Efficiency PolyPhase Buck-Boost Power Supply

## DESCRIPTION

Demonstration circuit DC1601B is a PolyPhase® power supply featuring the LTM®4607 power module, a complete high efficiency switching mode buck-boost power supply. The DC1601B input voltage range is from 6V to 36V and is capable of delivering high power through paralleled LTM4607 modules. The demo circuit can deliver up to 10A of output current for two paralleled modules (DC1601B-A), 15A for three paralleled modules (DC1601B-B) and up to 20A for four paralleled modules (DC1601B-C). The DC1601B demonstrates that paralleling modules is easy and reliable.

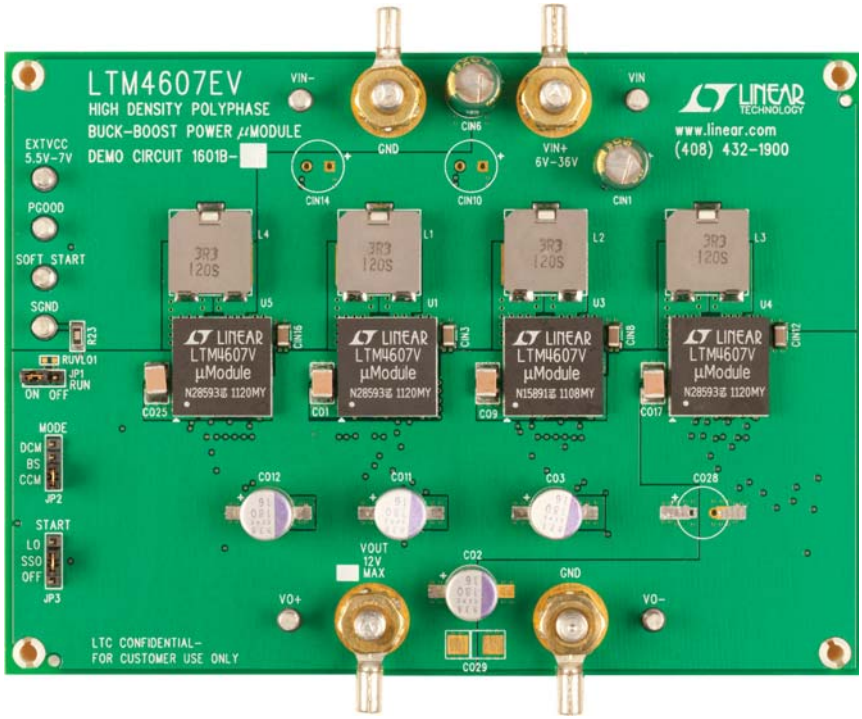
The output voltage for the board is 12V. The rated load current per module is 5A in boost mode, however current derating may be necessary under certain $V_{IN}$, $V_{OUT}$, frequency, and thermal conditions. An onboard external clock is provided for synchronization and interleaving of phases to minimize input and output ripple. An internal phase-locked loop allows the LTM4607 to be synchronized to an external clock within the range of 200kHz to 400kHz. The LTM4607 default switching frequency on the DC1601B is set to 300kHz through the onboard LTC6902 clock generator which interleaves the paralleled phases. The frequency and phase separation set by the LTC6902 are resistor programmable.

These features, including the availability of the LTM4607 in a compact thermally enhanced 15mm × 15mm × 2.8mm LGA package make the demonstration circuit ideal for use in high density point of load regulation applications.

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



## BOARD PHOTO




DC1601B-C SHOWN

## PERFORMANCE SUMMARY ($T_A$ = 25°C)

| PARAMETER | CONDITIONS | VALUE |
|---|---|---|
| Maximum Input Voltage | | 36V |
| Minimum Input Voltage | | 6V |
| Output Voltage $V_{OUT}$ | Programmed by R22 | 12V |
| Maximum Continuous Output Current $I_{OUT(MAX)}$ | Current Derating May Be Necessary for Certain $V_{IN}$, $V_{OUT}$, Frequency and Thermal Conditions. | 10A (DC1601B-A)<br>15A (DC1601B-B)<br>20A (DC1601B-C) |
| Default Operating Frequency | | 300kHz |
| External Clock Sync. Frequency Range | | 200kHz to 400kHz |
| Output Voltage Ripple (Typical) | $V_{OUT}$ = 12V<br>300kHz (20MHz BW) | $V_{IN}$ = 9V, $I_{OUT}$ = 10A (DC1601B-A), See Figure 5a<br>$V_{IN}$ = 12V, $I_{OUT}$ = 15A (DC1601B-B), See Figure 5b<br>$V_{IN}$ = 32V, $I_{OUT}$ = 20A (DC1601B-B), See Figure 5c |
| Efficiency | $V_{IN}$ = 9V, $V_{OUT}$ = 12V<br>300kHz | 95.7% at $I_{OUT}$ = 10A (DC1601B-A), See Figure 2a<br>94.8% at $I_{OUT}$ = 15A (DC1601B-B), See Figure 2b<br>94.8% at $I_{OUT}$ = 20A (DC1601B-C), See Figure 2c |
| Load Transient | $V_{OUT}$ = 12V<br>300kHz (20MHz BW) | $V_{IN}$ = 9V, $I_{OUT}$ = 10A (DC1601B-A), See Figure 4a<br>$V_{IN}$ = 12V, $I_{OUT}$ = 15A (DC1601B-B), See Figure 4b<br>$V_{IN}$ = 32V, $I_{OUT}$ = 20A (DC1601B-B), See Figure 4c |

## QUICK START PROCEDURE

Demonstration circuit DC1601B is easy to set up to evaluate the performance of paralleled LTM4607 modules. Please refer to Figure 1 for proper measurement equipment setup and follow the procedure below:

1. With power off, connect the input power supply, load, and meters as shown in Figure 1. Preset the load to 0A and $V_{IN}$ supply to be 0V. Place jumpers in the following positions for a typical $12V_{OUT}$ application:

| JP2 | JP1 | JP3 |
|---|---|---|
| **MODE** | **RUN** | **START** |
| CCM | OFF | SSO |

2. Turn on the power at the input. Increase $V_{IN}$ to 18V (Do not hot-plug the input supply or apply more than the rated maximum voltage of 36V to the board or the modules may be damaged).

3. Set the run pin jumper (JP1) to the ON position. The output voltage should be regulated. The output voltage meter should read 12V ±2% (11.76V to 12.24V).

4. Vary the input voltage from 6V to 36V and adjust the load current from 0A to 10A (for DC1601B-A), 0A to 15A (for DC1601B-B), 0A to 20A (for DC1601B-C). $V_{OUT}$ should remain regulated at 12V ±2% (11.76V to 12.24V). Observe the load regulation, efficiency and other parameters.

5. Set the load current to 0A. Set the RUN pin jumper (JP1) to the OFF position. Turn off input supply before disconnecting the circuit.

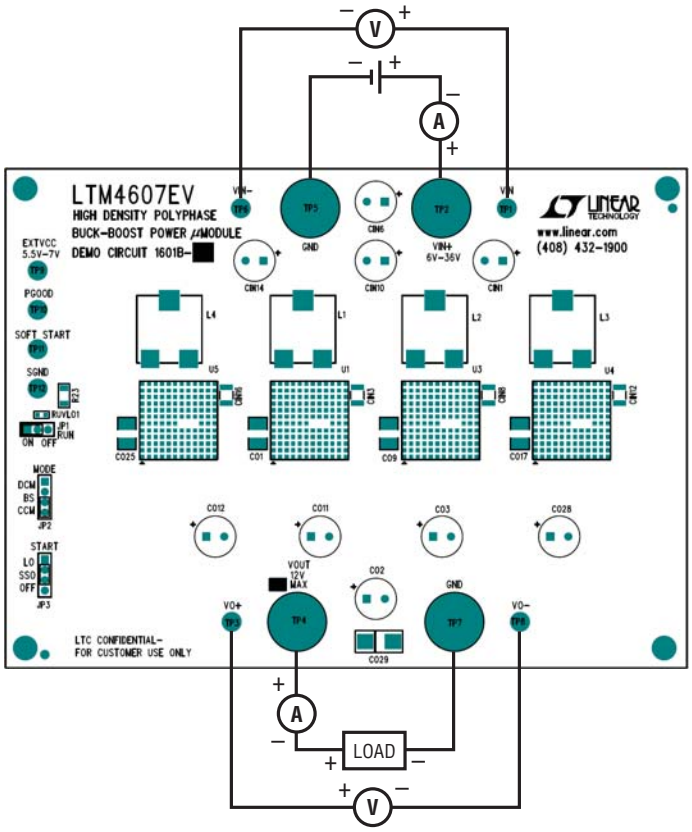



**Figure 1**

## QUICK START PROCEDURE

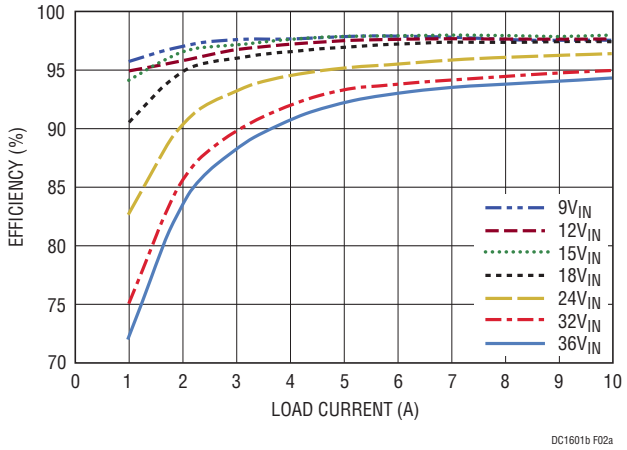



Figure 2a. Measured Efficiency at $12V_{OUT}$, 300kHz (DC1601B-A)

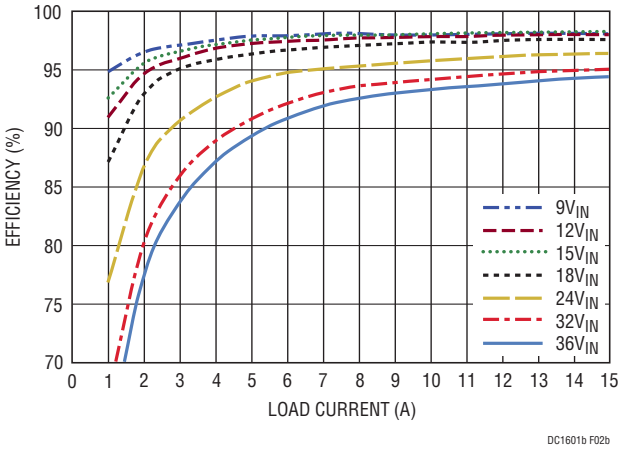



Figure 2b. Measured Efficiency at $12V_{OUT}$, 300kHz (DC1601B-B)

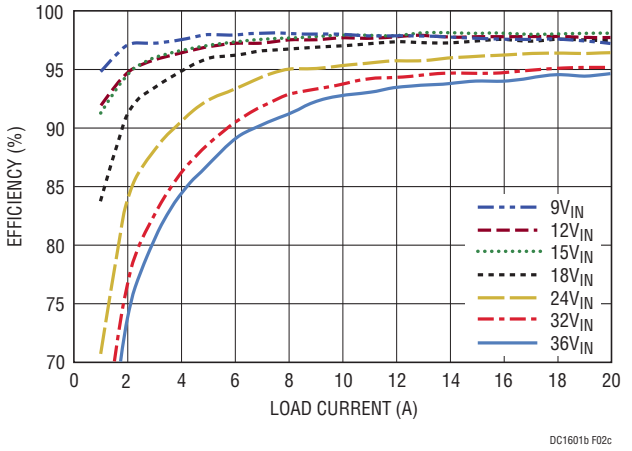



Figure 2c. Measured Efficiency at $12V_{OUT}$, 300kHz (DC1601B-C)

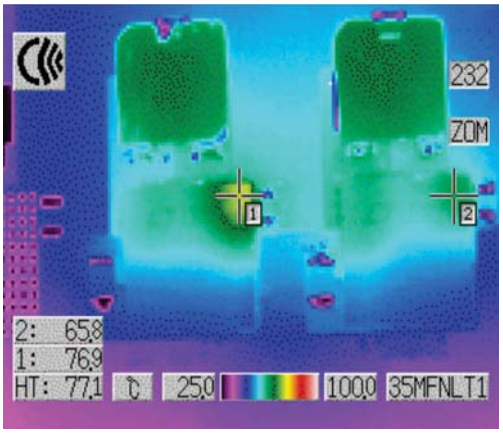



Figure 3a. Thermal Capture at $6V_{IN}$, $12V_{OUT}$, 10A, 300kHz (DC1601B-A) No Forced Airflow (Convection)

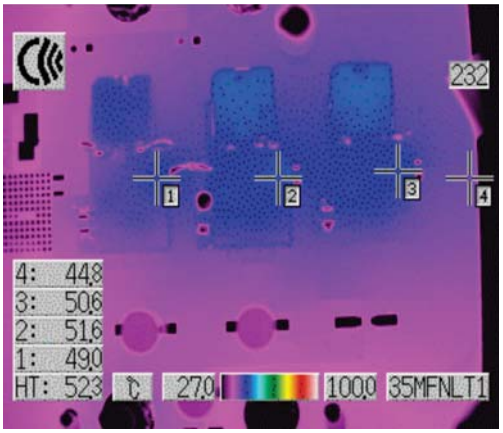



Figure 3b. Thermal Capture at $12V_{IN}$, $12V_{OUT}$, 15A, 300kHz (DC1601B-B) No Forced Airflow (Convection)

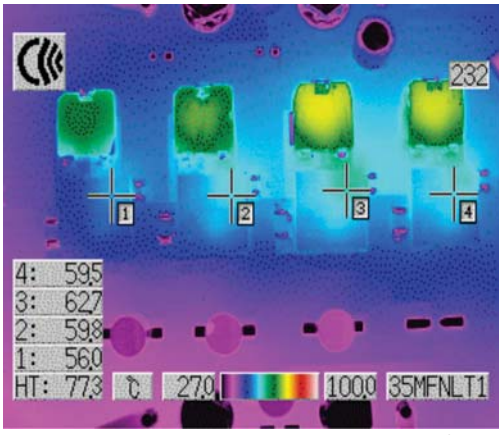
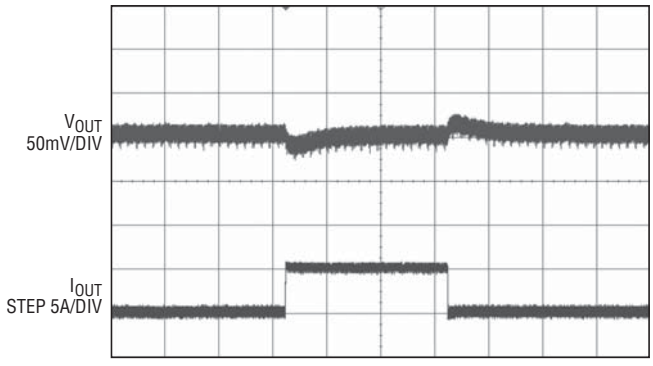


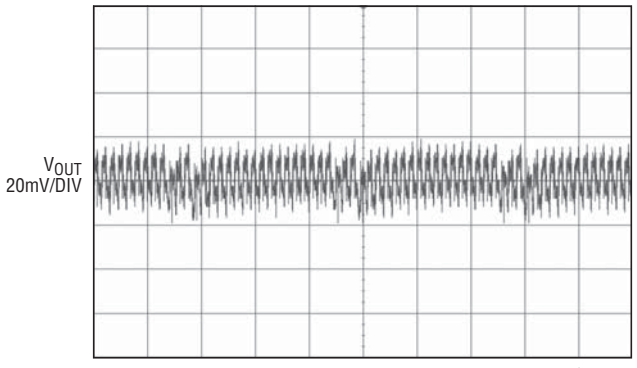

Figure 3c. Thermal Capture at $32V_{IN}$, $12V_{OUT}$, 20A, 300kHz (DC1601B-C) No Forced Airflow (Convection)

## QUICK START PROCEDURE



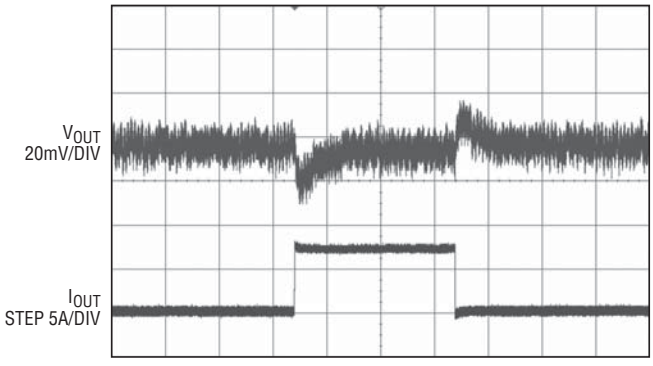

$V_{IN}$ = 9V, $V_{OUT}$ = 12V
$I_{OUT}$ DC = 5A, $I_{OUT}$ STEP = 5A
$f_{SW}$ = 300kHz

**Figure 4a. Measured Load Step Response (DC1601B-A)**



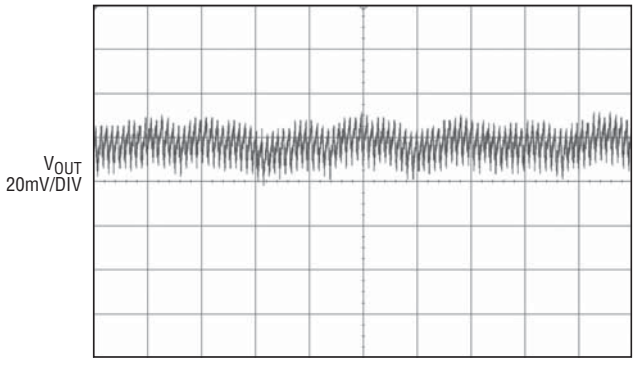

$V_{IN}$ = 9V, $V_{OUT}$ = 12V
$I_{OUT}$ = 10A
$f_{SW}$ = 300kHz

**Figure 5a. Measured Output Voltage Ripple (DC1601B-A)**



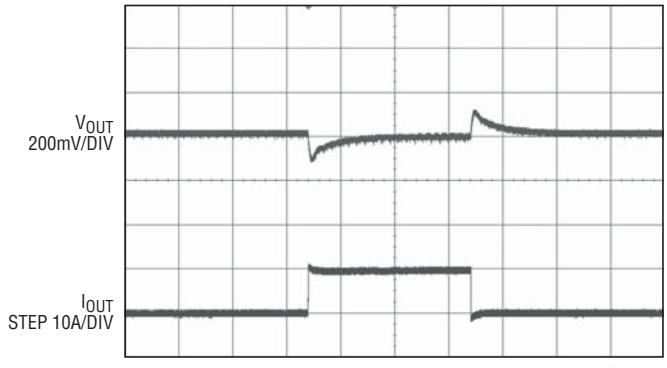

$V_{IN}$ = 12V, $V_{OUT}$ = 12V
$I_{OUT}$ DC = 7.5A, $I_{OUT}$ STEP = 7.5A
$f_{SW}$ = 300kHz

**Figure 4b. Measured Load Step Response (DC1601B-B)**



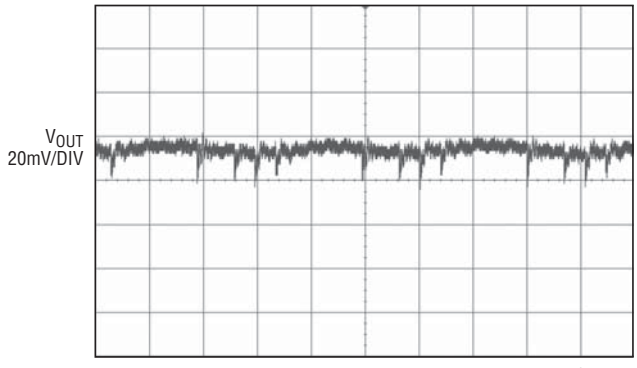

$V_{IN}$ = 12V, $V_{OUT}$ = 12V
$I_{OUT}$ = 15A
$f_{SW}$ = 300kHz

**Figure 5b. Measured Output Voltage Ripple (DC1601B-B)**




$V_{IN}$ = 32V, $V_{OUT}$ = 12V
$I_{OUT}$ DC = 10A, $I_{OUT}$ STEP = 10A
$f_{SW}$ = 300kHz

**Figure 4c. Measured Load Step Response (DC1601B-C)**




$V_{IN}$ = 32V, $V_{OUT}$ = 12V
$I_{OUT}$ = 20A
$f_{SW}$ = 300kHz

**Figure 5c. Measured Output Voltage Ripple (DC1601B-C)**

## PARTS LIST

| ITEM | QTY | REFERENCE | PART DESCRIPTION | MANUFACTURER/PART NUMBER |
|---|---|---|---|---|
| **Common Required Circuit Components:** | | | | |
| 1 | 2 | CIN1, CIN6 | CAP, ALUM, 100µF, 20%, 50V | SUNCON, 50ME100WX+TS |
| 2 | 4 | CIN2, CIN3, CIN7, CIN8 | CAP, X5R, 4.7µF, 10%, 50V, 1206 | TAIYO YUDEN, UMK316BJ475KL-T |
| 3 | 4 | CO1, CO4, CO9, CO10 | CAP, X5R, 22µF, 25V, 20%, 1812 | TDK, C4532X5R1E226M |
| 4 | 4 | CO2, CO3, CO11, CO12 | CAP, OS-CON, 180µF, 16V, E9 | SANYO, 16SEPC180MX+T |
| 5 | 1 | CSS1 | CAP, X7R, 0.01µF, 25V, 10%, 0603 | AVX, 06033C103KAT4A |
| 6 | 1 | C4 | CAP, X5R, 0.1µF, 25V, 10%, 0603 | AVX, 06033D104KAT4A |
| 7 | 2 | C3, C6 | CAP, COG, 22pF, 25V, 10%, 0603 | AVX, 06033A220KAT4A |
| 8 | 2 | L1, L2 | IND IRON POWER SMT FIXED, 3.3µH | TOKO, FDA1254-3R3M=P3 |
| 9 | 4 | RS1 TO RS4 | RES, CHIP, 0.015Ω 1/2W, 1%, 1206 | VISHAY, WSL1206R0150FEA |
| 10 | 1 | R1 | RES, CHIP, 100k, 1/16W, 5%, 0603 | VISHAY, CRCW0603100KJNEA |
| 11 | 4 | R10 TO R13 | RES, CHIP, 0Ω, 0603 | VISHAY, CRCW06030000Z0EA |
| 12 | 4 | R6, R7, R8, R9 | RES, CHIP, 100Ω, 1/16W, 1%, 0603 | VISHAY, CRCW0603100RFKEA |
| 13 | 1 | U2 | IC, LTC6902CMS | LINEAR TECHNOLOGY, LTC6902CMS#PBF |
| **Common Additional Demo Board Circuit Components:** | | | | |
| 1 | 0 | C1, C2, C5, C7, C9 TO C17 | CAP, 0603 | |
| 2 | | CFF1, CP1 TO CP4 (OPT) | | |
| 3 | 0 | CO7, CO15, CO23, CO31, CIN9, | CAP, 1206 | |
| 4 | | CIN4, CIN5, CIN13, CIN17 (OPT) | | |
| 5 | 0 | CIN10, CIN14 (OPT) | CAP, ALUM, SIZE 8mm × 12.5mm | |
| 6 | 0 | CO28 (OPT) | CAP, OS-CON, 180µF, 16V, E9 | SANYO, 16SEPC180MX |
| 7 | 0 | RUVLO1, R3, (OPT) | RES, CHIP, 0603 | |
| 8 | 0 | CO19, CO20, CO27 (OPT) | CAP, OS-CON, F8 | |
| 9 | 0 | CO5, CO13, CO21, CO29 (OPT) | CAP, D3L | |
| 10 | 1 | D1 | ZENER DIODE, 4.7V | CENTRAL SEMI, CMDZ5230B-7-F |
| 11 | 1 | R2 | RES, CHIP, 5.1k, 1/16W, 5%, 0805 | VISHAY, CRCW08055K10JNEA |
| 12 | 1 | R23 | RES, CHIP, 0, 1206 | VISHAY, CRCW12060000Z0EA |
| **Common Hardware:** | | | | |
| 1 | 1 | JP1 | 2mm SINGLE ROW HEADER, 3-PIN | SAMTEC, TMM-103-02-L-S |
| 2 | 2 | JP2, JP3 | 2mm SINGLE ROW HEADER, 4-PIN | SAMTEC, TMM-104-02-L-S |
| 3 | 3 | JP1, JP2, JP3 | SHUNT | SAMTEC, 2SN-BK-G |
| 4 | 8 | TP1, TP3, TP6, TP8 TO TP12 | TESTPOINT, TURRET, 0.095" | MILL-MAX, 2501-2-00-80-00-00-07-0 |
| 5 | 8 | TP2, TP4, TP5, TP7(X2) | STUD, TESTPIN | PEM KFH-032-10 |
| 6 | 4 | TP2, TP4, TP5, TP7 | NUT, BRASS 10-32 | ANY #10-32 |
| 7 | 4 | TP2, TP4, TP5, TP7 | RING, LUG #10 | KEYSTONE #10 |
| 8 | 4 | TP2, TP4, TP5, TP7 | WASHER, TIN PLATED BRASS | ANY #10 |
| 9 | 4 | STAND OFF | STAND-OFF, NYLON 0.50" TALL | KEYSTONE, 8833 (SNAP ON) |

# PARTS LIST

**Demo Board 1601B-A**

| ITEM | QTY | REFERENCE | PART DESCRIPTION | MANUFACTURER/PART NUMBER |
|---|---|---|---|---|
| **Required Circuit Components:** | | | | |
| 1 | 1 | DC1601 (COMMON BOM) | | |
| 2 | 1 | R4 | RES, CHIP, 0Ω, 0603 | VISHAY, CRCW06030000Z0EA |
| 3 | 1 | R5 | RES, CHIP, 154k, 1/16W, 1%, 0603 | VISHAY, CRCW0603154KFKEA |
| 4 | 1 | R22 | RES, CHIP, 3.57k, 1/16W, 1%, 0603 | VISHAY, CRCW06033K57FKEA |
| 5 | 2 | U1, U3 | IC, LTM4607EV#PBF, 15mm × 9mm × 2.3mm | LINEAR TECHNOLOGY, LTM4607EV#PBF |
| **Additional Demo Board Circuit Components:** | | | | |
| 1 | 0 | CIN11, CIN12, CIN15, CIN16 (OPT) | CAP, 1206 | |
| 2 | 0 | CO17, CO18, CO25, CO26 (OPT) | CAP, 1812 | |
| 3 | 0 | C8, C10 (OPT) | CAP, 0603 | |
| 4 | 0 | L3, L4 (OPT) | IND IRON POWER SMT FIXED, 3.3µH | |
| 5 | 0 | R14 TO R21 (OPT) | RES, CHIP, 0603 | |
| 6 | 0 | RS5 TO RS8 (OPT) | RES, CHIP, 1206 | |
| 7 | 0 | U4, U5 (OPT) | IC, LTM4607EV#PBF, 15mm × 9mm × 2.3mm | LINEAR TECHNOLOGY, LTM4607EV#PBF |

**Demo Board 1601B-B**

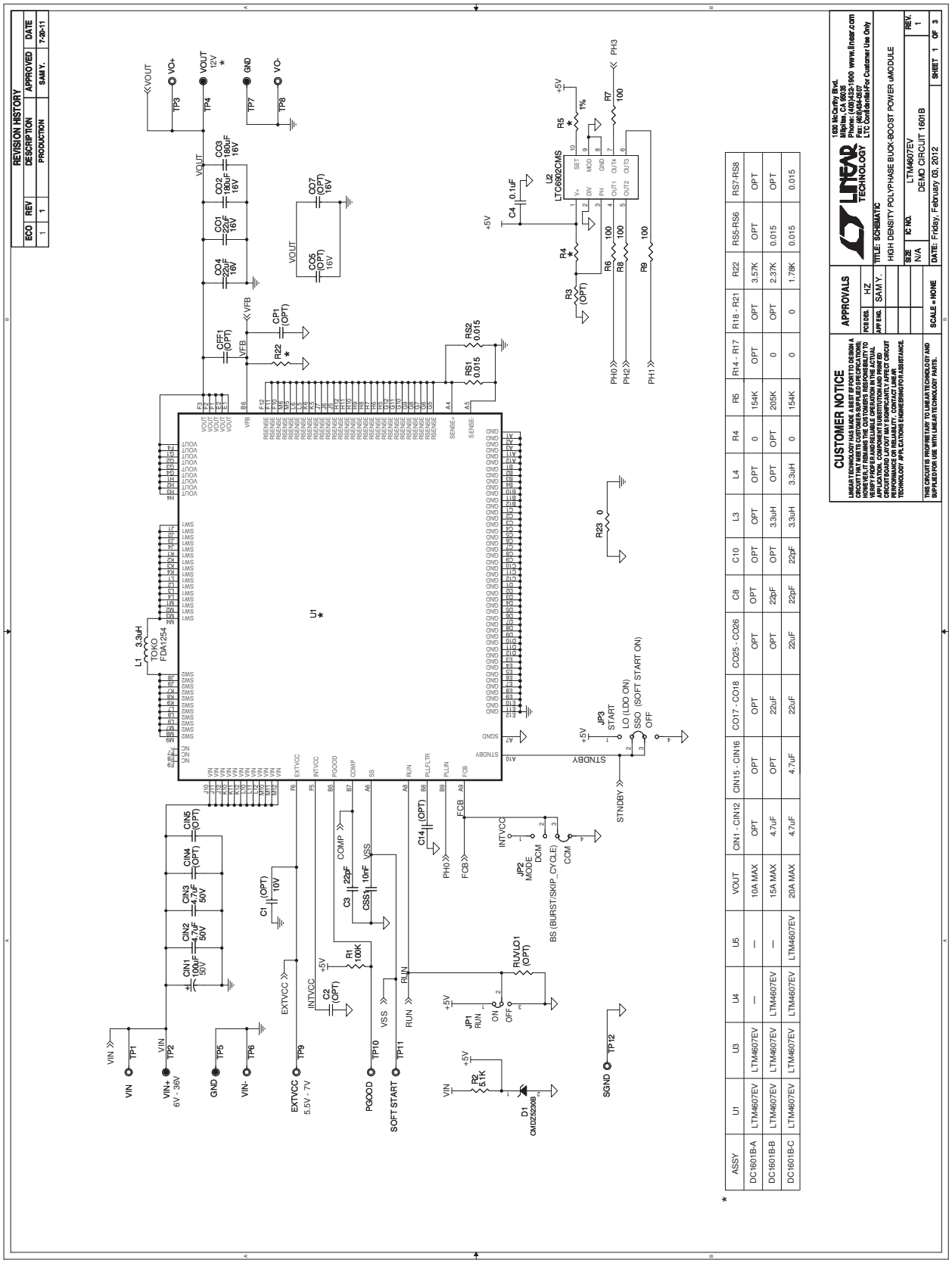
| ITEM | QTY | REFERENCE | PART DESCRIPTION | MANUFACTURER/PART NUMBER |
|---|---|---|---|---|
| **Required Circuit Components:** | | | | |
| 1 | 1 | DC1601 (COMMON BOM) | | |
| 2 | 2 | CIN11, CIN12 | CAP, X7R, 4.7µF, 50V, 10%, 1206 | MURATA, GRM31CR71H475K |
| 3 | 2 | CO17, CO18 | CAP, X5R, 22µF, 16V, 20%, 1812 | TDK, C4532X7R1C226M |
| 4 | 1 | C8 | CAP, NPO, 22pF, 50V, 5%, 0603 | AVX, 06035A220JAT2A |
| 5 | 1 | L3 | IND IRON POWER SMT FIXED, 3.3µH | TOKO, FDA1254-3R3M=P3 |
| 6 | 1 | R5 | RES, CHIP, 205k, 1/16W, 1%, 0603 | VISHAY, CRCW0603205KFKEA |
| 7 | 4 | R14 TO R17 | RES, CHIP, 0Ω, 0603 | VISHAY, CRCW06030000Z0EA |
| 8 | 1 | R22 | RES, CHIP, 2.37k, 1/16W, 1%, 0603 | VISHAY, CRCW06032K37FKEA |
| 9 | 2 | RS5, RS6 | RES, CHIP, 0.015Ω 1/2W, 1%, 1206 | VISHAY, WSL1206R0150FEA |
| 10 | 3 | U1, U3, U4 | I.C., LTM4607EV#PBF, 15mm × 9mm × 2.3mm | LINEAR TECHNOLOGY, LTM4607EV#PBF |
| **Additional Demo Board Circuit Components:** | | | | |
| 1 | 0 | CIN15, CIN16 (OPT) | CAP, 1206 | |
| 2 | 0 | CO25, CO26 (OPT) | CAP, 1812 | |
| 3 | 0 | C10 (OPT) | CAP, 0603 | |
| 4 | 0 | L4 (OPT) | IND IRON POWER SMT FIXED, 3.3µH | |
| 5 | 0 | R4, R18 TO R21 (OPT) | RES, CHIP, 0603 | |
| 6 | 0 | RS7, RS8 (OPT) | RES, CHIP, 1206 | |
| 7 | 0 | U5 (OPT) | IC, LTM4607EV#PBF, 15mm × 9mm × 2.3mm | LINEAR TECH., LTM4607EV#PBF |

## PARTS LIST

**Demo Board 1601B-C**

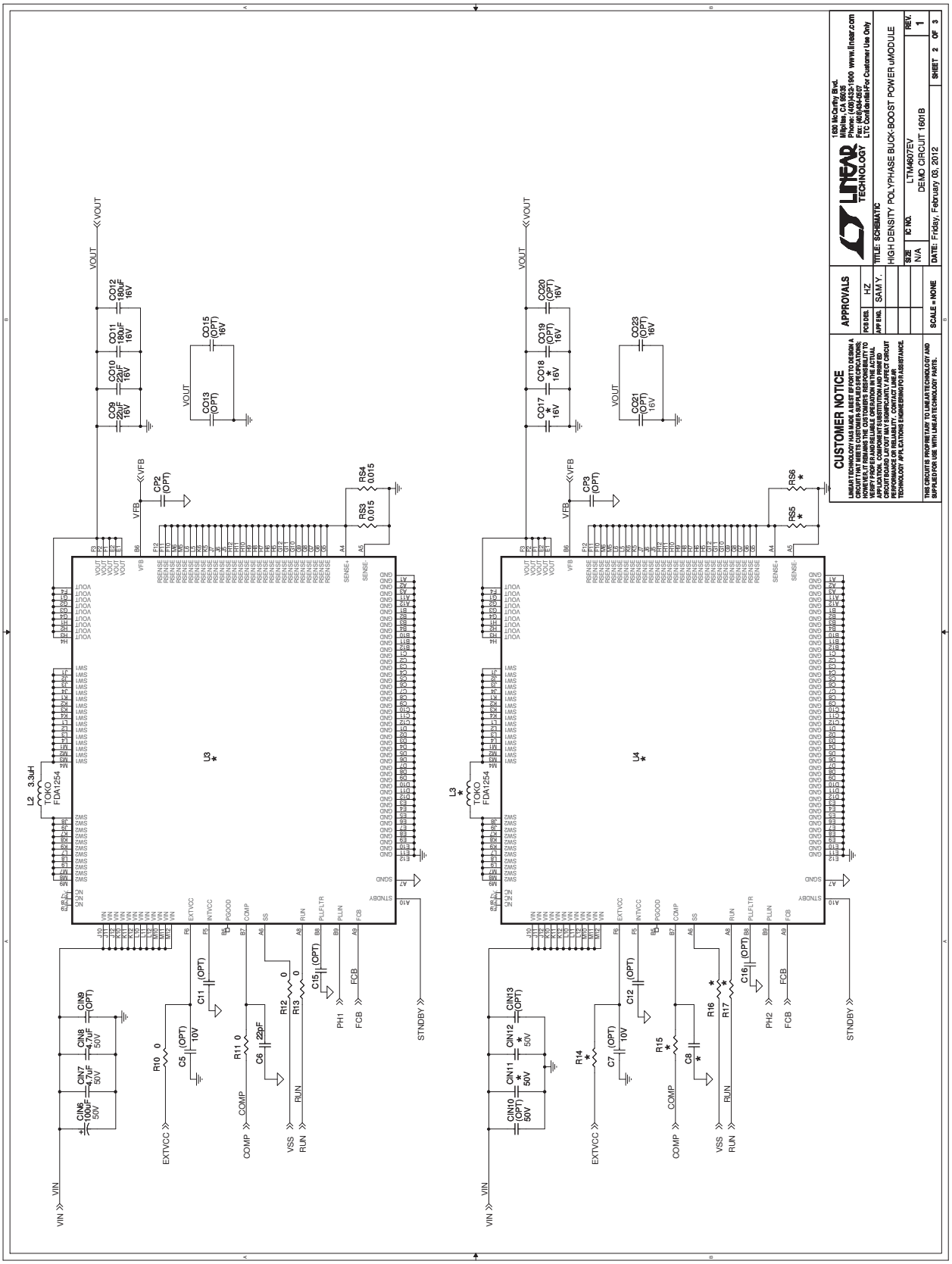
| ITEM | QTY | REFERENCE | PART DESCRIPTION | MANUFACTURER/PART NUMBER |
|---|---|---|---|---|
| **Required Circuit Components:** | | | | |
| 1 | 1 | DC1601 (COMMON BOM) | | |
| 2 | 4 | CIN11, CIN12, CIN15, CIN16 | CAP, X7R, 4.7µF, 10%, 50V, 1206 | MURATA, GRM31CR71H475K |
| 3 | 4 | CO17, CO18, CO25, CO26 | CAP, X5R, 22µF, 16V, 20%, 1812 | TDK, C4532X7R1C226M |
| 4 | 2 | C8, C10 | CAP, NPO, 22pF, 50V, 5%, 0603 | AVX, 06035A220JAT2A |
| 5 | 2 | L3, L4 | IND IRON POWER SMT FIXED, 3.3µH | TOKO, FDA1254-3R3M=P3 |
| 6 | 9 | R4, R14 TO R21 | RES, CHIP, 0Ω, 0603 | VISHAY, CRCW06030000Z0EA |
| 7 | 1 | R5 | RES, CHIP, 154k, 1/16W, 1%, 0603 | VISHAY, CRCW0603154KFKEA |
| 8 | 1 | R22 | RES, CHIP, 1.78k, 1/16W, 1%, 0603 | VISHAY, CRCW06031K78FKEA |
| 9 | 4 | RS5 TO RS8 | RES, CHIP, 0.015Ω 1/2W, 1%, 1206 | VISHAY, WSL1206R0150FEA |
| 10 | 4 | U1, U3, U4, U5 | IC, LTM4607EV#PBF, 15mm × 9mm × 2.3mm | LINEAR TECHNOLOGY, LTM4607EV#PBF |

# SCHEMATIC DIAGRAM



| ASSY | U1 | U3 | U4 | U5 | VOUT | CIN1 - CIN12 | CIN15 - CIN16 | CO17 - CO18 | CO25 - CO26 | C8 | C10 | L3 | L4 | R4 | R5 | R14 - R17 | R18 - R21 | R22 | RS5-RS6 | RS7-RS8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DC1601B-A | LTM4607EV | LTM4607EV | — | — | 10A MAX | OPT | OPT | OPT | OPT | OPT | OPT | OPT | OPT | 0 | 154K | OPT | OPT | 3.57K | OPT | OPT |
| DC1601B-B | LTM4607EV | LTM4607EV | LTM4607EV | — | 15A MAX | 4.7uF | OPT | 22uF | OPT | 22pF | OPT | 3.3uH | OPT | OPT | 205K | 0 | OPT | 2.37K | 0.015 | OPT |
| DC1601B-C | LTM4607EV | LTM4607EV | LTM4607EV | LTM4607EV | 20A MAX | 4.7uF | 4.7uF | 22uF | 22uF | 22pF | 22pF | 3.3uH | 3.3uH | 0 | 154K | 0 | 0 | 1.78K | 0.015 | 0.015 |

## SCHEMATIC DIAGRAM



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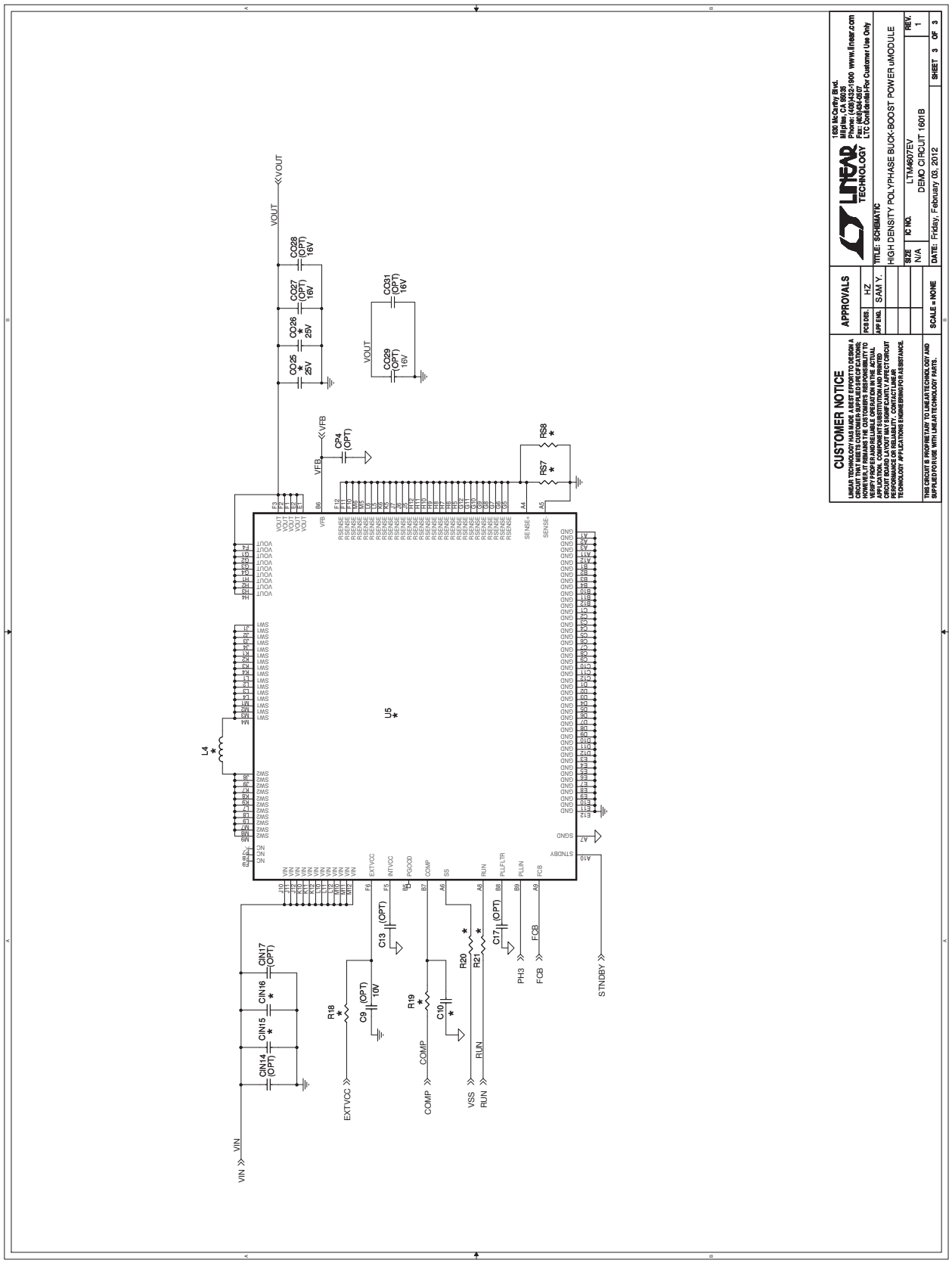

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**Please read the DEMO BOARD manual prior to handling the product**. Persons handling this product must have electronics training and observe good laboratory practice standards. **Common sense is encouraged**.

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

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