

# 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

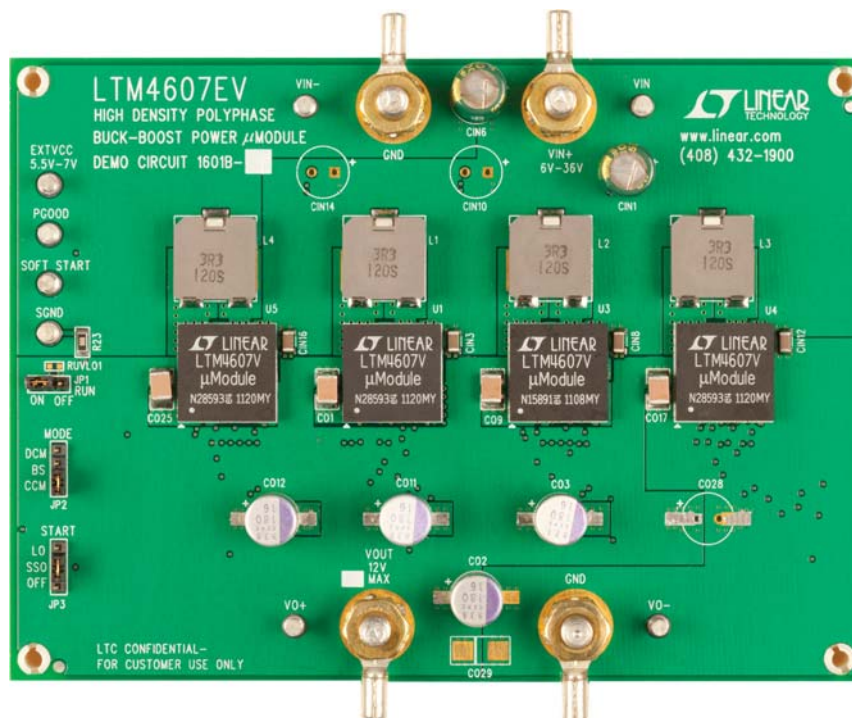
phases to minimize input and output ripple. An internal phase-locked loop allows the LTM4607 to be synchronized to an external clock within the range of 200kHz to 400kHz. The LTM4607 default switching frequency on the DC1601B is set to 300kHz through the onboard LTC6902 clock generator which interleaves 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>

LT, LT, LTC, LTM, Linear Technology, PolyPhase and the Linear logo are registered trademarks of Linear Technology Corporation. All other trademarks are the property of their respective owners.

## BOARD PHOTO



DC1601B-C  
SHOWN

# DEMO MANUAL DC1601B

## PERFORMANCE SUMMARY (T<sub>A</sub> = 25°C)

| PARAMETER                                               | CONDITIONS                                                                                                           | VALUE                                                                                                                                                                                                                           |
|---------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Maximum Input Voltage                                   |                                                                                                                      | 36V                                                                                                                                                                                                                             |
| Minimum Input Voltage                                   |                                                                                                                      | 6V                                                                                                                                                                                                                              |
| Output Voltage V <sub>OUT</sub>                         | Programmed by R22                                                                                                    | 12V                                                                                                                                                                                                                             |
| Maximum Continuous Output Current I <sub>OUT(MAX)</sub> | Current Derating May Be Necessary for Certain V <sub>IN</sub> , V <sub>OUT</sub> , 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 <sub>OUT</sub> = 12V<br>300kHz (20MHz BW)                                                                          | V <sub>IN</sub> = 9V, I <sub>OUT</sub> = 10A (DC1601B-A), See Figure 5a<br>V <sub>IN</sub> = 12V, I <sub>OUT</sub> = 15A (DC1601B-B), See Figure 5b<br>V <sub>IN</sub> = 32V, I <sub>OUT</sub> = 20A (DC1601B-B), See Figure 5c |
| Efficiency                                              | V <sub>IN</sub> = 9V, V <sub>OUT</sub> = 12V<br>300kHz                                                               | 95.7% at I <sub>OUT</sub> = 10A (DC1601B-A), See Figure 2a<br>94.8% at I <sub>OUT</sub> = 15A (DC1601B-B), See Figure 2b<br>94.8% at I <sub>OUT</sub> = 20A (DC1601B-C), See Figure 2c                                          |
| Load Transient                                          | V <sub>OUT</sub> = 12V<br>300kHz (20MHz BW)                                                                          | V <sub>IN</sub> = 9V, I <sub>OUT</sub> = 10A (DC1601B-A), See Figure 4a<br>V <sub>IN</sub> = 12V, I <sub>OUT</sub> = 15A (DC1601B-B), See Figure 4b<br>V <sub>IN</sub> = 32V, I <sub>OUT</sub> = 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<sub>OUT</sub> 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  $\pm 2\%$  (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  $\pm 2\%$  (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.

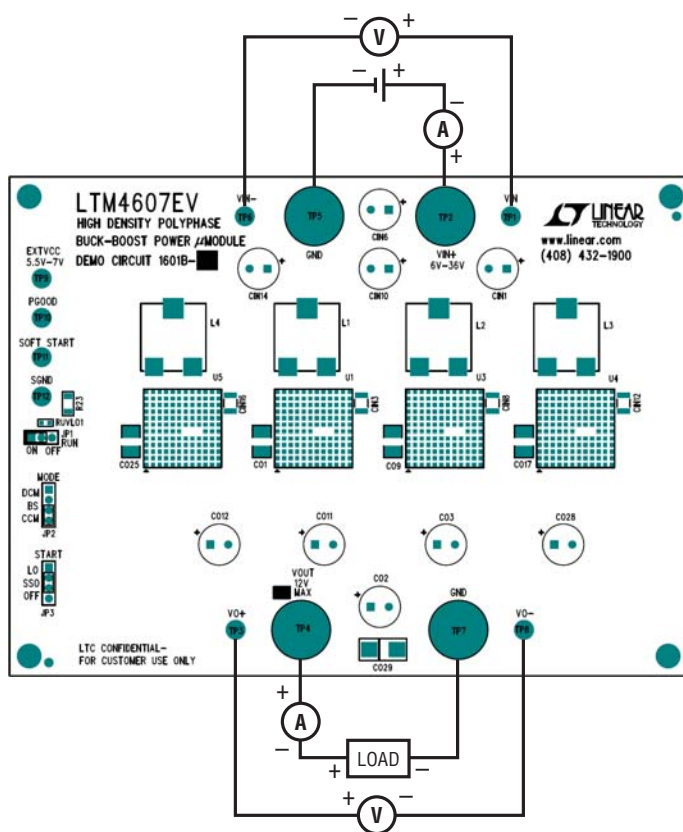


Figure 1

QUICK START PROCEDURE

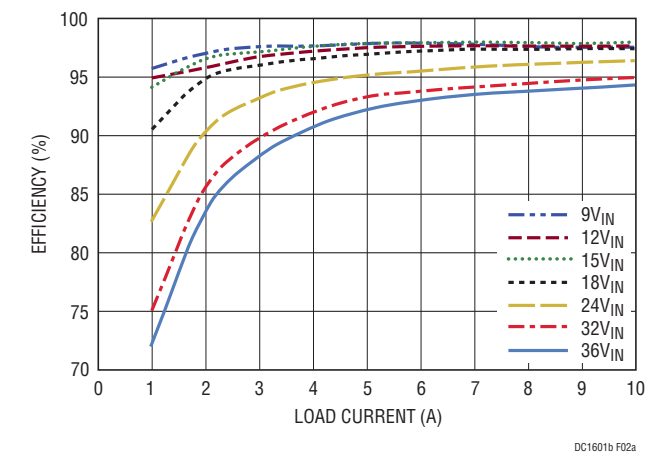


Figure 2a. Measured Efficiency at 12V<sub>OUT</sub>, 300kHz (DC1601B-A)

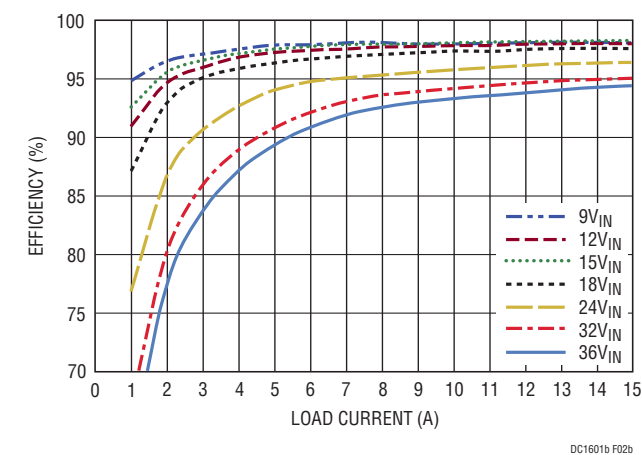


Figure 2b. Measured Efficiency at 12V<sub>OUT</sub>, 300kHz (DC1601B-B)

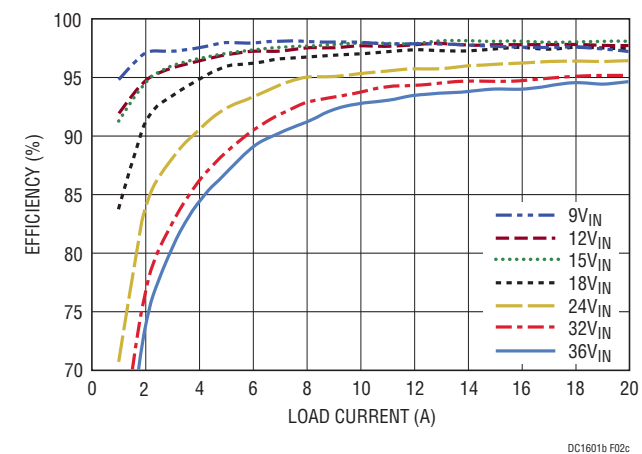


Figure 2c. Measured Efficiency at 12V<sub>OUT</sub>, 300kHz (DC1601B-C)

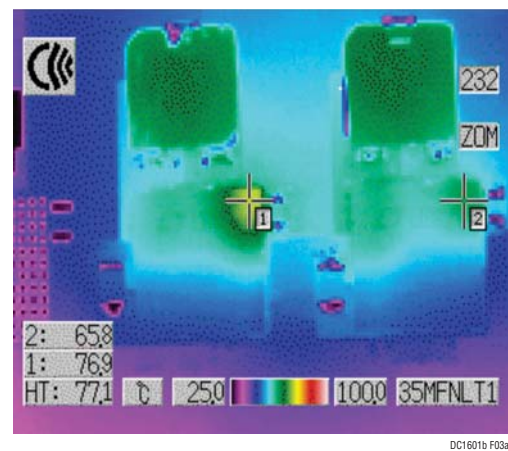


Figure 3a. Thermal Capture at 6V<sub>IN</sub>, 12V<sub>OUT</sub>, 10A, 300kHz (DC1601B-A) No Forced Airflow (Convection)

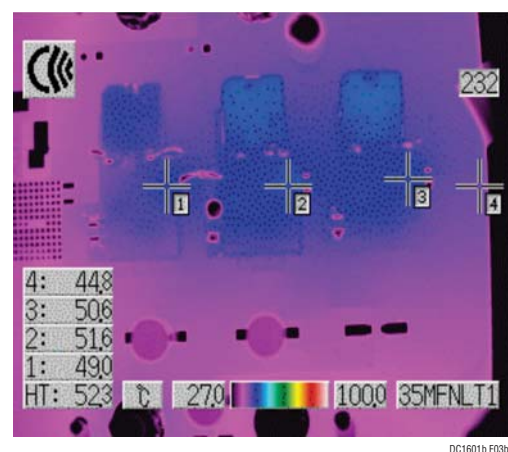


Figure 3b. Thermal Capture at 12V<sub>IN</sub>, 12V<sub>OUT</sub>, 15A, 300kHz (DC1601B-B) No Forced Airflow (Convection)

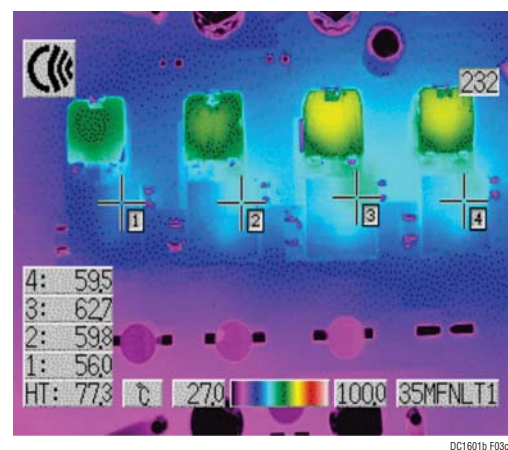


Figure 3c. Thermal Capture at 32V<sub>IN</sub>, 12V<sub>OUT</sub>, 20A, 300kHz (DC1601B-C) No Forced Airflow (Convection)

dc1601bf

## QUICK START PROCEDURE

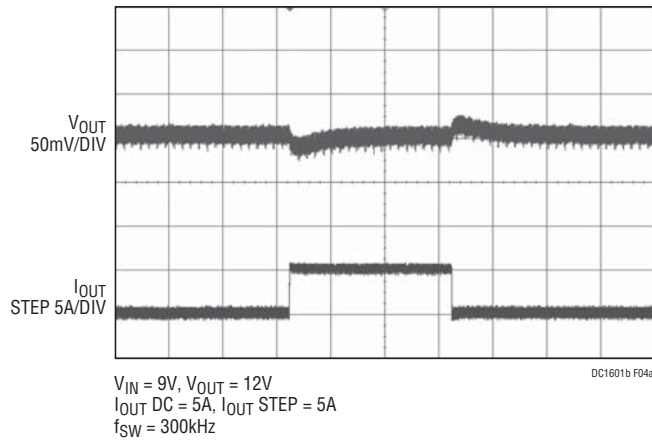


Figure 4a. Measured Load Step Response (DC1601B-A)

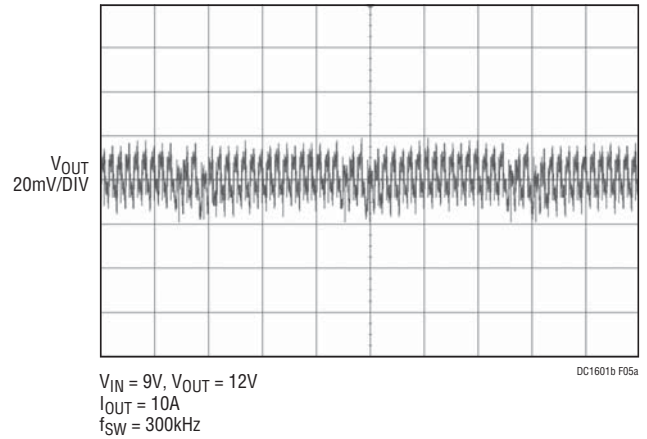


Figure 5a. Measured Output Voltage Ripple (DC1601B-A)

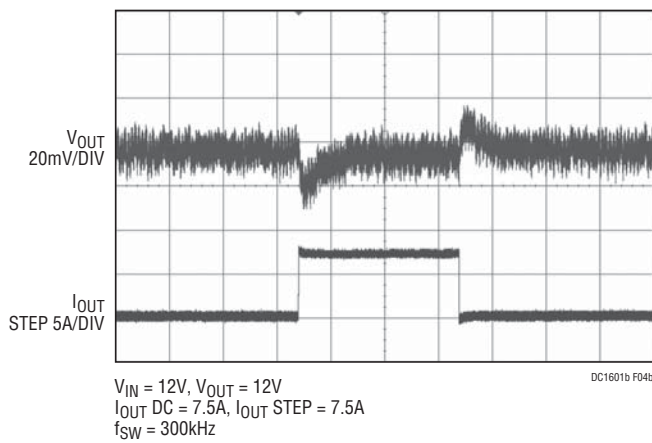


Figure 4b. Measured Load Step Response (DC1601B-B)

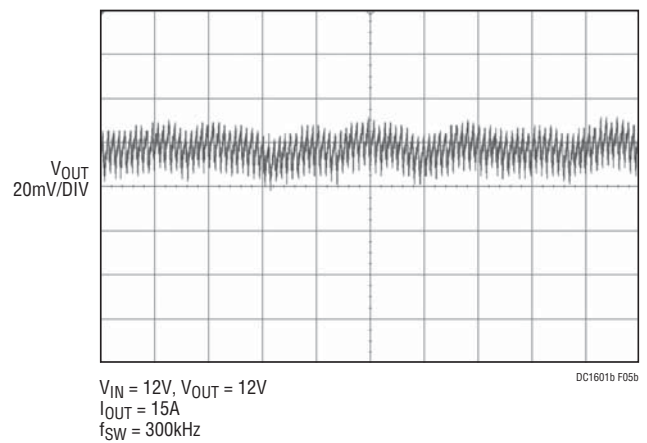


Figure 5b. Measured Output Voltage Ripple (DC1601B-B)

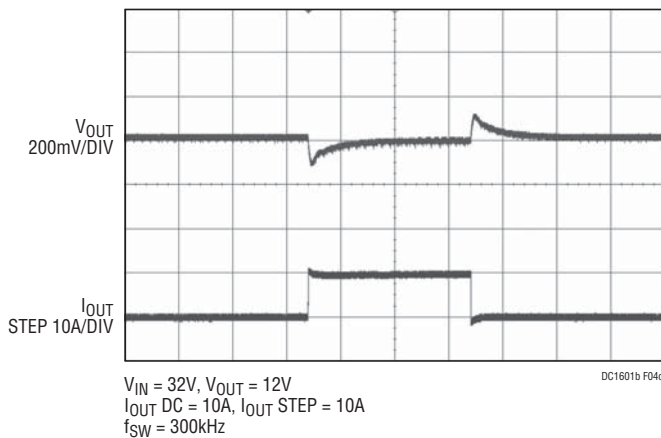


Figure 4c. Measured Load Step Response (DC1601B-C)

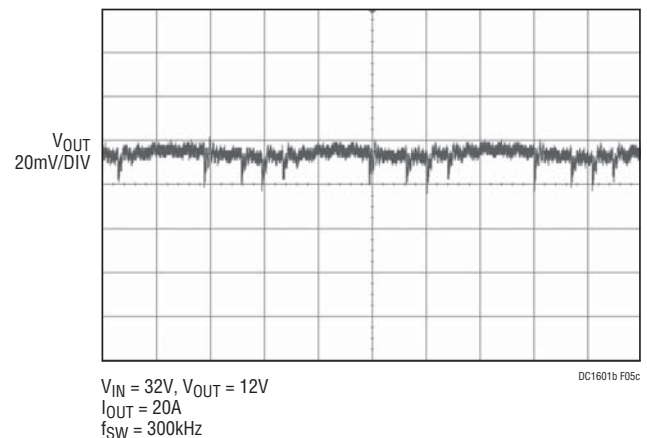


Figure 5c. Measured Output Voltage Ripple (DC1601B-C)

dc1601bf



# DEMO MANUAL DC1601B

## PARTS LIST

| ITEM                                                    | QTY | REFERENCE                      | PART DESCRIPTION                 | MANUFACTURER/PART NUMBER          |
|---------------------------------------------------------|-----|--------------------------------|----------------------------------|-----------------------------------|
| <b>Common Required Circuit Components:</b>              |     |                                |                                  |                                   |
| 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 |
| <b>Common Additional Demo Board Circuit Components:</b> |     |                                |                                  |                                   |
| 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   | RUVL01, 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          |
| <b>Common Hardware:</b>                                 |     |                                |                                  |                                   |
| 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         |
|-------------------------------------|-----|---------------------|-----------------------------------------------------|----------------------------------|
| <b>Required Circuit Components:</b> |     |                     |                                                     |                                  |
| 1                                   | 1   | DC1601 (COMMON BOM) |                                                     |                                  |
| 2                                   | 1   | R4                  | RES, CHIP, 0 $\Omega$ , 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 $\times$ 9mm $\times$ 2.3mm | LINEAR TECHNOLOGY, LTM4607EV#PBF |

### Additional Demo Board Circuit Components:

|   |   |                                  |                                                     |                                  |
|---|---|----------------------------------|-----------------------------------------------------|----------------------------------|
| 1 | 0 | CIN11, CIN12, CIN15, CIN16 (OPT) | CAP, 1206                                           |                                  |
| 2 | 0 | C017, C018, C025, C026 (OPT)     | CAP, 1812                                           |                                  |
| 3 | 0 | C8, C10 (OPT)                    | CAP, 0603                                           |                                  |
| 4 | 0 | L3, L4 (OPT)                     | IND IRON POWER SMT FIXED, 3.3 $\mu$ H               |                                  |
| 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 $\times$ 9mm $\times$ 2.3mm | LINEAR TECHNOLOGY, LTM4607EV#PBF |

### Demo Board 1601B-B

| ITEM                                | QTY | REFERENCE           | PART DESCRIPTION                                      | MANUFACTURER/PART NUMBER         |
|-------------------------------------|-----|---------------------|-------------------------------------------------------|----------------------------------|
| <b>Required Circuit Components:</b> |     |                     |                                                       |                                  |
| 1                                   | 1   | DC1601 (COMMON BOM) |                                                       |                                  |
| 2                                   | 2   | CIN11, CIN12        | CAP, X7R, 4.7 $\mu$ F, 50V, 10%, 1206                 | MURATA, GRM31CR71H475K           |
| 3                                   | 2   | C017, C018          | CAP, X5R, 22 $\mu$ F, 16V, 20%, 1812                  | TDK, C4532X7R1C226M              |
| 4                                   | 1   | C8                  | CAP, NPO, 22pF, 50V, 5%, 0603                         | AVX, 06035A220JAT2A              |
| 5                                   | 1   | L3                  | IND IRON POWER SMT FIXED, 3.3 $\mu$ H                 | TOKO, FDA1254-3R3M=P3            |
| 6                                   | 1   | R5                  | RES, CHIP, 205k, 1/16W, 1%, 0603                      | VISHAY, CRCW0603205KFKEA         |
| 7                                   | 4   | R14 TO R17          | RES, CHIP, 0 $\Omega$ , 0603                          | VISHAY, CRCW06030000Z0EA         |
| 8                                   | 1   | R22                 | RES, CHIP, 2.37k, 1/16W, 1%, 0603                     | VISHAY, CRCW06032K37FKEA         |
| 9                                   | 2   | RS5, RS6            | RES, CHIP, 0.015 $\Omega$ 1/2W, 1%, 1206              | VISHAY, WSL1206R0150FEA          |
| 10                                  | 3   | U1, U3, U4          | I.C., LTM4607EV#PBF, 15mm $\times$ 9mm $\times$ 2.3mm | LINEAR TECHNOLOGY, LTM4607EV#PBF |

### Additional Demo Board Circuit Components:

|   |   |                      |                                                     |                             |
|---|---|----------------------|-----------------------------------------------------|-----------------------------|
| 1 | 0 | CIN15, CIN16 (OPT)   | CAP, 1206                                           |                             |
| 2 | 0 | C025, C026 (OPT)     | CAP, 1812                                           |                             |
| 3 | 0 | C10 (OPT)            | CAP, 0603                                           |                             |
| 4 | 0 | L4 (OPT)             | IND IRON POWER SMT FIXED, 3.3 $\mu$ H               |                             |
| 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 $\times$ 9mm $\times$ 2.3mm | LINEAR TECH., LTM4607EV#PBF |

# DEMO MANUAL DC1601B

## 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   | C017, C018, C025, C026     | 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 |



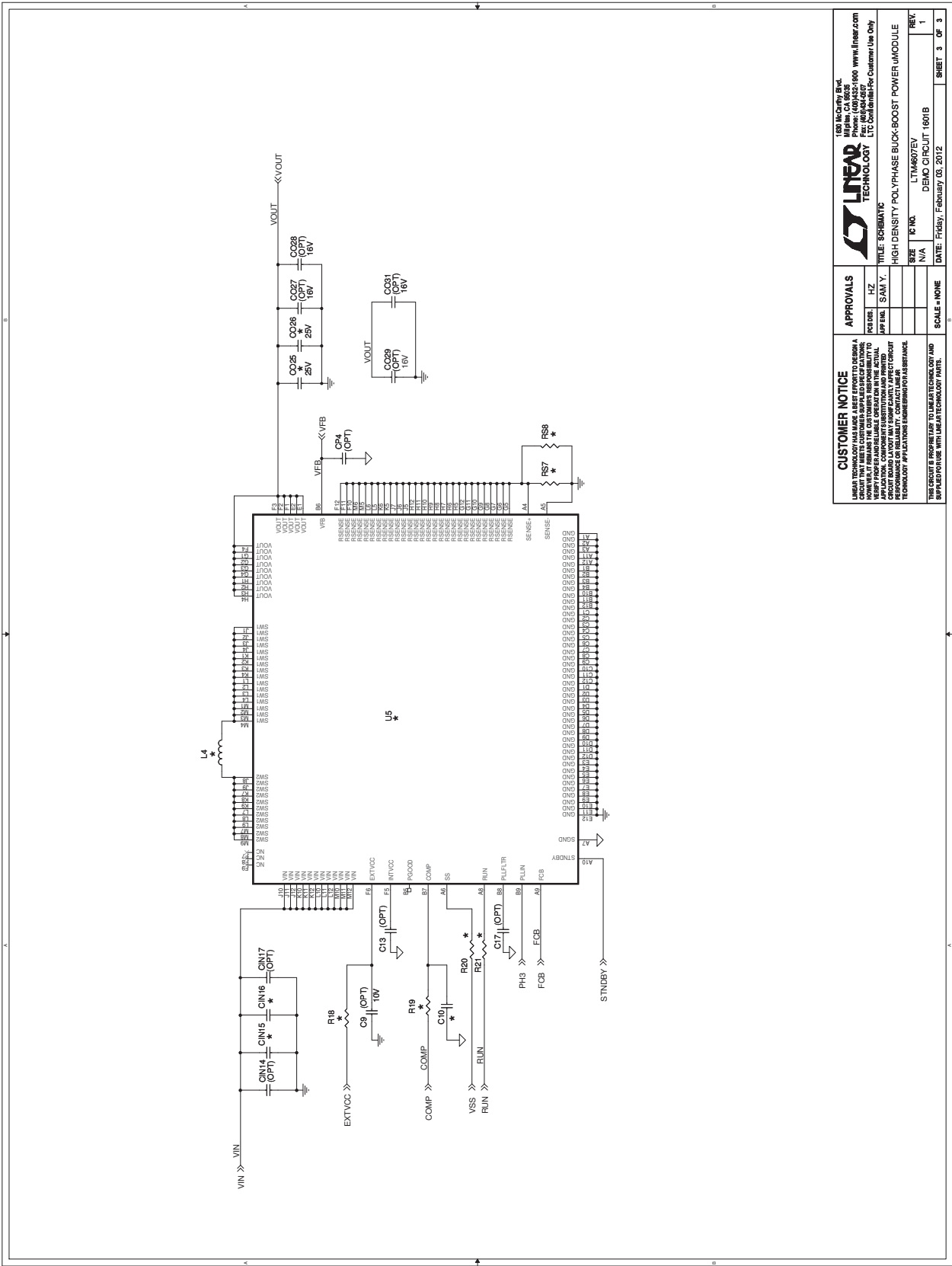
## SCHEMATIC DIAGRAM



## SCHEMATIC DIAGRAM



SCHEMATIC DIAGRAM



dc1601bf

# DEMO MANUAL DC1601B

---

## DEMONSTRATION BOARD IMPORTANT NOTICE

Linear Technology Corporation (LTC) provides the enclosed product(s) under the following **AS IS** conditions:

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.

The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user releases LTC from all claims arising from the handling or use of the goods. Due to the open construction of the product, it is the user's responsibility to take any and all appropriate precautions with regard to electrostatic discharge. Also be aware that the products herein may not be regulatory compliant or agency certified (FCC, UL, CE, etc.).

No License is granted under any patent right or other intellectual property whatsoever. **LTC assumes no liability for applications assistance, customer product design, software performance, or infringement of patents or any other intellectual property rights of any kind.**

LTC currently services a variety of customers for products around the world, and therefore this transaction **is not exclusive**.

**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.

Mailing Address:

Linear Technology  
1630 McCarthy Blvd.  
Milpitas, CA 95035

Copyright © 2004, Linear Technology Corporation

dc1601bf

# Mouser Electronics

Authorized Distributor

Click to View Pricing, Inventory, Delivery & Lifecycle Information:

[Analog Devices Inc.:](#)

[DC1601B-A](#) [DC1601B-C](#)