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# LTC4012

## High Current High Efficiency Multi-Chemistry Battery Charger with PowerPath Control

### DESCRIPTION

Demonstration circuit 1614 features the LTC4012CUF, a multi-chemistry single battery charger controller with PowerPath™ control. The input supply voltage is 13.5V to 20V and is initially configured for a current limit of 10A. The charger float voltage is programmed by jumpers to support 1- to 4- series cells of both Li-Ion/Polymer and Li-iron phosphate ( $\text{LiFePO}_4$ ) at 4.2V/cell and 3.6V/cell, for a total of eight settings. The demo board is initially configured for constant-voltage charging of a 12.6V Li-Ion/Polymer battery and constant-current charging at 8A, though current derating may be necessary due to certain operating conditions.

Charging can be enabled/disabled by properly setting the shutdown jumper. LED indicators for  $\overline{\text{CHG}}$ ,  $\overline{\text{ICL}}$ ,  $\overline{\text{ACP}}$ , and C/10 display the current state of the charger system. Although this charger is not a smart battery charger, a popular smart battery connector is provided that can be used for further data-logging with the optional DC1223A-B demo board and software. Note that a smart battery is not required to use this board; however, smart batteries are

compatible with this charger. The optional DC1223A-B SMBus-to-RS232 Serial port adapter and associated software can be used to monitor a smart battery for demonstration purposes only. Contact your Linear Technology representative to order a DC1223A-B.

DC1614 features an optional circuit for sealed lead acid (SLA) batteries for constant-voltage charging with temperature compensation and fast/float voltage toggling. DC1614 also features layout for extra components and external gate drivers for improved efficiency at higher charge currents.

This demo board is capable of supporting the LTC4012 and LTC4012-3 with a simple IC swap-out. See the Schematic Diagram.

**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                       | CONDITIONS                                | VALUE  |
|---------------------------------|---|--|
| Minimum Input Voltage           | $V_{IN} > V_{BAT}$ Float Voltage          | $13.5V_{MIN}$ When Using 12.6V Li-Ion/Polymer. Recommend 15V |
| Maximum Input Voltage           | Limited by Input Capacitor Voltage Rating | 20V  |
| Input Current Limit             | Set by R1 ( $100\text{mV}/R1$ )           | $10A_{DC} \pm 4\%$   |
| Default Float Voltage $V_{BAT}$ | Jumper Selectable: 4.2V/Cell or 3.6V/Cell | $12.6V \pm 1\%$  |
| Maximum Charge Current          | $V_{IN} > V_{BAT}$                        | $8A_{DC} \pm 5\%$  |



## QUICK START PROCEDURE

Demonstration circuit 1614 is easy to set up to evaluate the performance of LTC4012. Refer to Figure 1 for proper measurement equipment setup and follow the procedure below.

1. With all power off, connect an input power supply capable of more than 10A, system load, battery, and meters as shown in Figure 1. Preset the load to 0A and  $V_{IN}$  to 0V, 0A current limit. The input supply voltage **must** be greater than the full voltage value of the battery to allow a full charge to take place.

2. Connect the jumpers as shown below for normal LED-indicated operation:

| JP2      | JP3             | JP4               | JP5     |
|----------|-----------------|-------------------|---------|
| Shutdown | $V_{CC}$ Select | Internal $V_{CC}$ | LED PWR |
| THM      | INT             | ON                | ON      |

3. Connect the system load to  $V_{OUT}$  and GND terminals.
4. Connect the jumper JP1 for the specific battery to be tested.
5. Turn the input power supply on, setting the current limit up to 10A. Adjust the voltage to the desired value, up to 20V.
6. Plug in the battery. An industry-standard 5-pin AMP smart battery connector is provided for convenience. The board will automatically charge a battery upon insertion and detection of a thermistor. Optionally set jumper JP2 to ON to charge a battery without a thermistor.

7. Turn the load on and adjust as necessary. At 10A input, the input current will limit and the ICL LED will turn on. Note that above a certain load setting, depending on your  $V_{IN}$  and battery voltage, the charger will start to decrease charge current until the system load is consuming all of the current from the input. For 15V input and 12.6V<sub>BAT</sub> setting this will occur at about 3.3A.
8. Optionally evaluate the SLA circuit, removing the jumper on JP1, as well as R14. The voltage feedback network can now be customized to match the battery manufacturer's specifications. The SLA circuit can be found in the bottom left-hand corner on the top side of the board.
9. Optionally use the provided DC1223A-B demonstration software to configure and communicate with the DC1614A, connecting DC1223A-B as in Figure 1.
10. For improved efficiency at high charge currents, install additional MOSFETs in Q8 and Q10 positions and/or gate driver circuit transistors and supply capacitors in Q7, Q9, C21, and C25. These components may be installed on the bottom side of the board.

## QUICK START PROCEDURE

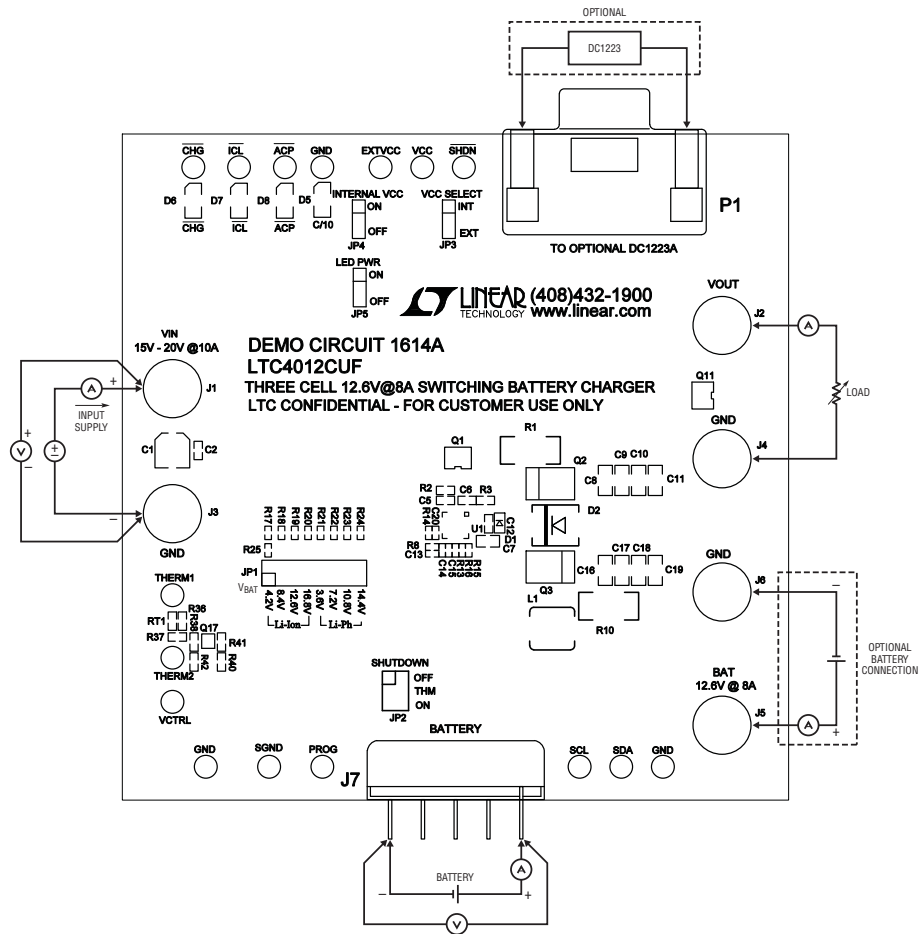


Figure 1. Proper Measurement Equipment Setup

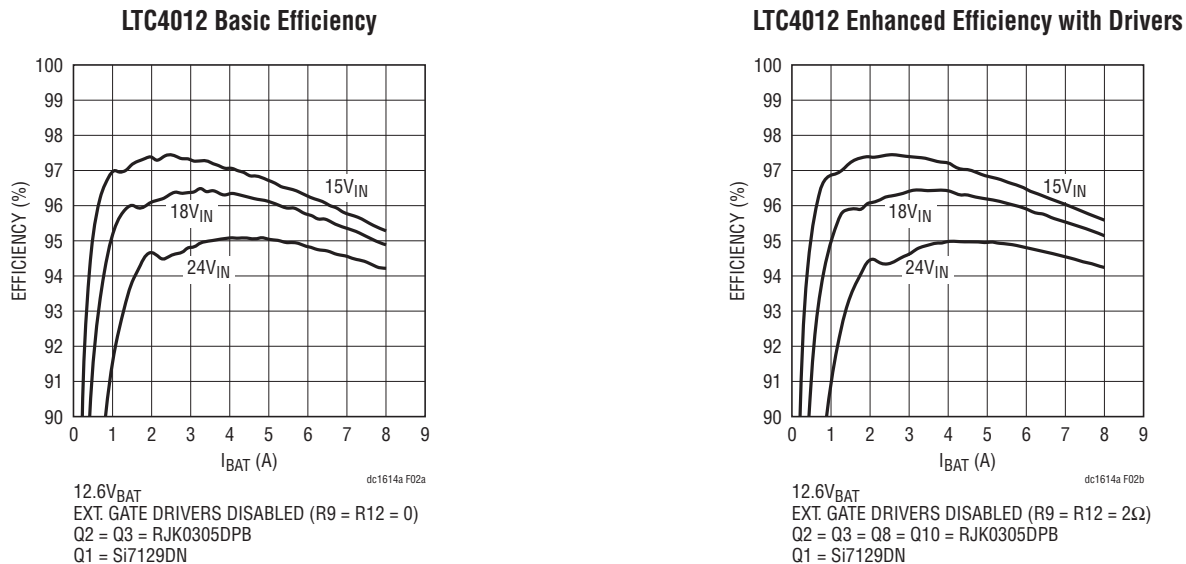


Figure 2. Efficiency Comparison with and without External Gate Drivers at 15V<sub>IN</sub>, 18V<sub>IN</sub>, and 24V<sub>IN</sub>

# DEMO MANUAL DC1614A

## PARTS LIST

| ITEM                                  | QTY | REFERENCE                            | PART DESCRIPTION                             | MANUFACTURER/<br>PART NUMBER |
|---------------------------------------|-----|--------------------------------------|--|------------------------------|
| <b>REQUIRED CIRCUIT COMPONENTS:</b>   |     |                                      |  |                              |
| 1                                     | 3   | C5, C6, C12                          | Capacitor, 0.1μF, 50V, 10% 0603              | TDK C1608X7R1H104K           |
| 2                                     | 1   | C7                                   | Capacitor, 2.2μF, 16V, 20% 0805              | TDK C2012X5R1C225M           |
| 3                                     | 8   | C8, C9, C10, C11, C16, C17, C18, C19 | Capacitor, 10μF, 25V, 20% 1206               | Taiyo Yuden TMK316BJ106ML    |
| 4                                     | 1   | C13                                  | Capacitor, 0.1μF, 16V, 10% 0402              | TDK C1005X7R1C104K           |
| 5                                     | 1   | C15                                  | Capacitor, 4.7nF, 50V, 10% 0402              | TDK C1005X7R1H472K           |
| 6                                     | 1   | C20                                  | Capacitor, 10pF, 50V, ±0.5% 0402             | TDK C1005C0G1H100D           |
| 7                                     | 1   | D1                                   | Diode Schottky, 30V, SOD-323                 | Central Semi. CMDSH-3TR      |
| 8                                     | 1   | D2                                   | Diode Schottky, 40V/3A                       | ON Semiconductor MBRS340T3   |
| 9                                     | 1   | L1                                   | Inductor, 2.2μH                              | Vishay IHLP-2525CZ-01 2R2uH  |
| 10                                    | 1   | Q1                                   | MOSFET P-Channel, 30V, PowerPAK1212-8        | Vishay Si7129DN-T1-GE3 #PbF  |
| 11                                    | 4   | Q2, Q3                               | MOSFET N-Channel, 30V/10A                    | Renesas RJK0305DPB-00-J0     |
| 12                                    | 1   | R1                                   | Resistor, 0.010Ω, 1W, 1% 2512                | IRC LR2512-01-R010-F         |
| 13                                    | 1   | R3                                   | Resistor, 5.1k, 1/16W, 1% 0603               | Vishay CRCW06035K10FKEA      |
| 14                                    | 1   | R8                                   | Resistor, 6.04k, 1/16W, 1% 0402              | Vishay CRCW04026K04FKEA      |
| 15                                    | 1   | R10                                  | Resistor, 0.012Ω, 1W, 1% 2512                | IRC LR2512-01-R012-F         |
| 16                                    | 1   | R13                                  | Resistor, 27.4k, 1/16W, 1% 0402              | Vishay CRCW040227K4FKEA      |
| 17                                    | 1   | R14                                  | Resistor, 184k, 1/16W, 0.25% 0402            | NIC Comp NTR-04C1843DTRF     |
| 18                                    | 2   | R15, R16                             | Resistor, 3.01k, 1/16W, 1% 0402              | Vishay CRCW04023K01FKEA      |
| 19                                    | 1   | R19                                  | Resistor, 19.6k, 1/16W, 0.25% 0402           | NIC Comp NTR-04C1962DTRF     |
| 20                                    | 1   | U1                                   | I.C. Battery Charger QFN (20) (UF) 4mm × 4mm | Linear Technology LTC4012CUF |
| <b>ADDITIONAL CIRCUIT COMPONENTS:</b> |     |                                      |  |                              |
| 1                                     | 1   | C1                                   | Capacitor, 10μF, 35V, 20% CAP-CE-5X6.0       | Sanyo 35CE10AX               |
| 2                                     | 1   | C2                                   | Capacitor, 0.1μF, 50V, % 0603                | TDK C1608X7R1H104K           |
| 3                                     | 1   | C14                                  | Capacitor, 0402 Optional                     |                              |
| 4                                     | 2   | C21, C25                             | Capacitor, 0.1μF, 16V, 10% 0402              | TDK C1005X7R1C104K           |
| 5                                     | 1   | C22                                  | Capacitor, 1μF, 25V, 10% 1206                | AVX 12063C105KAT             |
| 6                                     | 1   | C23                                  | Capacitor, 0.1μF, 50V, 10% 0603              | TDK C1608X7R1H104K           |
| 7                                     | 1   | C24                                  | Capacitor, 10μF, 16V, 20% 3528               | AVX TAJB106M016              |
| 8                                     | 0   | D3                                   | Diode Schottky Rectifier, 40V/5A Powermite 3 |                              |
| 9                                     | 1   | D4                                   | Diode Zener, 18V, SOD-323                    | Diodes Inc., MMSZ5248BS      |
| 10                                    | 2   | D5, D8                               | Diode (Green)                                | Panasonic LN1351C-(TR) PBF   |
| 11                                    | 2   | D6, D7                               | Diode (Yellow)                               | Panasonic LN1451C-(TR) PBF   |
| 12                                    | 0   | L2                                   | Inductor, IHLP5050 Optional                  |                              |
| 13                                    | 0   | L3                                   | Inductor, CEP125 Optional                    |                              |
| 14                                    | 2   | Q4, Q16                              | MOSFET N-Channel, SOT23                      | Zetex 2N7002                 |
| 15                                    | 0   | Q5, Q6                               | MOSFET P-Channel, 30V, PowerPAK1212-8        | Vishay Si7129DN-T1-GE3 #PbF  |
| 16                                    | 2   | Q7, Q9                               | XSTR., 12V NPN/PNP SOT23-6                   | Diode Inc ZXTC2063E6         |
| 17                                    | 2   | Q8, Q10                              | MOSFET N-Channel, 30V/10A                    | Renesas RJK0305DPB-00-J0     |

## PARTS LIST

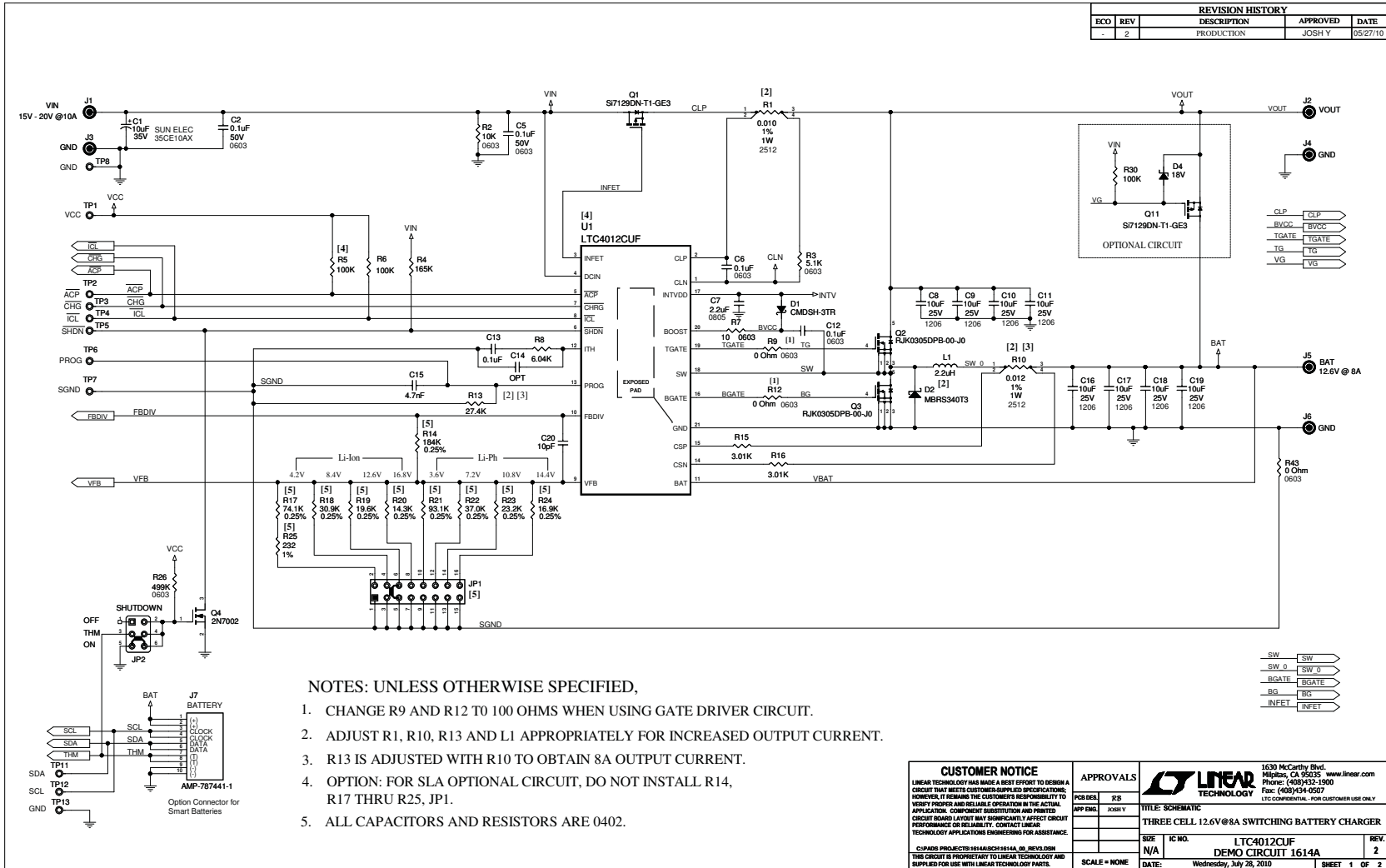
| ITEM | QTY | REFERENCE                    | PART DESCRIPTION                                       | MANUFACTURER/<br>PART NUMBER  |
|------|-----|------------------------------|--|-------------------------------|
| 18   | 1   | Q11                          | MOSFET P-Channel, 30V, PowerPAK1212-8                  | Vishay Si7129DN-T1-GE3 #PbF   |
| 19   | 1   | Q12                          | Transistor, SOT-323                                    | On Semi., MMBT3906WT1G        |
| 20   | 3   | Q13, Q14, Q15                | MOSFET P-Channel, SOT23                                | Siliconix TP0610T             |
| 21   | 1   | Q17                          | MOSFET N-Channel, 20V SC-75                            | Philips Semi. (NXP) PMR280UN  |
| 22   | 0   | RT1                          | Thermistor, 0603 Optional                              |                               |
| 23   | 1   | R2                           | Resistor, 10k, 1/16W, 1% 0603                          | NIC Comp NCR06F1002TRF        |
| 24   | 1   | R4                           | Resistor, 165k, 1/16W, 1% 0402                         | Vishay CRCW0402165KFKEA       |
| 25   | 3   | R5, R6, R30                  | Resistor, 100k, 1/16W, 1% 0402                         | AAC, CR05-104JM               |
| 26   | 1   | R7                           | Resistor, 10 $\Omega$ , 1/16W, 5% 0603                 | Vishay CRCW060310R0JNEA       |
| 27   | 3   | R9, R12, R43                 | Resistor, 0 $\Omega$ , 1/16W, 1A 0603                  | Vishay CRCW06030000ZEA        |
| 28   | 1   | R17                          | Resistor, 74.1k, 1/16W, 0.25% 0402                     | NIC Comp NTR-04C7412DTRF      |
| 29   | 1   | R18                          | Resistor, 30.9k, 1/16W, 0.25% 0402                     | NIC Comp NTR-04C3092DTRF      |
| 30   | 1   | R20                          | Resistor, 14.3k, 1/16W, 0.25% 0402                     | NIC Comp NTR-04C1432DTRF      |
| 31   | 1   | R21                          | Resistor, 93.1k, 1/16W, 0.25% 0402                     | NIC Comp NTR-04C9312DTRF      |
| 32   | 1   | R22                          | Resistor, 37k, 1/16W, 0.25% 0402                       | NIC Comp NTR-04C3702DTRF      |
| 33   | 1   | R23                          | Resistor, 23.2k, 1/16W, 0.25% 0402                     | NIC Comp NTR-04C2322DTRF      |
| 34   | 1   | R24                          | Resistor, 16.9k, 1/16W, 0.25% 0402                     | NIC Comp NTR-04C1692DTRF      |
| 35   | 1   | R25                          | Resistor, 232 $\Omega$ , 1/16W, 1% 0402                | Vishay CRCW0402232RFKED       |
| 36   | 1   | R26                          | Resistor, 499k, 1/16W, 1% 0603                         | Vishay CRCW0603499KFKEA       |
| 37   | 1   | R27                          | Resistor, 10 $\Omega$ , 1/16W, 5% 0603                 | AAC, CR05-104JM               |
| 38   | 1   | R31                          | Resistor, 28k, 1/16W, 1% 0603                          | Vishay CRCW060328K0FKEA       |
| 39   | 4   | R32, R33, R34, R35           | Resistor, 300 $\Omega$ , 1/16W, 5% 0603                | AAC CR16-301JM                |
| 40   | 0   | R36, R37, R38, R40, R41, R42 | Resistor, 0603 Optional                                |                               |
| 41   | 1   | U2                           | I.C., Voltage Regulator DFN (06) (DC) 2mm $\times$ 2mm | Linear Technology LT3008EDC-5 |

## HARDWARE-FOR DEMO BOARD ONLY:

|    |    |   |  |                          |
|----|----|---|--|--------------------------|
| 1  | 1  | JP1   | Headers, Double-Row, 2mm $\times$ 8mm, 2mm Centers | Samtec TMM-108-02-L-D    |
| 2  | 1  | JP2   | Headers, Double-Row, 2mm $\times$ 3mm, 2mm Centers | Samtec TMM-103-02-L-D    |
| 3  | 3  | JP3, JP4, JP5   | Headers, Single-Row, 3 Pins, 2mm Centers           | Samtec TMM-103-02-L-S    |
| 4  | 5  | XJP1, XJP2, XJP3, XJP4, XJP5  | Shunt, 2mm Centers                                 | Samtec 2SN-BK-G          |
| 5  | 6  | J1, J2, J3, J4, J5, J6  | Connector, Banana Jack                             | Keystone 575-4           |
| 6  | 1  | J7  | Connector, AMP-787441-1                            | Amp Inc. 787441-1        |
| 7  | 1  | P1  | Connector DB, R-Angle Female 15-pin                | Amp 1-1734530-3          |
| 8  | 13 | TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12, TP13 | Turret, Test Point MM/2308                         | Mill Max 2308            |
| 9  | 0  | THERM1, THERM2, TP14  | Turret, Test Point MM/2308 Optional                | Mill Max 2308            |
| 10 | 4  |   | Stand-Off, Nylon 0.5" tall                         | Keystone, 8833 (Snap On) |

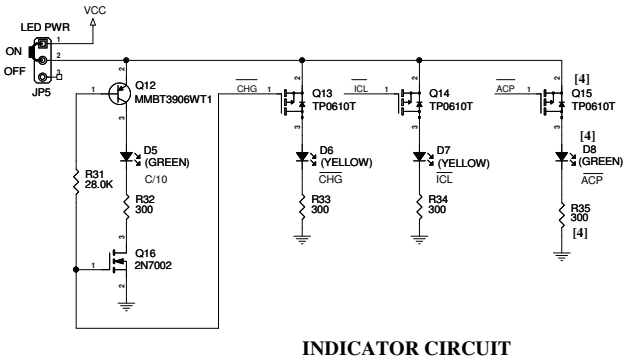
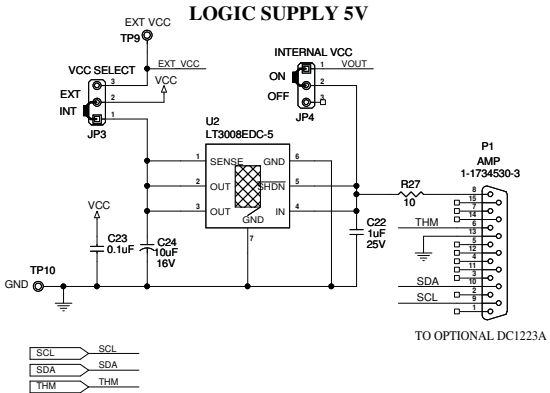
# SCHEMATIC DIAGRAM

## DEMO MANUAL DC1614A

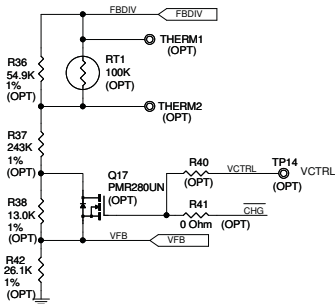
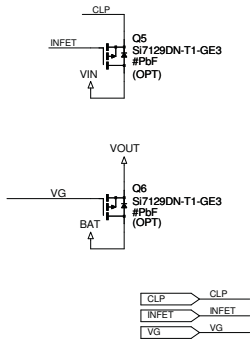


# SCHEMATIC DIAGRAM

# DEMO MANUAL DC1614A



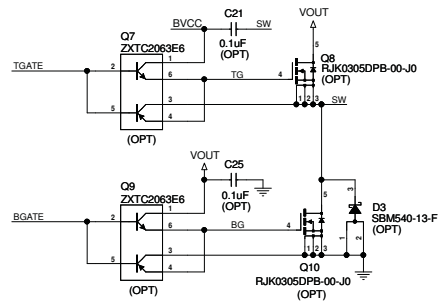
## OPTIONAL CIRCUIT(INFET) & VOUT



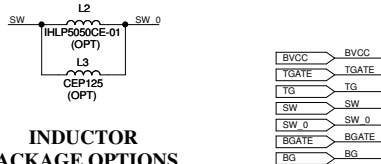
## OPTIONAL CIRCUIT (SEALED LEAD ACID)

1. REMOVE ALL ABOVE COMPONENTS WHEN NOT USING SLA CIRCUIT.

## OPTIONAL INCREASED GATE DRIVE CIRCUIT



## INDUCTOR PACKAGE OPTIONS



| CUSTOMER NOTICE  |  |  |  | APPROVALS |       |   |                    |
|--|--|--|--|-----------|-------|---|--------------------|
| LINEAR TECHNOLOGY HAS MADE A BEST EFFORT TO DESIGN A CIRCUIT THAT MEETS CUSTOMER-SUPPLIED SPECIFICATIONS. HOWEVER, IT REMAINS THE CUSTOMER'S RESPONSIBILITY TO VERIFY PROPER AND RELIABLE OPERATION IN THE ACTUAL APPLICATION. COMPONENT SUBSTITUTION AND PRINTED CIRCUIT BOARD LAYOUT MAY SIGNIFICANTLY AFFECT CIRCUIT PERFORMANCE OR RELIABILITY. CONTACT LINEAR TECHNOLOGY APPLICATIONS ENGINEERING FOR ASSISTANCE. |  |  |  | PCB DES.  | RB    | TITLE: SCHEMATIC                              |                    |
| C:\PADS\PROJECTS\1614A\DC1614A_02_REV0.DGN   |  |  |  | APP ENG.  | JOB Y | THREE CELL 12.6V@8A SWITCHING BATTERY CHARGER |                    |
| THIS CIRCUIT IS PROPRIETARY TO LINEAR TECHNOLOGY AND SUPPLIED FOR USE WITH LINEAR TECHNOLOGY PARTS.  |  |  |  |           |       | SIZE  | IC NO.             |
|  |  |  |  |           |       | N/A   | LTC4012CUF         |
|  |  |  |  |           |       | DATE:   | DEMO CIRCUIT 1614A |
|  |  |  |  |           |       | Wednesday, July 28, 2010                      | REV. 3             |
|  |  |  |  |           |       |   | SHEET 2 OF 2       |

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# DEMO MANUAL DC1614A

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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.

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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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