

# 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 (LiFePO<sub>4</sub>) 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 <sub>MIN</sub> 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 (100mV/R1)	10A <sub>DC</sub> ±4%
Default Float Voltage $V_{BAT}$	Jumper Selectable: 4.2V/Cell or 3.6V/Cell	12.6V ±1%
Maximum Charge Current	$V_{IN} > V_{BAT}$	8A <sub>DC</sub> ±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

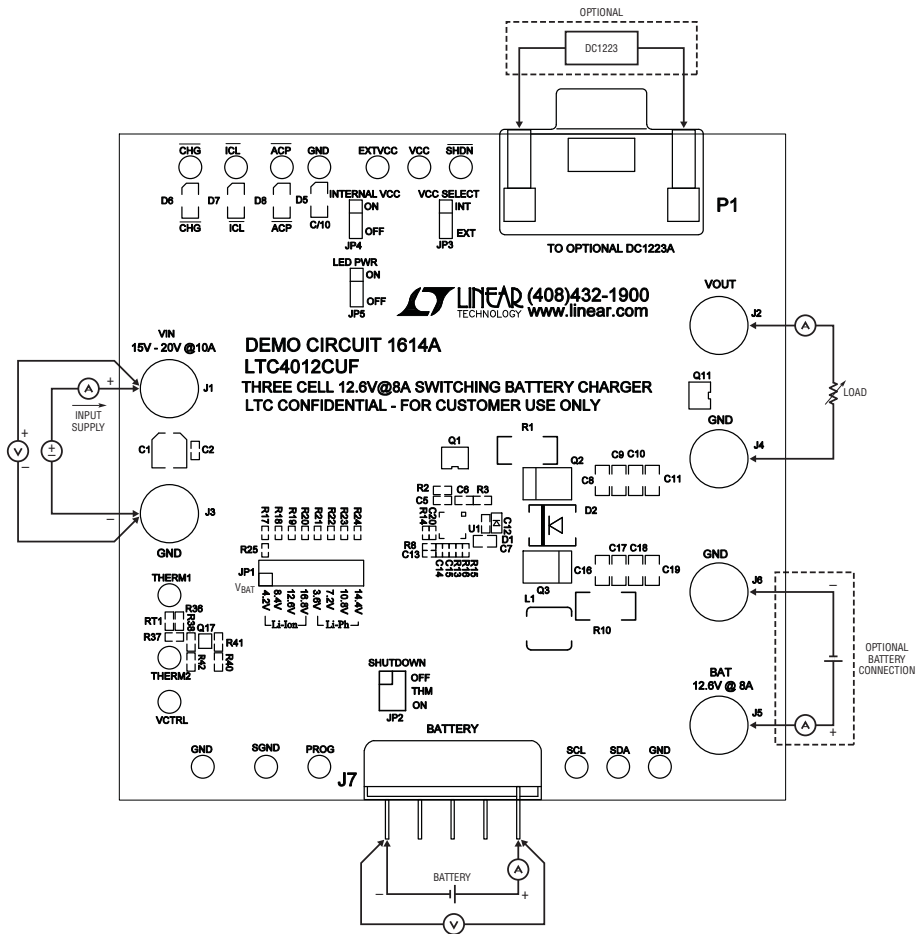


Figure 1. Proper Measurement Equipment Setup

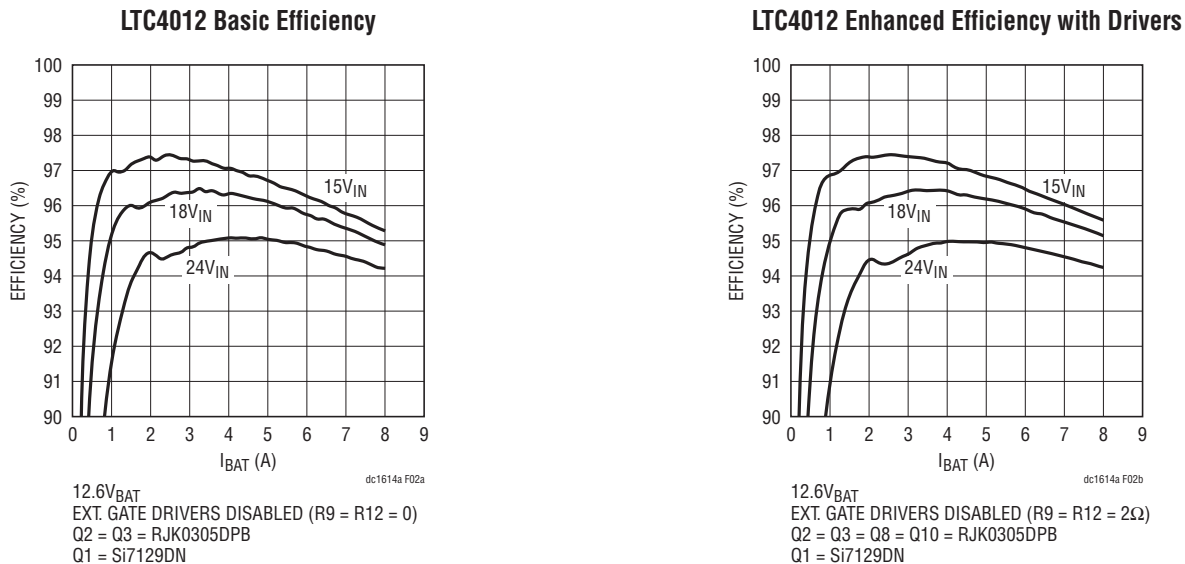


Figure 2. Efficiency Comparison with and without External Gate Drivers at 15V<sub>IN</sub>, 18V<sub>IN</sub>, and 24V<sub>IN</sub>

# DEMO MANUAL DC1614A

## PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/ PART NUMBER
<b>REQUIRED CIRCUIT COMPONENTS:</b>				
1	3	C5, C6, C12	Capacitor, 0.1 $\mu$ F, 50V, 10% 0603	TDK C1608X7R1H104K
2	1	C7	Capacitor, 2.2 $\mu$ F, 16V, 20% 0805	TDK C2012X5R1C225M
3	8	C8, C9, C10, C11, C16, C17, C18, C19	Capacitor, 10 $\mu$ F, 25V, 20% 1206	Taiyo Yuden TMK316BJ106ML
4	1	C13	Capacitor, 0.1 $\mu$ F, 16V, 10% 0402	TDK C1005X7R1C104K
5	1	C15	Capacitor, 4.7nF, 50V, 10% 0402	TDK C1005X7R1H472K
6	1	C20	Capacitor, 10pF, 50V, $\pm$ 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, 2.2 $\mu$ H	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, 0.010 $\Omega$ , 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, 0.012 $\Omega$ , 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 $\times$ 4mm	Linear Technology LTC4012CUF
<b>ADDITIONAL CIRCUIT COMPONENTS:</b>				
1	1	C1	Capacitor, 10 $\mu$ F, 35V, 20% CAP-CE-5X6.0	Sanyo 35CE10AX
2	1	C2	Capacitor, 0.1 $\mu$ F, 50V, % 0603	TDK C1608X7R1H104K
3	1	C14	Capacitor, 0402 Optional	
4	2	C21, C25	Capacitor, 0.1 $\mu$ F, 16V, 10% 0402	TDK C1005X7R1C104K
5	1	C22	Capacitor, 1 $\mu$ F, 25V, 10% 1206	AVX 12063C105KAT
6	1	C23	Capacitor, 0.1 $\mu$ F, 50V, 10% 0603	TDK C1608X7R1H104K
7	1	C24	Capacitor, 10 $\mu$ F, 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

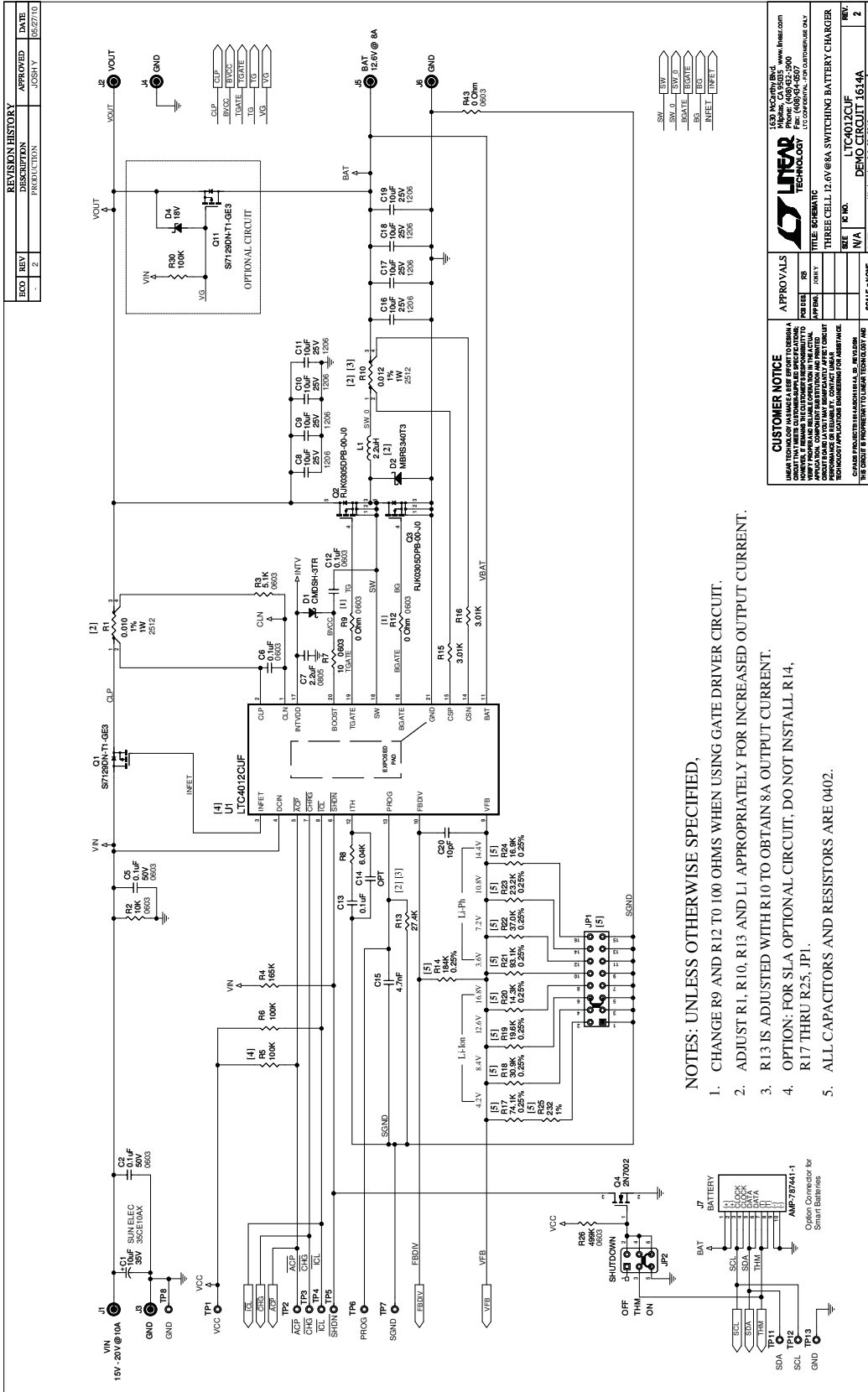
## PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/ 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, 10Ω, 1/16W, 5% 0603	Vishay CRCW060310R0JNEA
27	3	R9, R12, R43	Resistor, 0Ω, 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, 232Ω, 1/16W, 1% 0402	Vishay CRCW0402232RFKED
36	1	R26	Resistor, 499k, 1/16W, 1% 0603	Vishay CRCW0603499KFKEA
37	1	R27	Resistor, 10Ω, 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, 300Ω, 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 × 2mm	Linear Technology LT3008EDC-5

### HARDWARE-FOR DEMO BOARD ONLY:

1	1	JP1	Headers, Double-Row, 2mm × 8mm, 2mm Centers	Samtec TMM-108-02-L-D
2	1	JP2	Headers, Double-Row, 2mm × 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



APPROVALS		TITLE		SCALE	
DESIGN	TEST	REV	DATE	SCALE	HOME

**LINEAR TECHNOLOGY**

LTC4012CUIF  
THREE CELL 12.6V@8A SWITCHING BATTERY CHARGER

REV: 2  
DATE: 05/27/10  
SCALE: 1:1  
SHEET 1 OF 1

**SCHEMATIC DIAGRAM**

### OPTIONAL CIRCUI(T) (INFET) & VOUT

**LOGIC SUPPLY 5V**

TO OPTIONAL DC123A

### OPTIONAL GATE DRIVE CIRCUIT

**INDICATOR CIRCUIT**

### OPTIONAL CIRCUIT (INFET) & VOUT (SEALED LEAD ACID)

**INDUCTOR PACKAGE OPTIONS**

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

2. Q7 AND Q9 CAN BE PRESS44HDON OR CMLF3474 DEPENDING ON REQUIRED DRIVE STRENGTH.

<b>CUSTOMER NOTICE</b>		<b>APPROVALS</b>	
THIS CIRCUIT IS PROPRIETARY TO LINEAR TECHNOLOGY AND SHOULD NOT BE REPRODUCED OR TRANSMITTED IN ANY FORM OR BY ANY MEANS, ELECTRONIC OR MECHANICAL, INCLUDING PHOTOCOPYING, RECORDING, OR BY ANY INFORMATION STORAGE AND RETRIEVAL SYSTEM. LINEAR TECHNOLOGY ASSUMES NO RESPONSIBILITY FOR THE PROPER USE OF THIS CIRCUIT. THE USER OF THIS CIRCUIT ASSUMES ALL LIABILITY FOR THE PROPER USE OF THIS CIRCUIT. CONTACT LINEAR TECHNOLOGY APPLICATIONS ENGINEERING FOR ASSISTANCE.		PWB DES: R3 APP NO:	DATE:
USE THIS CIRCUIT AT YOUR OWN RISK. LINEAR TECHNOLOGY MAKES NO REPRESENTATION OR WARRANTY, EXPRESS OR IMPLIED, REGARDING THE PERFORMANCE OF THIS CIRCUIT. THE USER OF THIS CIRCUIT ASSUMES ALL LIABILITY FOR THE PROPER USE OF THIS CIRCUIT. CONTACT LINEAR TECHNOLOGY APPLICATIONS ENGINEERING FOR ASSISTANCE.		TITLE: SCHEMATIC THREE CELL 1.26V@8A SWITCHING BATTERY CHARGER	SCALE: NONE
© 1998 LINEAR TECHNOLOGY CORPORATION 1630 McCarty Blvd. Milpitas, CA 95035 Tel: (408) 255-3000 Fax: (408) 255-3000 WWW.LINEAR.COM		TYPE: I6N0 N/A	SHEET 2 OF 2

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dc1614af

# DEMO MANUAL DC1614A

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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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