LT3651EUHE-8.4/-8.2
4A High Voltage 2-Cell Li-Ion Battery Charger

DESCRIPTION

Demonstration circuit 1484A-A/-B is a 4A high voltage 2-Cell Li-Ion battery charger featuring the LT®3651EUHE-8.4/-8.2. The LT3651 is a complete, high power Li-Ion battery charger that can operate over a wide input voltage range. The charger is a constant-current, constant-voltage type with a maximum charge current of 4A that can be externally set. A precondition feature trickle charges a low voltage battery and bad battery detection provides a signal if the battery doesn't respond to preconditioning. The LT3651EUHE is available in a 36-lead (5mm × 6mm) QFN surface mount package with two exposed thermal pads.

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°C

Input Voltage Range	12V to 32V
V_{OUT}	5.8V to 8.48V (−A)/5.4V to 8.28V (−B)
Output Float Voltage (Constant Voltage Mode)	8.4V (−A)/8.2V (−B)
Output Current Limit I_{LIM}	4A

OPERATING PRINCIPLE

LT3651 is a complete Li-Ion battery charger, addressing wide input voltage (12V to 32V) and high charge current (up to 4A). High charging efficiency, as shown in Figure 1, is produced with a constant frequency, average current mode synchronous step-down switcher architecture.

The charger includes the necessary circuitry to allow for programming and control of constant-current, constant-voltage (CC/CV) charging with both current only and timer termination. High charging efficiency is achieved by using a bootstrapped supply for low switch drop on the high side driver and a MOSFET for the low side (synchronous) switch.

Maximum charge current is set with an external sense resistor in series with the inductor and is adjusted through the RNG/SS pin. The total system input current is monitored with an input sense resistor and is used to maintain constant input current by regulating battery charge current. It is adjusted through the I_{LIM} pin.

If the battery voltage is low, charge current automatically reduces to 15% of the programmed current to provide safe battery preconditioning. Once the battery voltage climbs above the battery precondition threshold, the IC automatically increases the maximum charging current to the full programmed value.

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OPERATING PRINCIPLE

Charge termination can occur when charge current decreases to one-tenth of the programmed maximum charge current (C/10 termination). Alternately, termination can be timer based through the use of an internal programmable charge cycle control timer. When using the timer termination, charging continues beyond the C/10 level to top off a battery. Charging typically terminates three hours after initiation. When the timer-based scheme is used, bad battery detection is also supported. A system fault is triggered if a battery stays in precondition mode for more than one-eighth of the total charge cycle time.

Once charging is terminated and the LT3651 is not actively charging, the IC automatically enters a low current standby mode in which supply bias currents are reduced to <85μA. If the battery voltage drops below 2.5% from the full charge float voltage, the LT3651 engages an automatic charge cycle restart. The IC also automatically restarts a new charge cycle after a bad battery fault once the failed battery is removed and replaced with another battery.

After charging is complete, the input bias current lines connected to the battery are reduced to minimize battery discharge.

The LT3651 contains provisions for a battery temperature monitoring circuit. Battery temperature is monitored by using an NTC thermistor located with the battery. If the battery temperature moves outside the safe charging range of 0°C to 40°C the charging cycle suspends and signals a fault condition.

The LT3651 contains two digital open-collector outputs, which provide charger status and signal fault conditions. These binary coded pins signal battery charging, standby or shutdown modes, battery temperature faults and bad battery faults.

A precision undervoltage lockout is possible by using a resistor divider on the shutdown pin ($\overline{SHDN}$). The input supply current is 17μA when the IC is in shutdown.
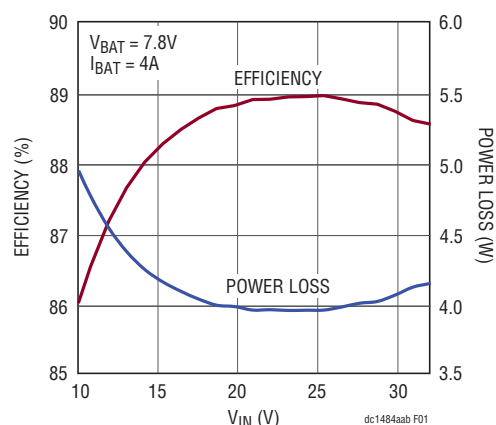

Figure 1. Efficiency and Power Loss vs V_{IN}

QUICK START PROCEDURE

Demonstration circuit 1484A-A/-B is easy to set up to evaluate the performance of the LT3651EUHE-8.4/-8.2.

Using short twisted pair leads for any power connections, with all loads and power supplies off, refer to Figure 2 for the proper measurement and equipment setup.

Follow the procedure below:

1. Jumper and power supply setting:

   JP1 = RUN   PS1 = OFF

   JP2 = C/10   PS2 = OFF

2. Turn on PS2 and slowly increase the voltage to 5.4V while monitoring the current into the BAT pin. If the current is less than 5mA, turn on PS1. Increase the voltage on PS1 to 8V while monitoring the input current. If the current is less than 5mA, increase PS1 to 24V.

3. Verify that the battery charging current, IBAT is between 400mA and 600mA. The CHRG LED and ACPR LED should be on and the FAULT LED should be off.

QUICK START PROCEDURE

4. Increase PS2 until VBAT is 7.2V. Verify the input current IIN is between 1.4A and 1.7A, the battery current IBAT is between 3.75A and 4.45A and that the CHRG LED and ACPR LED are on.

5. Increase PS2 until VBAT is 8.5V. Verify the battery charging current IBAT is less than 5mA and that the CHRG LED and ACPR LED are off.

6. Decrease PS2 until VBAT is 7.8V. Verify the battery current IBAT is between 3.75A and 4.45A that the CHRG LED and ACPR LED are on.

7. Decrease PS2 until VBAT is 7.2V. Connect a 10k resistor from the RNG/SS pin to ground. Verify the charging current IBAT is between 1.7A and 2.0A. Verify the voltage VNTC on the NTC turret is between 1.6V and 1.9V and the voltage VRNG on the RNG/SS turret is between 450mV and 700mV. Remove the 10k resistor from the RNG/SS pin to ground

8. Set JP1 to SHDN. Verify the charging current IBAT is less than 5mA and that the FAULT LED, CHRG LED and ACPR LED are off.

9. Set JP1 to RUN. Connect a jumper from the NTC pin to ground. Verify the charging current IBAT is less than 5mA and that the FAULT LED, CHRG LED and ACPR LED are on.

10. Remove the jumper from NTC to ground. Verify the charging current IBAT is between 3.75A and 4.45A and that the FAULT LED is off and the CHRG LED and ACPR LED are on.

11. Turn on LOAD1 and set to 1A. Verify the voltage V_{SYSTEM} on the system voltage turret is approximately equal to V_{IN}.

12. Turn off PS1, PS2 and LOAD1.
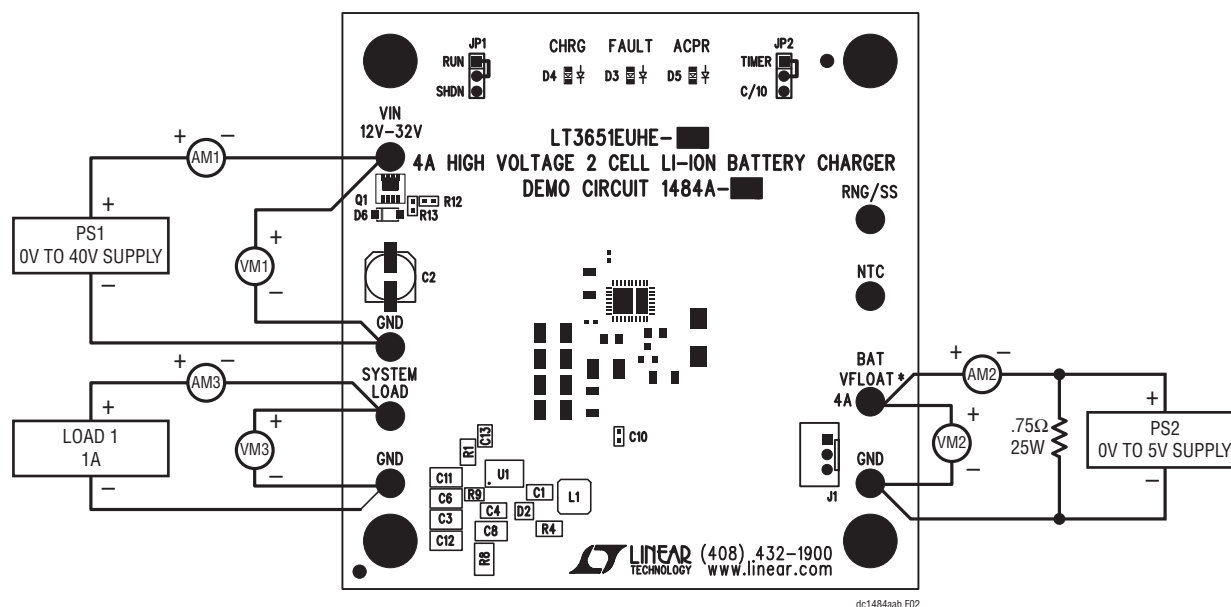
NOTE: ALL CONNECTIONS FROM EQUIPMENT SHOULD BE KELVIN CONNECTED DIRECTLY TO THE BOARD PINS WHICH THEY ARE CONNECTED TO ON THIS DIAGRAM AND ANY INPUT, OR OUTPUT, LEADS SHOULD BE TWISTED PAIR.
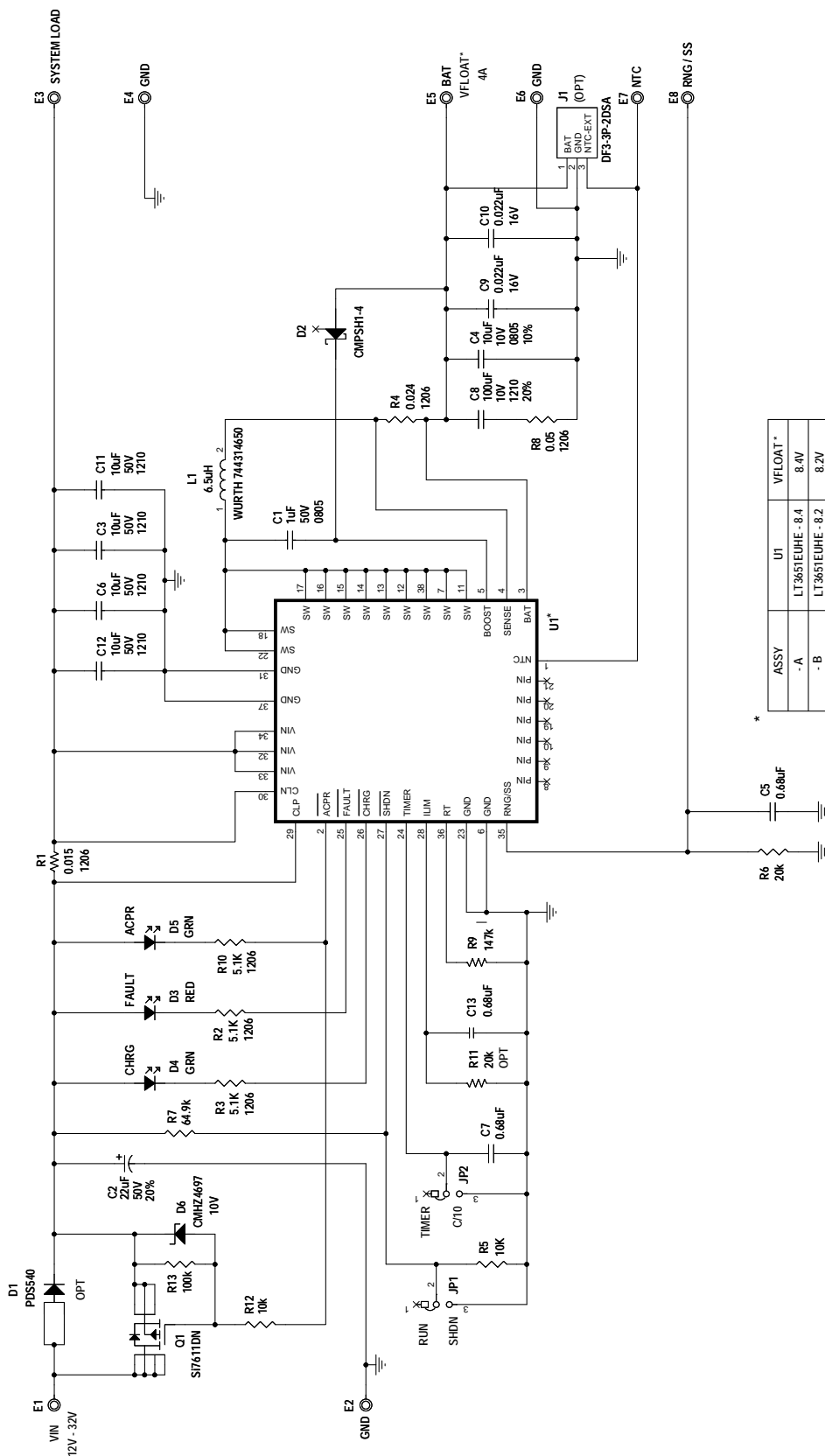
Figure 2. Proper Measurement Equipment Setup

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	1	C1	CAP., X7R, 1µF, 50V, 10%, 0805	MURATA, GRM21BR71H105KA12L
2	4	C3, C6, C11, C12	CAP., X7S, 10µF, 50V, 20%, 1210	TDK, C3225X7S1H106M
3	1	C4	CAP., X7R, 10µF, 10V, 10%, 0805	MURATA,GRM21BR71A106KE51L
4	3	C5, C7, C13	CAP., X5R, 0.68µF, 10V, 10%, 0402	MURATA, GRM155R61A684KE15D
5	1	C8	CAP., X5R, 100µF, 6.3V, 20%, 1210	TAIYO YUDEN, LMK325BJ107MM-T
6	1	D2	SMD, SCHOTTKY DIODE, SOT-23	CENTRAL SEMI, CMPSH1-4 TR
7	1	D6	DIODE, ZENER, 10V SOD-123	CENTRAL SEMI, CMHZ4697
8	1	L1	POWER INDUCTOR 6.5µH, 20%, 6.0A, 21.5mΩ	WÜRTH, 744314650
9	1	Q1	MOSFET, PCHANNEL, 40V, 25mΩ, 1212-8	VISHAY, Si7611DN
10	1	R1	RES., CHIP, 0.015Ω, 1/2W, 1%, 1206	IRC, LRC-LR1206LF-01-R015-F
11	1	R4	RES., CHIP, 0.024Ω, 1/2W, 1%, 1206	IRC, LRC-LR1206LF-01-R024-F
12	2	R5, R12	RES., CHIP, 10k, 1/16W, 1%, 0402	VISHAY, CRCW040210K0FKED
13	1	R7	RES., CHIP, 64.9k, 1/16W, 1%, 0402	VISHAY, CRCW040264K9FKED
14	1	R8	RES., CHIP, 0.05Ω, 1/2W, 1%, 1206	IRC, LRC-LR1206LF-01-R050-F
15	1	R9	RES., CHIP, 147k, 1/16W, 1%, 0402	VISHAY, CRCW0402147KFKED
16	1	R13	RES., CHIP, 100k, 1/16W, 1%, 0402	VISHAY, CRCW0402100KFKED
17	1	U1 (DC1484A-A) U1 (DC1484A-B)	4A HIGH VOLTAGE 8.4V LI-ION BATTERY CHARGER 4A HIGH VOLTAGE 8.2V LI-ION BATTERY CHARGER	LINEAR TECH.,LT3651EUHE-8.4 LINEAR TECH.,LT3651EUHE-8.2
Optional Electrical Components				
1	1	C2	CAP, SMT, 22µF, 50V 20%	SUNCON, 50CE22BS
2	2	C9, C10	CAP, CHIP, X7R, 0.022µF, ±10%, 16V, 0402	AVX, 0402YC223KAT2A
3	0	D1	SMD, SCHOTTKY, 5A, 40V	DIODES INC, PDS540-13
4	1	D3	LED, RED	PANASONIC, LNJ208R8ARA
5	2	D4, D5	LED, GREEN	LITE-ON, LTST-C190KGKT
6	0	J1	HEADER, 3 PINS	HIROSE ELECTRIC, DF3A-3P-2DSA
7	3	R2, R3, R10	RES, CHIP, 5.1k,1/4W, 5%, 1206	VISHAY, CRCW12065K10JNED
8	0	R6, R11	RES, CHIP, 20k, 1/16W, 1%, 0402	VISHAY, CRCW040220K0FKED
Hardware for Demo Circuit				
1	8	E1 TO E8	TESTPOINT, TURRET, 0.095"	MILL-MAX, 2501-2-00-80-00-00-07-0
2	2	JP1, JP2	2MM SINGLE ROW HEADER, 3 PIN	SAMTEC, TMM-103-02-L-S
3	2	JP1, JP2	SHUNT	SAMTEC, 2SN-BK-G
4	4	MH1 TO MH4	STAND-OFF, NYLON 0.375" TALL (SNAP ON)	KEYSTONE, 8832 (SNAP ON)

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LINEAR
TECHNOLOGY

SCHEMATIC DIAGRAM

E3 SYSTEM LOAD
E4 GND

E5 BAT VFLOAT* 4A
E6 GND
J1 (OPT)
E7 NTC
E8 RNG/SS

DF3-3P-2DSA
1 BAT
2 GND
3 NTC-EXT

C10 0.022uF 16V
C9 0.022uF 16V
C4 10uF 10V 0805 10%
C8 100uF 10V 1210 20%
R4 0.024 1206
R8 0.05 1206
D2 CMPSH1-4

L1 6.5uH WURTH 744314650
C1 1uF 50V 0805

C11 10uF 50V 1210
C3 10uF 50V 1210
C6 10uF 50V 1210
C12 10uF 50V 1210

U1*
18 SW
17 SW
16 SW
15 SW
14 SW
13 SW
12 SW
38 SW
7 SW
11 SW
5 BOOST
4 SENSE
3 BAT
1 NTC
22 SW
31 GND
37 GND
34 VIN
32 VIN
33 VIN
30 CLN
29 CLP
2 ACPR
25 FAULT
26 CHRG
27 SHDN
24 TIMER
28 ILIM
36 RT
23 GND
6 GND
35 RNG/SS
PIN

R1 0.015 1206

D5 GRN ACPR
R10 5.1K 1206
D3 RED FAULT
R2 5.1K 1206
D4 GRN CHRG
R3 5.1K 1206

R9 147k
C13 0.68uF
R11 20k OPT
C7 0.68uF

R7 64.9k

C2 22uF 50V 20%
D6 CMHZ4697 10V
R13 100k
Q1 Si7611DN
R12 10k

D1 PDS540 OPT

C5 0.68uF
R6 20k

TIMER
JP2
C/10
R5 10K
JP1
RUN
SHDN

E1 VIN 12V - 32V
E2 GND

ASSY	U1	VFLOAT*
- A	LT3651EUHE - 8.4	8.4V
- B	LT3651EUHE - 8.2	8.2V

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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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