LINEAR TECHNOLOGY

LTC4095
Standalone USB Li-Ion/Polymer Battery Charger in 2mm x 2mm DFN

DESCRIPTION

Demonstration circuit 1094 is a Standalone USB Li-Ion/Polymer Battery Charger in 2mm x 2mm DFN featuring the LTC4095.

The LTC4095 may provide up to 950mA of charge current programmed by a single resistor. The HPWR pin allows the current to be set at 100% or 20% full charge current. The LTC4095 also has an NTC thermistor input to monitor battery temperature, C/10 current detection output, bad battery detection, and low battery trickle charge. The final float voltage is preset to 4.2V. The LTC4095 only requires an input capacitor and a program resistor to make a complete battery charger circuit, making it an ideal solution for portable USB power applications.

Refer to the LTC4095 datasheet for more information on this part.

Design files for this circuit board are available. Call the LTC factory.

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PERFORMANCE SUMMARY Specifications are at $T_A = 25°C$

PARAMETER	CONDITION	VALUE
USB IN Voltage Range IN		4.3V – 5.5V
Output Float Voltage V_{BAT}	Constant Voltage Mode	4.200V ($\pm$ 0.5%)
Charge Current I_{BAT}	HPWR Jumper = 100%, R_{PROG} = 1.74K	460mA
Charge Current I_{BAT}	HPWR Jumper = 20%, R_{PROG} = 1.74K	92mA
Charge Current I_{BAT} USB Input Power	Trickle Charge Mode, R_{PROG} = 1.74K	46mA
V_{PROG}	Full Charge Current, HPWR Jumper = 100%	1V
V_{PROG}	1/5 Full Charge Current HPWR Jumper= 20%	200mV
V_{PROG}	Trickle Charge Current	100mV

OPERATING PRINCIPLES

Demonstration Circuit 1094 is programmed to provide 460mA full charge current with the HPWR jumper, JP1, in the 100% position. The input current to this demonstration circuit may be 470mA total with the CHRG LED current, battery charge current, NTC thermistor current, and IC quiescent current. Moving the HPWR jumper from the 100% position to the 20% position limits the charge current to 92mA.

QUICK START PROCEDURE

Demonstration circuit 1094 is easy to set up to evaluate the performance of the LTC4095. The charger may be evaluated using an actual Li-Ion battery, a bi-polar supply, or a battery simulator. A battery simulator consists of an adjustable supply with a load resistor across the supply output. A 3.6Ω 5W resistor value will provide an 800mA load at 2.9V. This will allow the power supply to sink and source current similar to a battery, but allows the battery voltage to be changed quickly or remain at the same value indefinitely.

Refer to Figure 1 for proper measurement equipment setup and follow the procedure below:

NOTE. When measuring the input or output voltage ripple, care must be taken to avoid a long ground lead on the oscilloscope probe. Measure the input or output voltage ripple by touching the probe tip directly across the USB IN or BAT and GND terminals. See Figure 2 for proper scope probe technique.

1. Place jumpers in the following positions:

   JP1. HPWR = 100% (Up)

   JP2. SUSP = HI (Up)

   JP3. NTC = INT (Down)

2. With the power supplies adjusted to 0V, connect the USB IN power supply and Battery or Battery Simulator with series ammeters, as illustrated in Figure 1. An ammeter or a 100mΩ current sense resistor may be used to measure the battery charge current.

3. Connect voltmeters, as shown in Figure 1, across the USB IN and GND terminals, and across the BAT and GND terminals. These voltmeters may also be used to measure the voltage on the PROG terminal.

4. Turn on the Battery Simulator supply to 2.5V and set the SUSP jumper to the LO position.

   NOTE. Make sure that the battery voltage does not exceed 6V.

5. Increase the USB IN voltage until the CHRG LED illuminates and observe the USB IN voltage and charge current. The USB IN voltage is approximately at the rising Under Voltage Lockout threshold. The LTC4095 will be in trickle charge mode with a trickle charge current of 46mA.

   NOTE. Make sure that the input voltage does not exceed 7V.

6. Increase the Battery Simulator supply to 3V and observe that the LTC4095 charge current will jump to a full charge current of 460mA.

7. Slowly decrease the USB IN voltage until the CHRG LED suddenly shuts off. The USB IN voltage is approximately at the falling Under Voltage Lockout threshold.

8. Set the USB IN voltage to 5V and slowly increase the Battery Simulator voltage until the charge current or the PROG voltage starts to decrease. The charger is now in constant voltage mode.

9. Slowly increase the Battery Simulator voltage until the CHRG LED shuts off. This is approximately when the charge current has decreased to 10% of its full value.

10. Continue to slowly increase the Battery Simulator voltage while observing the charge current. When the charge current decreases to 0mA the device is in Standby Mode.

11. Slowly decrease the Battery Simulator voltage until the CHRG LED illuminates. This is the recharge voltage threshold.

12. Move the HPWR jumper, JP1, from the 100% to the 20% position. Observe that the charge current is 20% of its full value, about 92mA.

13. Move the NTC jumper, JP3, from INT to EXT and observe the CHRG LED blinking at 1.5Hz with a 50% duty cycle. With an oscilloscope on the $\overline{CHRG}$ terminal, observe a 35KHz signal pulsing at 6.25% and 93.75% duty cycles.

14. With a clip-to-clip test lead, connect the NTC terminal to the GND terminal. Observe the CHRG LED is on steady and the charge current is about 92mA. The NTC function is now disabled.

15. With the NTC and HPWR jumpers in their present positions, (EXT & 20% respectively), move the SUSP jumper, JP2, to the HI position, and remove the test lead from the NTC and GND terminals. Observe that the input current is 17uA or less. The LTC4095 is now in Suspend Mode.

16. When finished, turn off the circuit by setting the SUSP jumper, JP2, to the HI position, turn off the input supplies and disconnect and/or turn off the battery or battery simulator.
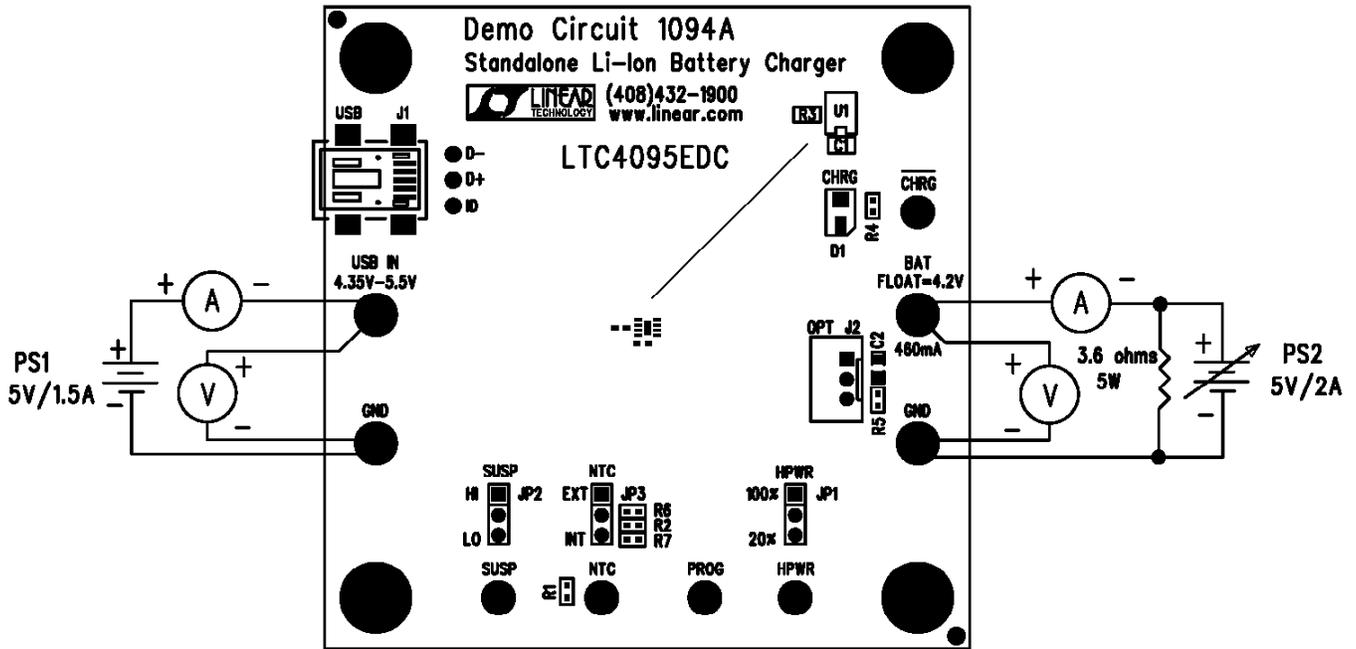

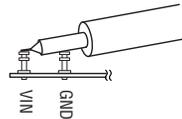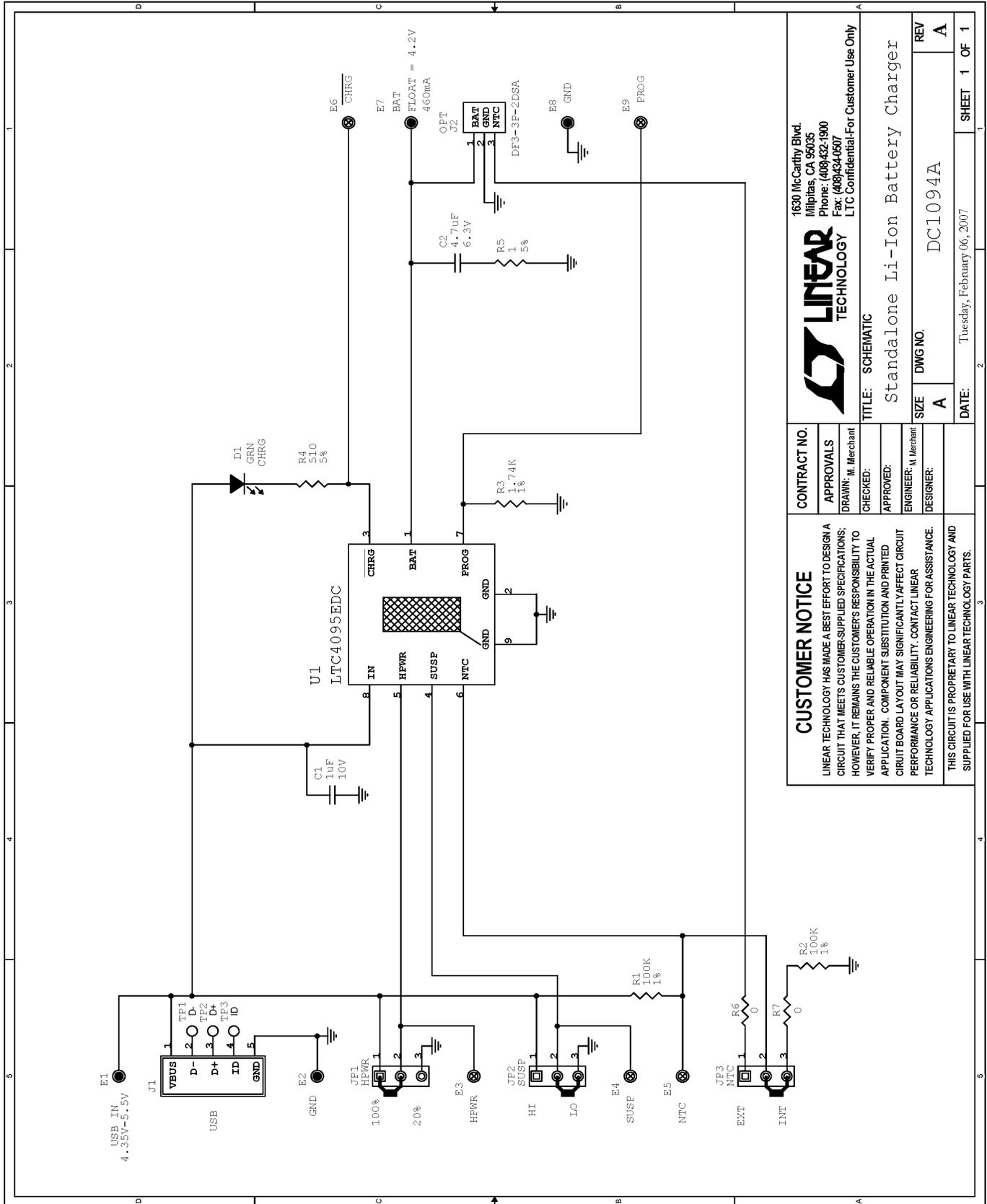**Figure 1. Proper Measurement Equipment Setup**

Figure 2. Measuring Input or Output Ripple

U1
LTC4095EDC

CHRG 3
BAT 1
PROG 7
GND 2
GND 9
IN 8
HPWR 5
SUSP 4
NTC 6

D1 GRN CHRG
R4 510 5%

C1 1uF 10V

E6 CHRG
E7 BAT
FLOAT = 4.2V 460mA
OPT J2
DF3-3P-2DSA
BAT GND NTC
1 2 3

C2 4.7uF 6.3V
R5 1 5%

E8 GND
E9 PROG

R3 1.74K 1%

J1
VBUS 1
D- 2
D+ 3
ID 4
GND 5

TP1 D-
TP2 D+
TP3 ID

E1 USB IN 4.35V-5.5V
E2 GND
USB

JP1 HPWR
1 2 3
100% 20%
E3 HPWR

JP2 SUSP
1 2 3
HI LO
E4 SUSP

E5 NTC

JP3 NTC
1 2 3
EXT INT

R6 0
R7 0

R1 100K 1%
R2 100K 1%

TITLE: SCHEMATIC
Standalone Li-Ion Battery Charger

DWG NO. DC1094A
SIZE A
REV A

DATE: Tuesday, February 06, 2007
SHEET 1 OF 1

CONTRACT NO.
APPROVALS
DRAWN: M. Merchant
CHECKED:
APPROVED:
ENGINEER: M. Merchant
DESIGNER:

Item	Qty	Ref - Des	Desc	Manufacturer's Part Number
		REQUIRED CIRCUIT COMPONENTS:		
1	1	C1	Cap., X5R 1uF 10V 10% 0402	MURATA, GRM155R61A105KE15D
2	1	R3	Res., Chip 1.74K 1/16W 1% 0402	VISHAY, CRCW04021K74FKED
3	1	U1	I.C., Batt. Charger Controller	Linear Tech. Corp. LTC4095EDC
		ADDITIONAL DEMO BOARD CIRCUIT COMPONENTS:		
1	1	C2	Cap., X5R 4.7uF 6.3V 10% 0603	TDK, C1608X5R0J475K
2	1	D1	LED, GRN	Panasonic, LN1351-C-TR
3	1	R5	Res., Chip 1 Ohm 0.06W 5% 0402	VISHAY, CRCW04021R00JNED
4	1	R4	Res., Chip 510 0.06W 5% 0402	VISHAY, CRCW0402510RJNED
5	2	R1,R2	Res., Chip 100K 1/16W 1% 0402	VISHAY, CRCW0402100KFKED
6	2	R6,R7	Res., Chip 0 Ohm 0402	VISHAY, CRCW04020000Z0ED
7	1	J1	Connector, USB Mini-B	Tyco Electronics, 1734035-2
8	0	J2(OPT)	Connector, 2MM THRU HOLE	HRS, DF3-3P-2DSA
		HARDWARE FOR DEMO BOARD ONLY:		
1	5	E3-E6,E9	Turret, Testpoint	Mill Max, 2308-2
2	4	E1,E2,E7,E8	Turret, Testpoint	Mill Max, 2501-2
3	3	JP1-JP3	Headers, 3 Pins 2mm Ctrs.	SAMTEC, TMM-103-02-L-S
4	3	JP1-JP3	Shunt, 2mm Ctrs.	SAMTEC, 2SN-BK-G
5	4		STAND-OFF, NYLON 0.25" TALL	KEYSTONE, 8831

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