

## DESCRIPTION

Demonstration circuits 904A-A and -B are complete stand alone constant-current, constant-voltage battery chargers for one Lithium-Ion cell. Input power can come from either a USB port (100mA or 500mA charge current) or from an AC adapter (800mA charge current) with automatic switching to the appropriate source. The charge termination method used is minimum current.

The LTC4076EDD or LTC4077EDD used on this demo circuit features an internal P-Channel power MOSFET with a unique thermal feedback loop that reduces the output current under high ambient temperature and/or high power dissipation conditions. This feature allows the charger to provide higher charge current under normal conditions and still provide safe charging under abnormal conditions such as high ambient temperature, high input voltage or low battery voltage.

A jumper on the board can select 100mA or 500mA charge current when powered from USB power and a jumper to shut down the charger when powered from either power source.

Separate terminals are provided for monitoring charge current when powered from an AC adapter or from a USB port. A USB mini-A connector is included on the board for easy connection to a USB port. Provisions are provided for programming the minimum charge current termination level (LTC4076) or for programming the lower charge current selected by the HPWR pin when charging from a USB power source (LTC4077).

Two LEDs are included, one indicates when the charge current has dropped below the minimum charge current termination level and the second indicates that sufficient input voltage is available for charging.

The IC is available in a 10-Pin 3mm x 3mm DFN thermally enhanced package featuring an exposed bottom-side metal pad for soldering to the PC board.

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

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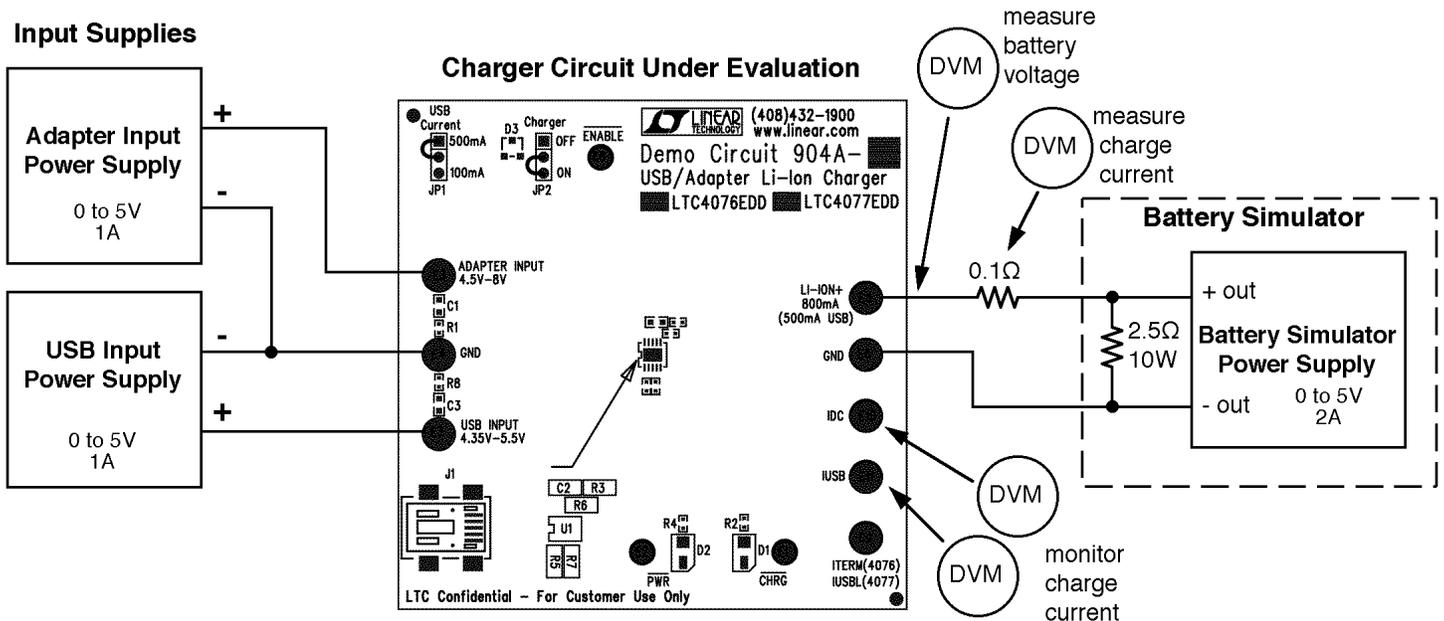
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# QUICK START GUIDE FOR DEMONSTRATION CIRCUIT 904A-A & B DUAL INPUT USB/AC ADAPTER LI-ION BATTERY CHARGER

**Table 1. Typical Specifications (25°C)**

Adapter Input Voltage Range $DC_{IN}$	4.5 to 8V (upper range limited by PC board power dissipation)
Adapter Input Under Voltage Lockout	4.15V Typ
USB Input Voltage Range $USB_{IN}$	4.35 to 5.
USB Input Under Voltage Lockout	3.95V Typ
Output Float Voltage $V_{BAT}$ (constant voltage mode)	4.200V $\pm$ 0.6%
Charge Current $I_{BAT}$ (CC mode) Adapter Input Power	800mA $\pm$ 5%
Trickle Charge Current $I_{BAT}$ Adapter Input Power ( $V_{BAT} = 2.5V$ )	80mA $\pm$ 25%
Charge Current $I_{BAT}$ (CC mode) USB Input Power, JP1 in 500mA position	500mA $\pm$ 25%
Charge Current $I_{BAT}$ (CC mode) USB Input Power, JP1 in 100mA position	100mA $\pm$ 5%
Trickle Charge Current $I_{BAT}$ , USB Input Power, JP1 in 100mA or 500mA position ( $V_{BAT} = 2.5V$ )	50mA $\pm$ 25%
IDC Current Monitor Output	1V $\pm$ 5% @ Full Current
IUSB Current Monitor Output	1V $\pm$ 5% @ Full Current
Minimum Charge Current Termination	50mA $\pm$ 5% (DC904A-A, LTC4076) 80mA $\pm$ 5% (DC904A-B, LTC4077)



**Figure 1. Demonstration Board Hookup Diagram**

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### OPERATION

Demonstration circuits 904A-A and 904A-B are capable of charging a single 4.2V Li-Ion battery, complete with charge termination, from both wall adapter and USB power sources. The charger detects input power and automatically selects the appropriate source.

Terminals are provided for monitoring or re-programming charge current from either input source. Re-programming charge or termination current involves replacing the surface mount resistors with different values, or removing them and using leaded resistors from the respective terminals to ground.

Jumper JP1 (USB Current) selects high or low charge current when powered from a USB port and jumper JP2 (Charger) shuts the charger down.

There are two versions of the demonstration circuit . DC904A-A has an LTC4076 charger while DC904A-B uses an LTC4077 charger IC. The differences are:

DC904A-A (LTC4076) has a programmable minimum charge current termination threshold (ITERM pin) and has a fixed low power USB current setting (20% of high power).

DC904A-B (LTC4077) has a fixed minimum charge current termination threshold of C/10, and replaces the ITERM pin with a IUSBL pin allowing the low power USB current to be programmable.

Minimum charge current termination ends the charge cycle when the charge current drops to a programmed threshold level after the battery has reached the constant voltage portion of the charge cycle. The CHRГ LED also goes off.

The IDC and the IUSB terminals can be used to indicate charge current level at all times during the charge cycle with 1 Volt indicating 100% of the programmed current. These terminals can also be used to program other charge current values by removing the surface mount resistors and connecting an external programming resistor from the appropriate terminals to ground.

The ITERM terminal (DC904A-A, LTC4076) allows the user to change the minimum charge current termination threshold level by removing the surface mount resistor (R7) and adding an appropriate leaded resistor from the terminal to ground. Likewise, when using DC904A-B (LTC4077), the terminal becomes IUSBL which allows the user to change the low power charge current setting (using JP1) when powered from a USB power source.

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### QUICK START PROCEDURE

The charger can be evaluated using an actual Lithium Ion battery or a battery simulator. The battery simulator is faster because all battery state-of-charge conditions can be quickly simulated.

A battery simulator consists of an adjustable power supply with a load resistor across the power supply output. The resistor value is selected that will provide approximately 1A when the power supply is set for 2.5V and the power supply must provide at least 1.7A when adjusted for 4.2V. For this battery simulator, a 2.5 Ohm, 10 Watt power resistor connected to the output of a 5V, 2A adjustable output voltage bench supply will work fine. The power supply can now sink and source current, similar to a battery, and by changing the power supply voltage, any battery state-of-charge condition can be quickly simulated.

Begin evaluation by placing jumper JP1 in the upper position and JP2 in the lower position. With the adapter input power supply, USB input power supply and battery simulator power supply adjusted to 0V, connect all three as shown in Figure 1. An ammeter or 100mΩ current sense resistor can be placed between the BAT terminal and the positive terminal of the battery simulator to measure charge current. Connect a 4½ digit DVM to the LI-ION+ and GND terminals to measure battery voltage. If desired, additional voltmeters can be used to measure voltages on the IDC and IUSB terminals.

Increase the battery simulator power supply voltage to 2.5V and the adapter input supply to 5V. When the adapter supply voltage reaches approximately 4.1V (undervoltage lockout threshold), the CHRГ and PWR LED will turn on and the preconditioning

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## DUAL INPUT USB/AC ADAPTER LI-ION BATTERY CHARGER

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trickle charge of 80mA (10% of the programmed current) will begin flowing into the battery simulator.

Slowly increase the battery simulator power supply voltage. When the battery voltage reaches approximately 3V, the charge current will abruptly increase to the programmed constant current of 800mA as programmed by R6. Continue slowly increasing the battery simulator power supply up to approximately 4V, thus simulating the Li-Ion battery accepting charge. Observe the voltage on the IDC terminal (1V indicates 100% of the programmed current).

Increase the USB input power supply to 5V, and disconnect the adapter input supply and note that the USB charge current drops to approximately 475mA, as programmed by R5. The voltage at the IDC terminal will drop to 0 and the voltage at the IUSB terminal will now read 1V indicating 100% of the programmed USB current. Moving jumper JP1 from the upper (500mA) position to the lower (100mA) position will drop the charge current to 100mA. With the jumper in the 100mA position, the voltage on the IUSB terminal will be approximately 200mV indicating 20% of the full 500mA USB charge current (DC904A-A, LTC4076 only). For DC904A-B, LTC4077, the voltage on the IUSB terminal will be 0V, and the IUSBL terminal will now be approximately 200mV indicating 20% of the full 500mA USB charge current. This only occurs with the DC904A-B, LTC4077 and only with jumper JP1 in the lower 100mA position. DC904A-B allows the lower USB charge current to be adjustable using R7.

Reconnecting the adapter input power supply will increase the charge current to the programmed 800mA. Slowly increase the battery simulator power supply voltage.

As the battery simulator approaches the float voltage of 4.200V, the charge current will begin to drop as the charger begins the constant voltage portion of the charge cycle. When the charge current has dropped to approximately 200mA, the float voltage can be measured at the Li-Ion battery terminal on the demoboard. Also, when the charger is in the constant voltage portion of the charge cycle, small changes in the simulator power supply voltage will result in relatively large changes in charge current.

For demoboard DC904A-A (LTC4076), when the charge current drops below the ITERM threshold of 50mA (as set by R7), the charge current will drop to 0, the CHRG LED will go off and the charge cycle ends. For demoboard DC904A-B (LTC4077), when the charge current drops below 10% of the programmed charge current or 80mA, the charge cycle ends. For both boards, if the battery voltage drops approximately 100mV, a recharge cycle will begin. Note; the charger can also be shutdown by moving jumper JP2 (Charger) to the upper Off position.

Disconnecting the battery or battery simulator from the charger will result in a sawtooth waveform of several hundred mV p-p appearing at the charger output. This waveform is a function of the output capacitor and the charger output voltage cycling between the recharge threshold voltage and the float voltage. The waveform frequency is dependant on the size of the output capacitor. The CHRG LED will be on, although it is pulsing at a relatively fast rate. The sawtooth waveform is the result of the minimum charge current termination method used and the recharge feature. The charger uses minimum charge current to terminate the charge cycle. With no battery, the charger quickly turns on, quickly charging up the output capacitor. When the charger output reaches 4.2V, the charger turns off and the output capacitor begins to discharge. As the output voltage drops below the recharge threshold of 4.1V, the charger briefly turns on and charges the output capacitor again. This cycle repeats as long as there is no battery connected.

Included on the pc board are 1 $\Omega$  resistors in series with the input bypass capacitors on both the adapter and USB inputs. This resistor reduces the ringing produced by the ceramic bypass capacitors when the input voltage is quickly applied. Without the resistors, the ringing can produce voltage transients that can exceed the absolute maximum voltage ratings resulting in damage to the IC.

Note that the PWR LED is powered from the battery which can discharge the battery after an extended period of time although the auto recharge will keep the battery fully charged. If desired, the LEDs can be powered from the input supplies.

**See LTC4076 and LTC4077 Data Sheets for additional information.**

