

# QUICK START GUIDE FOR DEMONSTRATION CIRCUIT 1068A DUAL INPUT LI-ION BATTERY CHARGER WITH SYNCHRONOUS BUCK REGULATOR

LTC3550

## DESCRIPTION

Demonstration circuit 1068A is a complete single cell Lithium-Ion battery charger and a synchronous buck voltage regulator with adjustable output voltage. Operating at a frequency of 1.5MHz, the regulator can be powered from either the Li-Ion battery or from the AC adapter (selected by a jumper). The battery charger automatically selects input power from the AC adapter or USB port, whichever is appropriate.

This demonstration circuit allows the user to quickly evaluate the LTC3550 performance. Individual jumpers are provided for shutting down the charger from either input power source, shutting down the regulator and for selecting several regulated output voltages.

LEDs indicate charger information (input power and charge status) and terminals on the board allow easy hookup to input supplies and battery or battery simulator. Provisions are provided for programming and monitoring charge current

from each input power source individually, programming the minimum charge current termination level and two charge current levels when charging from USB power.

The high switching frequency of the DC/DC converter allow tiny LC components to be used and the 16-Pin 5mm x 3mm DFN thermally enhanced package with the metal backside allow the linear charger to provide up to 950mA of charge current in addition to the regulators output current. The charge current on this board is set for either 100mA or 500mA when powered from USB power and 800mA when used with an AC adapter.

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

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

Adapter and USB Input Voltage Range (Buck regulator powered from Battery)	4.25V to 8V
Adapter Input Voltage Range (Buck regulator powered from Adapter Input)	4.25V to 5.5V
Charger Output Float Voltage, $V_{BAT}$ (constant voltage mode)	4.2V $\pm$ 0.5%
Charge Current, $I_{BAT}$ from Adapter Input (constant current mode)	800mA $\pm$ 6%
Charge Current, $I_{BAT}$ from USB Input (constant current mode) HPWR terminal High/Low	500mA/100mA $\pm$ 6%
Trickle Charge Current, $I_{BAT}$ from Adapter Input (Battery Voltage <2.9V)	80mA $\pm$ 6%
Adapter and USB Current Monitor Output	1V $\pm$ 2.5% @ Full Current
Charge Termination Threshold Current	50mA $\pm$ 10%
C/x Output Indication Level LED (CHRG)	50mA $\pm$ 10%
VOUT Regulator Output Voltage — 1.2V, 1.8V, 2.5V (100mA Load)	$\pm$ 2.5%
VOUT Ripple Voltage — (400mA Load)	18mV p-p
VOUT Ripple Voltage — Burst mode (Light Load)	80mV p-p
Regulator Maximum Output Current	600mA

### OPERATION

The battery charger portion of demonstration circuit 1068A uses a constant-current/constant voltage charge algorithm with a programmable minimum charge current termination. The battery float voltage is fixed at 4.2V and the charge current is programmed for 100mA, 500mA or 800mA, depending which power source is used and the status of the HPWR terminal. The charge cycle terminates when the charge current drops below 50mA after reaching the float voltage. Power and Charge LEDs indicate charger status. The Power LED indicates the input voltage from either input power source is greater than the undervoltage lockout threshold level and at least 180mV greater than the battery voltage.

The Charge LED indicates a charge cycle is in progress. The LED is ON when the charger is in the trickle current, constant current, or the constant voltage portion of the charge cycle (when the charge current is dropping). When the charge current drops below the charge termination current threshold level of 50mA, the LED goes off and the charge cycle ends.

If the battery voltage drops approximately 100mV from the float voltage, after the charge cycle has ended, a recharge cycle will begin.

With power applied to the adapter input, placing the EN Jumper (JP1) in the upper position

can shut down the charger. When USB power is present, the charger can be shut down by moving the jumper to the middle position. The lower position enables the charger when either input is used.

The IDC and the IUSB terminals can be used to measure the charge current that is being supplied from either input supply anytime in the charge cycle. The voltage on these pins is directly proportional to the charge current where one Volt is equal to full programmed current.

The 1.5MHz synchronous buck regulator has jumpers to select output voltages of 1.2V, 1.8V, or 2.5V at up to 600mA of output current. Burst mode operation occurs at low load current and automatically changes to continuous mode at high current. Burst mode provides higher efficiency at low load current.

The input power for the buck regulator can be from either the adapter input or from the battery, selected by jumper JP2. Note that when the regulator is powered from the adapter input, the maximum input voltage is limited to 5.5V. Normally, a Li-Ion battery would be connected to the BAT pin, although the buck regulators can be operated without a battery. When no battery is present, some additional capacitance may be needed on the battery terminal.

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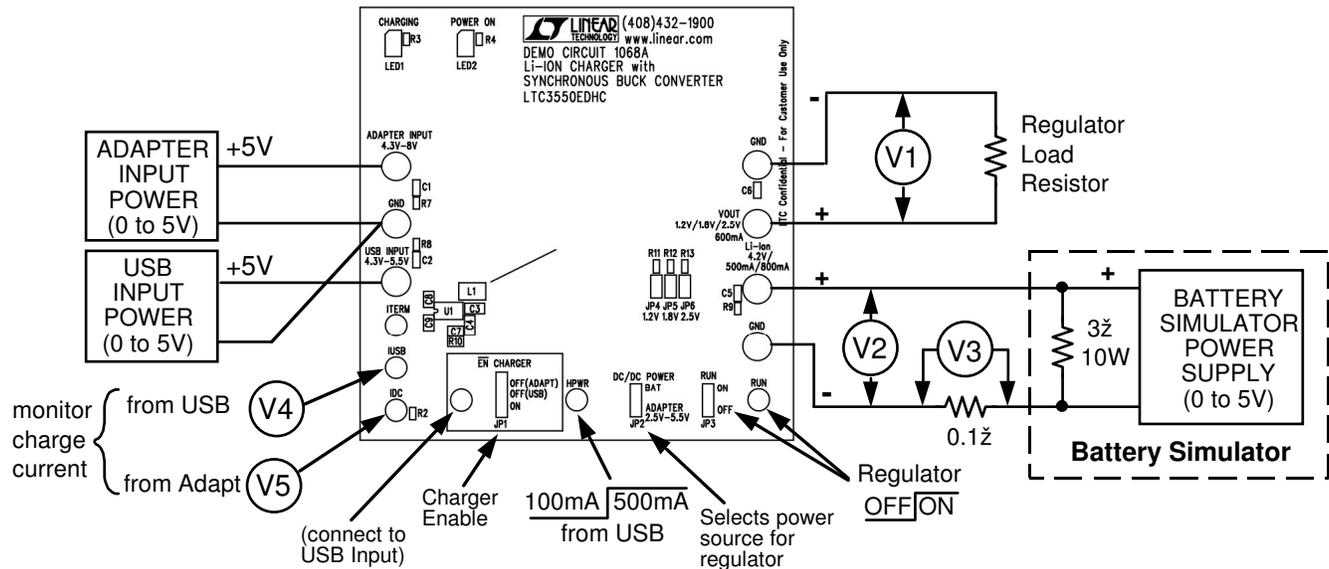


Figure 1. Demonstration Circuit Test Setup

## QUICK START PROCEDURE

The charger section 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.

### Battery Simulator

A battery simulator consists of an adjustable power supply with a load resistor across the power supply output. The load resistor allows the battery simulator to source and sink current, similar to an actual battery. Any battery state-of-charge condition can be quickly simulated by simply changing the power supply output voltage. The load resistor value is selected that will sink at least 800mA when the power supply is set for 2.6V and the power supply must provide at least 1.4A when adjusted for 4.2V. For this battery simulator, a 3 Ohm 10 Watt power resistor connected to the output of a 5V, 1.5A bench supply will work fine.

### Charger Evaluation

Begin circuit evaluation by placing the jumpers to the following positions; JP1 lower, JP2 upper, JP3 lower, and place a jumper in the JP4 (1.2V) position. With the input power supply and battery simulator power supply turned on and adjusted for 0V, connect the demonstration circuit as shown in Figure 1. Note: Connect an external wire from the USB input terminal to the HPWR terminal to pull it high.

Adjust the battery simulator power supply to approximately 2.5V, then begin increasing the USB input supply up to 5V. At approximately 3.9V (the USB undervoltage lockout threshold), the Power and Charge LEDs will turn on and a preconditioning trickle charge of 50mA will begin flowing into the battery simulator. The IUSB pin voltage (Voltmeter V4) will measure about 100mV indicating 10% of the programmed current. Increase the battery simulator power

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supply to 3V as measured by V2. At approximately 2.85V, the charge current will abruptly increase to the programmed constant current of 500mA, which is the maximum rated current available from a USB port. Voltmeter V4, connected to the IUSB terminal, will measure 1 Volt and V3 will measure 50mV across the 100mΩ charge current sense resistor indicating the full 500mA charge current is flowing. Remove the wire connected to the HPWR terminal allowing the internal pull-down resistor to pull the HPWR pin low, dropping the charge current to 100mA. V4 will measure 200mV & V3 will be 10mV.

Adjust the Adapter input supply to 5V. At approximately 4.15 (the Adapter input undervoltage lockout threshold) the charge current will abruptly increase to the programmed adapter charge current of 800mA. Voltmeter V4 will be 0V and V5 will now measure 1V indicating full programmed current from the Adapter input power supply. Note; reducing the simulator power supply voltage below the trickle charge voltage of 2.85V will reduce the charge current to 10% of the programmed value.

Slowly increase the battery simulator power supply, thus simulating the Li-Ion battery accepting charge. As the battery simulator approaches the float voltage of 4.200V, as measured by V2, the charge current will begin to drop as the charger begins the constant voltage portion of the charge cycle. 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. The IUSB and the IDC terminals indicate charge current levels from the respective input power sources at all times during the charge cycle with 1 Volt indicating 100% of the programmed current. When the charge current drops below the End-of-Charge threshold

of 50mA (programmed by R6), the Charge LED will go OFF and the charge cycle ends.

Reducing the battery simulator voltage by approximately 100mV will start a recharge cycle.

When no battery is present, the charger output will exhibit a sawtooth waveform of several hundred mV centered on 4.2V. This is a result of the repeated cycling between charge termination and recharge threshold. This also causes the Charge LED to pulse rapidly and appear to light dimly.

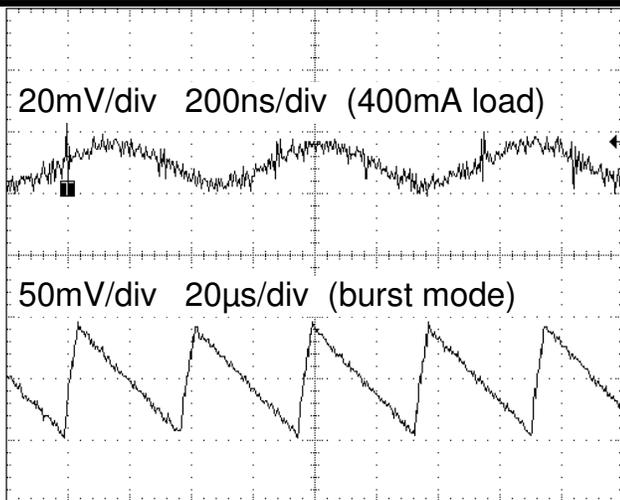
The one-Ohm resistor in series with the ceramic input capacitors minimizes the ringing and overshoot that appears at the input when the input voltage is hot switched. Input voltage transients can easily exceed the maximum ratings causing serious damage to the LTC3550.

### Buck Regulator Evaluation

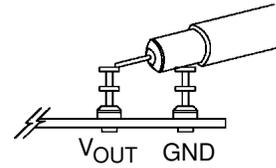
Move the DC/DC Power jumper (JP2) to the ADAPT (lower) position and select the desired output voltage using jumpers JP4 through JP6. Place the RUN jumper, JP3 in the ON (upper) position and connect a suitable load resistor between the VOUT terminal and GND. The maximum load current is approximately 600mA. With Adapter input power applied, verify that the output voltage, as measured by V1 is between the limits as shown in Table 1. A scope can also be used to measure the regulator output ripple voltage. When evaluating output ripple, observe proper scope probe measuring technique as shown in Figure 3. To increase efficiency at light loads, the regulator operates in burst mode resulting in higher output ripple voltage. As the load current increases, the output ripple decreases as the regulator changes to continuous operation.

See LTC3550 Data Sheet for additional information.

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**Figure 2. Output Ripple Voltage**



**Figure 3. Scope Probe Placement for Measuring Output Ripple Voltage**

