

# QUICK START GUIDE FOR DEMONSTRATION CIRCUIT 1061A LINEAR LI-ION BATTERY CHARGER WITH DUAL SYNCHRONOUS BUCK REGULATOR

LTC3552

## DESCRIPTION

Demonstration circuit 1061A is a complete single cell Lithium-Ion battery charger and two synchronous buck voltage regulators with adjustable output voltages. Operating at a frequency of 2.25MHz, the regulators can be powered from either the Li-Ion battery or from the AC adapter selected by a jumper.

This demonstration circuit allows the user to quickly evaluate the LTC3552 performance. Individual jumpers are provided for shutting down the charger and/or each of the switching regulators. Jumpers also allow for selecting several regulator output voltages and the mode of operation (Pulse Skip or Burst). LEDs indicate charger information (input power and charge)

and pins on the board allow easy hookup to an input supply and battery or battery simulator.

The high switching frequency of the voltage regulators 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 600mA.

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

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

Input Voltage Range $V_{IN}$ (Buck regulators powered from Battery)	4.25V to 6.5V
Input Voltage Range $V_{IN}$ (Buck regulators powered from $V_{IN}$ )	2.5V to 5.5V
Charger Output Float Voltage, $V_{BAT}$ (constant voltage mode)	4.2V $\pm$ 0.5%
Output Current, $I_{BAT}$ (constant current mode)	600mA $\pm$ 6%
Current Monitor Output	1V $\pm$ 2.5% @ Full Current
Charge Termination Current Threshold	40mA $\pm$ 10%
C/x Output Indication Level (CHRG)	40mA $\pm$ 10%
VOUT1 Regulator 1 Output Voltages — 1.2V, 1.5V, 1.8V (100mA load)	$\pm$ 2.5%
VOUT1 Ripple Voltage — skip mode (300mA load)	10mV p-p
VOUT1 Ripple Voltage — Burst mode (1mA load)	45mV p-p
Regulator 1 Maximum Output Current	800mA
VOUT2 Regulator 2 Output Voltages — 2.5V, 3.3V (100mA load)	$\pm$ 2.5%
VOUT2 Ripple Voltage — Skip mode (100mA load)	4mV p-p
VOUT2 Ripple Voltage — Burst mode (1mA load)	20mV p-p
Regulator 2 Maximum Output Current	400mA

### OPERATION

The battery charger portion of demonstration circuit 1061A uses a constant-current/constant voltage charge algorithm with minimum charge current termination. The battery float voltage is fixed at 4.2V and the charge current is programmed for 600mA, although other charge currents up to 950mA can be programmed by replacing the program resistor (R4) with a suitable value. Either a leaded resistor, from PROG to GND, or a 0402 surface mount resistor can be used.

Power and Charge LEDs indicate charger status. The Power LED indicates the input voltage is greater than the undervoltage lock-out threshold level.

The Charge LED indicates a charge cycle is in progress. The LED is ON when the charger is in the trickle 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 40mA, 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.

The charger can be shut down by pulling the EN terminal to VIN. The PROG terminal can

be used to program different charge current and also measure the charge current anytime in the charge cycle. The PROG pin voltage is directly proportional to the charge current where one Volt is equal to full programmed current.

The 2.25MHz synchronous buck regulators have jumpers to select output voltages of 1.2V, 1.5V, or 1.8V at 800mA for VOUT1 and output voltages of 2.5V or 3.3V at 400mA for VOUT2. Individual jumpers are also provided for low quiescent current shutdown and for either pulse skip or Burst mode operation. Both regulators operate in the continuous mode at high current and automatically switch to the selected mode at low current levels. Burst mode provides higher efficiency at low load current.

The input power for the regulators can be from either the VIN terminal or from the battery, selected by a jumper. Note that when the regulators are powered from VIN, 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 on the BAT pin may be needed.

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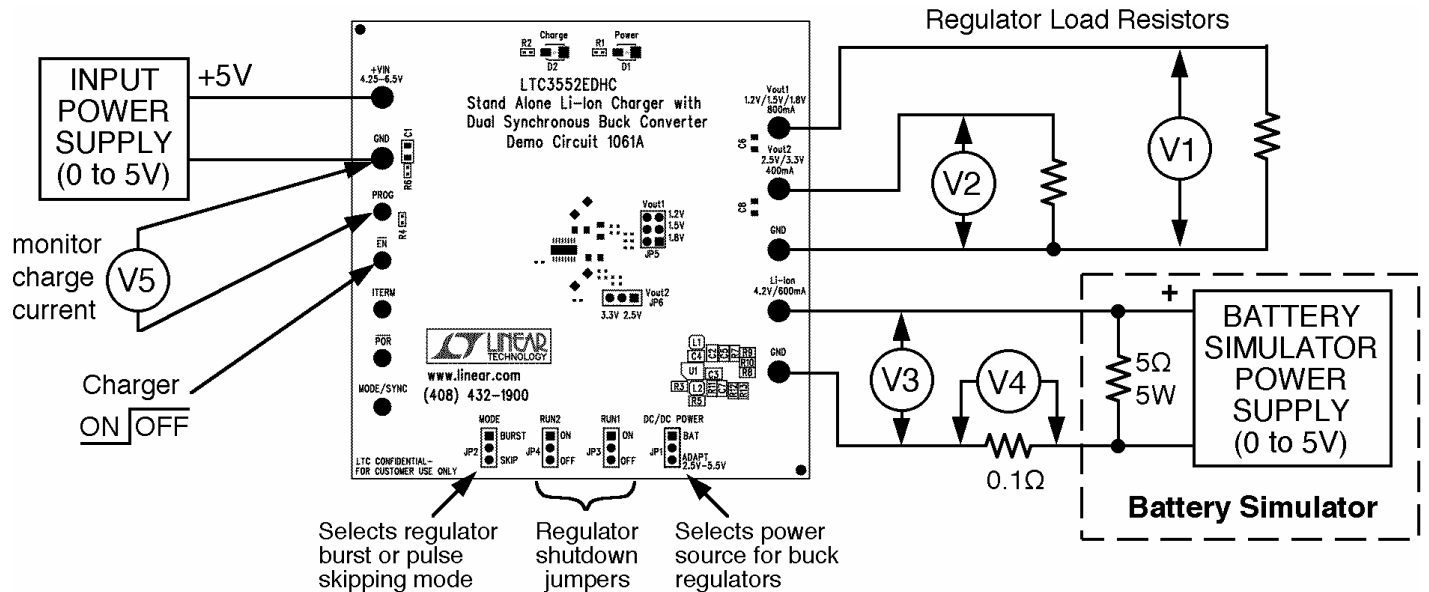


Figure 1. Demonstration Circuit Test Setup

## 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 600mA when the power supply is set for 2.5V and the power supply must provide at least 1.1A when adjusted for 4.2V. For this battery simulator, a 4 Ohm, 5 or 10 Watt power resistor connected to the output of a 5V, 1.25A bench supply will work fine.

### Charger

Begin circuit evaluation by placing the jumpers to the following positions; JP2 in SKIP, JP3 and JP4 in OFF, and JP1 in the ADAPT. With the input power supply and battery simulator power supply adjusted to 0V, connect the demonstration circuit as shown in Figure 1.

Begin increasing the input supply voltage, up to 5V. At approximately 3.6V (the undervoltage lockout threshold), the Power and Charge LEDs will turn on and the preconditioning trickle charge of 60mA will begin flowing into the battery or battery simulator. The PROG pin voltage (Voltmeter V5) will measure 100mV indicating 10% of the programmed current. Adjust the battery simulator power supply to 3V as measured by V3. At approximately 2.9V, the charge current will abruptly increase to the programmed constant current of 600mA. Voltmeter V5 will measure 1 Volt and V4 will

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measure 60mV indicating the full 600mA charge current is flowing. Continue slowly increasing 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 V3, 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 PROG terminal can be used to indicate charge current level 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 40mA, the Charge LED will go OFF and the charge cycle ends.

Reducing the battery simulator by approximately 100mV will start a new charge 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 capacitor (C1) on Vcc minimizes the ringing and overshoot that appears at the input when the input voltage is hot switched. Refer to

Figure 2. The effects of the one Ohm series resistor are obvious. The picture also compares the input transient (waveforms C and D) when C1 is increased to 6 $\mu$ F when the switching regulator is powered from the AC adapter. Paralleling a tantalum or polymer capacitor can also be used to minimize input voltage transients.

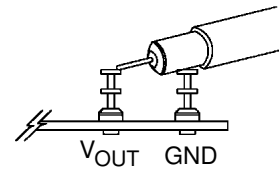
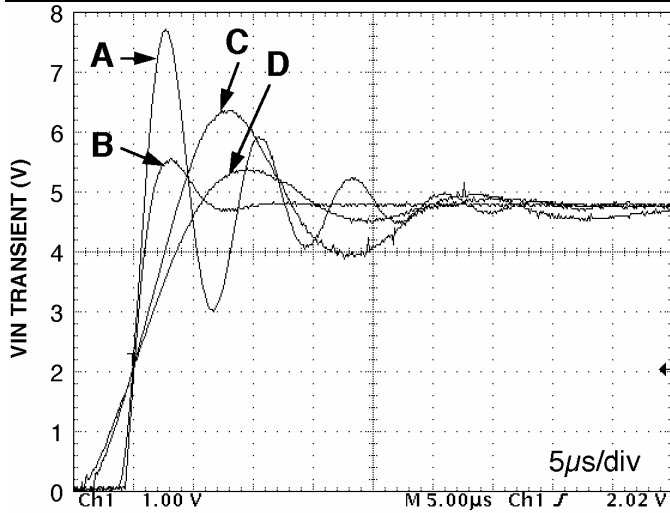
Without precautions, serious damage to the LTC3552 can occur.

### **Buck Regulator**

With the DC/DC Power jumper (JP1) in the ADAPT position, select the desired output voltage for VOUT1 and VOUT2 using jumpers JP5 and JP6 respectively. Place the RUN jumpers, JP3 and JP4 in the ON position and connect suitable load resistors between VOUT terminals and GND. The maximum load current for VOUT1 is approximately 800mA and VOUT2 is 400mA. With input power applied, verify that the output voltages, as measured by V1 and V2 are 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. For high efficiency at light load conditions, move jumper J2 to the BURST position. The transition between continuous mode and BURST mode is automatic.

**See LTC3552 Data Sheet for additional information.**

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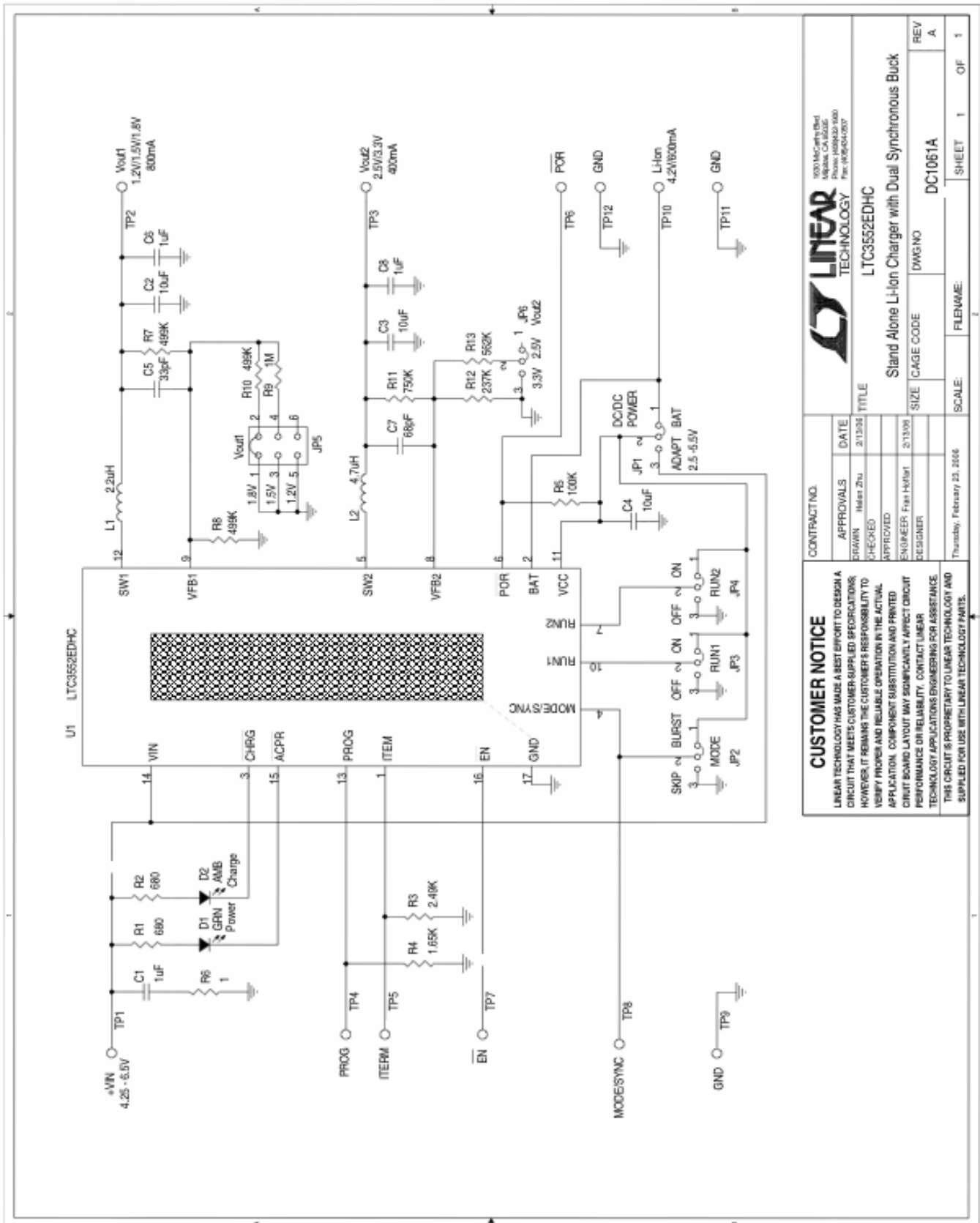


**Figure 3. Scope Probe Placement for Measuring Output Ripple Voltage**

Waveform	C1	R1	JP1
A	1µF	0	BAT
B	1µF	1	BAT
C	1µF	1	ADAPT
D	6µF	1	ADAPT

**Figure 2. Input Voltage Transient When Input Power is Hot Switched**

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<b>CONTRACT NO.</b>		<b>APPROVALS</b>		<b>DATE</b>	
DRAWN: Helen Zhu		CHECKED:		2/13/06	
APPROVED:		ENGINEER: Fritzi Huhnt		2/13/06	
DESIGNER:		SIZE		DWG NO	
		DC1061A		REV	
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		SHEET		1	
		FILENAME:		2	
		SCALE:		3	
		Thursday, February 23, 2006		4	

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**LTC3552EDHC**  
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