Application Report
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Building Your Own Battery Simulator

Rushil KK

ABSTRACT

Use a power amplifier circuit with TI™ single-cell Li-ion battery chargers to quickly characterize their charge profile. With an R_{IN} × C_{IN} time constant at its input, the output of the power amplifier simulates a battery charging. The power amplifier both sources and sinks current. One can characterize the entire charging profile of the charger by tying the output of the battery charger to the power amplifier output.

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1 Operating Principle of the Circuit

Batteries are rated in mAHrs. A 2-A battery charger requires approximately one hour to charge a 2000-mAHr battery, longer when including the effects of the connector resistance and the internal resistance of the battery. It is inefficient to evaluate charger performance by waiting one hour to charge and additional time to discharge the battery for additional testing. This application note explains how to make a circuit that can provide an observably slow output dv/dt, while sinking the entire 2-A charge current that the charger supplies. Figure 1 shows the power operation amplifier and additional circuitry needed to make the battery simulator.

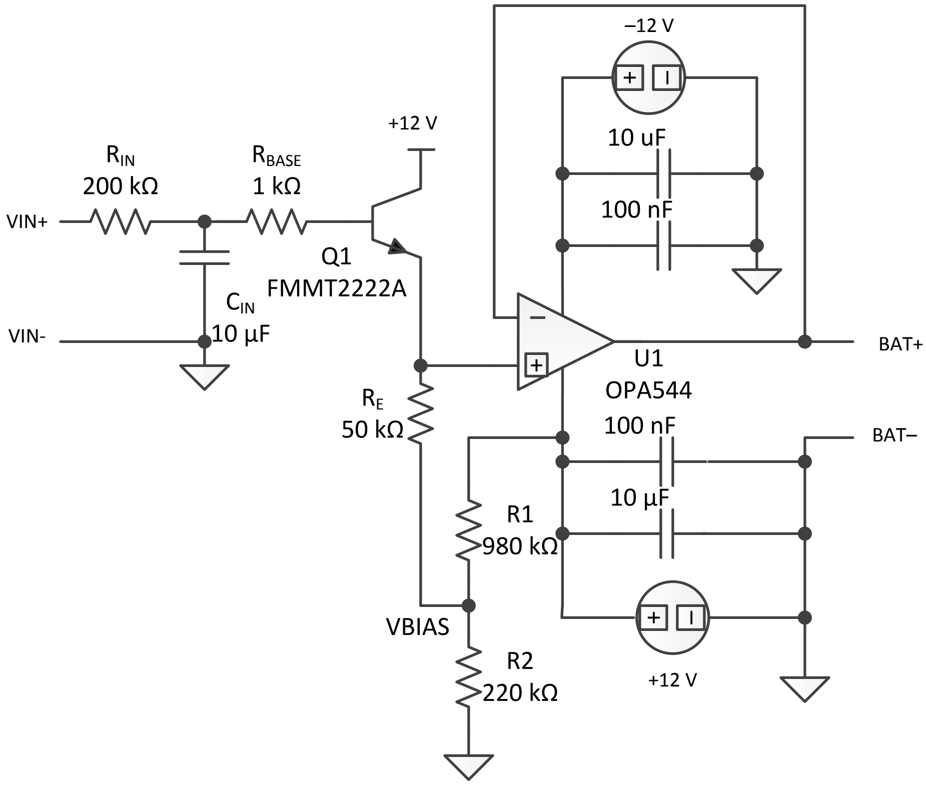

Figure 1. Battery Simulator Circuit

2 Explanation of the Circuit

2.1 Stage One

The first stage of the circuit comprises a charging circuit of $R_{IN} \times C_{IN}$. In Figure 1, the values chosen are R_{IN} = 200 kΩ and C_{IN} = 10 µF, giving a time constant of $R_{IN} \times C_{IN}$ = 2 s. Users can change these values for their convenience. For slower charging, increase the value of $R_{IN} \times C_{IN}$, and for faster charging, decrease the value of $R_{IN} \times C_{IN}$.

2.2 Stage Two

The voltage developed across the capacitor C_{IN} is fed to an emitter follower. NPN bipolar transistor FMMT2222A makes the follower. The collector terminal of the transistor connects to the +12-V supply. The emitter connects through an emitter resistance R_E of 50 kΩ to create a biasing voltage, VBIAS. This bias voltage simulates the internal protection mechanism of most LiIon batteries to ensure that the battery voltage never falls below a certain level (usually 2 to 2.5 V). The user can adjust the VBIAS voltage through the resistor divider formed by R1 and R2.

$$\text{VBIAS} = 12 \times \frac{\text{R2}}{\text{R1} + \text{R2}} \quad (1)$$

Change the value of VBIAS by varying R2. R2 can be a potentiometer to facilitate changing the bias voltage.

NOTE: A Zener diode and series resistor with breakdown voltage of about 4.4 V (for example PMLL5230B) can be connected from the junction of R1 and R2 to ground. This connection prevents the voltage at BAT+ from exceeding the maximum voltage of the battery charger.

2.3 Stage Three

The output of the source follower is fed to the non-inverting terminal of the OPA544 unity-gain, stable-power amplifier, which can comfortably source and sink currents of up to 4 A. This unity-gain configured OPA544 amplifier is supplied with +12 V and –12 V. The output of the OPA544 is connected to the BAT+ terminal of the battery charger.

3 Test Procedure

1. Power the OP-AMP circuit with +12 V and –12 V. The output voltage must be almost equal to VBIAS.
2. Apply DC voltage between the VIN+ and VIN– terminals. For the example circuit, an input DC voltage of about 5.5 V is required in order to get a final output voltage of 4.3 V. The user may have to find the exact value of VIN by trial and error, to provide the exact final output voltage that the user desires. VIN changes slightly according to the choice of transistor and other components.
3. When the input voltage is applied, the voltage across capacitor C_{IN} starts rising from 0 V. The output voltage should not follow the voltage across capacitor C_{IN}, until it exceeds VBIAS (plus voltage across base-emitter junction).
4. After the voltage across the capacitor does exceed VBIAS (plus voltage across base-emitter junction), the output voltage BAT+ follows C_{IN} up to the final output voltage.
5. Connect the BAT+ and BAT– terminals to a battery charger to observe the charge current with an oscilloscope and the behavior of the charger at different battery voltages.

4 Test Results

4.1 bq24090 Charger With ICHG of 1 A, Battery Simulator $R_{IN} \times C_{IN}$ Time Constant of 2 s

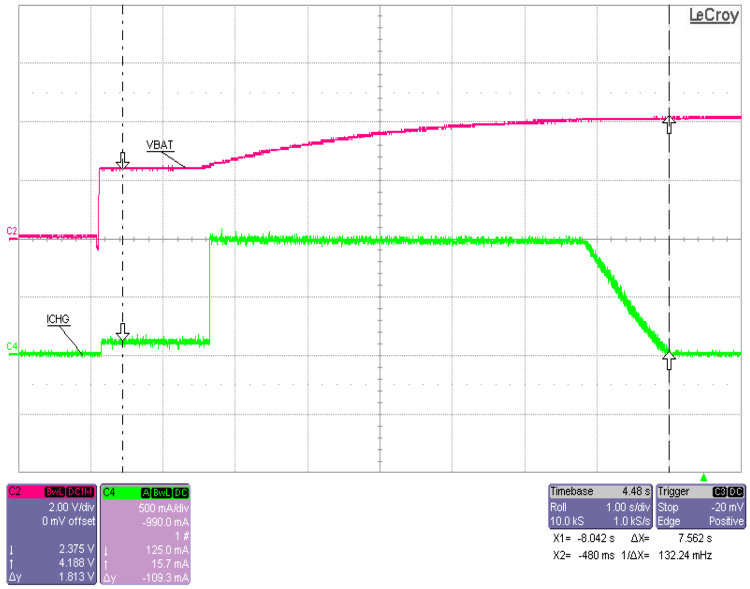

Figure 2. Charge Profile Obtained Using the Battery Simulator Circuit With bq24090 Charger

4.2 bq24157 Charger With ICHG of 850 mA, Battery Regulation Voltage 4.2 V, Battery Simulator Time Constant of 2 s

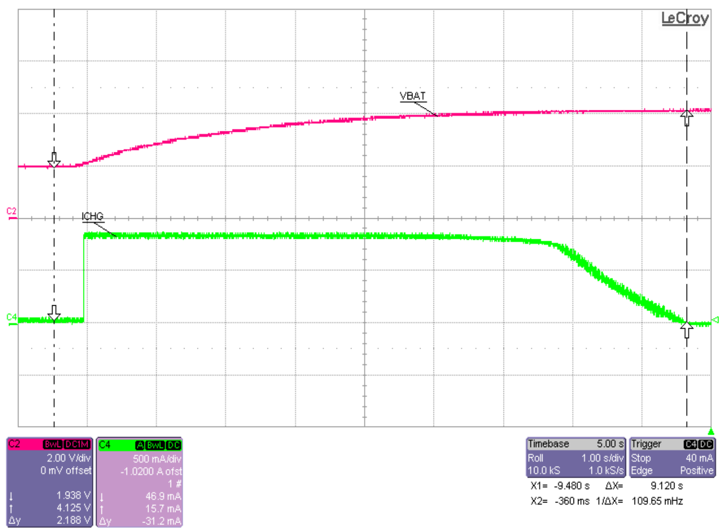

Figure 3. Charge Profile Obtained Using Battery Simulator Circuit With bq24157 Charger

5 Conclusion

Use the circuit described in this application note to create the charge profile for single-cell battery chargers, as shown in the previous examples.

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Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265