KEITHLEY
A Tektronix Company

Application Note Series

Number 3209

Simulating Lead-Acid Batteries Using a Series 2260B Power Supply

We encounter batteries in all aspects of our lives. The use of batteries ranges from consumer electronics such as cell phones and toys to industrial applications in transportation, communication, and power control. Due to the specific application needs, there exists a long list of different types of batteries that ranges from non-rechargeable types such as alkaline batteries to rechargeable types such as lithium-ion batteries. Although, a simple power supply can be used in place of any battery to supply the necessary voltage and current required by a test setup, each battery type does have its characteristics that can alter the expected result of the test. The impact of the internal resistance of a battery is a perfect example. For instance, a rechargeable lead-acid battery has a typical internal resistance in the tens of milliohms. However, as the temperature decreases, this resistance increases. Larger internal resistance leads to a reduced amount of current output from the battery. Therefore, it is important that a power supply be capable of simulating a lead-acid battery's operation in an environment with a varying temperature.

Lead-acid batteries have a well-known association with car batteries which start engines through short bursts of high current. They are also widely used in other applications such as handling fluctuations in electrical demand, serving as backup power for telephone systems, guarding against power-outages at hospitals and air traffic towers, and storing electricity generated by solar panels and windmills. A lead-acid battery stores electricity through a chemical reaction that occurs when two dissimilar materials, called electrodes, are immersed in a sulfuric acid and water solution, called the electrolyte. These elements comprise the elements of an electrochemical cell. This cell construction leads to some amount of internal resistance due the electrodes, the electrode-electrolyte interface, and the electrolyte. ***Figure 1*** illustrates the difference between an ideal battery and a real battery.

In an ideal battery scenario, all of the battery voltage is applied to the load. The total current that flows into the load is $I = V_{battery}/R_{load}$.

$$V_{load} = I*R_{load} = V_{battery}$$

However, a real battery carries an internal resistance, R_{int}, which reduces the amount of current supplied by the battery. Thus, the internal resistance in a real battery reduces current flow into the load, such that $I^1 < I$, and reduces the actual voltage that is applied at the load.

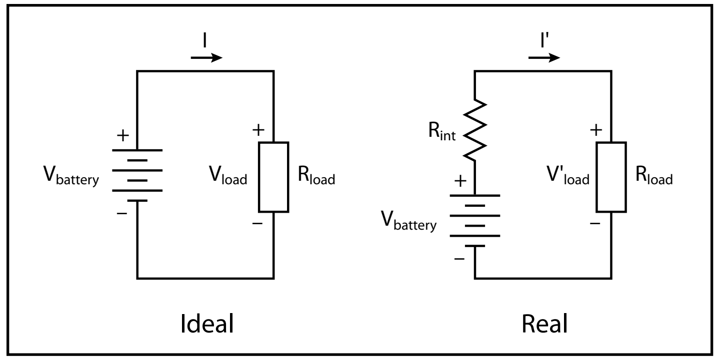

Figure 1.

$$V_{load} < V_{battery}$$

$$V_{load} = V_{battery} - I'R_{int}$$

$$I' = V_{load} / (R_{int} + R_{load})$$

To test a battery-powered device under its actual operating conditions, the power source must emulate the response of an actual battery. The power source must include the effects of the internal resistance.

Keithley Instruments' Series 2260B Power Supplies are equipped with a special feature called "Internal Resistance" that allows a user to simulate a real battery's internal resistance.

The configurable internal resistance values are especially useful in battery simulation applications such as for lead-acid batteries. The 2260B power supplies can be easily adjusted on the fly to reflect any change in the internal resistance values due

Model	R_{int}
2260B-30-36	0.000 – 0.833Ω
2260B-30-72	0.000 – 0.417Ω
2260B-80-13	0.000 – 5.962Ω
2260B-80-27	0.000 – 2.963Ω

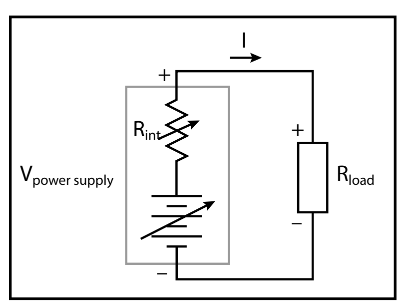

Figure 2. Keithley 2260B Power Supply Simulating a Lead-Acid Battery

to changes in test conditions thereby outputting more realistic current to the load as a battery would.

The following example illustrates the steps, both front panel and remotely, to configure the internal resistance of a 2260B-xx-xx to 15mΩ, the output voltage to 10V and the current limit to 5A.

Front Panel Operation

STEP 1. Set the Power Supply to the Internal Resistance Mode

1. Press the Function key. The Function key will light up, and the display should show **F-01** on the top line.
2. Rotate the Voltage knob to change the F setting to **F-08** (Internal Resistance Select).
3. Set the internal resistance to 0.015Ω.
   a. Press in the Current knob as necessary to highlight a specific digit.
   b. Turn the Current knob until the desired digit is displayed.
   c. Repeat for each digit that needs to be changed until 0.015 is displayed.
4. Press in the Voltage knob to save the configuration setting. ***ConF*** will be displayed when successful.
5. Press the Function key again to exit the configuration settings. The function key light will turn off.

STEP 2. Set the Output Voltage and Current limit

1. Press in the Voltage knob to highlight specific digits, then turn the Voltage knob to adjust the digits until **10.00V** is displayed.
2. Press in the Current knob to highlight specific digits, then turn the Current knob to adjust the digits until **5.00A** is displayed.

STEP 3. Turn on the Output

1. Press the Output key. The Output key becomes illuminated the when the output is on.

Remote Operation

```
*RST
;SOUR:RES 0.015
:SOUR:VOLT 10.0
:SOUR:CURR 5.0
:OUTP ON
```

Keithley Instruments' Series 2260B Power Supplies make simulating a battery's output both feasible and easy.

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A Greater Measure of Confidence

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