Circuit provides constant-current load for testing batteries

Vladimir Rentyuk - February 19, 2009

Suppose that you need to test a 1.5V, AA-size alkaline battery. You can apply a short circuit and measure current, or you can measure open-circuit voltage, but neither method properly tests the battery. A suitable test current of approximately 250 mA gives you a more reasonable test. You can use a 6Ω resistive load at 1.5V, which produces an output voltage of 1.46V at an ambient temperature of 25°C if the battery is in excellent condition. A poor battery might produce less than 1.2V. Given the load, the output current at 1.2V will be 200 mA instead of 250 mA. The battery will have just 80% of a full load current. Instead, you can use the circuit in Figure 1 to produce a constant-current load.

![Figure 1](image)

Figure 1 A tester of AA- or AAA-sized batteries uses constant-current load.

The circuit uses a 9V battery and a voltage regulator to produce a steady power-supply voltage of 5V. From that voltage, the circuit produces a constant sink current, which is independent of the battery’s output voltage, using IC$_1$, IC$_2$, and Q$_3$. Your choice of current depends on battery size. You calculate the sink current of this circuit as $I_{TEST} = \frac{1}{R_{19}} \times [V_{CC} \times R_{18} / (R_4 + R_{18})]$, where $I_{TEST}$ is the current you are testing and $V_{CC}$ is the voltage of resistive divider $R_4$ and $R_{18}$. The voltage across $R_{19}$ should
range from 0.3 to 0.85V for AAA and AA batteries. Transistor Q₃ should be in its active region. Resistor R₁₄ limits Q₃'s base current to a safe level.

A suitable choice for the operational amplifier, IC₂, is also important. You should use a single-supply op amp with a rail-to-rail input and a rail-to-rail output, such as Analog Devices' OP484ES or OP496GS.

When you connect the battery under test, Q₂ turns on, which then turns on Q₁, applying voltage from the 9V battery to the regulator. That action lights D₃, indicating that the battery under test has enough voltage to be tested. LEDs D₂, D₅, and D₆ indicate the battery's condition. Table 1 shows the voltage ranges necessary for these LEDs to light.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Battery voltage¹ (V)</th>
<th>D₂</th>
<th>D₄</th>
<th>D₅</th>
<th>D₆</th>
<th>D₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>&gt;1.46</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Good</td>
<td>&gt;1.33</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Poor</td>
<td>&gt;1.2</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Bad</td>
<td>&gt;1²</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Unable to test</td>
<td>&gt;12</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

¹Ambient temperature is 25°C.
²This estimated value can be less.

Op amps IC₂ₐ, IC₂₇, and IC₂₀ work as comparators with some hysteresis for operational stability. The resistive divider comprising R₅, R₆, R₈, R₁₇, and R₂₂ sets the voltage levels. Diodes D₁ and D₂ are optional but are useful when you need to operate the circuit outdoors, where temperatures vary widely. Resistor R₁₅ protects the inputs of IC₂ₐ, IC₂₇, and IC₂₀.

When you connect a battery to test, you should test it for at least 5 seconds. LED D₃ shines if the battery is in relatively normal condition. In this case, switch Q₁ applies power to the battery tester. The sink-current generator comprising IC₂₈ and Q₃ loads the battery under test, and the resistor-divider network sets the comparator voltages.

You can add an optional self-testing button for checking the 9V battery to ensure that it has enough voltage to drive the circuit. You can also connect a digital multimeter to the multimeter terminals if you need a more accurate measurement. You can use a suitable rotary switch or a variable resistor and change the value of the test current by changing the value of R₄ to test another type or size of battery.

Also see:
- Configure a low-cost, 9V battery-voltage monitor
- Circuit measures battery capacity
- The Batteriser: scam or savior?
- Test batteries without a voltmeter
- Design Idea Submission Guide