Circuit provides constant-current load for testing batteries

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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 IC1, IC2, and Q3. Your choice of current depends on battery size. You calculate the sink current of this circuit as \( I_{\text{TEST}} = \frac{1}{R_{19}} \times \left[ V_{\text{CC}} \times R_{18} / (R_4 + R_{18}) \right] \), where \( I_{\text{TEST}} \) is the current you are testing and \( V_{\text{CC}} \) 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 \( Q_3 \) should be in its active region. Resistor \( R_{14} \) limits \( Q_3 \)’s base current to a safe level.

A suitable choice for the operational amplifier, \( IC_{2r} \), 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, \( Q_2 \) turns on, which then turns on \( Q_1 \), applying voltage from the 9V battery to the regulator. That action lights \( D_3 \), indicating that the battery under test has enough voltage to be tested. LEDs \( D_4 \), \( D_5 \), and \( D_6 \) 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 voltage(^1) (V)</th>
<th>( D_2 )</th>
<th>( D_4 )</th>
<th>( D_5 )</th>
<th>( D_6 )</th>
<th>( D_3 )</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;1(^2)</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>

\(^1\)Ambient temperature is 25°C.
\(^2\)This estimated value can be less.

Op amps \( IC_{2A} \), \( IC_{2C} \), and \( IC_{2D} \) work as comparators with some hysteresis for operational stability. The resistive divider comprising \( R_5 \), \( R_6 \), \( R_8 \), \( R_{17} \), and \( R_{22} \) sets the voltage levels. Diodes \( D_1 \) and \( D_2 \) are optional but are useful when you need to operate the circuit outdoors, where temperatures vary widely. Resistor \( R_{15} \) protects the inputs of \( IC_{2A} \), \( IC_{2C} \), and \( IC_{2D} \).

When you connect a battery to test, you should test it for at least 5 seconds. LED \( D_3 \) shines if the battery is in relatively normal condition. In this case, switch \( Q_1 \) applies power to the battery tester. The sink-current generator comprising \( IC_{2A} \) and \( Q_3 \) 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 \( R_4 \) 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