Simple battery-status indicator uses two LEDs

Abhijeet Deshpande, People’s Education Society Institute of Technology, Bangalore, India; Edited by Martin Rowe and Fran Granville - August 12, 2010

Properly maintained rechargeable batteries can provide good service and long life. Maintenance involves regular monitoring of battery voltage. The circuit in Figure 1 works in most rechargeable batteries. It comprises a reference LED, LED_{REF}, which operates at a constant current of 1 mA and provides reference light of constant intensity regardless of battery voltage. It accomplishes this task by connecting resistor R_1 in series with the diode. Therefore, even if the battery voltage changes from a charged state to a discharged state, the change in current is only 10%. Thus, the intensity of LED_{REF} remains constant for a battery state from a fully charged state to a fully discharged state.

![Figure 1](image_url) This circuit works in most rechargeable batteries. It comprises a reference LED, LED_{REF}, which operates at a constant current of 1 mA and provides reference light of constant intensity regardless of battery voltage.

The light output of the variable LED changes with respect to changes in battery voltage. The side-by-side-mounted LEDs let you easily compare light intensities and, thus, battery status. Using diffused LEDs as crystal-clear LEDs can damage your eyes. Instead, mount the LEDs with sufficient optical isolation so that the light from one LED does not affect the intensity of the other LEDs.
The variable LED operates from 10 mA to less than 1 mA as the battery voltage changes from fully charged to fully discharged. Zener diode $D_z$ in series with resistor $R_2$ causes the current to change with battery voltage. The sum of the zener voltage and the drop across the LED should be slightly less than the lowest battery voltage. This voltage appears across $R_2$. As the battery voltage varies, it produces a large variation of current in $R_2$. If the voltage is approximately 1V, then 10 mA will flow through LED$_{VAR}$, which is much brighter than LED$_{REF}$. If the voltage is less than 0.1V, then the light intensity of LED$_{VAR}$ will be less than LED$_{REF}$, indicating that the battery has discharged.

Immediately after the battery has charged, the battery voltage is more than 13V. The circuit can withstand this voltage because it has a 10-mA margin. If the LEDs are bright, quickly release pushbutton switch $S_1$ to avoid damage to the LEDs (Figure 2).

![Figure 2](image-url) This circuit can withstand 13V because it has a 10-mA margin. If the LEDs are bright, quickly release pushbutton switch $S_1$. 
The figure uses a 12V lead-acid battery indicator as an example, but you can extend the design to accommodate other types of chargeable batteries. You can also use it for voltage monitoring. It uses two green LEDs to indicate whether the battery has charged above 60%. A set of red LEDs indicates whether the battery charge drops below 20%. LED\textsubscript{REFG} and LED\textsubscript{REFR} feed through 10-kΩ resistors R\textsubscript{1} and R\textsubscript{2}. For the variable-intensity LEDs, a zener diode works in series with 100Ω resistors R\textsubscript{3} and R\textsubscript{4}. Diodes D\textsubscript{1}, D\textsubscript{2}, and D\textsubscript{3} provide the required clamping voltages. Table 1 shows how LED intensity indicates battery charge.

<table>
<thead>
<tr>
<th>Light output of LED\textsubscript{VAR}</th>
<th>Light output of LED\textsubscript{VAR}</th>
<th>Battery status (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Much brighter than LED\textsubscript{REFG}</td>
<td>Much brighter than LED\textsubscript{REFR}</td>
<td>70 to 100</td>
</tr>
<tr>
<td>Equally as bright as LED\textsubscript{REFG}</td>
<td>Much brighter than LED\textsubscript{REFR}</td>
<td>60</td>
</tr>
<tr>
<td>Off</td>
<td>Brighter than LED\textsubscript{REFR}</td>
<td>50 to 30</td>
</tr>
<tr>
<td>Off</td>
<td>Equally as bright as LED\textsubscript{REFR}</td>
<td>20</td>
</tr>
<tr>
<td>Off</td>
<td>Off</td>
<td>0 to 10</td>
</tr>
</tbody>
</table>

The following equation calculates the variable intensity for the green LED: \( V_{\text{BATT}} = I_G \times 100 + V_{D1} + V_{D2} + V_{\text{LEDG}} + V_{ZD1} \). For a green-LED current of 1 mA, \( V_{\text{BATT}} = 10^{-3} \times 100 + 0.6 + 0.6 + 1.85 + 9.1 = 12.25 \text{V} \). The selected LEDs have a drop of 1.85V at 1 mA.

If the LED has different characteristics, then you must recalculate the resistor values. At this voltage, the LEDs have the same intensity, and the battery is 60% charged. See Reference 1 for lead-acid-battery voltages.

The following equation calculates the variable intensity for the red LED: \( V_{\text{BATT}} = I_R \times 100 + V_{D3} + V_{\text{LEDR}} + V_{ZD2} \). For a green-LED current of 1 mA, \( V_{\text{BATT}} = 10^{-3} \times 100 + 0.6 + 1.85 + 9.1 = 11.65 \text{V} \).

At this voltage, both red LEDs have equal intensities, and the battery is 20% charged. LED\textsubscript{VAR} is off. Figure 3 shows that both variable-intensity LEDs are brighter than the reference LEDs, indicating that the battery is 100% charged.

Figure 3 Both variable-intensity LEDs are brighter than the reference LEDs, indicating that the battery is 100% charged.

Reference

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