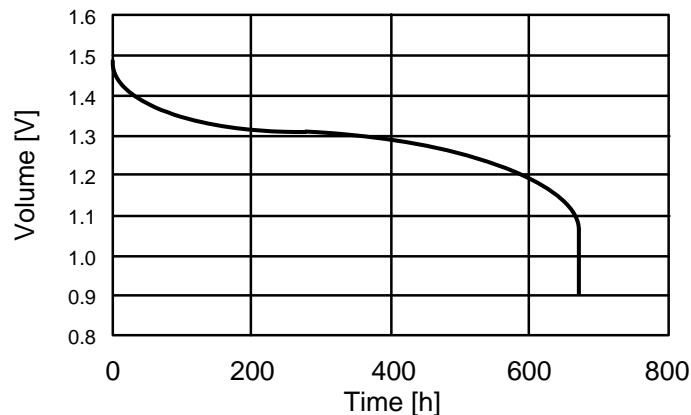


## ALKALINE BATTERY LOW-VOLTAGE INDICATOR

### 1. Overview\*

In many battery-powered systems, a user would like to know when it is time to replace the batteries before they are completely discharged, causing the device being powered to fail completely. Alkaline batteries have an open cell voltage of about 1.5 V. As they are discharged, the voltage slowly drops as shown in Figure 1. When the cell voltage reaches about 1.25 V, they have delivered about 90% of their stored energy.

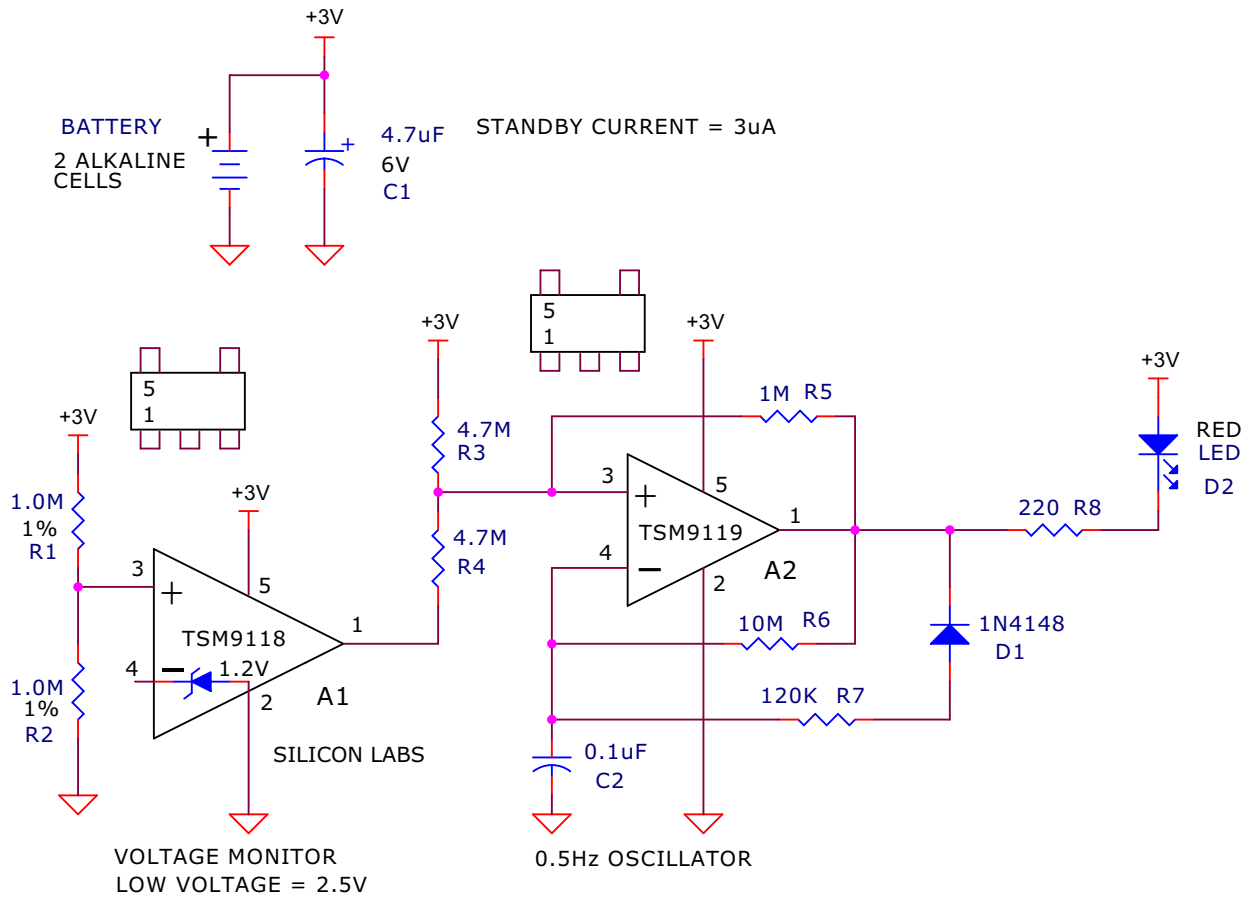
Constant Load    8.25 k $\Omega$   
Starting Drain    181.8  $\mu$ A  
Temperature      20  $^{\circ}$ C



**Figure 1. Alkaline Battery Voltage Discharge Characteristic**

The circuit shown in Figure 2 monitors the voltage of two alkaline cells in series and begins flashing an efficient red LED when the total battery voltage drops below 2.5 V, alerting the user that the batteries need to be replaced.

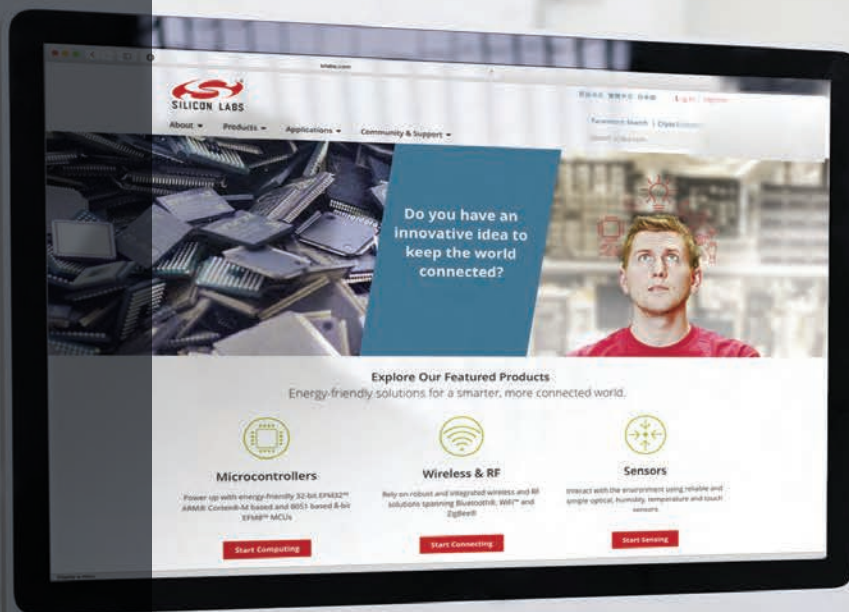
**\*Note:** This application note has previously been published on the Discover Circuits web site and is republished here with the permission of the author, David Johnson of Discover Circuits.



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**Figure 2. Voltage Monitoring Circuit**

This circuit takes advantage of some new voltage comparators from Silicon Labs. The TSM9118 has an internal 1.25 V reference and an open drain output while drawing an astoundingly low 0.7 µA. That circuit is configured as a classic voltage monitoring circuit, which changes state at a 2.5 V battery voltage. A second TSM9119 part is wired as a 0.5 Hz oscillator which is configured to produce short 20 ms output pulses every 2 seconds. The TSM9119 is a conventional comparator with a push-pull output, which also draws a very low current. Using the two low power parts, the total standby current of the circuit is kept at a low 3 µA. When the LED starts flashing, the average current will increase to about 50 µA. This is still low enough that the circuit should continue flashing for some time, giving the user time to notice the warning and replace the batteries. For additional information, contact Silicon Labs.



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Silicon Laboratories Inc.  
400 West Cesar Chavez  
Austin, TX 78701  
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