A Single LED Battery Status Indicator for the Rover

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Fading batteries are an all too frequent part of rover operation. Battery voltage fades slowly and silently, usually unnoticed until something doesn't work quite right, and then the problem is still sometimes overlooked. A simple warning device that doesn't distract from normal operation would help.

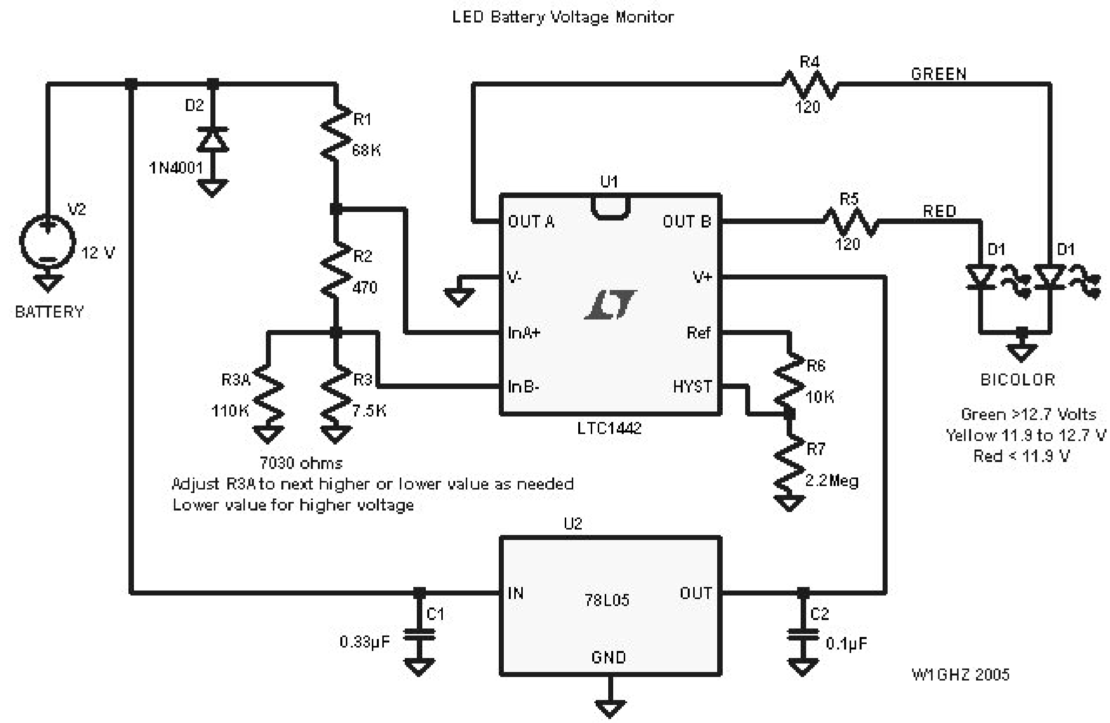
Battery status is easily monitored by the battery voltage – a "12 volt" battery, like a car battery, delivers around 13 volts when fully charged, dropping to below 12 volts when nearly discharged. A rover operator could check this periodically, but there are periods of attention overload: simultaneously digging out weak signals, maintaining liaison, doing PR with onlookers, and keeping antennas from blowing over in the wind can fully occupy most of us. So, while we could easily read a DVM, or just push the right button sequence on an FT-817 to measure the voltage, it may get neglected until something doesn't seem right…

A simple indicator, like an LED, is much easier to notice without being a distraction. It occurred to me that a multi-colored LED could be used as a status indicator. The most common combination is red and green; obviously, green for good and red for bad. When both colors are lit, the output is yellow, which could be a warning state. Thus the simple display would be green if the battery is good, yellow when the battery is getting low, and red when it is dying.

Now we need a simple circuit to detect the voltage and drive the LED. Integrated circuit comparators are cheap, but the difference between a good battery and a dead one isn't large, so the voltage must be reasonably accurate. The comparison voltage, reasonably accurate over time and temperature, may be obtained from an integrated circuit voltage reference at a modest price.

A comparator has two output states: high when the "+" input is at a higher voltage than the "—" input, and low when the "+" input is at a lower voltage. To drive the bi-color LED, one comparator should turn off the green light when battery is nearly dead and another comparator should turn off the red light when the battery is near full charge. In between, both lights are on, so the display will be yellow.

I have some LM393 comparators, the cheapest one available, in the junk box. However, all the available bi-color LEDs have a common cathode lead and separate anodes, so the open-collector outputs of the LM393 would not drive the LED without external transistors – too many parts for a simple circuit. A bit of research located a dual comparator with a built-in voltage reference, the LTC1441 (www.linear.com), with a price comparable to a voltage reference alone. The only drawback was that this comparator will not operate at 12 volts, so a 5-volt three-terminal regulator is necessary to reduce the voltage.

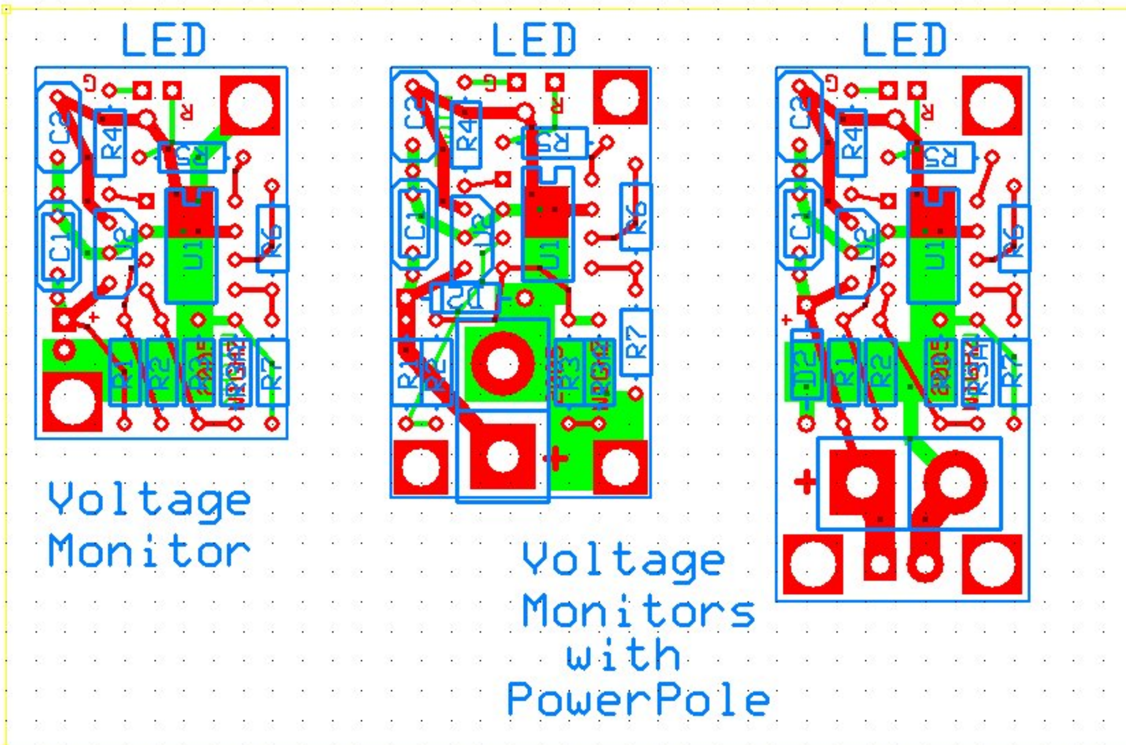


The complete circuit is shown in the schematic, Figure 1. The voltage divider R1, R2, and R3 sets the voltage trip points for the comparators in U1, so that the red light goes out at voltages above about 12.7 volts and the green light goes on at voltages above 11.8 volts. Since I used ordinary 5% resistors, the necessary adjustment for tolerances is provided by R3a. If the trip points are too low, R3 is decreased by replacing the nominal value of R3a, 110K, with the next lower standard value, 100K, or 91K if necessary. If the trip points are too high, R3a is increased to 120K or 130K. Once the adjustment is made, the resistors will probably drift and age together to maintain the desired ratio.

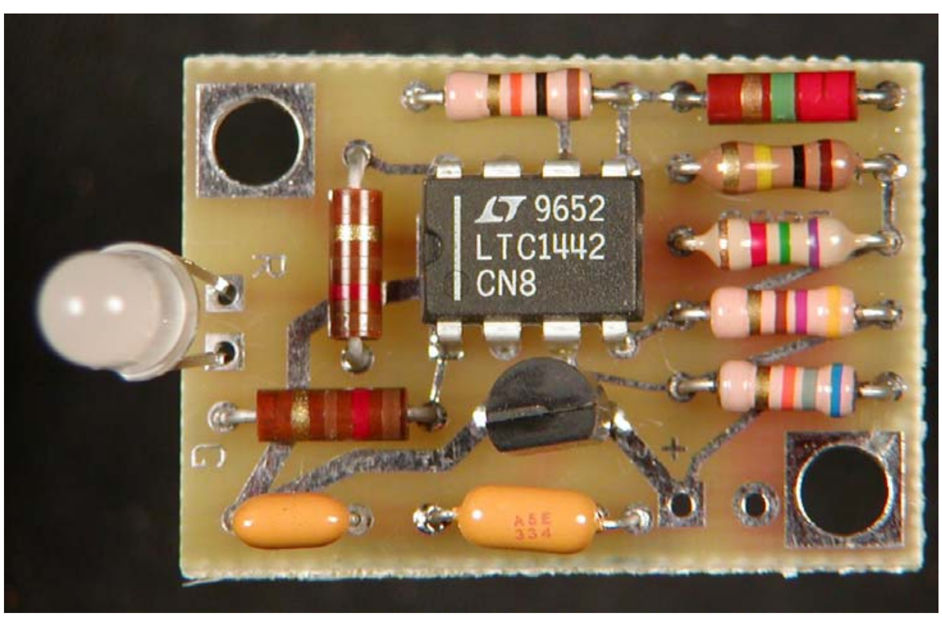
When I breadboarded this circuit, it appeared to work fine, with the color changing as planned. However, when the voltage was set exactly at the trip point, thermal noise switched the comparator on and off randomly at a rate invisible to the eye but visible on an oscilloscope. The comparators are too sensitive! The solution is to add some hysteresis, so that there is a slight difference between the on and off trip points. The LTC1441 has a pin for adding hysteresis, by adding R6 and R7. The values shown provide about 0.1 volts difference between the on and off voltages.

My breadboard didn't look robust enough for rover use, and I had a bit of spare area on a PCB for another project, so I made a quick layout of Figure 1 and added it to the board, piggybacking on a $59 Miniboard with ExpressPCB (www.expresspcb.com). Figure 2 is the PCB layout for use with the free ExpressPCB software – the plain version I built and two others with PowerPole connectors on the board, to monitor voltage as it enters a box. The file is available at www.w1ghz.org .

A photo of the complete battery status indicator is shown in Figure 3. Small and simple, with one LED, two ICs, eight resistors, and two capacitors. Total parts cost, new from DigiKey (www.digikey.com) , is about $3. I found three choices for bi-color LEDs in the catalog: the 160-1057-ND had the best three color combination, the 67-1124-ND was pretty good, but the 160-1715-ND had a very greenish color when both are lit so the yellow state is harder to discern. Any of the three LEDs run about $0.30, so choosing the best color doesn't cost extra.



I included the unit in Figure 3 inside my Battery-Sharing Switch, so I now have one box to control my batteries with just one light to keep an eye on.



Single-sided PCB

Something on the microwave reflector reminded me that some folks still make their own printed-circuit boards. Usually, these are simple, single-sided boards without plated-thru holes. Since this layout was pretty simple, I went back to see if I could do the PCB layout on a single side. I made the lines and spaces larger, to allow for kitchen-sink technology, so the board came out slightly larger. Here is the PCB pattern, seen from the metal side, and the parts placement, looking from the other side – go for it!