A Battery-sharing Switch

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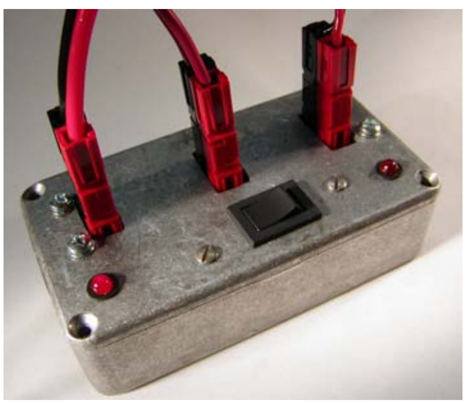
If you have ever tried rover operation, you know that batteries fade out at the least opportune times – usually in the middle of a difficult QSO (generators just run out of gas). Most of us have spare batteries, but don't want to shut down and risk losing a weak signal. What we need is a way to switch batteries without shutting down. It would be nice to have some warning or indication before the battery gets too low, other than equipment misbehavior – my IC-706Mk2g just goes blank on transmit if the battery is low.

RV drivers have similar problems, and use a box with two diodes to connect two batteries. I'm told that these fail frequently, which may be due to poor design, inadequate heatsinking, or just plain abuse. For ham use, West Mountain Radio (www.westmountainradio.com) offers the PWRgate, which uses Schottky diodes for reduced voltage drop – roughly 0.4 volts rather than 0.7 volts for ordinary diodes.

Modern low-voltage power supplies use FETs as synchronous rectifiers rather than diode rectifiers. The FETs offer less voltage drop, are probably cheaper, and they are controllable.

Laptop computers also use multiple batteries, want to switch between them without shutting down, and minimum voltage drop is desirable for longest battery operation. Since laptops are made by the million, clever semiconductor solutions are available.



One IC that seems like an attractive solution is the LTC4412, available from www.linear.com for under $2. The chip is designed for automatic battery sharing – if the battery voltage is within 20 millivolts of the voltage at the output, the battery is connected through a FET switch. If the battery voltage is lower, then it is disconnected. Manual override is also available. Voltage drop depends on the FET chosen for the switch – I chose the IRF4905, an inexpensive PMOS power FET with an ON resistance of 0.02 ohms. It is rated at 74 amps, which should be sufficient, and is available from Digikey.

I designed a simple printed-circuit board to share two batteries, with an LTC4412 and power FET switch for each. Adding more batteries or power supplies is a simple matter of adding more copies of the circuit in parallel, feeding a common output. The circuit has LEDs to show that a battery is supplying current, and a switch to disconnect either battery – for instance, to swap out a dead one without powering down.

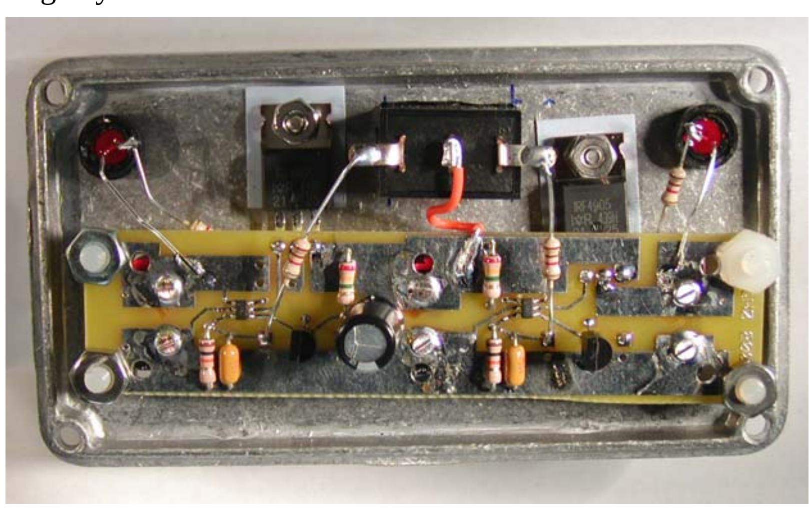


Figure 1 is photos of the completed unit, inside and out, Figure 2 is the schematic diagram, and Figure 3 is the PCB layout. I used ExpressPCB (www.expressPCB.com) free software to design the board and had them built there using the Miniboard service. The board file is on my web page, www.w1ghz.org. Since this board does not fill an entire Miniboard, I am able to combine it with other designs, have several different designs built on one Miniboard, and end up with three copies of each for $59 total.

Performance was pretty good. Voltage drop was less than 0.25 volts at 10 amps, about as expected (0.02 ohms x 10 amps = 0.2 volts), and switching between batteries seems smooth. One test was to run a transceiver from a small power supply and a battery; only the supply was active during receive, but the battery supplied additional current on transmit, as soon as the voltage from the power supply was pulled down to the battery voltage.

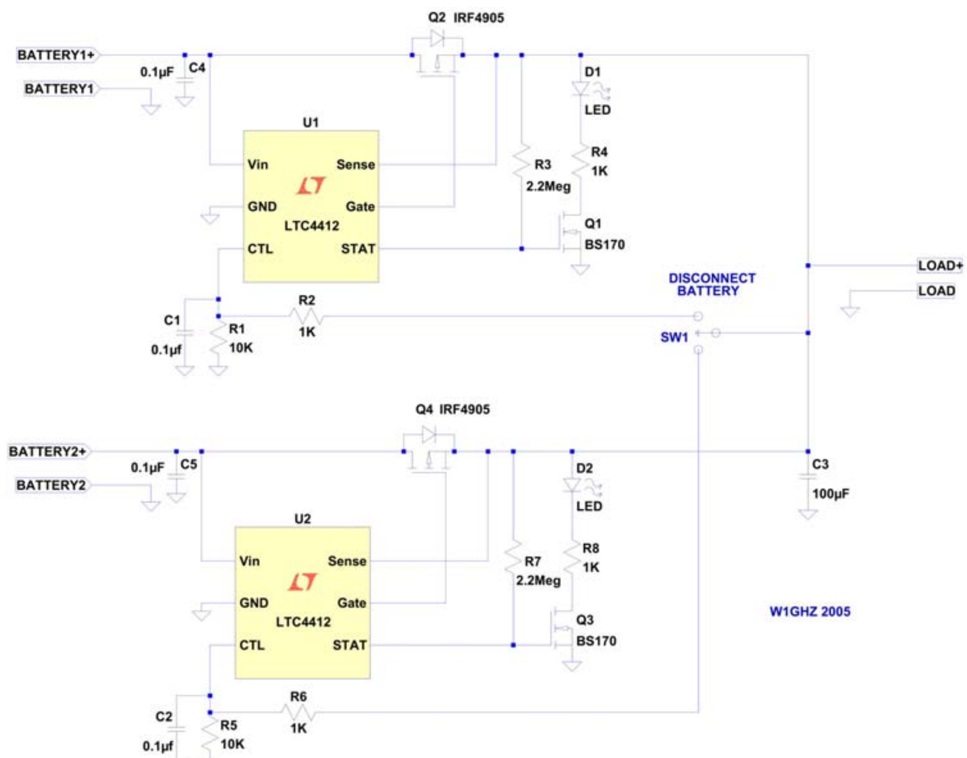


Figure 2 Battery-sharing switch

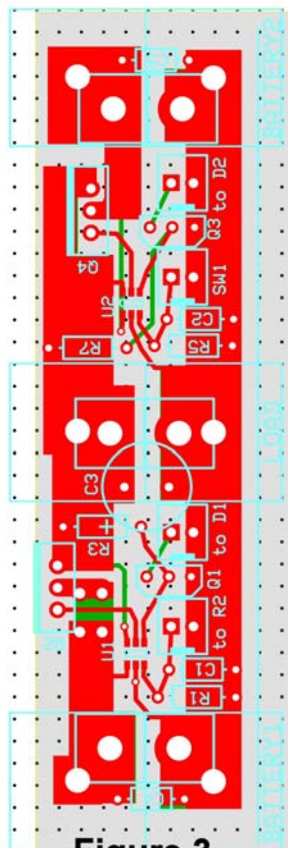


Figure 3

Improvements

The measured voltage drop really wasn't good enough – one of the goals was to run the IC-706Mk2g more reliably from batteries, and it draws around 20 amps at full power. Better FETs were needed, but I had already used the FET with the lowest ON resistance available from DigiKey. A short search located the a better FET – the Vishay/Siliconix SUP75P05 from Mouser Electronics (www.mouser.com), rated at 0.008 ohms. I ordered a few and replaced the FETs in the battery-sharing switch. Now the voltage drop is about 100 mV at 10 amps and 200 mV at 20 amps – much better, and significantly lower drop than a simple diode box. In fact, this is less than the voltage drop through a 6-foot jumper cable of #12 wire – voltage drops add up quickly at high currents.

The next improvement was an under-voltage indicator. I took this a step farther, and squeezed in a multi-color LED status indicator board. Now I can see at a glance not only which battery is active, but the status: green for well-charged, yellow for marginal, or red for nearly dead.

Another potential enhancements might be battery-charging circuit. I would wire the switch so the disconnected battery would be recharging if AC power were available – maybe I'll build another this way. Bigger FETs with lower ON resistance could reduce voltage drop even further.

Summary

With this switch and warning system, I can notice a low battery and swap it out without shutting down, before the voltage gets low enough to cause problems. The simple LED indicator provides the warning without requiring a lot of attention.