Homebrew PowerSwitch/SmartCharger Project Success

Inexpensive project suitable for important radio assets / club projects

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For more reliable battery-backup of 24/7/365 radio assets, an inexpensive MOSFET-based automatic switch between AC-powered radio power supplies and battery backups, but also providing "smart charging" of the backup battery, has been successfully designed and prototyped.

My previous method for battery backup of important radio assets (AX.25 digipeaters/nodes, RMS servers) was a combination of large 12V batteries feeding the radio/computer asset, and an over-taxed smart battery maintainer operating continuously to recharge the battery. An uninterruptible power supply for AC backup is optional. This works, but is continuously *using the backup battery*, reducing lifespan. The PowerSwitch/SmartCharger allows a typical ham radio 13.8-14.5VDC power supply to power both the radio, and keep a backup battery at optimum charge, and then almost instantly switch back and forth, if there is any disruption of the AC supply. This system could also serve simply as a smart battery charger for any of multiple types of batteries.

SPECIFICATIONS

Battery types supported	12-14 VDC batteries including: • Flooded lead acid (e.g. lawn tractor of deep cycle battery) • Sealed lead acid • AGM • LIFEPO4 with proprietary external charger (Bioenno) • LIFEPO4 using PowerSwitch/SmartCharger as the charger (Bioenno)
Battery Capacities supported	5-50+ Amp-hour (practical limit is probably 100 Ahr)
Radio power supported	High-power MOSFETS with channel resistance of < 7 mOhm utilized: Vishay SQP90P06-07L_GE3 rated at up to 120A https://www.vi shay.com/docs/62665/sqm90p06-07l.pdf • ***Builder-choice of capacity (by size of heat sink chosen) to greater than 40A.*** Modest heatsinks easily allow 20-30 Amps (see construction manual) • Optional relays can be added to further reduce voltage loss / increase power • 10A capacity without any heat sinks at all
Switching speed	Battery and AC-based supply voltages are tested every 50 milliseconds (20Hz sampling speed) Software adjustable
Setting battery type / capacity	Choices entered by setting trimmer potentiometers at power-up; adjustable during any power-up. Display shows adjustments.
Smart Charger	Current-controlled, pulse-width modulated, voltage guided charging

	Includes proper support for LIFEPO4 to avoid long term damage that would occur from inappropriate currents / voltages. Provides necessary trickle charging for lead-acid types. PWM frequency does not appear to cause RF hash.
Low Voltage Cutoff	Software adjustable; default settings are 11.0 VDC for lead acid chemistries; 12.0 VDC for LIFEPO4 (designed to avoid activating battery management systems. Optimized for Bioenno brand.)
Current monitoring	Circuit monitors both battery current and radio current using simple 12” #14 AWG current shunts in negative leads.
Software	Simple Arduino C-code can be edited or maintained by amateurs. GNU GPL Version 3 license, copyleft.

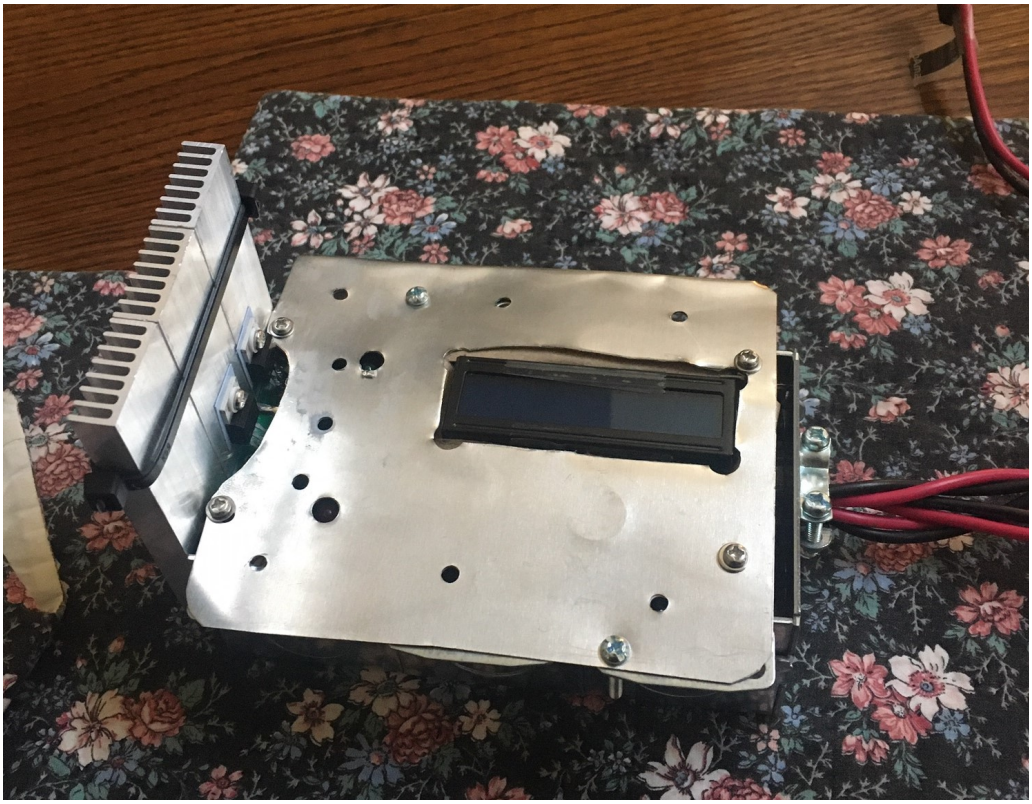

Figure 1: Prototype #2 suitable for currents in the 30-40A range.

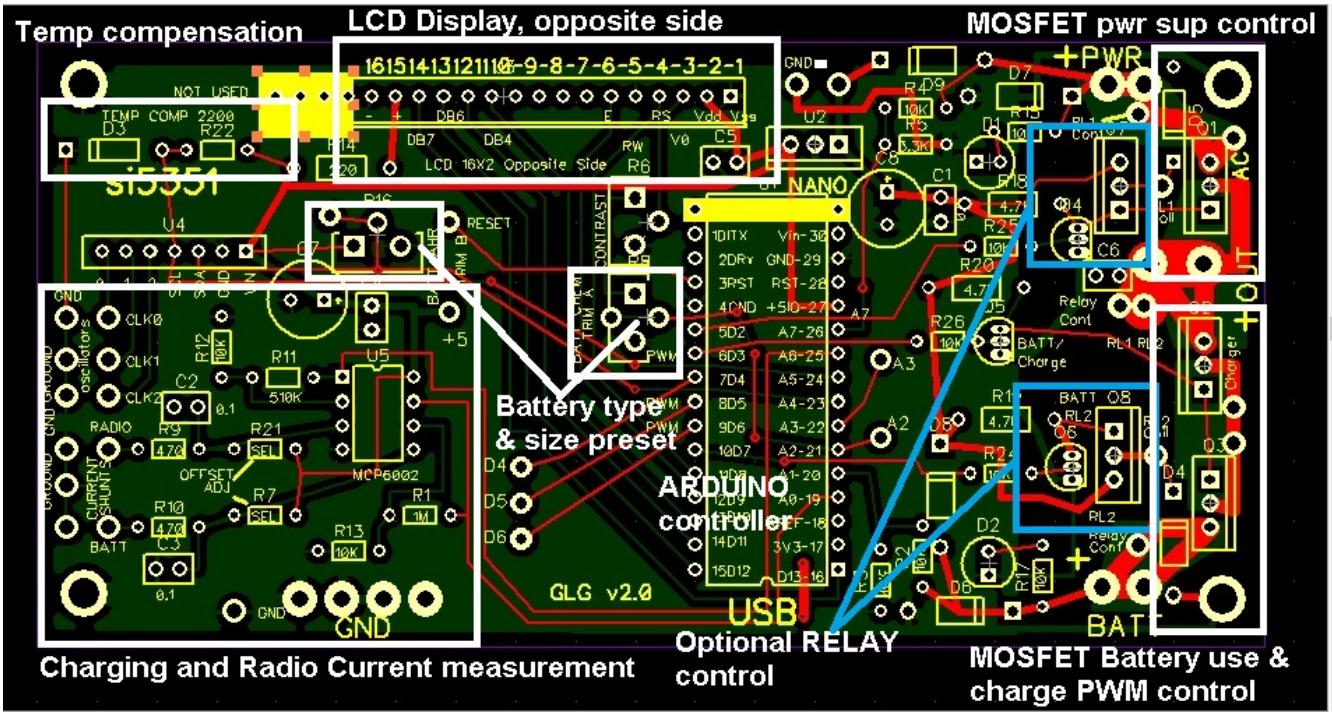

Figure 2. Modular portions of printed circuit board..

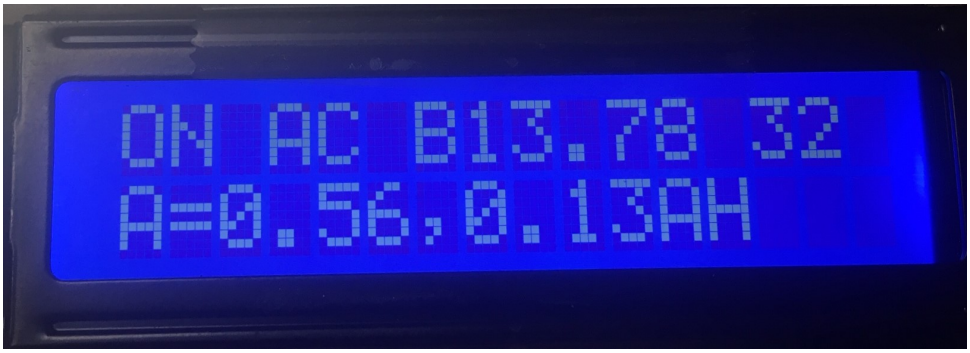

Figure 3. Example of Screen Display.

Explanation of Display

ON AC	Radio is powered by AC-based supply
B13.78	Battery voltage is 13.78VDC Note: On 10 second intervals this automatically reports the AC based supply output voltage in the same position
A=0.56	Battery is being charged with 0.56 Amps
0.13AH	Battery has so far absorbed 0.13AH since charging began
32	Pulse width modulation is 32/255 duty cycle

In addition to the illustrated display variables, the screen can display warning flags and accumulated discharge information.

This project has freely available Gerber files for printed circuit board fabrication by inexpensive Chinese fabricators, a complete bill of materials, and a construction/operation manual. Estimated cost for a single construction of the electronics alone is under $35. Similarly qualified commercial systems are available in the $150 range.

Enclosure: The cost of the "box" for projects like this can easily overwhelm the project cost. This design was made to fit inside three ganged inexpensive electrical outlet boxes, by simply removing screws and connecting boxes. (e.g. https://www.homedepot.com/p/3-in-x-2-in-Gangable-Switch-Electrical-Box-Plaster-Ears-8500/100548372 $2.44 ea.) Aluminum roof flashing (available inexpensively in long rolls) can be used to make the "front panel" and can be easily shaped with tin-snips or even toenail scissors; drilled to allow attachment to standoffs to hold the printed circuit board to the flanges of the electrical box. One 10-foot flashing roll ($7) will handle an entire club. (https://www.homedepot.com/p/Amerimax-Home-Products-10-in-x-10-ft-Mill-Finish-Aluminum-Roll-Valley-Flashing-68310/100054269) More expensive extruded metal or plastic enclosures can certainly be used. The construction manual will give suggestions for adequate heatsinking for different levels of intended maximum current. To accommodate larger heatsinks, one end of the electrical boxes is easily removed by one screw.

Measurements & protections: The hardware design includes transient over-voltage suppression diodes. To protect the power supply against over-draw, battery charging is automatically inhibited during periods of high radio current draw. Battery and AC-based power supply voltages are accurately measured and displayed. Battery charging current / accumulated charge is measured at 10 second intervals. As radio usage is highly irregular, accumulated discharge current measurement is approximate due to 10-second current samples. Project code exceeds 1000 lines, and is event-based with multiple time-based interventions, and includes watchdog re-start timer protection.

URLs for Free Resources

Zipped Gerber printed circuit board files suitable for direct submission to PCB fabricator such as pcbway.com	https://qsl.net/nf4rc/2020/TopSilk.zip
Bill of Materials	https://qsl.net/nf4rc/2020/BillofMaterials.pdf
Current version of software (GNU GPL license for freely available usage) as a zip file. Arduino IDE may be freely downloaded here: https://www.arduino.cc/en/Main/Software	http://qsl.net/nf4rc/2020/BatteryBackupVer2.0.zip (Internal version at time of this writing is 2.004)
Construction manual (current version)	https://qsl.net/nf4rc/2020/FinalPowerSwitchManual.pdf

Persons interested in using this for a club project or asset protection are welcome to contact the author for further information at docvacuumtubes@gmail.com