TITLE: Waggin' Them Volts Around (or, Another Volts-Waggin')

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In the past month, I've had no less than a dozen requests for some way of powering a "battery" powered device in the airplane. That's understandable; I write this in late January, and I'll betcha those Christmas goodies you got under the tree have gone through a couple of sets of batteries by now. Not only are batteries relatively expensive, but even if you use rechargeables, losing your GPS in the muck because of a dead battery isn't my idea of a fun day. There are much better ways of getting lost than this.

The problem, of course, can be resolved relatively simply by using the good old panel mounted aircraft supply plug that we showed you how to make and install in the July '99 Kitplanes® (and reprinted for your convenience at the author's Kitplanes website www.rstengineering.com/kitplanes). Absent this little goody on your instrument panel, you can certainly use the old standard cigarette lighter plug adapter method to get at the aircraft battery supply.

Of course, the aircraft supply is 12 volts and most of the battery-powered stuff is somewhere between 3 and 9 volts (2 to 6 cells at a nominal 1.5 volts apiece). And, since I can't tell right up front how much voltage your particular unit will require, I'll just have to give you a design that will take the 12 volt battery (anywhere from 12.5 to 14.5 volts) bus and regulate the voltage down to anything you set from 0 to 10 volts. Regulated to a fare-thee-well and very "clean" as far as noise goes (the better to simulate the near-noiseless battery).

In keeping with our time-honored policy of KISS and BURP (Keep It Simple Simon and Build Under Required Price) we bring you the very latest in rock-simple design that will give you the voltage you set (0 to 10 volts) at any current you wish up to half an amp (500 mA). A real state of the (1960s) art design, but one that is easy to construct and use.

We'll even throw in a simple overcurrent sensor and limiter for the price…not bad for 5 bucks worth of parts including chassis box. Let's get started.

The fundamental regulator itself is referenced to a 5-volt zener diode (D102). A fraction of this 5 volts is selected by adjusting R101 and is then applied to the (+) input of U101A. The output of U101A is used as the base drive to emitter follower transistor Q101. Whatever the output voltage of U101A is, the emitter of Q101 is exactly 0.6 volts less. This emitter voltage is fed back to U101A through voltage divider R112 and R111. This voltage divider is set up to divide the emitter voltage (which is also the output battery voltage) by just a little less than 2. Thus, if the output is, say, 6 volts, then the (-) input of U101A is a little less than 3 volts.

Let's presume that we've set the voltage adjustment pot R101 to 4 volts at the (+) terminal of U101A. When the voltage divider applies the correction voltage to U101A (-) terminal, the U101A output rises to make the (+) and (-) terminals equal. In this case, the output voltage will rise to a little more than 8 volts, be divided down to a bit less than half of 8 volts, and is then compared to the voltage on the (+) terminal. If it is too low, the output rises. If it is too high, the output decreases. No matter what load you put on the output (right until the limit point is hit) this comparison of output voltage to reference voltage continues and the output voltage is thus very well regulated.

If we were to stop here, Hamhand The Screwdriver Man would have a real good shot at destroying the circuit should the output (X104) be shorted to ground. U101B is set up to keep this from happening.

There will be a voltage developed across R115 that is proportional (Remember Brother Ohm?) to the current being drawn from the output. When there is a small current being drawn by the load, the voltage drop across R115 is low, and the resistive voltage dividers R103-R106 sense this voltage drop and set the levels of the (-) and (+) inputs of U101B so that the output is very near ground (zero volts). When current is drawn by the load, the voltage drop across R115 increases. When it gets to a preset point (about 700 mA) all of a sudden U101B output jumps from zero to near battery voltage (12 volts). When this happens, the voltage turns on "Overcurrent" LED D103 and also turns on Q102 through R102.

When Q102 turns on, it "robs" the U101A (+) pin of all voltage and thus turns off U101A. Turning off U101A also turns off Q101 and lowers the current to the maximum value of 700 mA and no more.

Recognizing that a short-circuit proof regulator is only intended to prevent inadvertent shorts and not a continuous draw of overcurrent, I did not provide a heat sink for Q101 nor did I increase the wattage of R115 to withstand anything more than a few seconds (10-15 seconds or so) of short circuits. I also deliberately ran R115 close to its ratings so that if a short occurs, R115 is likely to open if the short persists. Call it a fuse, call it a sacrificial component, call it what you will. The half-cent resistor is going to keep the fifty cent transistor from overheating with a continuous direct short circuit.

Knowing that, if you are going to make a pc board for the unit (the layout is available at the RST Kitplanes website at www.rstengineering.com/kitplanes -- see the later note below) you should mount R115 off the board by a tenth of an inch or so to keep the board from blackening should the resistor burn.

QUESTIONS FROM THE AUDIENCE --

Q. How do I make it run on a 24/28 volt airplane?

A. Increase R108 to 1200 ohms, increase R110 to 1000 ohms. That should do it.

Q. Why are you throwing away those two amplifier stages. Couldn't you use a two-section op-amp?

A. Yes, the LM358 (and a whole slew of other 2-section op-amps) would do. This particular one is a Rat Shack off-the-shelf part.

Q. I want to use other color LEDs.

A. Use other color LEDs. The resistors (for a regular LED) won't change unless you want to use blue or white.

Q. My intercom hums. What do I do?

A. Teach it the words.

Q. You said something about PC boards. How do I get one?

A. There are several ways for you to get a PC board to make this circuit. First, let's talk about the files I use to lay boards out. These files are done in a combination program called "Circuitmaker" for the schematics and "Traxmaker" for the actual pc board layout. You can get a free downloadable copy of this program at

www.circuitmaker.com. Download the time-limited professional version as the student version is way out of date.

Now that you have the program, you can download the .ckt (schematic) and .pcb (circuit board layout) files from the www.rst-engr.com/kitplanes website. There are a few ways to use these files to make your own pc boards:

1. You can print out both positive and negative artwork on a laser printer on a sheet of transparency material and do photo masters directly on the transparency.

2. You can export "Gerbers" and "NC Drill" files for any pc board manufacturer you wish. If you choose to use Olimex (www.olimex.com) in Bulgaria, you can get four boards completely made in a week for about $34 including shipping. You don't even have to send them the Gerbers. I will make arrangements for you to use the files I've already sent him for the prototypes. If there are four of you making the project, this is about $9 apiece, which isn't all that bad for small quantities. Tsvetsan (the guy that runs the place) is a real nice fellow to do business with. Just tell him you want the RST Engineering KP0205 pc board.

3. You can send the Gerbers to any other pcb manufacturer and get boards. The only caveat is that the boards are copyright and you can't sell them for a profit. However, for your personal use and the use of anybody you want to split the actual cost with, please be my guest.

That be it for this month; next month we start the 3-part series on engine warmers -- and if you start building them this summer, they will be ready and waiting for next winter…see you all next month.

Author's Note: Jim Weir is the chief avioniker at RST Engineering. He will be glad to answer avionics questions for this article or on any avionics subject in the Internet newsgroup rec.aviation.homebuilt. If you are having trouble with newsgroups, go to www.rstengineering.com and click on the "How To Use The Net" link.