Housing for Electromagnetic Sensitives — Electrical

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There are numbers of us who are physically impacted by various aspects of electromagnetic fields. Cell phone and other wireless applications in the GHz range are perhaps the most common, but VLF (Very Low Frequency) magnetic fields are also problematic. How should housing be built to accommodate these Sensitives?

The ElectroMagnetic Sensitivity Research Institute (EMSRI) is being formed to address many of the issues that Sensitives must deal with, one of which is housing. Land has been acquired in the town of Rockvale, Colorado, a box canyon (locally known as a gulch) where incident electromagnetic fields are relatively low. There is space for perhaps 25 to 50 housing units (cabins, apartments, condos, or houses).

The advantages of electric lighting, heating, cooling, and Internet access are such that it is not reasonable to expect a return to the days before electricity. We must assume that it is possible to electrify dwelling units in such a way that the negative health effects are minimal. This may involve adjustments to the National Electrical Code and the Building Construction and Safety Code, a long and possibly contentious process. We do not want to enter the permitting process for a major construction project without some experience with the proposed electrical techniques.

For financial and practical reasons, it has been decided to gain this critical experience by placing an old camper on the property to serve as an experimental facility. It is not uncommon in this part of the world for people to buy an acreage with a view and put a camper on it. As long as the camper is off grid, not used for all-year housing, not involved with illegal activities (e.g. growing marijuana), and not a nuisance to the neighbors, the authorities tend not to get involved. The remainder of this document will deal with the experimental results of various electrical concepts implemented at the camper.

The camper is a 1977 Coachman Cadet pull-type, nominal length 23 feet. It was purchased for $2800 in April, 2012, from Wendell Franklin, who pulled it to the bottom of the gulch with his SUV. The wheels were removed and put into storage. This reduces the damage to the tires from UV light, and also reduces the step height into the camper. The inside dimensions are approximately 19 feet long by 7 feet wide. The front portion contains a table, two bench seats, and the entry. The middle portion consists of a narrow aisle with propane stove, sink, and cabinets on one side, and toilet area and refrigerator on the other. The rear portion contains a standard mattress on a platform over a water holding tank.

Electrical testing will be performed all year, but the camper was not intended to be used in temperatures below freezing because of the exposed water lines and tanks. It was therefore decided to not use the water lines and tanks at all. The flush toilet was removed and replaced with a composting toilet. This type of toilet will be evaluated along with the electrical aspects to see if it might be acceptable (smell, convenience, etc.) in the housing units to be built later. Water tends to be scarce and expensive in this desert, and septic systems are not cheap, so the use of composting toilets would reduce both initial and operating costs.

Commercial electric power and city water are available at the entrance to the property. The driveway to the location of the camper is then about 1750 feet long, cut into the side of the gulch. It would be technically possible to put in a long extension cord to power the camper, but rather expensive, and of concern because of the 60 Hz health effects. It was therefore decided to make the camper electrical supply totally off-grid. For a relatively light load, the economics strongly favor photovoltaic panels and lead-acid batteries. The next decision is the voltage level: 12, 24, 36, or 48 VDC.

The lowest level has the advantage of being the most common of the four choices. The recreational vehicle industry has developed a good variety of equipment that operates on 12 VDC, at acceptable prices. The problem is a relatively low efficiency. To get the same amount of power, the current at 12 VDC is twice the current at 24 VDC. The resistive losses are proportional to the square of the current, so for the same size wire and the same power, the wire losses at 12 VDC are four times as large as at 24 VDC. To keep the wire losses the same between 12 and 24 VDC, one would need to use wire at double the diameter or four times the area for 12 VDC. This can easily get prohibitively expensive. This factor has caused a shift toward the use of 24 VDC for higher power levels for a number of years. Light bulbs and motors are readily available at 24 VDC.

The argument about efficiency suggests that we should immediately go to 48 VDC (or higher). However, other economic factors must be considered. An off-grid cabin would require twice the number of photovoltaic panels and batteries at 48 VDC, compared with 24 VDC. This increases the initial cost substantially, probably far more than the savings from using smaller copper wire. We need to find an optimum point for the overall system, where power needs are adequately met at minimal initial and operating costs. One way of determining this optimum point is to build and test a 24 VDC system, such that cost and performance are well documented, and then theoretically extrapolate to higher voltages. If the 24 VDC system has acceptable performance at acceptable cost, then we would not have a strong incentive to go to a higher voltage. But we cannot know that until we fully evaluate a 24 VDC electrical system.

It should be noted that the power industry is taking a close look at 24 VDC distribution within buildings for economic and technical reasons. It is called a 24 VDC Microgrid. A Google search will reveal a paper by the Electric Power Research Institute on this topic. The website for the manufacturers involved is www.EMergeAlliance.org. The basic concept is the following. Power would continue to be delivered to a house or commercial building by AC, but would be converted to 380 VDC before entering the building. The 380 VDC would be used for washers, dryers, air conditioners, stoves, and battery charging of electric vehicles. There would be a 380 to 24 VDC converter to supply power to TVs, computers, other electronic loads, and LED lighting at 24 VDC. Manufacturers would have to modify their equipment to operate on either 380 or 24 VDC. In mass production, the cost of major appliances would be about the same as today while the cost of electronics should decrease slightly. The power quality seen by the neighbors and the utility would increase dramatically. Overall efficiency of electric usage would increase by as much as a few percent, due to the elimination of all the relatively inefficient 'bricks' that convert 120 VAC to whatever DC voltage is required by a particular electronics device. Integrated over enough buildings, this improvement in efficiency means that fewer new power plants need to be built, at a substantial saving to the utility (and to the ratepayers). The economic benefits of this shift are strong enough that it will probably happen regardless of any health benefits.

There are two options for the power source for the dwelling units: photovoltaic panels and batteries for each unit, or a 240 VAC to 380 VDC converter at the entrance to the property and a 380 VDC line to the units. Each unit (or a small cluster of units) would have a 380 to 24 VDC converter. The latter option would probably be less expensive and certainly more reliable during long periods of cloud cover, and would also open the possibility of funding from the power industry for research into 24 VDC Microgrids. We might explore the idea of powering the dwelling units closer to the entrance from the 380 VDC line, and the units further into the gulch from photovoltaic panels and batteries, but with the option of backup during long cloudy periods.

We continually experience quasi constant fields near the earth's surface. In fair weather the electric field is usually near 100 V/m, directed down. The magnetic field near the gulch is about 500 milligauss, measured with a Walker Scientific fluxgate magnetometer FGM-301. In bad weather, the electric field may be hundreds of V/m, directed either up or down. It can reach thousands of V/m during lightning storms. Variations in the magnetic field are much smaller, less than one percent. For either the electric or magnetic field, variations are much slower than the 60 Hz variations we experience with utility power. Wiring at 24 VDC would be expected to produce electric fields less than a few V/m and magnetic fields less than a few milligauss. If these fields are 'clean', without superimposed fields at 60 Hz and higher, it would be *extremely* surprising to experience any negative health effects. Power from a 24 VDC battery bank, without utility connection, should be in this category.

Power from a 240 VAC to 380 VDC converter, or a 380 to 24 VDC converter, will be less clean than power from a PV panel and battery bank. There will be fields at multiples of 60 Hz and also at the kHz frequency used in the converter. Filtering out the 'dirty' portion of the power will be a topic of research at EMSRI. There are no obvious technical barriers to making fields from the 380 and 24 VDC lines 'clean enough' for use by Sensitives.

Initial research at the 24 VDC level will be done with PV panels and lead acid batteries. This will be much cheaper than converters and a long 380 VDC power line for a single camper. It will also eliminate any possibility of 'dirty' electricity sneaking in from the local utility.

Photovoltaic Panels

The PV panels used on this project are two of the Sharp ND-130UJF modules. They were purchased from Dave Sampson, Oak Grove Fabrication, 15221 Schmedemann Rd., Alta Vista, KS 66834, (785) 499-5311 in December, 2008 and drop shipped to Cañon City, CO, for a different project. The nominal maximum power is 130 W (each) at a nominal operating voltage of 17.4 VDC and a nominal operating current of 7.5 A. The open circuit voltage is 21.9 V and the short circuit current is 8.2 A. These values are guaranteed to within $\pm 10\%$ for new panels under standard conditions of irradiance of 1000 W/m^2 and panel temperature of 25^{o}C. Solar irradiance above the earth's atmosphere is about 1350 W/m^2. Some rays are absorbed by water vapor and other atmospheric gases such that 1000 W/m^2 is about the best we see at sea level. The test camper is located at about 5400 feet above mean sea level, and the relative humidity is low (sometimes in the single digits), so we may see peak irradiances of 1050 W/m^2 or a little more on some days.

Panel power production degrades with panel age and with increasing panel temperature. And of course, it decreases as $\cos\theta$ where θ is the angle between the normal to the panel and the direction to the sun. All these issues must be considered in any calculations of power and energy from a given set of PV panels. But for our research on electrical health effects, these are not the most important issues. We need a modest amount of 'clean' electricity for testing purposes. If two panels are not enough, we will buy more panels.

A back-of-the-envelope calculation for expected energy production is obtained by assuming full sun for 6 hours per day, and no sun for 18 hours. The daily energy production is then (130 W)(2 panels)(6 hours) = 1560 Wh or 1.56 kWh. We should be able to execute tests using between 1 and 1.5 kWh each day.

Each PV panel is mounted on a 15 ft length of 2 inch steel pipe. A hole is dug with an old 8 inch hand auger to a depth of 30 to 36 inches for each pipe. The two pipes are cross braced with two lengths of aluminum angle and inserted into the holes. The pipes are braced in a vertical position and 120 pounds of premixed concrete is poured into each hole. The panels are then installed at the top of the pipe with U-bolts and a home made frame of aluminum angle and piano hinges that allow for a seasonal adjustment of panel angle. Mounting and wiring are done from a ladder leaned against the lower aluminum cross brace (more secure than a ladder leaned against a vertical pipe). The ladder is removed from the test facility after installation so thieves must bring their own ladder to steal the panels.

The driveway to the research property starts only a few feet from the driveway to the home of a prison guard, who has a wife, five children, and a collection of surveillance cameras. Trail cameras installed along the driveway will record activity day and night. The research area is open to hikers and neighborhood children. (This gulch has been a playground for Rockvale children for over a hundred years.) The result of the electronic and live surveillance is to make it unlikely that theft will be a major problem.

Electrically, the two panels were connected in series to form what might be called a three-wire ± 12 V system. The three wires (12 gauge stranded copper) were brought down one pole in half inch plastic conduit. A fourth 12 gauge stranded copper wire was connected to the aluminum frame of each panel, brought down the pole in the same conduit, and connected to two 5/8 inch copper plated ground rods, 10 feet long, driven full depth into the earth about 10 feet apart, near the poles. Earthing the panels is done for safety reasons and is required by the National Electrical Code. This was done under the supervision of a local licensed Master Electrician.

Batteries

Four Trojan 105RE deep cycle lead acid batteries were purchased from Royal Gorge Truck & RV in Cañon City on Sept. 12, 2012, for $171.95 each. These are 6 V batteries that weigh 67 pounds each. Connections between batteries were fabricated by soldering copper lugs onto the ends of short sections of 6 ga copper wire. These copper lugs were then bolted to the battery lugs with 5/16 bolts. If we decide to use PV panels and batteries for several cabins, we should measure the voltage drop across these jumpers at maximum current flow and do a cost/benefit study of using 2 ga or larger copper wire.

Battery performance degrades with decreasing temperature, and it is possible to damage batteries by freezing. Batteries can also be damaged by overheating. If batteries can be kept in a space that stays within the temperature range of 50^o to 100^oF we would expect satisfactory performance and a reasonably long life. It was decided to build a vault at the base of the PV panel poles to house the batteries. A pit about 2 feet deep was dug. Three layers of light weight concrete block, nominal size $8 \times 8 \times 16$ inches, were placed around the perimeter of the pit, without mortar. Three block were laid in a north-south row. The fourth block was turned 90^o, making the effective length of the side 3.5 blocks. The same pattern was used for the east-west row except four blocks in a row instead of three. The nominal outside dimensions of the concrete block structure was then $56 \times 72 \times 24$ inches.

Concrete was then poured into the web openings at the four corners and the center of each side. Concrete anchor bolts were placed in the wet concrete to hold down a 2×8 around the top. A 2×4 was installed on top the 2×8, with the outside dimension of 4 feet in the north-south direction. The roof for the vault was then fabricated from a 4×8 ft sheet of 1/8 inch aluminum, sheared to about 64 inches long. A skirt of 1.5 inch aluminum angle was fastened to the aluminum sheet with small bolts, such that it would extend downward around the 2×4 frame. Hinges were placed at one end and a lift handle at the other so the roof could be raised to allow access to the vault.

The final step in vault construction was to insulate it with 1.5 inch Bluboard to a height of about 20 inches above the bottom. Then three pieces of this insulation were glued together to form a plug that could be dropped into the vault and rest on top the Bluboard mounted to the vault sides. The batteries rest on the soil at the bottom of the vault, about 2 feet below grade. The soil acts as a heat source or heat sink to maintain the vault temperature relatively constant. A Taylor indoor/outdoor thermometer was installed with the outdoor sensor taped to the top of a battery and the sensor wire ran to the outside of the vault to a separate protective enclosure for the thermometer. The thermometer has max/min storage for the previous 24 hours. The maximum and minimum vault temperatures will be recorded during the course of this research to see if this type of vault construction is adequate.

The cost of materials for the vault was over $400. Time for construction was on the order of two days. The final result is sturdy, has a nice appearance, and has ample room for the four batteries and a person working on them. But if we decide to use PV panels and batteries for several cabins, we should look for prefab vaults, to see if a commercial product would be cheaper and quicker to install, and still give adequate performance.

Electrical access to the vault, in from the PV panels and out to the camper, is by plastic conduit. Two of the concrete block on the top layer of the vault had access ports chipped out before the concrete was poured down the web openings. The conduit from the PV panels was properly sized at 1/2 inch. The conduit to the camper was 3/4 inch, which allowed the wires to be pulled to the circuit breaker box (barely!). It should have been at least 1 inch conduit! Site grade was close to the top of the concrete block, so the conduits were buried a few inches deep.

A solar charge controller was installed in the vault and the input connected to the nominal 24 VDC of the two solar panels in series. The controller output was connected to the ends of the battery chain. The controller is the 10 A MPPT Tracer 1215RN, purchased on ebay for $99.95. It functions on either a nominal 12 or a nominal 24 VDC system to properly charge the batteries. It shifts the voltage applied to the batteries during charging to maximize the charge rate, detects when the batteries are fully charged, and maintains them at this level with a float charge. A direct connection of PV panels to batteries would result in overcharging under some conditions. This produces hydrogen and oxygen gases from battery water, undesirable for several reasons.

The controller contains transistors switching at frequencies between 30 and 80 kHz during operation. This is obviously of concern to Sensitives in the vicinity. Direct radiation from the controller should be minimal because of the aluminum roof on the vault and the earth around the vault. The batteries act as massive capacitors to filter out these signals, but it is conceivable that some would leak into the camper over the wiring during daylight hours. At night, when the controller is not operating, the battery voltage should be very clean. Like many other items, we will try to investigate the controller to see if it actually causes any negative health effects.

The controller has an Ethernet port and an inside display that displays information like battery voltage, charging current, and controller temperature. An Ethernet cable was pulled through the conduit with the rest of the wiring and RJ45 plugs installed at each end.

Circuit Breaker

Circuit breakers for AC depend partly on the fact that the AC voltage goes to zero twice per cycle, to help interrupt a fault current. There are circuit breakers specially designed to interrupt DC faults, which are more expensive than AC breakers for a similar current rating. There is at least one major manufacturer with a line of breakers that are rated for both AC and DC. This is the Square D company QO line. The QO breakers are rated to interrupt 250 VAC *or* 48 VDC at a given current. The search for DC circuit breakers stopped at this point, so it is not known what other manufacturers might have. A box with space for four double pole breakers was purchased. A 30 A double pole breaker was used as the Main breaker. Two 20 A double pole breakers were installed in the box, one for lighting and the other for the evaporative cooler.

The box was mounted on the outside of the camper at eye level. A 2 inch diameter knockout on the back of the box was removed and a hole made in the wall of the camper into the rear of a small closet. The interior display for the charge controller was mounted on the kitchen side of the closet. The thermostat for the evaporative cooler was mounted on the bedroom side of the closet, and a conduit ran back outside the camper to the cooler.

The box and the metal siding of the camper were electrically connected to the two ground rods. At this time, the battery chain is floating with respect to ground. If a jumper were placed from the midpoint of the four batteries to ground, we would have a ± 12 V system. If the jumper were moved to the most negative terminal, then we would have a 0 to $+24$ V system. In the latter case we can supply power to a 24 VDC load through a single pole breaker. In a floating system we are somewhat restricted to double pole breakers. It is unknown at this time whether the floating or the grounded system would be better, so we will keep our options open.

Lighting

The camper had half a dozen small overhead light fixtures wired to operate on 12 VDC with incandescent bulbs. These bulbs were replaced with 24 VDC incandescent bulbs of the same physical size and the camper wiring jumpered to the circuit breaker box. This was certainly quick, easy, and inexpensive. However, the resulting light is a bit dim, and certainly inefficient compared to the newer LED lights. So the investigation started on availability and performance of LED lights.

Light Emitting Diodes (LEDs) are inherently DC. Current only flows one way through a diode. Depending on the technology used, current will start to flow, and some light produced, at a voltage between 2 and 3 VDC. Full light production will occur somewhere between 3 and 4 VDC. We would therefore need 6 to 8 LEDs to be connected in series to work properly on our 24 VDC system. A search of Home Depot, ACE Hardware, and the Internet failed to reveal any LED packages built for 24 VDC without additional electronics. There were packages rated for input voltages of 8-30 VDC which had a DC to DC converter built in, which would accept the 8-30 VDC input and convert it into a constant 10 VDC output. The 10 VDC would then be applied to a chain of 3 LEDs in series. A number of these chains would be connected in parallel to get the desired light output. The converter would typically operate in a pulse width modulation scheme at frequencies between 30 and 80 kHz. Our research on health effects requires an absolute minimum of time varying fields, which immediately excludes such packages.

A search on ebay revealed a package without electronics and of an entirely different form from the incandescent and fluorescent lights that we are accustomed to. LEDs were mounted on a flexible plastic strip in which thin copper conductors were buried. The strip was 5 meters long, with LEDs mounted at the rate of 60 per meter, for a total of 300 LEDs on the strip. Slick paper on the back protected an adhesive layer, which allowed the strip to be mounted directly on the ceiling. Nominal voltage rating was 12 VDC. Different color temperatures were available. Six strips of warm white (2500 to 3000 K) were ordered at $9.82 each, which included shipping from China. Upon arrival it was determined that there were 100 chains of three series LEDs each, connected in parallel on each strip.

The exposed ceiling length in the camper is slightly over 5 meters. Two strips were mounted down each side of the aisle. Each pair was connected in series at the supply end to get to the nominal 24 VDC rating. The adhesive was not strong enough for this particular camper ceiling, so other adhesives were used (liquid nail, etc.) to keep the strips up in place. Detailed testing is yet to be done, but the first impression is that this is a good way to do lighting. Light levels are much more uniform than with the concentrated sources presently used. If the illuminance is not adequate, one simply installs another pair of strips.

Computer and Monitor

We are hopeful that it will be possible to have computers, monitors, and Internet access in our housing units with minimal impact on our health. Internet access to the camper will probably required the installation of an optical fiber along 1750 feet of driveway. This is down the list of priorities, such that it will not happen for several months or more. In the meantime, a computer and monitor can be used for word processing and watching movies on DVDs, as well as just gaining experience about off-grid computer usage.

Within the community of those sensitive to EMFs, there seems to be a wide variation in reaction to specific devices. Some computers, and some monitors, seem not to cause bad reactions, while others produce immediate reactions. At the moment, it seems necessary to buy and use a particular device to discover what reactions, if any, that it produces. We have purchased a 12 VDC computer and a 12 VDC monitor, more or less at random, as discussed later. If it turns out that they cause a reaction, we will test to try to determine what specifically is causing the problem. If not, we will enjoy the normal computer usage.

Computers internally run on 12, 5, 3.3, and perhaps other DC voltages. Laptop batteries are often rated at about 12 VDC. But laptop batteries need to be recharged after a couple of hours of usage, hence laptops are not the obvious solution to our off grid needs. It seemed intuitively obvious that there is a market for computers that would operate directly from a cable to a cigarette lighter for those people who will be in a car for extended periods away from 60 Hz power. But obvious seems not to work in this case. The standard solution for operating a laptop with a 12 VDC internal battery in a car is to buy an inverter, convert the car 12 VDC into 120 VAC, plug the 'brick' for the laptop into the inverter, and invert the 120 VAC back down to 12 VDC. This increases both the initial cost and the losses for operating a 12 VDC computer on a 12 VDC supply, in what seems to be a totally unnecessary practice!

A rather extensive Internet search revealed only one company in the world that assembles, tests, and sells a computer rated at 12 VDC and intended for off grid applications where minimal power consumption is critical. The company is Aleutia, located in London, England. Their T1 Fanless Eco PC was purchased on Sept. 9, 2012. The computer operates on input voltages between 10 and 19 VDC. A 12 VDC battery in a PV system will have voltages between perhaps 11.5 and 14 VDC. The nominal 24 VDC of our system will need to be reduced to a voltage in this range. This is simple to do if tight voltage regulation is not required.

The base price for the T1 is $286. A 60 GB solid state drive was added for $120, 2 extra GB of RAM for $16, and a USB Slimline DVD-RW Drive for $48. Aleutia would install the Ubuntu 12.04 LTS operating system (64 bit) for $24. The default browser would be Mozilla Firefox and the default email would be Mozilla Thunderbird, already being used on all of Dr. Johnson's computers. The alternative operating system would be Windows 7 Home (32 bit) for \$160. The cost difference of \$136 could not be justified for this application, so Ubuntu was installed. The total cost of the computer, including \$56 shipping, was \$539. The processor is the Intel Atom CPU D2700 at 2.13 GHz $\times 4$.

Performance of the T1 to date has been good. It is very quiet, with no fan and no hard drive. Power consumption is very close to the advertised 12 W. The boot time, from total shut down to fully operational, is about 30 seconds, substantially better than the Windows computers of our experience. There are two monitor ports, a VGA Display Port and a HDMI Display Port, that both support a maximum resolution of 2560×1440, and can operate at the same time. There are 6 USB ports plus a port that can be used by either the keyboard or mouse. There are options for wireless. In short, it appears to be an adequate computer at a reasonable price.

The next step was to find a monitor that also operated on 12 VDC. Like computers, this is not a feature considered to be of interest to potential customers, so it is difficult to find the information by Internet search. Eventually, it was discovered that at least some AOC monitors used 12 VDC input. The AOC e2343FK monitor was selected, and purchased from TigerDirect for \$149.55, including shipping. This is a 23 inch widescreen LED monitor, with 1080p display, 1920×1080, 16:9, 5 ms, 60 Hz, 50,000,000:1. There are ports for both DVI and VGA cables, the same as the T1 computer.

Both the computer and the monitor were shipped with 'bricks' to convert 120 VAC to 12 VDC. The brick for the monitor has a slightly larger current rating (5 A at 12 V as compared with 3.3 A). Both bricks were made by the same company, with identical center positive plugs and very similar voltage regulation. The open circuit output voltage was perhaps 12.4 VDC, which dropped to perhaps 11.6 VDC when the device was turned on. The monitor requires a greater current than the computer, perhaps between 1.5 and 2.5 A depending on screen settings like brightness.

One option for powering the computer and monitor would be to just bring out the center tap of the 24 VDC battery chain to supply a voltage in the 11.5 to 14.0 range. This option was rejected for two reasons. One was concern for the allowable voltage range for the monitor. This is not specified in the available literature. One would expect an allowable range of at least 11 to 13 VDC for a device rated at 12 VDC, but operating at 14 VDC just might shorten the life of the monitor. The other reason for rejection is that the 24 VDC charge controller would not be able to properly recharge the half of the batteries in the battery chain that were discharged into a 12 VDC load.

The other option would be to put a 12 zener diode in parallel with the computer and monitor and a resistor or other load in series. Three 12.0 V, 50 W, NTE5254A zeners were purchased from Allied Electronics for \$21.91 each. There are $\pm 5\%$ devices, so after testing all three devices, we can select the one that seems to give the 'best' range of voltages. Then we have two spares in case something goes wrong.

A resistor would need to have a 12 V drop across it when about 3 A are flowing, so we would need about a 4 Ω resistor. A current of 3 A in a 4 Ω resistor dissipates 36

W, which would be 'lost' power, especially in warm weather when no camper heating is needed. It was observed that the 12 V LED lighting strips described earlier draw about 1.5 A each. Two strips in parallel would draw 3 A. Preliminary testing indicates that the resulting circuit works nicely. The 3 A current from the 24 V battery bank first flows through the LED lighting strips and then through the computer and monitor, doing double duty so to speak. The zener draws only enough current to keep the computer voltage at about 12 VDC.