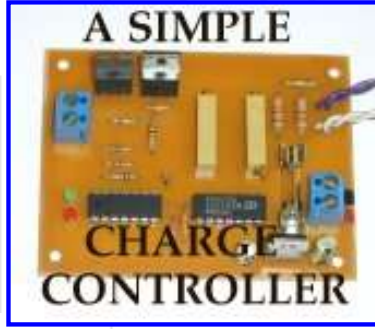


EMERGENCY POWER PROJECTS!



EXPERIMENTS WITH A THREE-PHASE WIND GENERATOR



CARVING A WIND GENERATOR PROP
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[ADDING RARE-EARTH MAGNETS TO AN INDUCTION MOTOR TO MAKE A POWERFUL ALTERNATOR](#)

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A SIMPLE MICROWIND GENERATOR



Here's a practical use for those large stepper motors that turn up surplus from time to time. I built this Microwind genny from some old pipe fittings, some scrap angle iron, and a stepper motor left over from the CNC DRILLING MACHINE project. The plastic fan came from a dead 20" box fan thrown in the trash by a neighbor down the street. Stepper motors become PM alternators when you spin them, and since they have LOTS of poles (needed to make tiny, precision steps) they generate power at fairly low RPMs, making them perfect for a wind generator.



Obviously, you're not going to power your house with a genny this size, but the one in the picture is putting out 15 watts of charging current as storm clouds gather in the background. That's plenty to charge emergency batteries, or supplement a small solar array. So far, we've seen some very intense windstorms with no damage to the little wind generators. In fact, I'm wondering if many small microwind generators might make sense in an area where high winds would cause a single large generator to be feathered and shut down when power is needed the most!



The stepper motor was mounted to a piece of angle iron which was welded to a 3/4" pipe flange. A short piece of 3/4" pipe threaded into the flange forms the pivot. This assembly fits over a piece of 1/2" electrical conduit which sticks out of the end of the mast, which was also made from 3/4" pipe. A large flat washer forms a bearing surface.

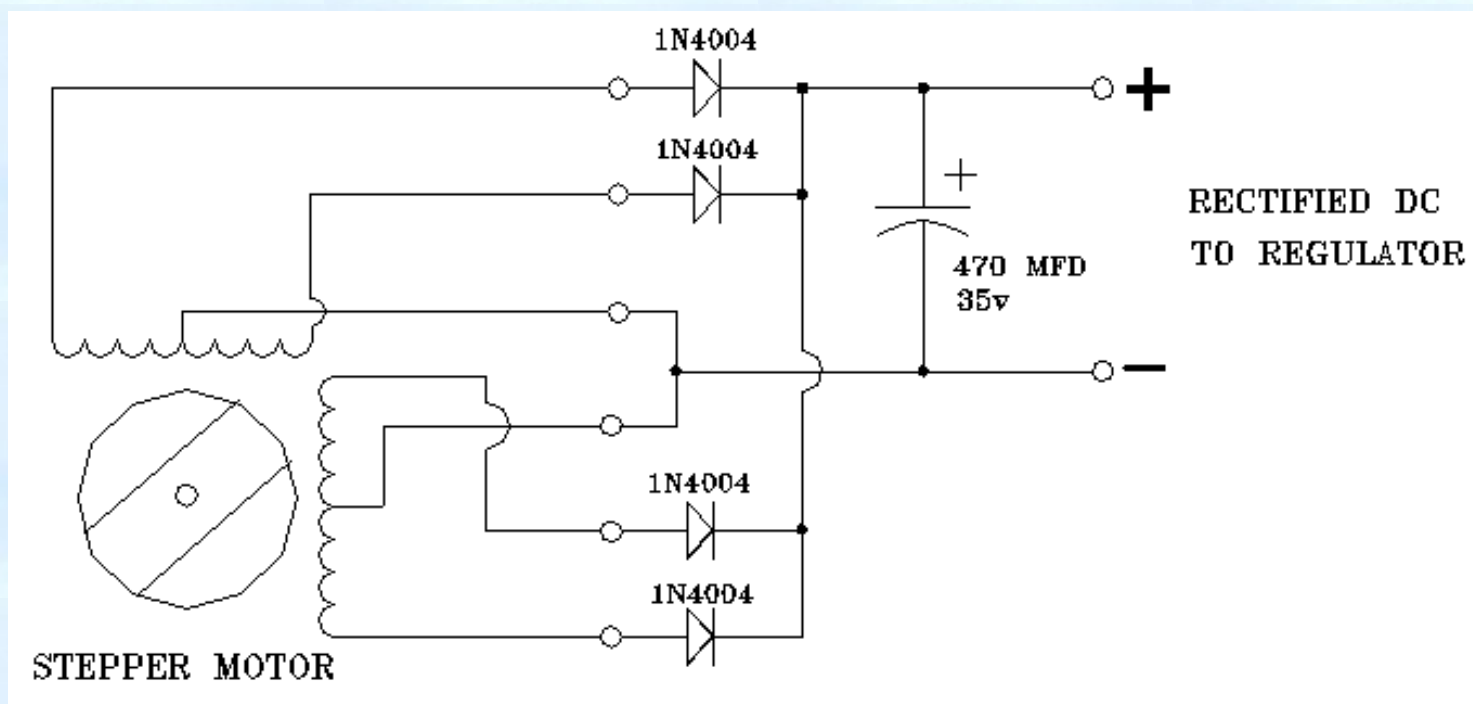


In this closeup you can see the small collar made from 3/4" pipe and drilled and tapped for a setscrew. The collar retains the pivoting head on the conduit. Mounted on a small angle bracket behind the motor, a small piece of plywood serves as a place to mount the two-phase rectifier board which turns the high-frequency AC into DC. Mounting the rectifier at the generator head lets us bring two wires down rather than six. The two-wire cable is simply passed down through the center of the mast and allowed to drop straight down. The circuit board, plywood and motor should be sprayed with several heavy coats of urethane to seal and protect them from moisture. A simple U-shaped cover was bent from light gauge aluminum sheet to cover everything from direct rain, held in place with two small sheet metal screws threaded into the edges of the plywood.

I've built many wind generators, and so far I've never built one with slip rings. Instead, I just pass the wires straight down through the mast. No slip rings or brushes are needed, since if the genny should rotate a full 360 degrees, it will only put a single twist in a long drop of wire, not a big deal. The wind seems to even out, at least around here... I had a large wind generator up for over a year and only had to untwist the wires once! Hooking a plug and socket at the bottom of the tower or mast makes this simple, and is a lot easier than building slip rings.

Since the fan blades had a deep hub that hit the motor flange, I made a blade adapter out of a piece of aluminum bar stock. I

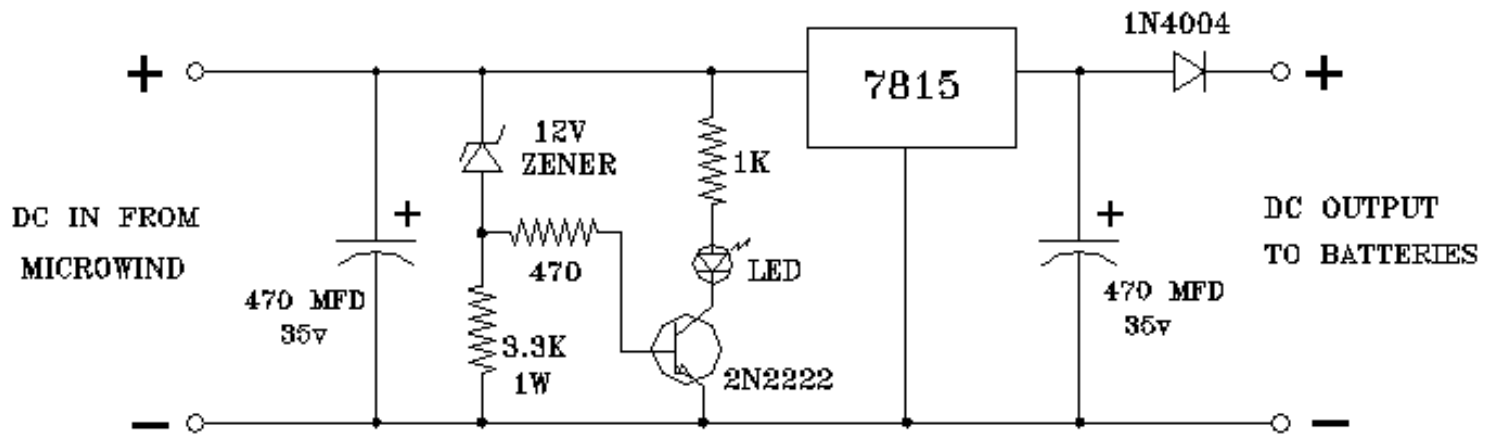
drilled through the center on the lathe, then added a couple of setscrews to hold it on the motor shaft. I tapped the other end for a 5/16" bolt, which holds the fan blades onto the adapter.



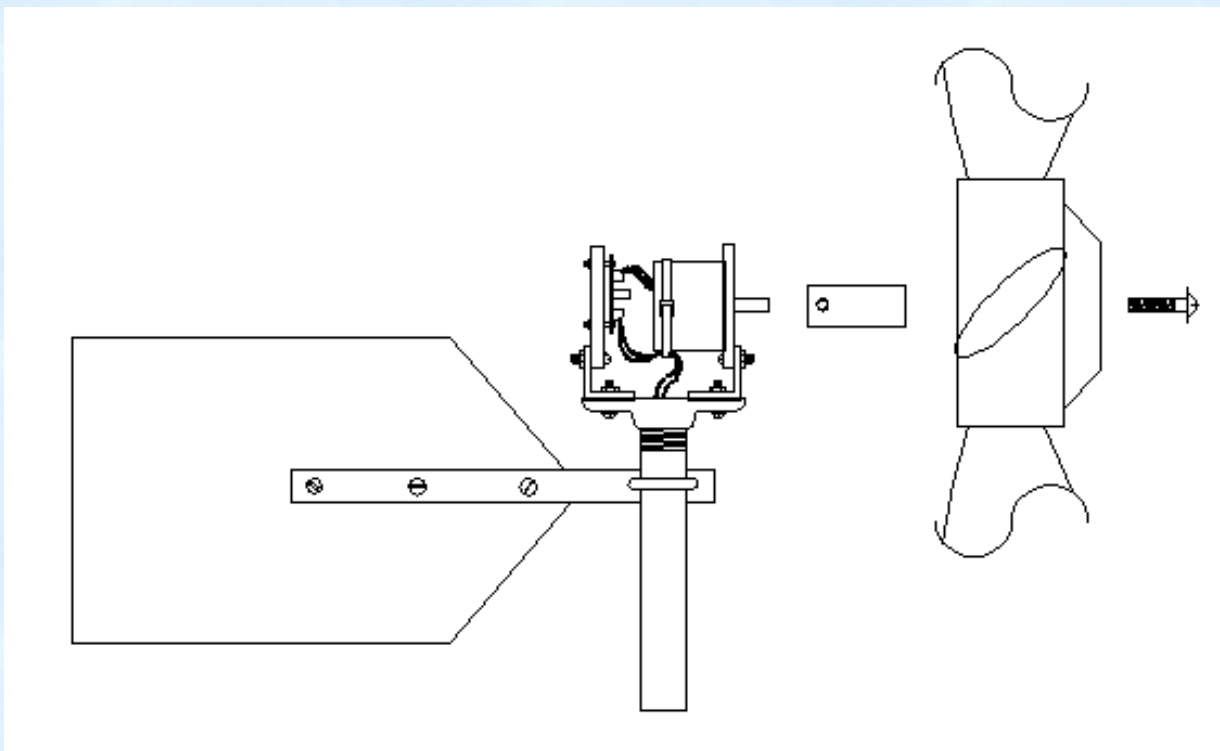
Here's a schematic of the stepper motor and the two-phase rectifier, which is built on a small circuit board and mounted behind the motor.



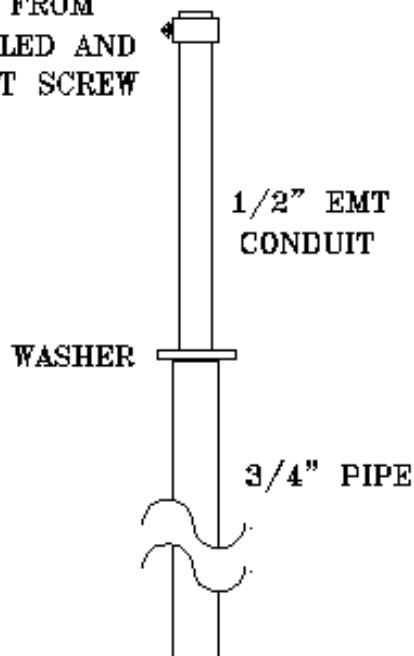
Here you can see the Microwind generating enough power to nearly blow out a 12 volt trailer light. Even with the light bulb as a load, it's cranking almost 20 volts at 620 milliamps. In peak winds it can produce 35 volts or more, and I've seen 750 milliamps going into the load.



Since these peaks would fry any electronic equipment connected to your batteries once they are fully charged, a simple regulator clamps the voltage at 15 volts. Also, a zener fires a transistor, lighting an LED when the voltage exceeds 12 volts, indicating that the generator is charging the batteries.



COLLAR MADE FROM
3/4" PIPE DRILLED AND
TAPPED FOR SET SCREW



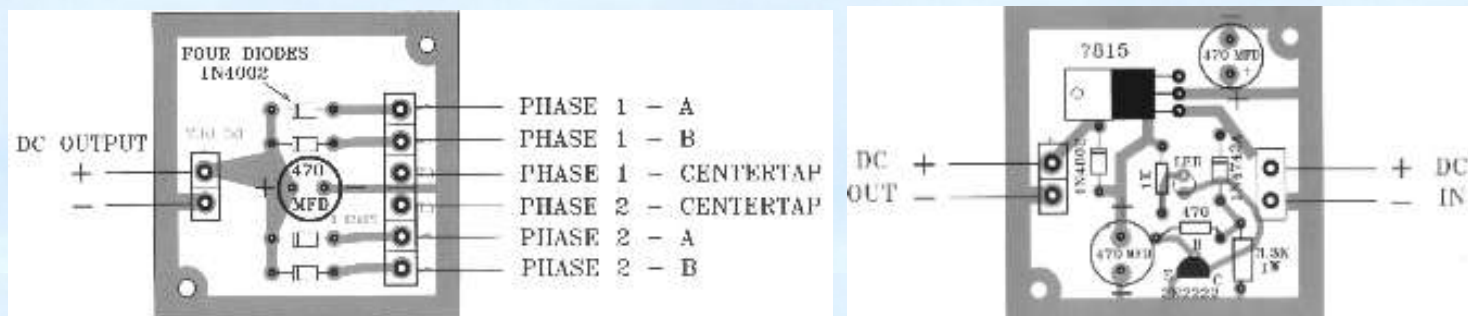
Here's some drawings of the Microwind. Since it was literally built from scraps and leftovers (along with the fan I found on the curb) there's nothing sacred about the construction. Use what you have, and modify it accordingly. I made the tail boom from a short section of slotted shelf bracket, and cut a nice tail fin from plastic sign board. I bent a U-bolt from a piece of #6-32 threaded rod to mount the boom to the generator head.

This Microwind generator project ended up as an article in the December 2001 issue of 73 AMATEUR RADIO TODAY magazine. From the response, I'd say that a lot of hams are going to be scrounging for old box fans and adding wind power to their emergency stations. The article in 73 goes into much more detail about the construction of the little genny, so you might want to look it up. Call (603) 924-0058 to subscribe or to request back issues.

PARTS!

While most of the parts for this project were mined from the junkbox and the local "Spring Cleanup", the more critical components are easy to purchase. The NEMA-34 stepper motor I used are made by Sanyo, and my original surplus source no longer lists them. However, you can order them from [DEAN'S HOBBY CNC website](http://www.deanshobby.com) either used or new.

I can supply the two printed circuit boards, etched and drilled, for \$5 for the pair. You can use [PayPal](https://www.paypal.com) or drop me snail-mail with a check, whichever you prefer.



The electronic components are installed on the circuit boards as shown. You can find the parts at Radio Shack, or order them from [CIRCUIT SPECIALISTS](http://www.circuitspecialists.com) or [MOUSER](http://www.mouser.com).



Here's a site that will give you a LOT of ideas on wind generator construction, including a discussion board where you can ask questions and receive replies from some people with a lot of experience with alternate energy.

WWW.OTHERPOWER.COM

Here's another site that will give you a dozen new ideas every time you visit: WWW.WINDSTUFFNOW.COM

[HOME](#)

BUILD A SIMPLE

CHARGE CONTROLLER

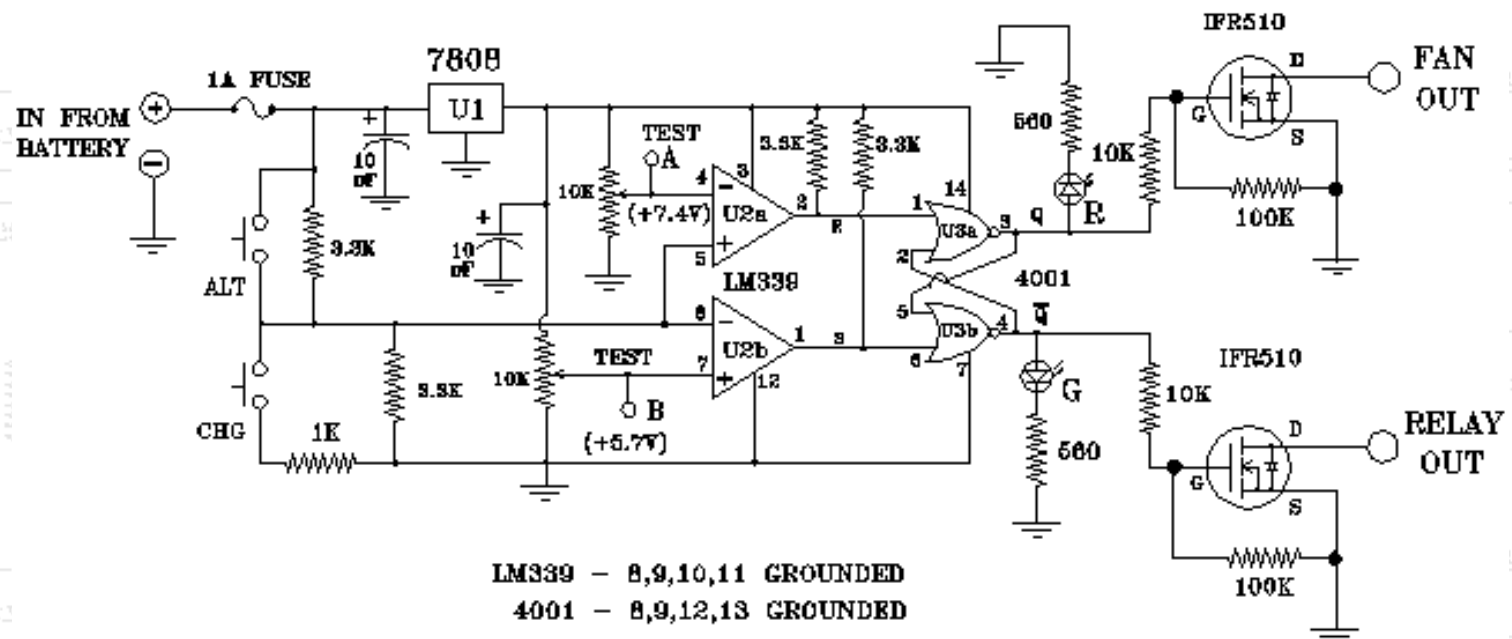
FOR WIND AND SOLAR POWER SYSTEMS

Once our wind generators and solar panels were up and running, the next obvious requirement was some sort of charge controller, since continuous overcharging would boil the electrolyte dry and ruin the expensive battery bank. Several small controllers came bundled with the solar panels, but they were totally unsuitable for wind power use.

Charge controllers intended for solar panels work by monitoring the battery voltage, and once it reaches full charge, the controller simply shorts the solar panel leads together. This doesn't harm the solar panels, but it does waste whatever power they're generating. The energy ends up heating the transistors in the controller.

This type of controller is not ideal for a wind generator, since shorting the output of the genny while it's spinning at high speed will generate a huge current spike, possibly destroying the controller and perhaps even the generator in the process. On the other hand, simply unhooking the generator from the batteries is not a good idea either, since with no load on it, the generator might overspeed in a strong wind and destroy itself.

The ideal solution is to charge the batteries until they reach a full charge, then switch to an alternate load where the energy can be safely handled. While we're at it, this energy should be used for some useful purpose, such as supplementing a water heater or powering a peltier-junction refrigerator, but in a pinch, a bank of 12 volt light bulbs will do.

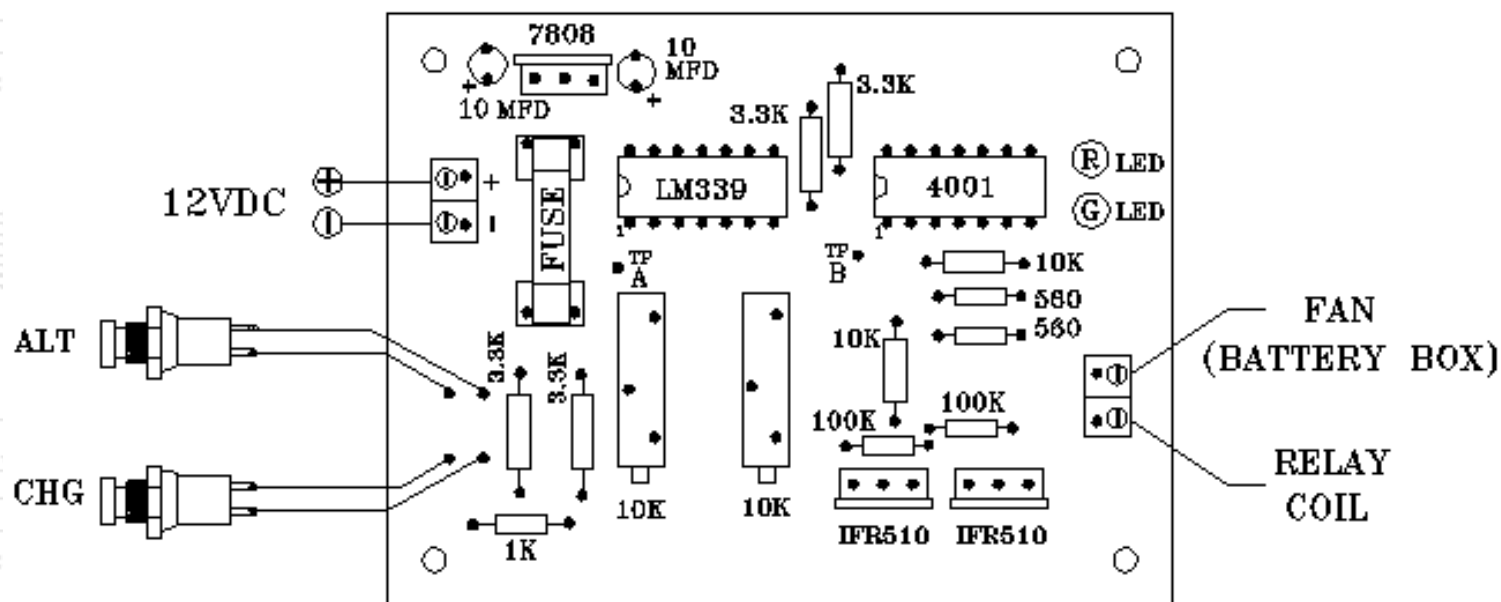


The above schematic shows the simple charge controller circuit. The incoming battery voltage is divided in half by a pair of 3.3K resistors, so the trip points are adjusted to one-half the desired levels. The actual trip

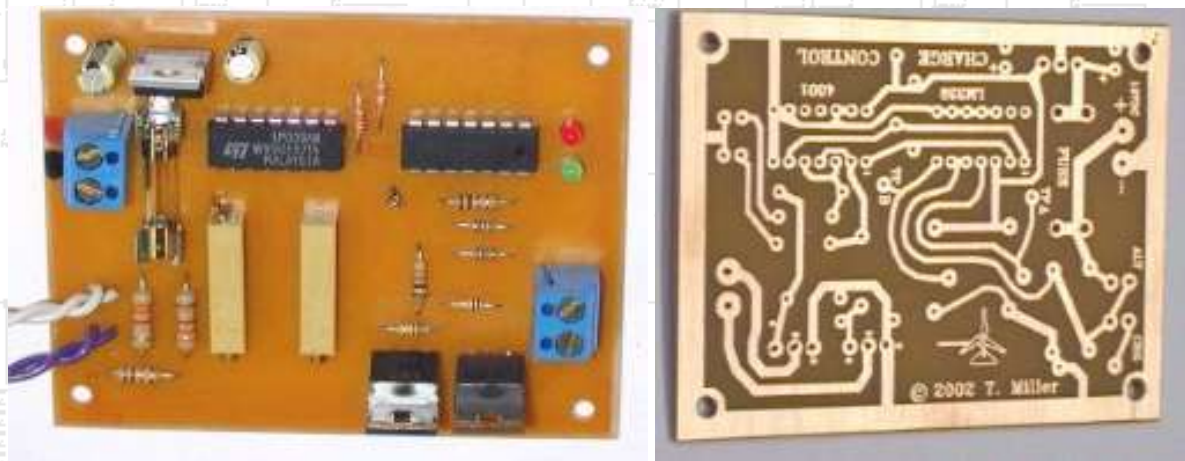
points will depend on your particular batteries, but a good starting point is 14.5 volts for full-charge, and 11.8 volts for discharged. In this case, the trimpots should be adjusted to read 7.25 volts at TP-A and 5.9 volts at TP-B. You will probably need to monitor your battery voltage through several charge - discharge cycles to determine the perfect trip points for your system.

The outputs of the controller are latched, and drive a pair of IFR510 power FETs, which serve as relay drivers. If you use a double-throw relay, only one output is necessary, since the relay can switch the incoming power to either the batteries or the alternate load as required. The second output can be used to switch a small 12 volt DC muffin fan to vent hydrogen gas from the battery enclosure to prevent the danger of explosion when charging the batteries.

The two push-buttons provide a way to toggle the output manually when the battery voltage was in the "null zone" between the trip points. By momentarily pressing one of the buttons, the output state will reverse and latch. A 1K resistor prevents a dead short, just in case someone decides to press both buttons at once!

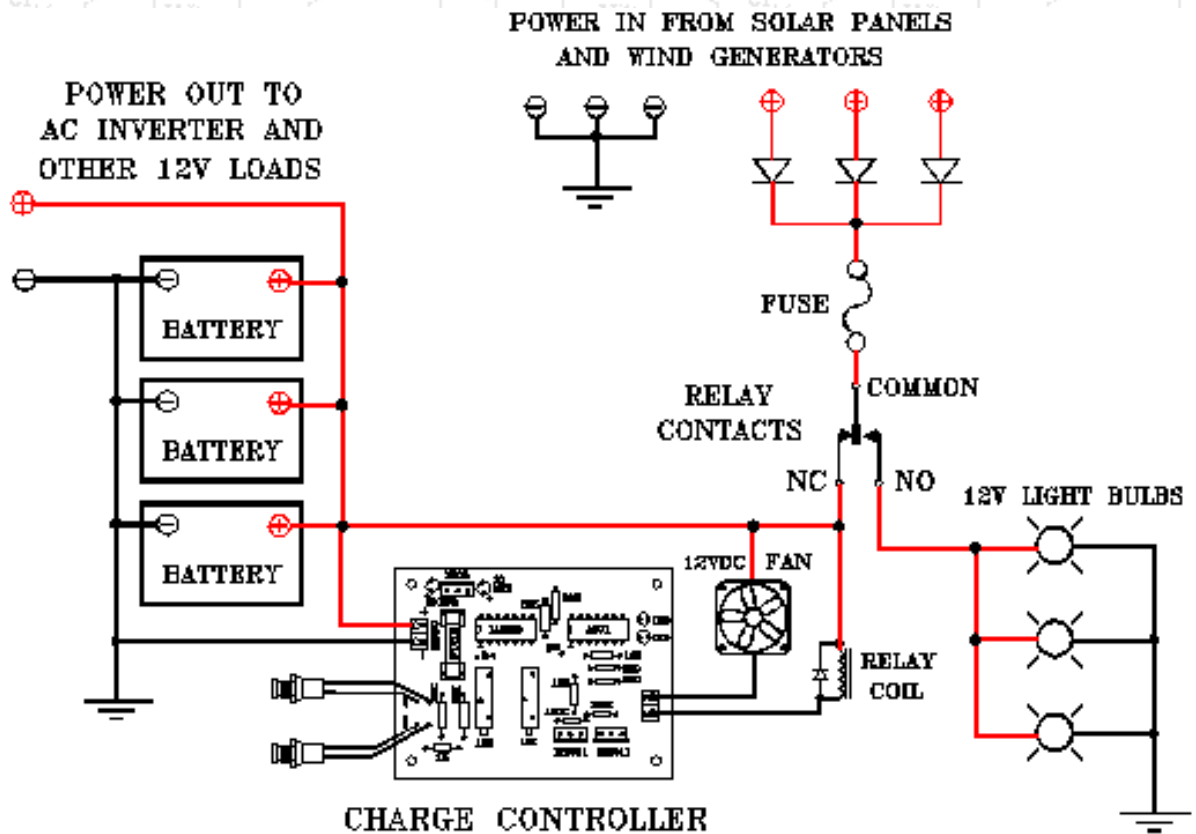


The charge controller is built on a small printed circuit board, as shown below. The diagram above shows the component layout. Be sure to install the I.C.s and capacitors correctly, as reversing them will most likely generate a puff of smoke. Terminal blocks are soldered to the board for the incoming 12 volts and for connections to the relay coil.



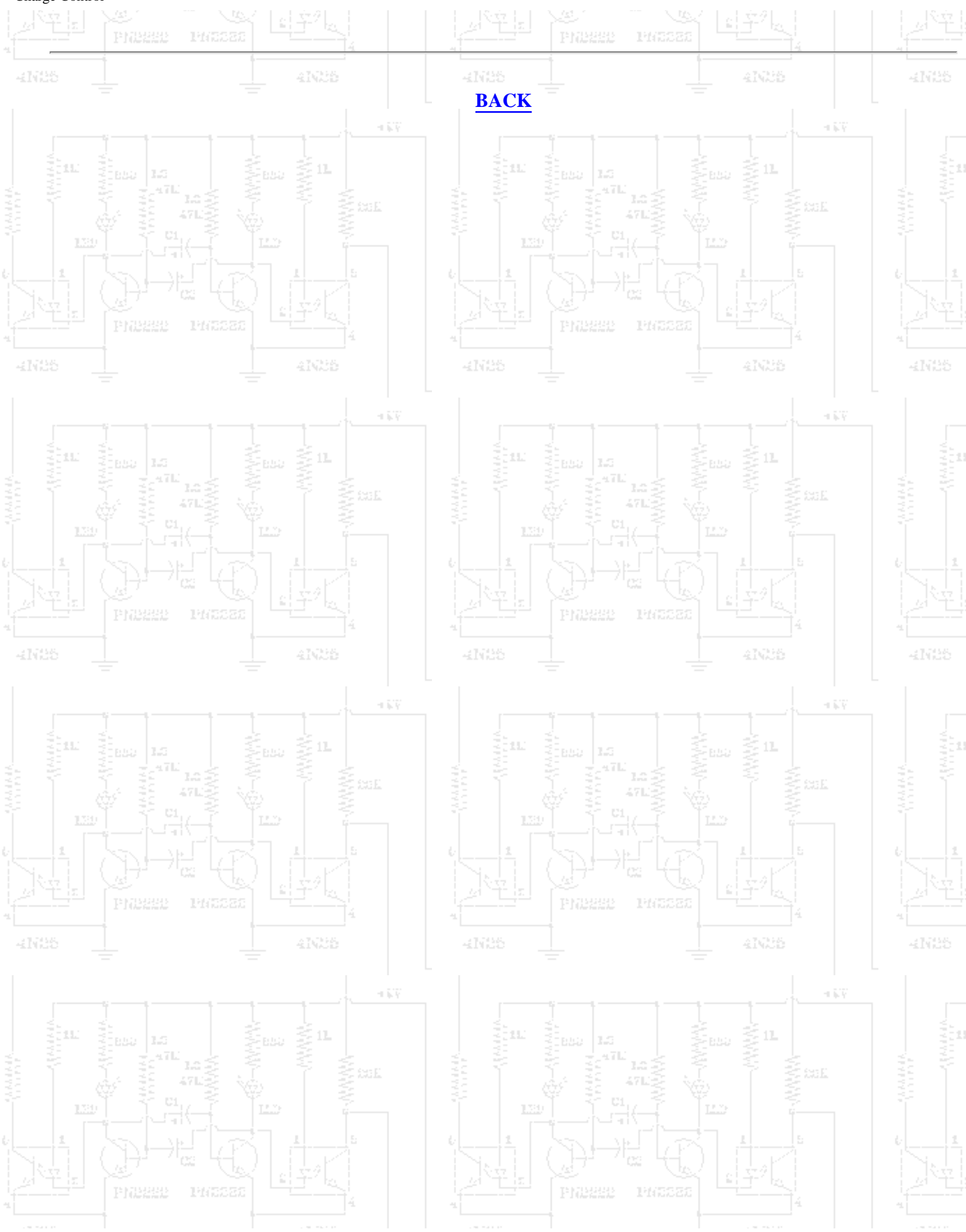
...(LEFT) COMPONENTS INSTALLED(RIGHT) BARE CIRCUIT BOARD...

Since the incoming power is produced by several different types of surplus solar panels and homebuilt wind generators each producing different voltages, they can't just all be hooked together... each has it's own blocking diode in series with the positive lead. When the battery is charging, each source is pulled down to the battery terminal voltage, so each source contributes whatever current it's capable of producing. Each blocking diode has to be sized for the current that source can generate. The negative lead from each source is connected to ground.



Here's the hookup as it's working here. As long as the batteries are charging I can see the red LED glowing. As soon as the trip voltage is reached, the red LED goes out and the green one comes on, and the power is shunted to the alternate load. This way, no power is wasted.

[BACK](#)



ANOTHER SMALL WIND GENERATOR

MADE FROM A LARGE STEPPER MOTOR AND PLASTIC BLADES

With the success of the "Microwind" genny made from a surplus NEMA 34 stepper motor, a prop from a trashed 20" box fan and some pipe fittings, I wanted to scale the design up to produce a bit more power, yet still retain the simplicity and the storm survival ability of the little genny.



After months of searching, I found a much larger surplus stepper motor. This one has the same diameter, shaft and flange dimensions, but is about twice as long. In addition, the shaft comes out of both ends, which brings up the possibility of coupling several together to be driven from a single prop. While the small stepper had one amp coils, the larger one has coils rated for four amps each. By using a bridge rectifier on each phase and connecting the DC outputs in parallel, this one should produce several times the power of the original Microwind.



I first thought about carving a set of wooden blades, but I ran across some scrap plastic pieces that were nearly the correct size, weight and shape. These were routed cutouts from a large plastic bin, and were curved in such a way as to form a somewhat undercambered airfoil. I cut a set of three tapered blades from this material and used a rotary file to thin the trailing edge. Since these were scrap cutouts from a molded plastic part, each piece had a vent hole in the center. Being small, it shouldn't hurt anything. Each blade is 21" long, 4 1/2" wide at the root, and 2 3/4" wide at the tip.



I found a scrap of heavy guage steel about 1 1/2" wide, and cut it into three equal strips about 7 inches long. These I sandwiched between two very large washers. A bolt and nut squished the washers together, capturing the steel strips. Once they were perfectly aligned, I welded them all together, forming a solid three-blade hub.

I bored a short piece of 1" aluminum barstock to fit the stepper motor shaft and added two #10 setscrews, then turned the piece around and counterbored it halfway, then tapped it for a 7/16" x 14 screw. While it was in the lathe, I turned a step on the O.D. to fit the hole in the washers. The step

is a bit shorter than the width of the hub, so the center screw will draw it down tight and square.

The aluminum piece wouldn't fit all the way through the hub, since the three steel strips had actually stuck through a little way into the hole in the washers (the bolt was smaller than the hole.) Rather than file them away, I instead filed three small flats on the aluminum piece. This way it could not rotate inside the hub... simpler than cutting a keyway!



The three steel strips were marked and drilled, then tapped for three 1/4"-20 screws in each one to mount the blades. At this time I also scribed a line an inch out from the washer across each one. Each strip was then clamped in the vice at this line, and using a large crescent wrench I twisted each one to the proper blade angle, sighting it with another line drawn across the top of the vice with magic marker.

The blades were mounted on the hub using three 1/4"-20 bolts and washers for each one. Since the hub itself is tapped, once the bolts were drawn down very tight, a nut was threaded on to the back side of each bolt and tightened down to lock everything together.

Once the blades were installed, I mounted the hub onto one of the large stepper motors and took it

out into the back yard. Shortly we had a small gust of wind, and as soon as I felt it on my face the genny started to rotate. It seems to start in a fairly low windspeed, and once spinning it maintained it's rotation quite well. With some of the larger gusts, it picked up quite a bit of speed. Since I can rotate it by hand and light a good-sized 12 volt bulb with each phase, it looks like this thing will produce some power once it's up in the air.



Since we've been known to get some storms around here with winds in excess of 85 mph, I thought it would be a good idea to reinforce the hub to prevent it from bending backwards. Rather than using a 7/16" bolt to secure the hub, I cut a piece of threaded rod and tightened it into the adapter. I then used a nut to secure the hub, leaving a few inches of rod sticking out. This gave me a point to attach three support rods from the center back to the outermost bolt on each blade. Before fastening the rods, I bent the arms of the hub slightly forward. This "rake" will allow the blades to flex a bit in high winds without risk of hitting the mast.



Here it is, up on the shop roof. To the right is the original Microwind prototype, fastened to the vent pipe where it's been adding it's share to the station batteries for over a year now. I've seen an amp out of the little guy, and I hope the bigger version will do much better.



This side view shows the forward rake of the blades. This should allow plenty of room for flexing in extreme weather.

The mini genny is an ongoing project. Now that it's up, naturally we have winds of less than 2 mph predicted for the next several days. Once we see some real wind, it won't take long to see what it's going to do. I expect to do some experimenting with the blade pitch to get the right angle to get as much out of the stepper motor as possible. Adjustment is a matter of putting the hub in the vice and twisting each arm with a very large wrench. So far, it seems to start in very light winds, and in a few light gusts shortly after it went up, it lit a 12 volt trailer light easily. Since these were very light gusts, this is a good sign... it should spin up much faster once the wind picks up. I'll post more data here as the project unfolds.

UPDATE!

Once we got some gusty winds peaking around 15 to 18 mph, I took some measurements on the new wind generator. It starts easily, and when feeding power to a battery through a blocking diode, it would begin charging somewhere around 10 mph. At higher windspeeds the RPM and the current would increase, but not as fast as I had hoped. Since the plastic blanks were straight, I had no twist to the blades, and I suspect that under load, the tips were stalling at the higher wind

speeds.

I brought the rotor down and trimmed some taper to the leading edge of the blades. Since the shape is undercambered, this did two things... first, it made the airfoil thinner at the tips. Second, it also made the airfoil fly at a lower angle of attack, adding a bit of "twist" to the blade.



The result is a bit more speed in the gusts. As I write this we're having winds with gusts up over 20 mph, and I'm seeing an easy 1 to 1 1/2 amps going into the batteries on the average, more in the strongest peaks. This is certainly not bad for a little NEMA 34 stepper motor. I have a feeling that it will do better in some real wind, at least as long as it holds together.

The biggest thing it needs now is good, clear, unobstructed wind. Once I'm sure it's doing what I want it to do, I'll move it from the shop roof to the top of one of the towers.

[HOME](#)

THREE-PHASE EXPERIMENTS

BUILDING A WIND GENERATOR FROM A THREE-PHASE MOTOR

The biggest problem with wind generators for charging 12 volt batteries is that the low voltage and high current creates excessive losses in the windings of the alternator (or generator) and also in the cables coming down the tower and feeding the batteries. By converting a three-phase AC induction motor into a PM alternator, it's possible to generate 3 phase AC at a higher voltage. This can then be stepped down and rectified to provide low voltage and high current for charging the batteries without the losses normally experienced. These experiments were intended to find out if ordinary surplus transformers would handle the constantly varying voltage and frequency from the wind generator, and if the gain in efficiency would more than offset the losses and complexity of the system.



The first step was to disassemble a surplus 1 hp, 3 phase motor and turn down the rotor to accept curved neodymium magnets. Two magnets end-to-end were needed to cover each pole. This was a four-pole motor, so four sets of magnets was glued to the rotor using slow-set, high-strength epoxy glue. This was not easy... the magnets are very powerful and really did not want to touch end-to-end. The trick is to install the first four, secure them with a stainless steel hose clamp, then install the second four. By the way, these magnets are available from Dan at the [OTHERPOWER](http://www.otherpower.com) web site.



Once the epoxy had cured, I filled the area between them with epoxy as well. The motor was cleaned, the windings were sprayed with a fresh coat of urethane varnish, new bearings were installed and the motor (now an alternator) was re-assembled.



Three wooden blades were carved, each 48" long.



The blades were then assembled onto a hub made from an 8" steel disk (a go-cart disk brake) along with a mounting backplate and front disk made from 3/4" plywood. Everything was thoroughly coated with slow-set epoxy, then through-bolted and drawn down tightly before the epoxy could start to set up. One blade ended up a bit heavy, and the other two needed small lead weights inletted into the blades to bring the prop into balance.



With the help of my cousin Brent, the three-phase genny ended up on top of the tower without much trouble. We hoisted it up with the help of a rope and gin pole, while carefully guiding it between the guy wires. I left the prop off for this operation, and the next morning while it was still dead calm, I hoisted the big 8 foot prop up and fastened it in place. Due to the cogging effect of the alternator, it takes a good 15 mph gust to break the magnetic lock and start it spinning. Once it's in motion, it will keep spinning with the slightest breeze.

With the wind generator in operation, the voltage output was measured and found to be in the 100 to 150 volt range. In order to step this down to something useful, I mounted three heavy transformers to a breadboard. Each transformer is rated at 13 volts, 20 amps with a 120 volt primary. There is also a tap on the primary to boost the output if the input is less than 120 volts.

The first experiment was to connect the three primaries in a delta configuration. This would give the highest output from the secondary. The results were not promising... when the genny was spinning slowly, connecting the leads made a spark and the prop stopped turning. The transformer winding (designed for 60 hz) was pretty much a dead short at the almost-DC frequency of the wind generator when it was just starting. This might work once it's up to full speed, but it would likely never start.

The next attempt was to Y-connect the three primaries. Surprisingly, this seemed to work down to the lowest speed. The Y configuration places two windings in series for each leg, increasing both the DC resistance and the inductance of the windings. I connected the three wires from the center of the Y to a knife switch so that I could open the circuit for testing, and found that the genny starts as easily in this configuration with the switch closed as it does with the windings open.

Since the Y-connection worked so well, I tried using the lower voltage taps (for 108 - 110 volt input) and it also worked fine, with about a volt higher output from the transformers.



Once the primaries were connected, I measured the voltage from each secondary and decided to try them with a Y-connection. Measuring the output showed a 6 to 1 step down ratio. I made up a three-phase bridge rectifier for the output using three 35 amp bridge rectifier modules. By jumpering the two AC terminals together, each module became essentially two 70 amp diodes in series. Three of these made up the six diodes necessary for a three-phase bridge, and this was fed through a meter shunt to the batteries with a section cut from an old set of jumper cables.

In the few windy days since this system has been up and flying, it looks promising. It starts around 15 mph. This is a little higher than most of the wind generators I've built, and is due to the cogging of the magnets in the alternator. At around 20 mph, the output of the alternator hits around 100 volts, which is enough to bring the output of the transformers and rectifier up to the charging point.

Once the wind exceeds 20 - 25 mph, the charging current jumps up fast. It hits 10 amps almost

instantly. So far, the strongest gust I've measured here was in the 35 - 40 mph range, and the charging current was measured at 42 amps. Since this was the DC current coming from the bridge, each leg of the three-phase coming down from the tower was carrying around 7 amps. This is well within the capacity of the 80 foot long #12-3 extension cord wire connected from the wind generator to the transformers down here in the shop.



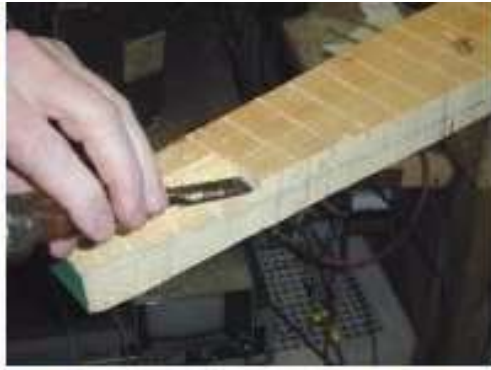
I *really* don't like three-bladed props. Two blades are stronger, lighter, faster, easier to balance and are quite a bit more efficient. The reason for the three blades on this machine is to generate the starting torque needed to overcome the cogging of the magnets.

Two-bladed props made from a single piece of wood can stand up to just about any winds we're likely to encounter around here, but since the three-blade hub is a weak point, I wanted some way

to shut this one down. I used an old TV antenna rotor to mount the tail boom, so by rotating the tail 90 degrees I can align the rotor sideways to the wind. It should be able to ride out a serious storm in this mode.

The next experiment on this machine will be to carve a two-bladed prop and compare the performance to this one. By making the blades about 8 or 9 inches wide at the root, a ten-foot prop should outperform this one and should still have enough torque to start in a reasonable wind. I'll update this page as the experiment progresses.

[BACK](#)



MISC. WIND GENERATOR EXPERIMENTS



I tried modifying a couple of old fan blades to make a hub to mount the new blades I got from [Jerry](#), but none fit the blades very well and the pitch was backwards. Rather than go to a lot of trouble trying to adapt them, I just made my own hub from some 2" wide steel strips, a couple of 3/4" washers and a short piece of 1" diameter steel bar stock.



Unfortunately, I'm running out of tall pointy places to mount wind machines. Here's the new tower going up.



Jerry's blades on a homebuilt 3-blade hub. The alternator is an old blower motor with magnets glued to the rotor. The alternator cogs a bit, so it probably won't start until there's a pretty good wind. There's NO wind now, so I'll have to wait on the weather to find out how it works.



This is my "test genny." Note the tail mounted on an old TV antenna rotor so it can be folded in serious weather.



Here's a small genny under construction. It uses a DC tape drive motor. These things work fairly well if you can get them spinning fast enough, hence the two-bladed prop on this one.



The two-bladed genny is up on the peak of the shop roof waiting for a wind. Naturally, whenever a new machine goes up, the wind stops for several days. This one should work well, though... so far, even the slight breeze needed to point it into the wind is enough to make the blades rotate slowly.



This 520AH battery was originally used to power an industrial lift truck. It was sulfated and the acid was stratified, and it wouldn't take or hold a charge. I added a dixie-cup full of VX-6 to each cell, and spent two weeks charging it with a pair of enormous surplus filament transformers and a big bridge rectifier. The white crystals are gone now, and it's about 80% recovered. In time, I can probably bring this thing back to nearly-full service. Not bad for something that was slated for "toxic waste."

This page is under construction, and in fact, it will probably never be "done." As old projects generate some test results, or new projects come up, I'll post it here.
