Alternators as steppers?

A *stepper motor* differs from an ordinary motor in that it can deliver incremental motion in the form of tiny precise steps, rather than as a continuous rotation. The important advantages of a stepper motor are the precision with which you can set an output shaft position, the ability to rapidly and conveniently change the direction or the speed of your output steps, and the capability of strongly holding a zero-speed position.

Small stepping motors are widely used for such things as printer paper feeds, automobile idle controls, pen plotters, and sometimes for disk-drive head positioners. And most any old surplus electronics catalog will have lots of small steppers and all their drivers cheaply available. But what about the heavy stuff?

There are lots of good hacking uses for power stepper motors. Obvious examples include robotics, machine-tool power feeds, animation stands, plotters, sign cutters, solar pumps, and even Santa Claus machines. As you have probably noticed by now, power stepper motors are rare, horrendously expensive, hard to get, and harder to drive. Did I mention being hot and noisy?

An industrial arts teacher out of Phoenix by the name of Bob Knight stopped in the other day with what just might be a brilliant hack. Junkyard car alternators cost under $5 each, especially if you don't particularly care which model you are getting. Can you convert an alternator into a power stepper?

The needed modifications do appear to be simple and obvious. And power FET or Darlington drivers are no big deal these days.

My first response was "yes, but...," and I immediately came up with a dozen good reasons why this flat out would not work. At least not very well. Things like a wide air gap, low-frequency mechanical resonances, DC biasing, giant step sizes, all the non-optimum magnetic paths, very poor damping, backlash, slow speeds, and an efficiency that probably would be an outright joke.

On the other hand, if you pulse an alternator, there is no way you can hold onto it when you do. The kick is definitely there.

At best, I would guess that you could not get as much useful force with a car alternator as you could by using a much smaller "real" stepper motor. And the alternator would end up ridiculously slower to boot.

I'd like you to try and prove me wrong. Either as this month's contest or for a winning school lab project, experiment with a car alternator and find out exactly how useful a power stepper motor you could convert it into. Could you in fact create a $5 machine-tool power feed with one? How fast can you go? How much output force can you get? How good are the steps? What is the best computer interface?

There will be the dozen or so of our usual *Incredible Secret Money Machine* book prizes, along with a big all-expense-paid (FOB Thatcher, AZ) *tinaja quest* for two going to the very best of all.

Okay, Fig. 4 shows you some conversion hints.

Most real stepper motors do use a permanent magnet rotor. With an alternator, you would use the field winding and slip rings as a giant electromagnet, running as much current through it as you can without overheating. This forms a group of seven shaft-attached magnets that you can rotate to a desired position by activating the stator coils.

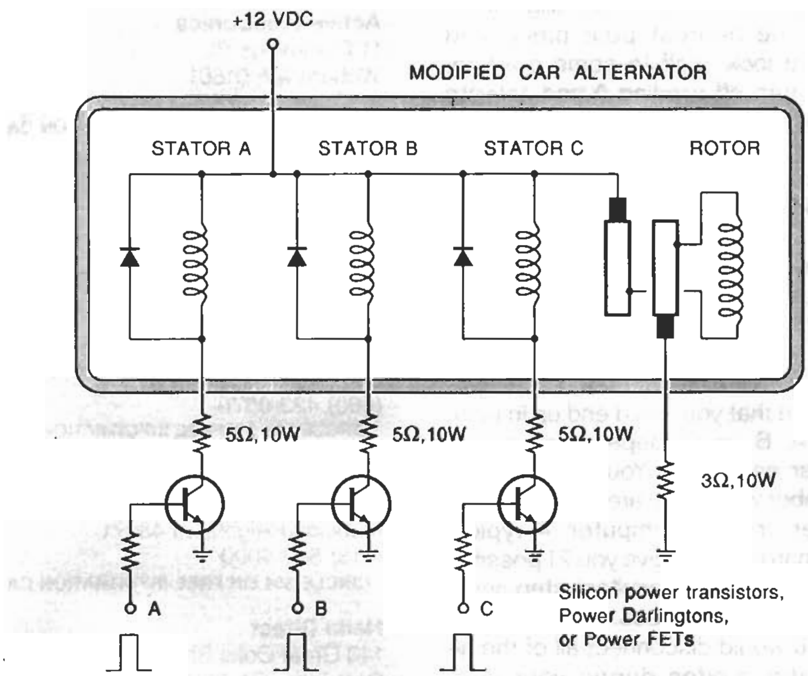


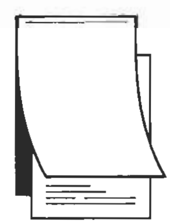
FIG. 4—CAN A CAR ALTERNATOR get converted into a $5 power stepper for a machine tool drive? Only hackers know for sure. To experiment, use the rotor as a powered electromagnet. Find the floating stator wye connection and bring it out as a power terminal. Pulse one stator winding at a time in an ABC (clockwise) or an ACB (counterclockwise) sequence. Be sure to limit stator currents.

And speaking of which, there are normally three sets of stator coils. These are usually hooked up in what is known as a three-phase *wye* circuit. For stepper use, you will want to find the floating splice where your wye connection is made and bring it out as a separate positive terminal. Which should then give you three distinct and independent winding sets.

Let's call the windings A, B, and C. Power the field via the slip rings, and pulse winding A. Keep your current down around an amp or two at first to

BAKERIZING

With BAKERIZING, your toner image is temporarily placed in close contact with a smooth film. Heat and pressure is then applied. The toner becomes much blacker and takes on a beautiful medium to high gloss. Some films can be reused.



LAMINATING

With LAMINATING, a thin clear plastic overlay is permanently attached to your copy by using heat and pressure. This process seems ideal for menus and book covers, or where extreme scuff resistance to "lock in" your toner is required.

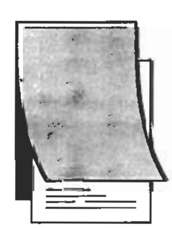


FIG. 5—THESE TWO "MAGIC" FILMS can dramatically improve the appearance and durability of any toner image. Evaluation sheets are newly available.

prevent any overheating or driver problems. The rotor will align itself with the nearest pole piece and should lock itself to some position. Now turn off winding A and activate winding B. The rotor should now jump one step clockwise. Turn off B and whap C. And you should jump yet another step clockwise.

To step clockwise, use an ABC sequence. To step counterclockwise, just use ACB instead. You'll probably want to keep at least one winding energized at all times so that you can hold a position when not stepping.

Note that you could end up in position A, B, or C, depending on your power sequence. You'll have to remember where you are with your controller or host computer. A typical alternator should give you 21 possible positions, and a resultant step angle of around 17 degrees.

You would disconnect all of the alternator diodes during your conversion. These could later get used as protection diodes with your driver circuits if you do not have anything better available.

One hint: Your slip ring brushes can "explode" whenever you take an alternator apart. And the two brush springs will fly off into the hinterlands. Look closely, and you'll find a toothpick-size hole in the insulated brush holders. To reassemble, you just put a toothpick or a stiff wire through the hole to hold the brush springs compressed. Done just right, you should be able to remove the toothpick from the outside after your reassembly.

The rotor winding of an alternator is a fairly high resistance, usually around 5 ohms or so. It will safely current limit itself. But your stator windings are an extremely low impedance, typically under a quarter ohm. Thus, you *must* externally limit your rotor currents to keep things from burning up. Plain old power resistors are a good way to handle this for your early experiments.

There are some tricks you could pull to improve the number of steps per revolution. One would be to allow two windings to be active at once. That could double your resolution.

A fancier technique would be to allow several different values of the current for each winding, leading to various new *microstepping* opportunities. Microstepping is a proven concept with real stepper motors.

Another possibility is to use a *bridge*-type drive that lets you run current either way through any given winding. You could now use both attraction and repulsion, and, once again, should be able to double the number of steps.

And a final resolution enhancer would be to put a nutplate of some sort on the shaft end, creating a *linear stepper*. A threaded shaft through the nutplate will then move forward or backward as the alternator steps.

For instance, with a ¼-20 thread, each full revolution would advance you fifty mils. One single step at 21 steps per revolution would advance you a mere 2.38 mils, besides giving you a really major mechanical advantage to boot.

Simple gearing could also be used to increase your step resolution. But you will have to watch for backlash when you try this. And do note that the finer the resolution, the slower your maximum allowable operating speed. Sorry about that.

You might also like to look at some *dual current* scheme that gives you a brief high-current pulse when stepping and some lower holding current between the actual steps.

After you do have your stepper working reasonably well, you'll want to increase the operating currents. Overheating, saturation effects, and overshoots set your ultimate limit.

It might also be very interesting to rewind all the stator coils. Use lots more turns of a much smaller-diameter wire, and try bridging only a single

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stator pole rather than three. Ampere turns is the name of the game here. You could also try improving the rotor flux paths and air gaps.

For further resources on power stepping in general, check out *Airpax* and *Slo-Syn* for iron, the *PCIM* and *Motion* trade journals for info, and *SGS*, *Sprague*, or else *Motorola* for drivers. One distributor that stocks a wide selection of power-electronics stuff is *Galco*. And good old *J.C. Whitney* has bunches of alternators and parts available, including some rewound 100-amp stators that go for around $18. You will find lots more on power electronics in our brand new *Hardware Hacker III* reprints. There's lots of possibilities here. Let's see what you can come up with.