Build Your Own 12 VDC Engine/Generator

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This small, easy to build, engine/alternator is the answer to a burning RE question. What do we do when the sun doesn't shine, the wind doesn't blow, and the creek dries up? This generator is a backup power source for times when our RE sources don't meet our demands. It is optimized to do only one thing — properly recharge batteries on demand.

Above: This engine/generator uses a Chrysler 70 Ampere alternator.

Engine/Generator Overview

I have built a dozen versions of this power plant in the last twenty years — three for myself and others for neighbors. Over the years the design has evolved, but the purpose remains the same — on-demand battery recharging and equalization. A version of this article first appeared in *Home Power* #2 — our most requested out-of-print back issue. Here is a revision of this information with an updated regulator design.

In the early days (1982–1985), we used this type of engine setup as a prime mover. It supplied almost all of the energy for our system. We only had two PV modules at the time. As our PV/wind system grew, our dependence on the engine faded. Now we only use it during the depths of winter to meet those cloudy, all-night deadline sessions. From this experience we learned that while an engine is still a great energy back-up, it is a miserable prime mover for the system. These units are most effective if used less than 200 hours yearly. Using the generator as the primary power input will yield 1,000 to 2,000 hours of engine operation yearly — a nightmare of expense, maintenance, and pollution.

Source Capacity and Flexibility for Battery Equalization

Every RE system should have at least one power source capable of recharging the batteries at between C/10 to C/20 rates of charge. For example, a battery pack of 700 Ampere-hours periodically needs to be recharged at a minimum of 35 Amperes (its C/20 rate). To figure the C/20 rate for your pack, simply divide its capacity in Ampere-hours by 20. The resulting number is the C/20 rate in Amperes. The C/20 rate is optimum for equalizing charges. An equalizing charge is a controlled overcharge of any already full battery. If your RE sources are not powerful enough, or flexible enough, to equalize the battery, then this engine-driven source can do the job.

Power Source Control

Energy sources which recharge batteries need to be controlled. If the charging source is not controlled, then the batteries may be overcharged or recharged too rapidly. The most common method of control is voltage regulation. This works fine in cars and in batteries with shallow cycle, float service. Voltage regulation alone is not enough for deeply cycled batteries. They must also be current regulated to prevent too rapid recharging.

Voltage Regulation

Voltage regulation only is OK for batteries that are very shallowly cycled. In shallow cycle service the battery refills almost immediately since it has only had a small amount of its stored energy removed. In deep cycle service the batteries have had about 80% of their energy removed before recharging. If deep cycle batteries are recharged from a source that is voltage regulated, they will be charged at the total output current of the source as it struggles to bring the batteries immediately to the set voltage limit. If the charging source has say 55 Amperes available, then it will charge the batteries at this 55 Ampere rate. If the battery is a 100 Ampere-hour battery, then the C/10 rate for this battery is 10 Amperes. The 55 Amperes from the source would recharge the 100 Ampere-hour battery at a rate over five times faster than it should be charged. This will result in premature battery failure, higher operating costs, and much lower system efficiency.

Above: The engine powering this generator is a Honda G40 model displacing 170 cc with a rated output of 4.5 horsepower. This particular engine has outlived four alternators and now powers a 100 Ampere Chrysler alternator. I estimate that this engine has run over 13,000 hours in the last fifteen years. It still has its original valves and piston rings.

Right: Proper pulley alignment is essential for efficiency and long belt life. This particular generator would produce 60 Amperes of current for five hours while consuming about ¾ of a gallon of gasoline.

Constant Current

Constant current charging means that the batteries are recharged at a fixed amperage rate until they are full. The voltage of the batteries is left unregulated until the batteries are full. The rate of charge is usually between C/10 and C/20. Constant current charging assures that the batteries are not charged too rapidly. Rates of charge greater than C/10 produce heat which can warp the thick plates of deep cycle batteries. Too rapid recharging wastes energy in heat and hydrolysis, and gradually ruins the batteries.

Engine-driven Power Plants

The engine-driven source has the distinct advantages of delivering large amounts of power when you need it. This is very different from wind and solar systems, where you have to take it when you can get it. Its major disadvantage is that it requires fuel and maintenance. Engines do not usually suffer from being undersized. If the power source is capable of delivering between C/20 and C/10 rates of charge to the batteries, then the system is happy.

Lawnmower Engines and Car Alternators

The idea here is to use a lawnmower engine (or any other small horizontal shaft engine) to drive an automotive alternator. The alternator puts out between 35 and 200 Amperes (depending on its size) of 12 to 16 Volt DC power to recharge the batteries. The first engine we used actually came from an old lawnmower we bought for $35. We got a 35 Ampere Delco alternator from a dead Chevy in the junkyard for $15. We bolted the entire works to a thick wood slab, and used an old oven heating element as a crude resistive field controller. The unit ran and charged our 350 Ampere-hour battery for two years before the engine died.

Type and Size of Engine

We've since tried many different combinations of engines and alternators. Small gas engines between 3 and 8 horsepower work well. We found that the Honda small engines will run more than 5,000 hours without major work, Tecumseh engines about 800 hours, and Briggs & Stratton engines about 600 hours. The particular Honda G40 (170 cc, ≈4.5 hp) engine pictured here has run for over 13,000 hours with the same rings, bearings and valves. The Honda also has the advantage of a 100 hour oil change interval, compared with 25 hours for both the Tecumseh and the Briggs & Stratton. If you consider the operating life and operating cost of small engines, then the higher quality engines are much less expensive despite their higher initial cost. The engine's size is determined by the size

of the alternator. This assures a balance between system efficiency and cost. A 35 Ampere alternator can be driven by a 3 hp engine. A 100 Ampere alternator needs at least a 5 hp engine. For alternators between 100 and 200 Amperes use the 8–12 hp engine. See Access at the end of this article for a source of small gasoline engines.

Type and Size of Alternator

Just about any automotive alternator will work in these systems. What really counts is the size of the alternator. Its current output (amperage rating) should be sized to match the capacity of the battery pack. The more capacity the battery pack has, the bigger the alternator must be. The alternator must be able to deliver at least a C/20 rate of charge to the batteries. We have had good results with 35 Ampere Delco alternators for battery packs under 700 Ampere-hours. Batteries up to 1,400 Ampere-hours are fed with the 100 Ampere Chrysler alternators. Packs larger than 1,400 Ampere-hours should have a 200 Ampere rated alternator. The higher amperage alternators are measurably more efficient than the smaller ones.

The higher amperage alternators are more difficult to find. Try your local auto electric shops, they may have a source for these high amp jewels. Regular alternators up to 70 Amperes are usually available from junkyards at less than $20. Alternator rebuilders can provide rebuilt units (new bearings and brushes) from $40 to $150. These alternators are a good investment. They are designed to run under the hood of a hot car on a summer day. In the type of service we give them, they run cool and last a very long time. I've seen these alternators last over 10 years with just the replacement of bearings and brushes.

The more modern alternators contain their voltage regulators within the alternator's case. These internal regulators need to be disabled and/or removed before these alternators are useful in this system. If you can't do this yourself, then take the alternator to an alternator shop for help. Some alternators have what is known as an "isolated field". These need to have one field connection grounded to the alternator's case and simply feed positive energy to the other field connection. The older Delco types are very simple and straightforward to use. They require no modification. Every alternator is a little different, so if you're not sure what you have, then go to the library and look it up in an automotive manual.

Getting it all together — Assembly

We originally bolted both the alternator and the engine to a wooden slab about 16 inches by 24 inches and 4 inches thick. Be very careful with engine and alternator

pulley alignment. If the engine pulley and the alternator pulley are not properly aligned (in the same plane), then the unit will wear belts out very rapidly. These engine/alternator combos work best on heavy metal bases. There is a lot of vibration and the wooden slabs give up after a few years. Either add a sheet of 1/4 inch to 3/8 inch thick steel between the wood and the engine/alternator, or make the base completely out of metal. A local welding shop made us a base out of 3/8 inch thick steel plate with a welded one inch by two inch steel square tubing perimeter for $50. You can see it in the photograph. If you can weld, the materials cost about $18. Use heavy bolts with lock washers to secure everything to the base.

We coupled the alternator to the engine with an "A" sized Vee belt. Keep the belt length to a minimum by mounting the engine and alternator close together. We use belts between 28 and 33 inches in total length. The stock pulley on the alternator works well. The best sized engine pulley is between five and six inches in diameter. This pulley ratio gears up the alternator for better efficiency while allowing the engine to run about 2,200 rpm. We have had very poor results with the lightweight cast aluminum pulleys or any pulley using set screws. These light pulleys were not up to the high vibration job and broke frequently. We're now using cast and machined iron pulleys (such as the Woods brand SDS pulleys) that work very well and are extremely rugged. These are available from power transmission product stores and cost about $40.

Be sure to get the alternator turning in the right direction. Electrically it makes no difference, but the alternator's fan is designed to suck air from the back of the alternator and to exhaust this air in front around the pulley. If the alternator's fan is running backwards then the alternator will overheat when heavily loaded.

Use large wire to hook up the output of the alternator. Something between 6 gauge and 0 gauge is fine, depending on the length of the runs. Locate the engine/alternator as close as possible to the batteries. This keeps power loss in the wiring to a minimum.

Control Systems

The very first engine-driven charger we built worked fine, but we had problems controlling it. We were using a standard car voltage regulator. It wanted to charge the batteries far too quickly and the large load often stalled the engine. We experimented with many forms of control and found two which work well.

Alternator controls work by limiting the amount of power supplied to the alternator's rotating magnetic field. All alternator control starts with controlling this magnetic field's energy.

Car Voltage Regulators

Car voltage regulators will not work well in deep cycle applications. The regulator makes its decisions based only on the system's voltage. This is fine with the average car battery which is cycled to less than 1% of its capacity before being refilled. However, the deep cycle battery is almost empty when it is recharged. The car voltage regulator attempts to instantly bring the system's voltage to 14–15 Volts. A 12 Volt deep cycle lead-acid battery will not reach a voltage of 14 Volts until it is almost filled. The net result is that the car regulator dumps the entire output of the alternator into the batteries until they are full. This is almost always too much energy too fast for a fully discharged battery.

To compound the problem, the car regulator's voltage limit is set too low for deep cycle service. This low voltage limit means that the batteries are charged too slowly when they are almost full, resulting in many extra hours of generator operation to totally fill the battery pack. Since the car regulator is set at about 14 Volts, we are unable to raise the system voltage up to over 16 Volts for the essential equalizing charges.
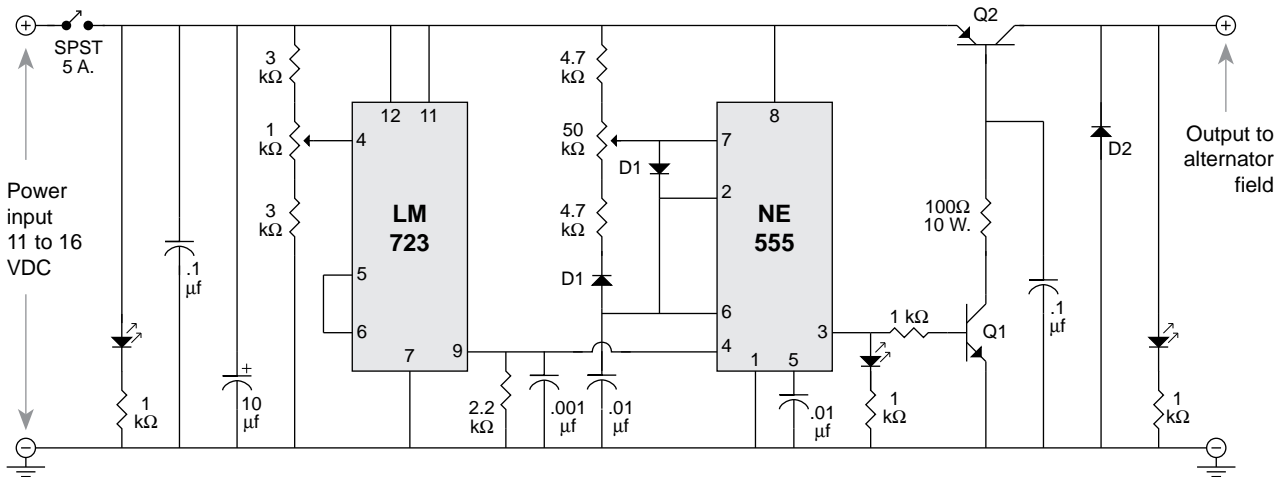
Resistive Field Controller

The simplest control for the alternator is resistance to limit the power to the alternator's field. The idea is simple: insert resistance between the battery's positive
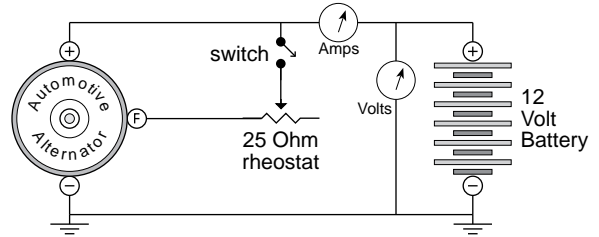
A resistive field controller.

pole and the alternator's field. This controls the intensity of the alternator's electromagnetic field and thereby its power output. Resistance of 2 to 25 Ohms works well. Adjust the resistance until the charge rate is between C/20 and C/10. The less resistance in the field line, the higher the amperage output of the alternator. Originally, we used a nichrome wire heating element from an old electric stove. We selected more or less wire (hence more or less resistance) with an alligator clip lead. It worked fine. A better resistor is a 0 to 25 Ohm rheostat (adjustable power resistor) rated at least 25 Watts. This allows smooth adjustment of the alternator's output. The illustration above shows the wiring hookup for a resistive field controller. The switch shown in this circuit needs to handle about 5 Amperes and prevents energizing of the field when the charger is not in use. See Access for a rheostat source.

Electronic Field Controller version 8.3

Field Controller version 8.3 — Parts Notes

Integrated Circuits

LM723 Voltage Regulator, in 14 pin DIP

NE555 Timer, in 8 pin DIP

Transistors

Q1- 2N2222A or eqiv. NPN

Q2- MJE 2955, or any PNP with Ic>5 Amps., heatsunk

Diodes

D1- 1N914 or equivalent

D2- 1N1202A, or any 3+ Ampere diode, heatsunk

All resistors 1/4 Watt & 5% unless otherwise noted

All capacitors are 25 Volt rated

Using resistive field control only regulates current. The resistive circuit does not provide any form of voltage regulation. When the batteries are full the system voltage can get high, over 16 Volts. Voltage this high can damage 12 VDC appliances. The highest voltage for most 12 Volt equipment is around 15 Volts. If you are using resistive field control, be sure to monitor the system's voltage and reduce the current output of the alternator to keep the system voltage under 15 Volts when appliances are being used.

Electronic Field Controller

We eventually solved the problem of control by designing electronic field controllers that regulate both the amperage and the voltage of the alternator. With this electronic field control, we simply set the desired charge rate, and set the system's voltage ceiling. The battery is recharged at a constant rate until it is full. When the batteries are full, the voltage limit predominates and the system is voltage regulated, thereby protecting the batteries from overcharging. And also protecting all electrical equipment on line. The amperage output is adjustable from 0 to the full rated output of the alternator. The voltage limit is adjustable from 13.5 Volts to 16.5 Volts.

For the intrepid electronic builder, this electronic field controller's schematic is included on page 31. It uses off-the-shelf parts available at Radio Shack or any electronics supply store.

Engines for Equalizing Charges

This engine-driven source is a good type to use for the equalizing charges and whenever the RE sources are not keeping up with the system's energy consumption. Its voltage output is capable of being adjusted to over 16 Volts in order to accomplish the equalizing charge. The engine-driven source is capable of delivering a C/20 rate of charge for the at least five continuous hours necessary for battery equalization. Remember the batteries must already be full before the equalizing charge is started.

Access

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Engines: Northern Hydraulics, PO Box 1219, Burnsville, MN 55337 • 800-533-5545 • 612-894-9510

Rheostats and surplus meters: Fair Radio Sales, PO Box 1105, Lima, OH 45802 • 419-223-2196