# Chapter 37 - The Rotoverter

The Rotoverter is a high-efficiency motor drive system which uses a standard three-phase electric motor. A three-phase motor has got three windings, each of which is powered up sequentially to provide rotation of the output drive shaft. This circuit has been presented as a Public Domain non-copyrightable circuit by Hector Perez Torres.

The Rotoverter has been reproduced by several independent researchers and it produces a substantial power gain when driving devices which need an electrical motor to operate. Typically, the input power requirement is cut to just 10% of the original power needed. For example, it is possible to power a Rotoverter with a solar panel and use it to pump water from a well. However, the greatest interest is in generating an electrical output. One method is shown here:
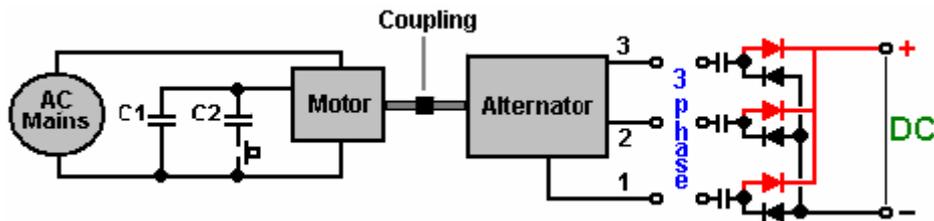
The output device is an alternator which is driven by a three-phase mains-powered, 3 HP to 7.5 HP motor (both of these devices can be standard 'asynchronous squirrel-cage' motors). The drive motor is operated in a highly non-standard manner. It is a 240V motor with six windings as shown below. These windings are connected in series to make an arrangement which should require 480 volts to drive it, but instead, it is fed with 120 volts of single-phase AC. The input voltage for the motor, should always be a quarter of its rated operational voltage. A virtual third phase is created by using a capacitor which creates a 90-degree phase-shift between the applied voltage and the current.   The arrangement needs a different value capacitor when starting compared to when the motor is running normally. The best capacitor size for any particular drive motor has to be determined by experiment.
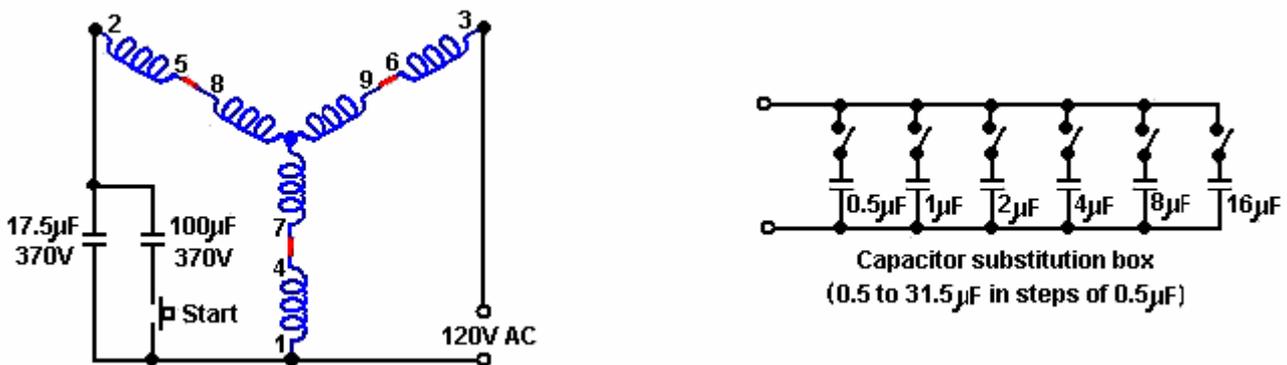
A capacitor switching box can be very helpful. The capacitors shown above, can produce any value from 0.5 microfarad to 31.5 microfarad, and can be rapidly switched to find the correct resonant value. These values allow combined values of 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, ...by selecting the appropriate switches to be ON or OFF. Should you need a value greater than this, then wire a 32 microfarad capacitor in place and connect the substitution box across it to test higher values step by step to find the optimum value of capacitor to use. The capacitors need to be powerful, oil-filled units with a high voltage rating - in other words, large, heavy and expensive.

The power being handled in one of these systems is large and setting one up is not without a certain degree of physical danger. These systems have been set to be self-powered but this is not recommended, presumably because of the possibility of runaway with the output power building up

rapidly and boosting the input power until the motor burns out.

The Yahoo EVGRAY Group at http://groups.yahoo.com/group/EVGRAY has many members many of whom are very willing to offer advice and assistance. A unique jargon has built up on this forum, where the motor is not called a motor but is referred to as a "Prime Mover" or "PM" for short, which can cause confusion as "PM" usually stands for "Permanent Magnet". RotoVerter is abbreviated to "RV" while "DCPMRV" stands for "Direct Current Permanent Magnet RotoVerter" and "trafo" is a non-standard abbreviation for "transformer". Some of the postings in this Group may be difficult to understand due to their highly technical nature and the extensive use of abbreviations, but help is always available there.

To move to some more practical construction details for this system. The motor (and alternator) considered to be the best for this application is the "Baldor EM3770T" 7.5 horsepower unit. The specification number is 07H002X790, and it is a 230/460 volts 60Hz 3-phase, 19/9.5 amp, 1770 rpm, power factor 0.81, device.

The Baldor web site is www.baldor.com and the following details should be considered carefully before trying any adaption of an expensive motor. The following constructional photographs are presented here by kind permission of Ashweth of the EVGRAY Group.

The end plate of the drive motor needs to be removed and the rotor lifted out. Considerable care is needed when doing this as the rotor is heavy and it must **not** be dragged across the stator windings as doing that would damage them.


The second end-plate is then removed and placed on the opposite end of the stator housing:

The fan is removed as it is not needed and just causes unnecessary drag, and the rotor is inserted the opposite way round to the way it was removed. That is, the housing is now the other way round relative to the rotor, since the rotor has been turned through 180 degrees before being replaced. The same part of the shaft of the rotor passes through the same end plate as before as the end plates have also been swapped over. The end plates are bolted in position and the rotor shaft spun to confirm that it still rotates as freely as before.

To reduce friction to an absolute minimum, the motor bearings need to be cleaned to an exceptional level. There are various ways of doing this. One of the best is to use a carburettor cleaner spray from your local car accessories shop. Spray inside the bearings to wash out all of the packed grease. The spray evaporates if left for a few minutes. Repeat this until the shaft spins perfectly, then put one (and only one) drop of light oil on each bearing and do not use WD40 as it leaves a residue film. The result should be a shaft which spins absolutely perfectly.

The next step is to connect the windings of the two units. The motor (the "Prime Mover") is wired for 480 volt operation. This is done by connecting winding terminals 4 to 7, 5 to 8 and 6 to 9 as shown below. The diagram shows 120 volts AC as being the power supply. This is because the RotoVerter design makes the motor operate at a much lower input than the motor designers intended. If this motor were operated in the standard way, a 480 volt 3-phase supply would be connected to terminals 1, 2 and 3 and there would be no capacitors in the circuit.
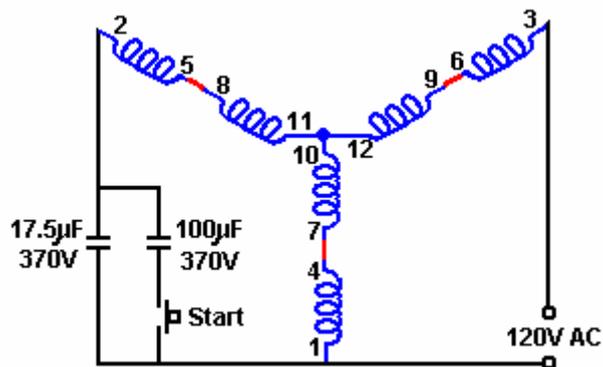

It is suggested that the jumpering of the motor windings is more neatly done by removing the junction box cover and drilling through it to carry the connections outside to external connectors, jumpered neatly to show clearly how the connections have been made for each unit, and to allow easy alterations should it be decided to change the jumpering for any reason.
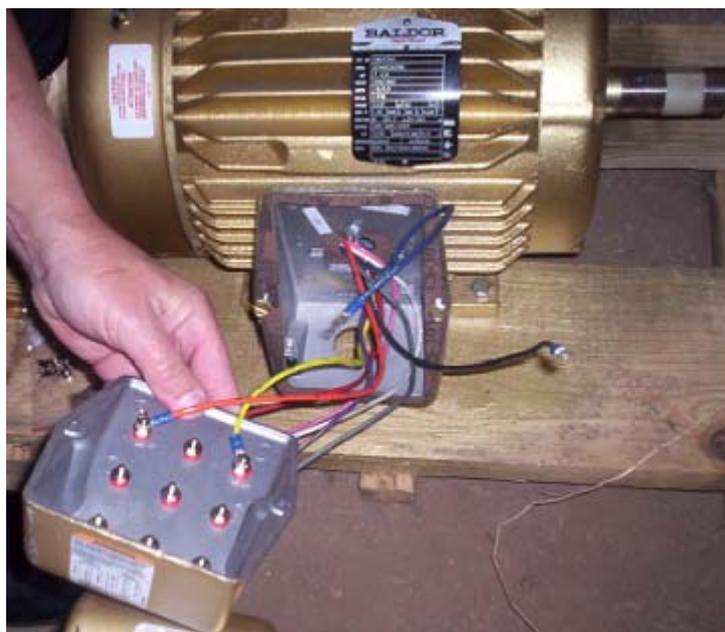
The same is done for the unit which is to be used as the alternator. To increase the allowable current draw, the unit windings are connected to give the lower voltage with the windings connected in parallel as shown below with terminals 4,5 and 6 strapped together, 1 connected to 7, 2 connected to 8 and 3 connected to 9. This gives a three-phase output on terminals 1, 2 and 3. This can be used as a 3-phase AC output or as three single-phase AC outputs, or as a DC output by wiring it as shown here:
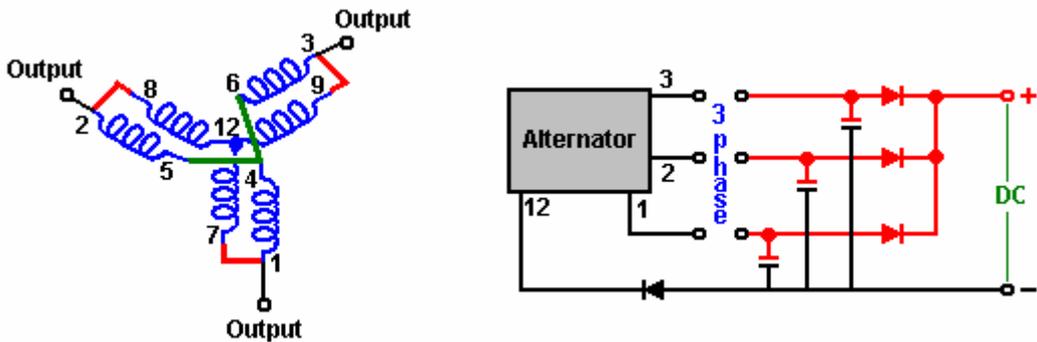
The motor and the alternator are then mounted securely in exact alignment and coupled together. The switching of the direction of the housing on the drive motor allows all of the jumpering to be on the same side of the two units when they are coupled together, facing each other:
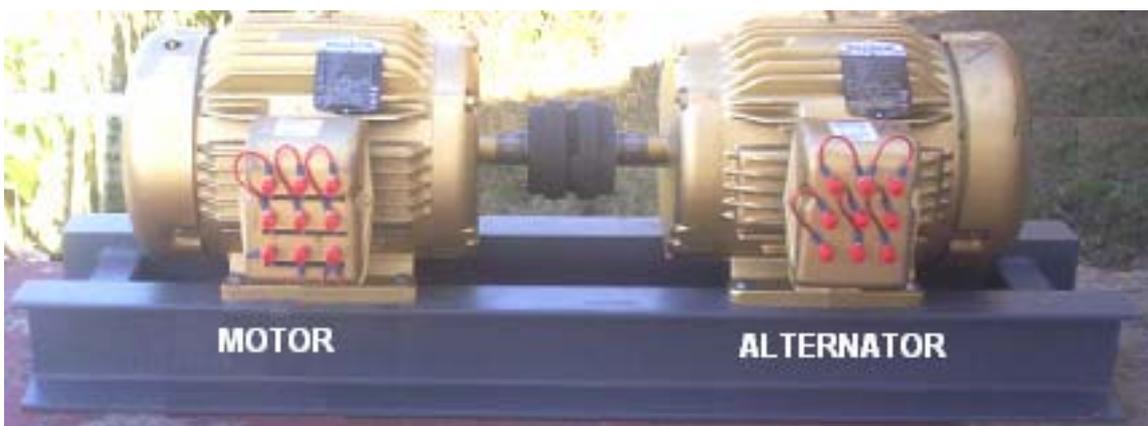

The input drive may be from an inverter driven from a battery charged via a solar panel. The system how needs to be 'tuned' and tested. This involves finding the best 'starting' capacitor which will be switched into the circuit for a few seconds at start-up, and the best 'running' capacitor value.

To summarise: This device takes a low-power 110 Volt AC input and produces a much higher-power electrical output which can be used for powering much greater loads than the input could power. The output power is much higher than the input power. This is free-energy under whatever name you like to

apply to it. One advantage which should be stressed, is that very little in the way of construction is needed, and off-the-shelf motors are used. Also, no knowledge of electronics is needed, which makes this one of the easiest to construct free-energy devices available at the present time. One slight disadvantage is that the tuning of the "Prime Mover" motor depends on its loading and most loads have different levels of power requirement from time to time. A 220 Volt AC motor can also be used if that is the local supply voltage.

It is not essential to construct the RotoVerter exactly as shown above, although that is the most common form of construction. The Muller Motor can have a 35 kilowatt output when precision-constructed as Bill Muller did. One option therefore, is to use one Baldor motor jumpered as the "Prime Mover" drive motor and have it drive one or more Muller Motor style rotors to generate the output power:
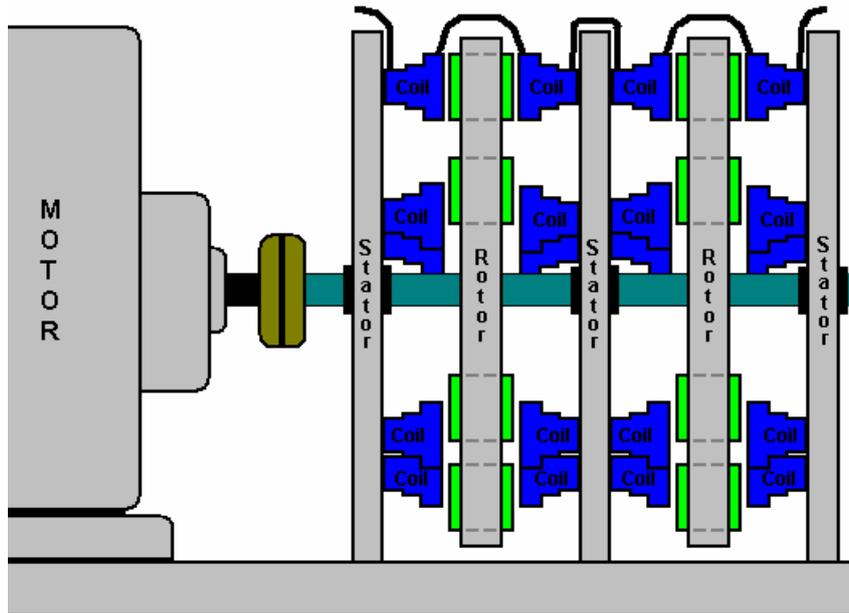
T. J. Chorister in America has used a Rotoverter style circuit for some time now. He uses a 200V 3-phase electric motor driven by a single-phase 120V 60 Hz mains. He says: The hot wire goes direct to one phase, and it also goes through a 'run' capacitor to the second phase, also through an inductor to the 3rd phase. You have to experiment with the values of the capacitor and inductor in order to get the smoothest running of the motor. Often you will not even need a switched starting capacitor. Generally, a one-horsepower motor will output about three-quarters of a horsepower. However, the arrangement will be much more efficient than a single phase motor. The neutral is not needed, but be sure to use a ground connected to the frame of the motor.

Run capacitors pass about 1-amp for each 22 microfarads of its capacity and so they act as current limiters when in series in an AC circuit. Inductors should have wire which is thick enough to carry the current needed by the motor. I have no guidelines for inductors, so just try it (if you can measure one leg of the motor winding, then that would be about right for the inductor). The inductor value is adjusted by trial and error until you find the value where the motor runs most smoothly.

If a starting capacitor is needed, then just parallel a starting capacitor and switch and connect a bleeder resistor to the run capacitor. The circuit is like this:
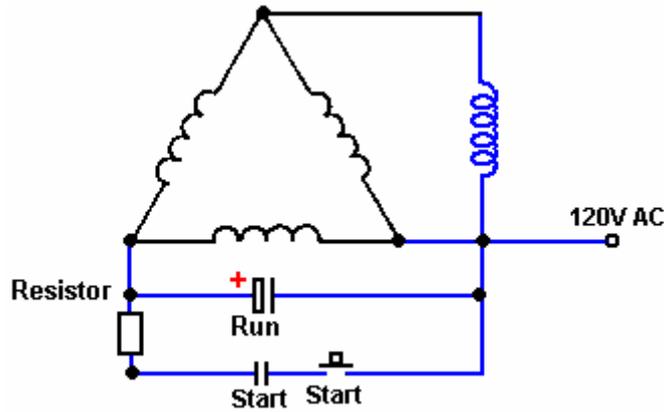
Phil Wood

has many years of experience working with all varieties of electric motor, has come up with a very clever circuit variation for the RotoVerter system. His design has a 240 volt Prime Mover motor driven with 240 volt AC. The revised circuit now has automated start-up and it provides an extra DC output which can be used to power additional equipment. His circuit is shown here:
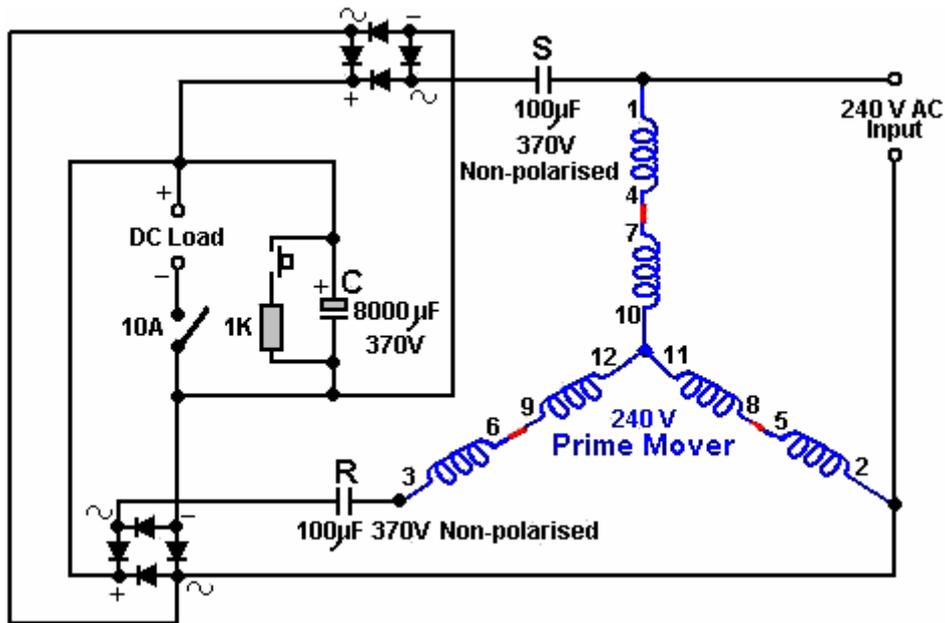
Phil specifies the diode bridges as 20 amp 400 volt and the output capacitor as 4000 to 8000 microfarads 370 volt working. The ON/OFF switch on the DC output should be 10 amp 250 volt AC working. The circuit operates as follows:

The charge capacitor "C" needs to be fully discharged before the motor is started, so the press-button switch is pressed to connect the 1K resistor across the capacitor to discharge it fully. If you prefer, the press-button switch and resistor can be omitted and the switch to the DC load closed before the AC input is applied. The switch must then be opened and the AC connected. The starting capacitor "S" and capacitor "R" both operate at full potential until capacitor "C" begins to charge. As capacitor "C" goes through its charging phase, the resistance to capacitors "R" and "S" increases and their potential capacitance becomes less, automatically following the capacitance curve required for proper AC motor operation at start-up.

After a few seconds of run time, the output switch is operated, connecting the DC load. By varying the resistance of the DC load, the correct tuning point can be found. At that point, the DC load resistance keeps both of the capacitors "R" and "S" operating at a potentially low capacitance value.

The operation of this circuit is unique, with all of the energy which is normally wasted when the AC motor is starting, being collected in the output capacitor "C". The other bonus is where a DC load is

powered for free while it keeps capacitors "R" and "S" in their optimum operating state. The DC load resistance needs to be adjusted to find the value which allows automatic operation of the circuit. When that value has been found and made a permanent part of the installation, then the switch can be left on when the motor is started (which means that it can be omitted). If the switch is left on through the starting phase, capacitor "C" can be a lower value if the DC load resistance is high enough to allow the capacitor to go through its phase shift.
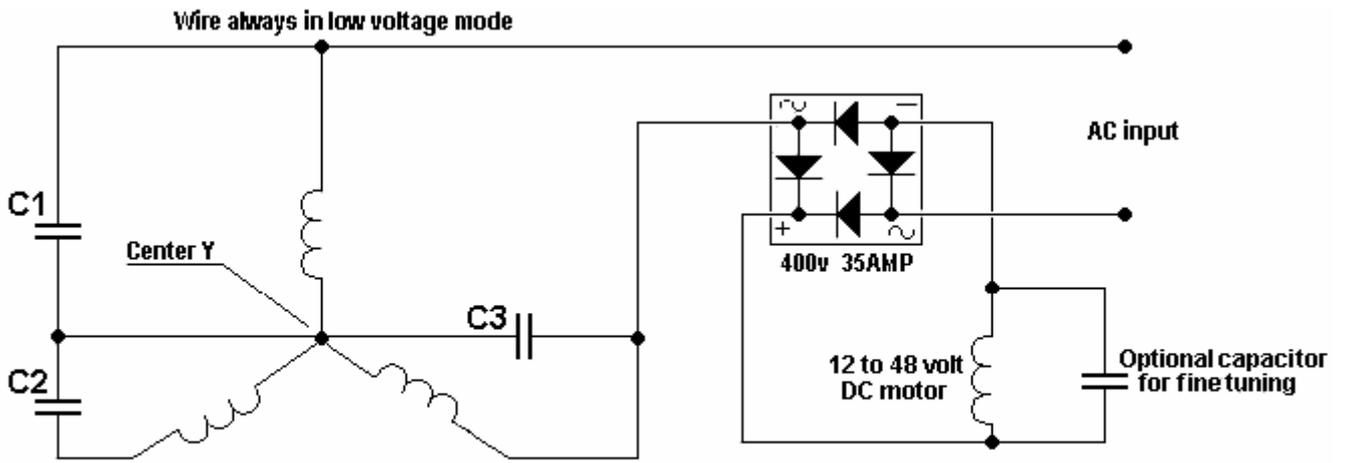
The capacitor values shown above were those found to work well with Phil's test motor which was a three-winding, 5 horsepower, 240 volt unit. Under test, driving a fan, the motor draws a maximum of 117 watts and a variable speed 600 watt drill was used for the DC load. The motor operates at its full potential with this circuit.

The circuit will need different capacitors for operation with a 120 Volt AC supply. The actual values are best determined by testing with the motor which is to be used, but the following diagram is a realistic starting point:
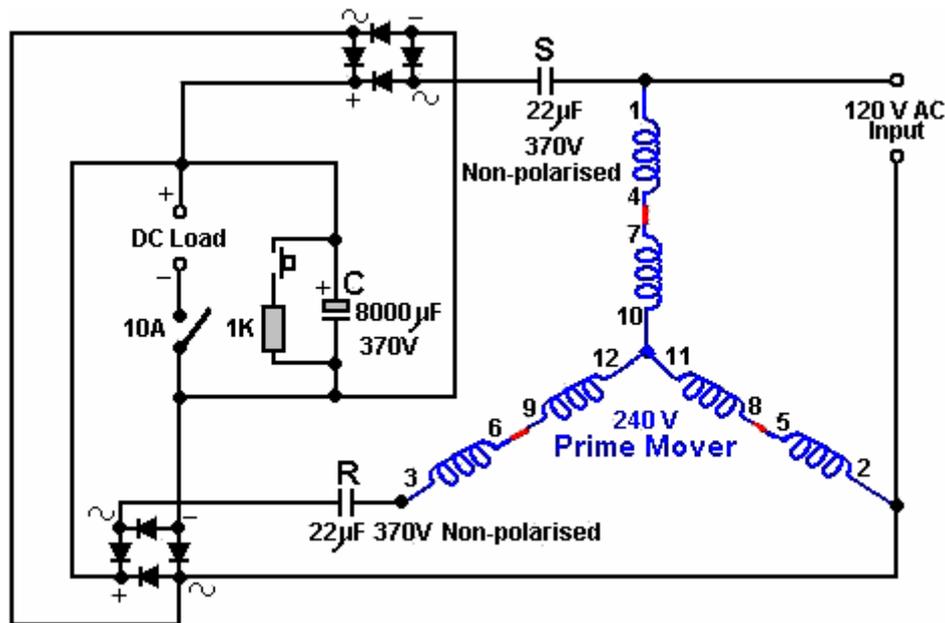
The 120 V AC motor runs very smoothly and quietly drawing only 20 watts of input power.

Advancing the design even further, Phil has now produced an extremely clever design by introducing an additional DC motor/generator coupled to the "Prime Mover" motor. The coupling is nominally mechanical with the two motors physically linked together with a belt and pulleys, but the electrical linking is such that the two motors will synchronise automatically if the mechanical linkage is omitted. I should like to express my thanks to him for sharing this information, diagrams and photographs freely.

Wire always in low voltage mode

C1

Center Y

C3

C2

AC input

400v 35AMP

12 to 48 volt DC motor

Optional capacitor for fine tuning

C1, C2 and C3 are all the same value between 10 µF and 47µF 400 V

By Phil Wood

This circuit is very clever as the DC motor/generator automatically adjusts the running of the AC motor both at startup and under varying loading. Also, the selection of the capacitors is not so critical and no manual intervention is needed at startup. In addition, the DC motor/generator can be used as an additional source of electricity.
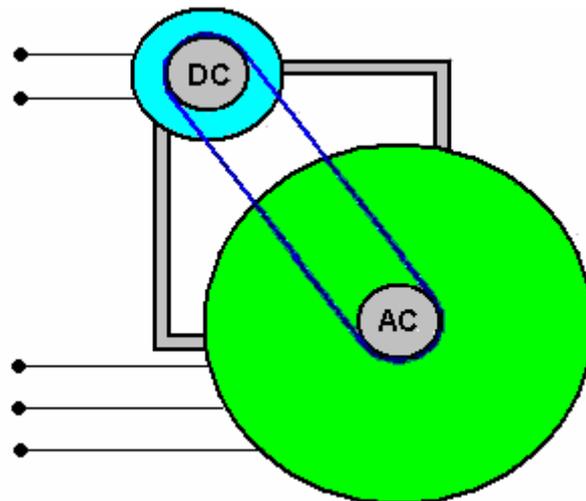
As the loading on the drive motor is quite low due to the very, very high efficiency of the RotoVerter arrangement, it is perfectly feasible to drive the whole system with a low-power inverter run from a battery. If that is done, then it is possible to use two batteries. One is charged by the DC generator while the other is driving the inverter. A timer circuit then switches the batteries over on a regular basis using relay switching.

Extra Energy Collection

A very effective additional circuit has been developed by **David Kousoulides**. This circuit allows extra current to be drawn off a RotoVerter while it is running, without increasing the input power needed to drive the RotoVerter. David's circuit can be used with a wide range of systems, but here it is being shown as an addition to the RotoVerter system, raising it's efficiency even higher than before.

As is common with many effective circuits, it is basically very simple looking, and it's apparent operation is easily explained. The objective is to draw additional current from the RotoVerter and use that current to charge one or more batteries, without loading the RotoVerter at all. The current take off is in the form of a rapid series of current pulses which can be heard as a series of faint clicks when fed into the battery.

Let us examine the circuit section by section:

First, we start with a standard "off the shelf" 3-phase motor. In this example, the motor is a 7.5 horsepower motor, which when wired in RotoVerter mode, using just a single-phase supply as shown here, only draws a very low amount of power when running, especially if the single-phase supply is about 25% of the voltage rating of the motor:
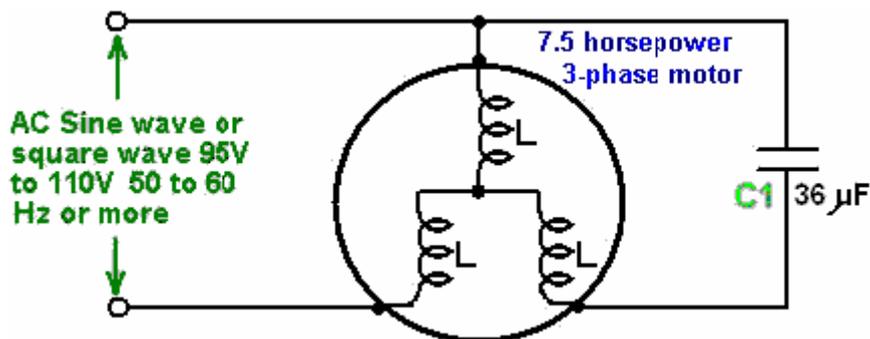

Because the running power draw is so low, it is possible to run this motor from a standard battery-powered inverter, but the current draw at start-up is some 17 amps, so the mains is used to get the motor started and then the motor is switched from the mains to the inverter. The inverter also allows easy measurement of the power input and so makes for easier calculation of the overall power efficiency of the system.

There is a power extraction device called a "diode-plug", which in spite of it's seeming simplicity, is actually much more subtle in it's operation than would appear from a quick glance at the circuit:
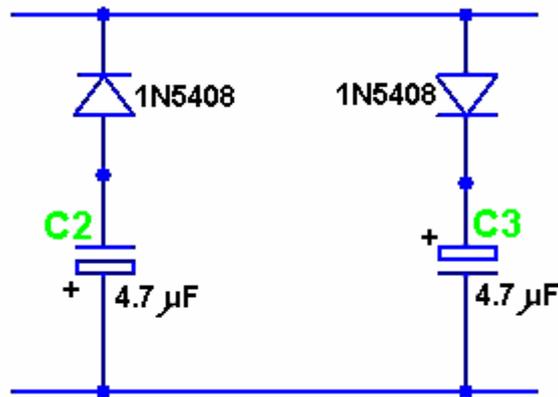
This circuit has been presented as a public-domain non-copyrightable circuit by Hector Perez Torres and it is capable of extracting power from a range of different systems, without affecting those systems or increasing their power draw. In the circuit presented below, just the first half of the diode plug is utilised, though it should perhaps be stressed that it would be perfectly feasible to raise the efficiency of the circuit even further by adding extra components to duplicate the power feed from the battery, drawing on both parts of the diode-plug circuit. For clarity, this is not shown here, but it should be understood that it is a possible, and indeed desirable, extension to the circuitry described here.

When the motor is running, high voltages are developed across the windings of the motor. As only the first half of the diode-plug is being shown here, we will be capturing and using the negative-going voltages. These negative-going pulses are picked up, stored in a capacitor and used to charge a battery using the following circuit:
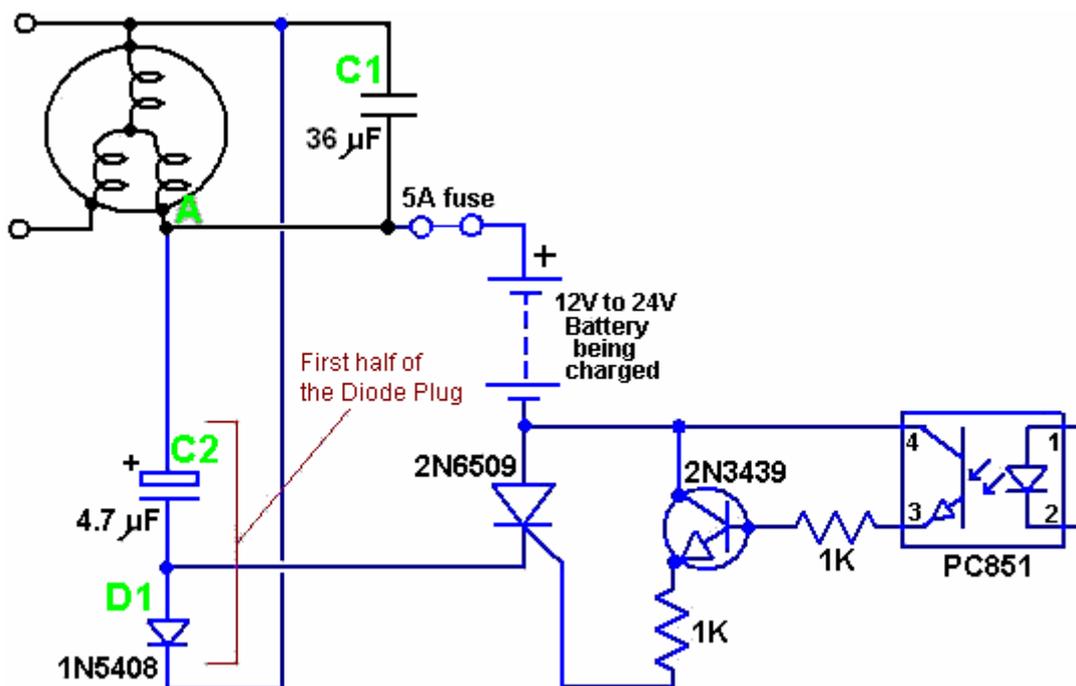

Here we have the same RotoVerter circuit as before, with high voltage being developed across capacitor C1. The battery-charging section is a free-floating circuit connected to point A of the motor. The high-voltage diode D1 is used to feed negative-going pulses to capacitor C2 which causes a large charge to build up in that capacitor. At the appropriate moment, the PC851 opto-isolator is triggered. This feeds a current into the base of the 2N3439 transistor, switching it on and firing the 2N6509 thyristor. This effectively switches capacitor C2 across the battery, which discharges the capacitor into the battery. This feeds a substantial charging power pulse into the battery. As the capacitor voltage drops, the thyristor is starved of current and it turns off automatically. The charging sequence for the capacitor starts again with the next pulse from the windings of the motor.

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The only other thing to be arranged is the triggering of the opto-isolator. This should be done at the peak of a positive voltage on the motor windings and has been built like this:
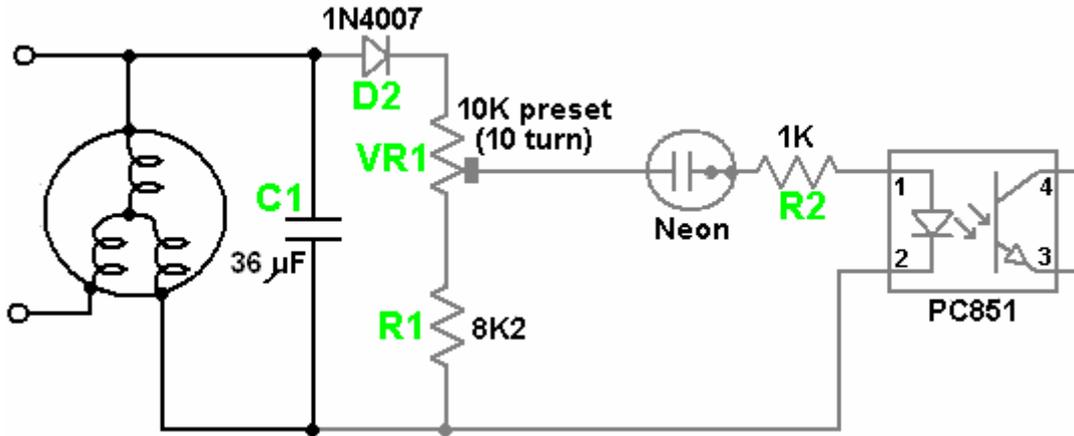
Here, we have the RotoVerter motor as before, with the voltage developed on C1 being used to trigger the opto isolator at the appropriate moment. The voltage on C1 is sensed by the diode D2, the pre-set resistor VR1 and the resistor R1. These place a load of some 18.2K ohms on capacitor C1 as the neon has a very high resistance when not conducting. The ten-turn preset resistor is adjusted to make the neon fire at the peak of the voltage wave coming from the motor. Although the adjustment screw of most preset resistors is fully isolated from the resistor, it is recommended that adjustment of the screw be done using an insulated main-tester type of screwdriver, or a solid plastic trimmer-core adjustment tool.

The circuit to test one half of the diode plug is then:
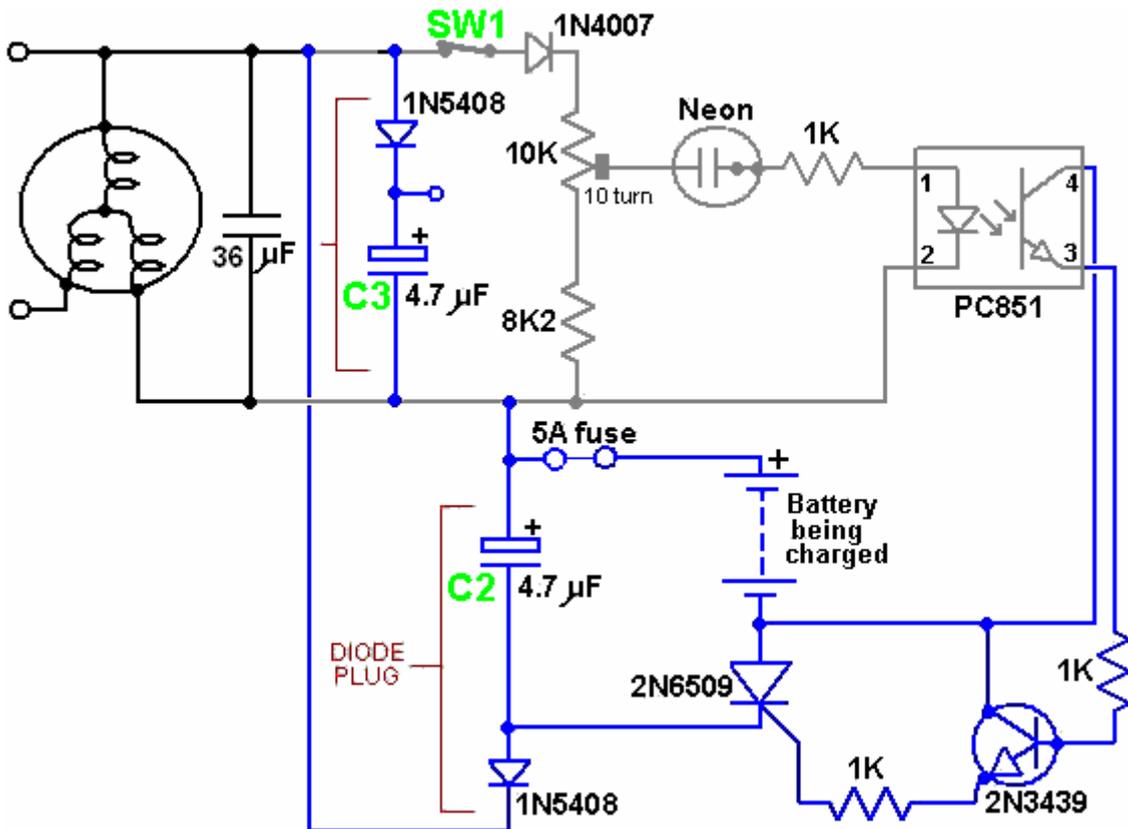
The switch SW1 is included so that the charging section can be switched off at any time and this switch

should not be closed until the motor gets up to speed. All wire connections should be made before power is applied to the circuit. Capacitor C1 which is shown as 36 microfarads, has a value which is optimised for the particular motor being used and will normally be in the range 17 to 24 microfarads for a well-prepared motor. The motor used for this development was retrieved from a scrap yard and was not prepared in any way.

The value of capacitor C2 can be increased by experimenting to find at what value the resonance gets killed and the charging section starts drawing extra current from the supply. It should be noted that many new thyristors (Silicon Controlled Rectifiers or "SCR"s) are faulty when supplied (sometimes as many as half of those supplied can be faulty). It is therefore important to test the thyristor to be used in this circuit before installing it. The circuit shown below can be used for the testing, but it should be stressed that even if the component passes the test, that does not guarantee that it will work reliably in the circuit. For example, while 2N6509 thyristors are generally satisfactory, it has been found that C126D types are not. A thyristor passing the test may still operate unpredictably with false triggers.
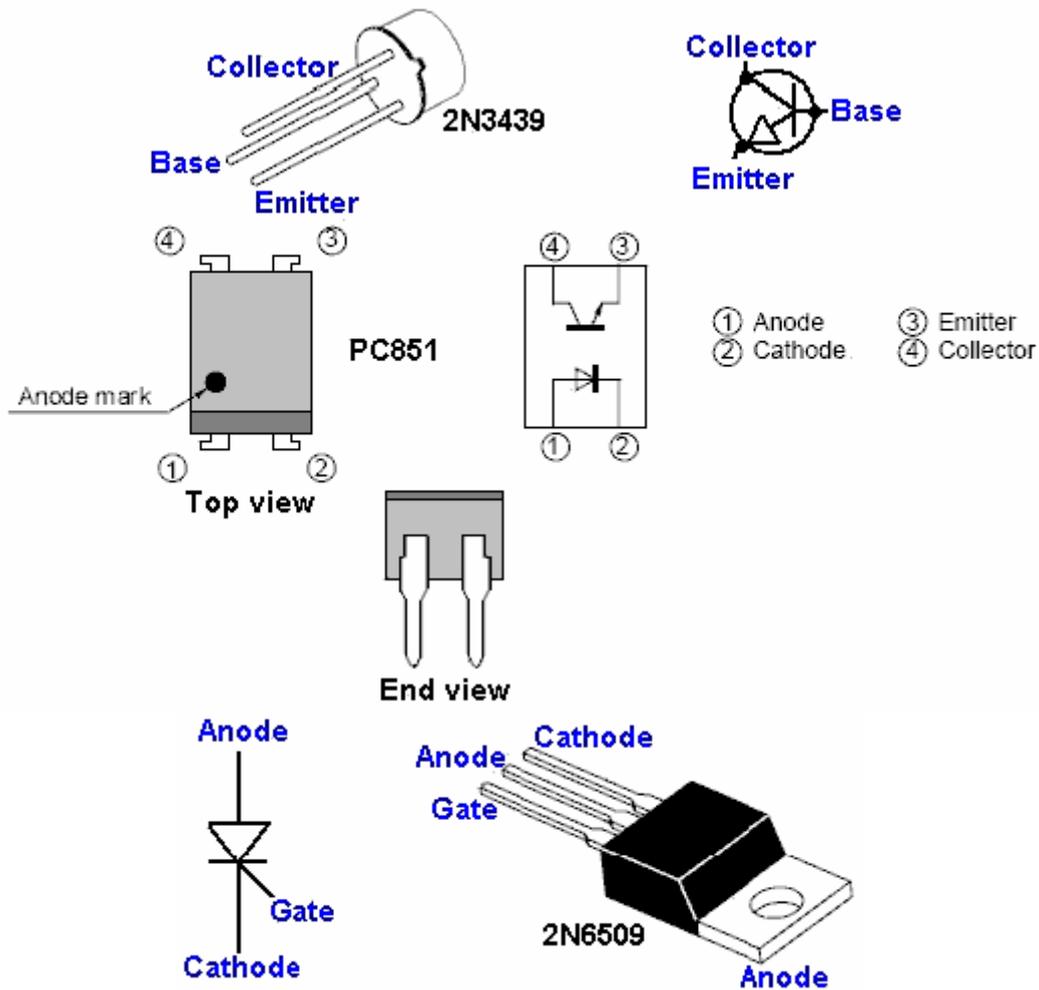
Please note that the 2N6509 package has the Anode connected inside the housing to the metal mounting tab.

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Components List:

Component	Quantity	Description
1K ohm resistor 0.25 watt	3	Bands: Brown, Black, Red
8.2K ohm resistor 0.25 watt	1	Bands: Gray, Red, Red
10K ohm preset resistor	1	Ten turn version
4.7 mF 440V (or higher) capacitor	1	Polypropylene
36 mF 440V (or higher) capacitor	1	Non-polarised polypropylene
1N5408 diode	1	
1N4007 diode	1	
2N3439 NPN transistor	1	
2N6509 thyristor	1	Several may be needed to get a good one
PC851 opto-isolator	1	
Neon, 6 mm wire-ended, 0.5 mA	1	Radiospares 586-015
5A fuse and fuseholder	1	Any convenient type
30A switch 1-pole 1-throw	1	Toggle type, 120-volt rated
Veroboard or similar	1	Your preferred construction board
4-pin DIL IC socket	1	Black plastic opto-isolator holder (optional)
Wire terminals	4	Ideally two red and two black
Plastic box	1	Injection moulded with screw-down lid
Mounting nuts, bolts and pillars	8	Hardware for 8 insulated pillar mounts
Rubber or plastic feet	4	Any small adhesive feet
Sundry connecting wire	4 m	Various sizes

When using and testing this circuit, it is important that all wires are connected securely in place before the motor is started. This is because high voltages are generated and creating sparks when making connections does not do any of the components any particular good. If the circuit is to be turned off while the motor is still running, then switch SW1 is there for just that purpose.

The operating technique is as follows:

Before starting the motor, adjust the slider of the preset resistor VR1 to the fixed resistor end of it's track. This ensures that the charging circuit will not operate as the neon will not fire. Power up the circuit and start adjusting the preset resistor very slowly until the neon starts to flash occasionally. There should be no increased load on the motor and so no extra current drawn from the input supply.

If there is an increase in the load, you will be able to tell by the speed of the motor and the sound it makes. If there is an increase in the load, then back off VR1 and check the circuit construction. If there is no increased load, then continue turning VR1 slowly until a position is reached where the neon remains lit all the time. You should see the voltage across the battery being charged increase without any loading effects on the motor.

If you use an oscilloscope on this circuit, please remember that there is no "ground" reference voltage and that the circuit is not isolated.

Here is a picture of David's actual board construction. There are various ways for building any circuit. This particular construction method uses plain matrix board to hold the components in position and the bulk of the interconnections are made underneath the board. The charge-collecting capacitor is made here from two separate polypropylene 440 volt capacitors wired in parallel. David has opted to use a separate diode on each capacitor as this has the effect of doubling the current-carrying capacity of a single diode and is a popular technique in pulse charge circuits where sometimes several diodes are wired in parallel.

David has included a heat sink, which he marks as being "not required" but you will notice that there is insulation between the SCR and the heat sink. Mica "washers" available from the suppliers of semiconductors are particularly good for this, as mica is a good insulator and it also conducts heat very well.
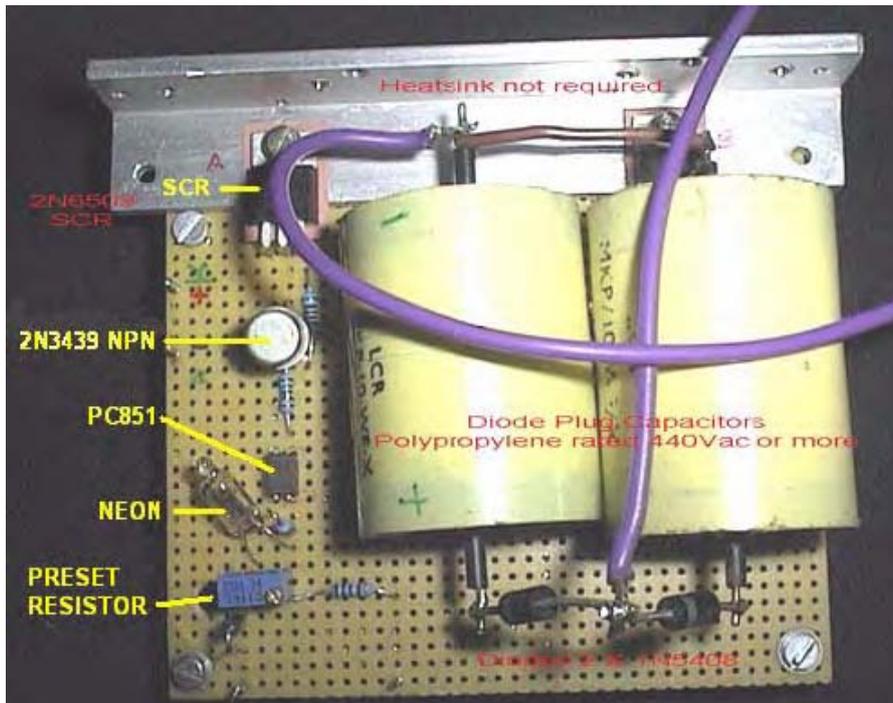
Phil Wood has developed a particularly effective method for extracting the excess resonant circulating energy of a RotoVerter Prime Mover. This is the circuit:
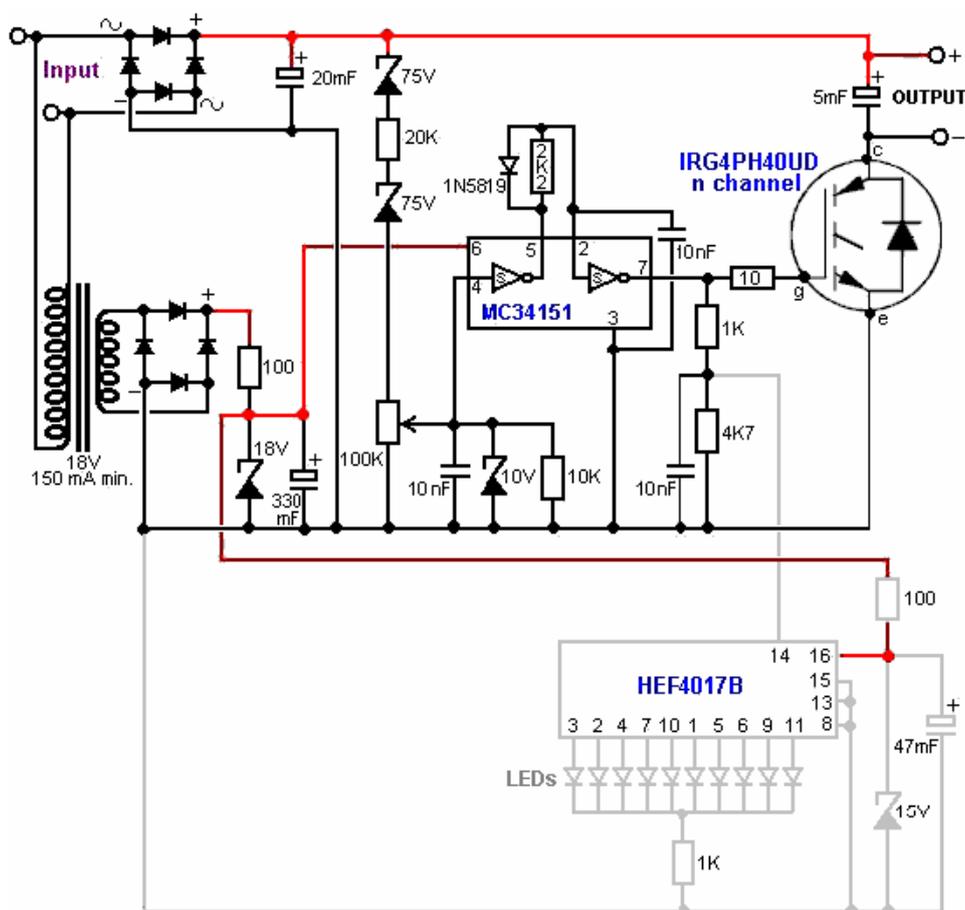
Care needs to be taken when constructing this circuit. For example, the circuit performance is displayed by an HEF4017B 5-stage Johnson counter, but for some lunatic reason, the 4017 designation is also used for a completely different chip of the same size and number of DIL pins, namely the "CMOS high-speed hex flip-flop with Reset", an action definitely worthy of a stupidity award. Another point to watch out for is that the 1A 1N5819 diode is a very high-speed Schottky barrier component.

The circuit operation is as follows: the input from the Rotovertor motor is stepped-down by a transformer to give an 18-volt (nominal) AC output, which is then rectified by a standard rectifier bridge and the output smoothed by an 18-volt zener diode and a 330mF smoothing capacitor, and used to power the MC34151 chip. This DC power supply line is further dropped and stabilised by a 15-volt zener diode and a 47mF capacitor and used to power the LED display chip HEF4017B.

The raw RotoVerter input is also taken direct and rectified by a second 400-volt 35-amp rectifier diode bridge and smoothed by a 20mF capacitor with a high voltage rating. It must be understood that the RotoVerter system is liable to produce considerable power surges from time to time and so this circuit must be capable of handling and benefiting from these surges. This is why the IRG4PH40UD IGBT device was selected (apart from it's very reasonable price) as it robust and can handle high voltages.

The resulting high-voltage DC is taken by the chain of components two 75-volt zener diodes, 20K resistor and the 100K variable resistor. The voltage developed on the slider of this variable resistor is loaded with a 10K resistor and voltage-limited with a 10-volt zener diode, and decoupled with a 10nF capacitor before being passed to the MC34151 high-speed MOSFET dual driver chip. Both of these drivers are used to sharpen up the pulse and drive the IGBT cleanly. The result is an output which is a series of DC pulses. The operation of the circuit can be seen quite clearly, thanks to the HEF4017B display circuit which drives a row of LEDs, triggered by the IGBT gate signal, divided by the 1K / 4.7K voltage divider decoupled by the 10nF capacitor. This display shows clearly when the IGBT is switching correctly - actually, the display circuit is quite a useful device for people who do not own an oscilloscope, not just for this circuit, but a wide range of different circuits.

The physical board layout for Phil's circuit is shown here: As you will notice from the notes on Phil's board layout shown above, the first of the 75-volt zener diodes used on the direct RotoVerter power feed, should be replaced with a 30-volt zener if a 120-volt motor is used in this circuit.
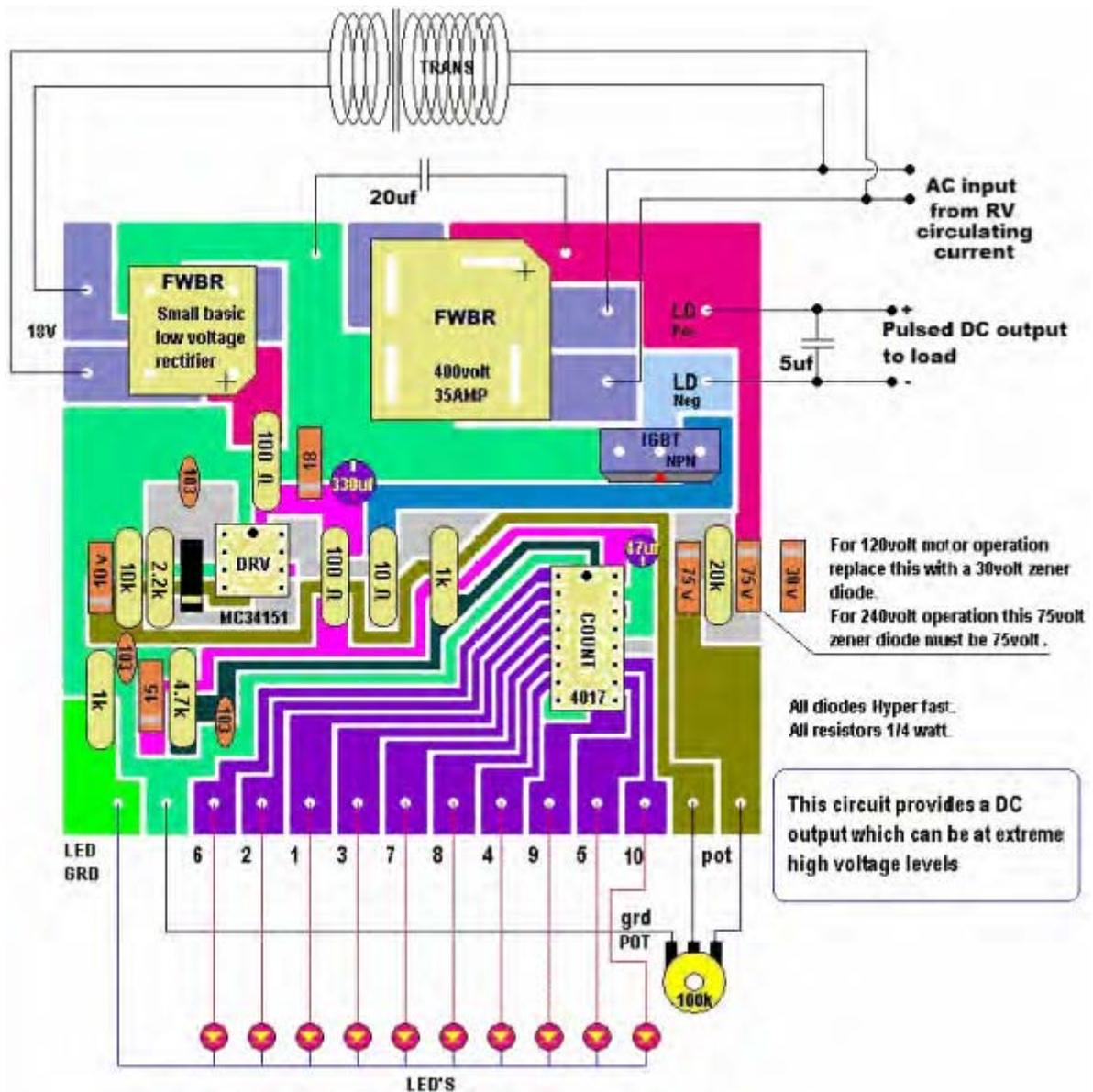
Another important point which needs to be stressed, is that the pulsed DC output from this circuit can be at extremely high voltages and needs to treated with considerable care. This is not a circuit for beginners and anyone who is not familiar with handling high voltages needs the supervision of an experienced person. Also, if either this circuit or the RotoVerter is connected to the mains, then no scope ground leads should be connected as the circuit can be a hundred volts or more below ground potential.
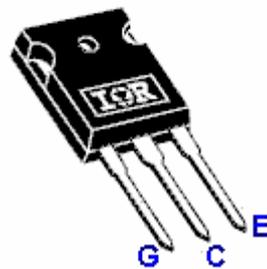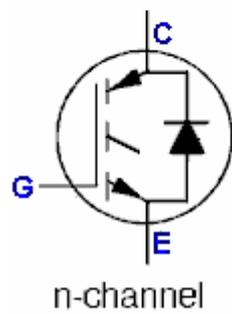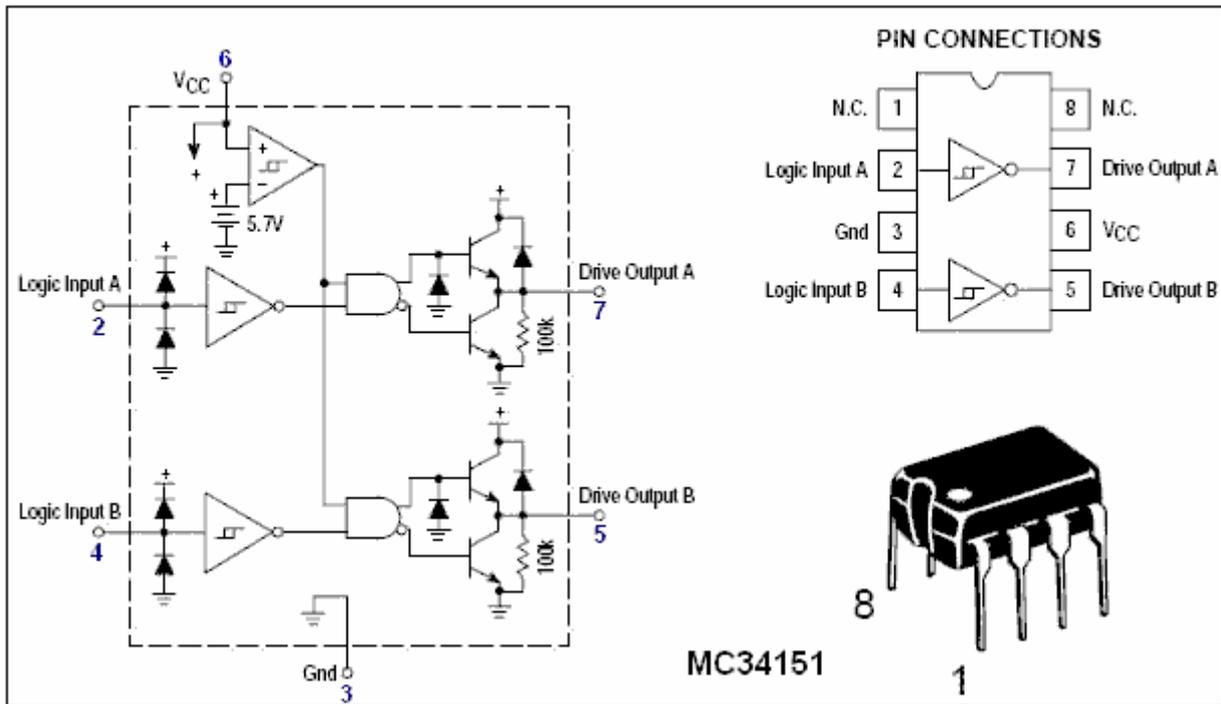

Adjustable level peak voltage
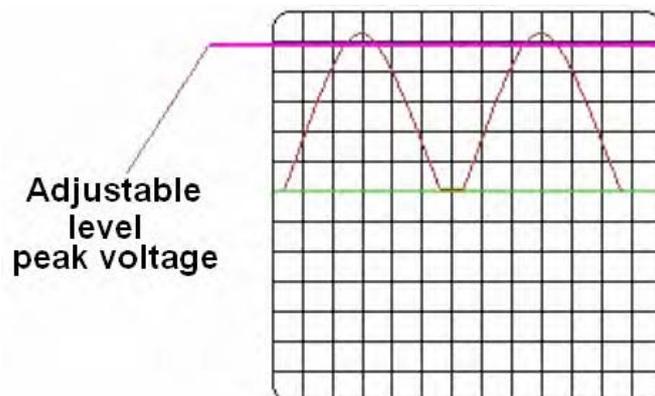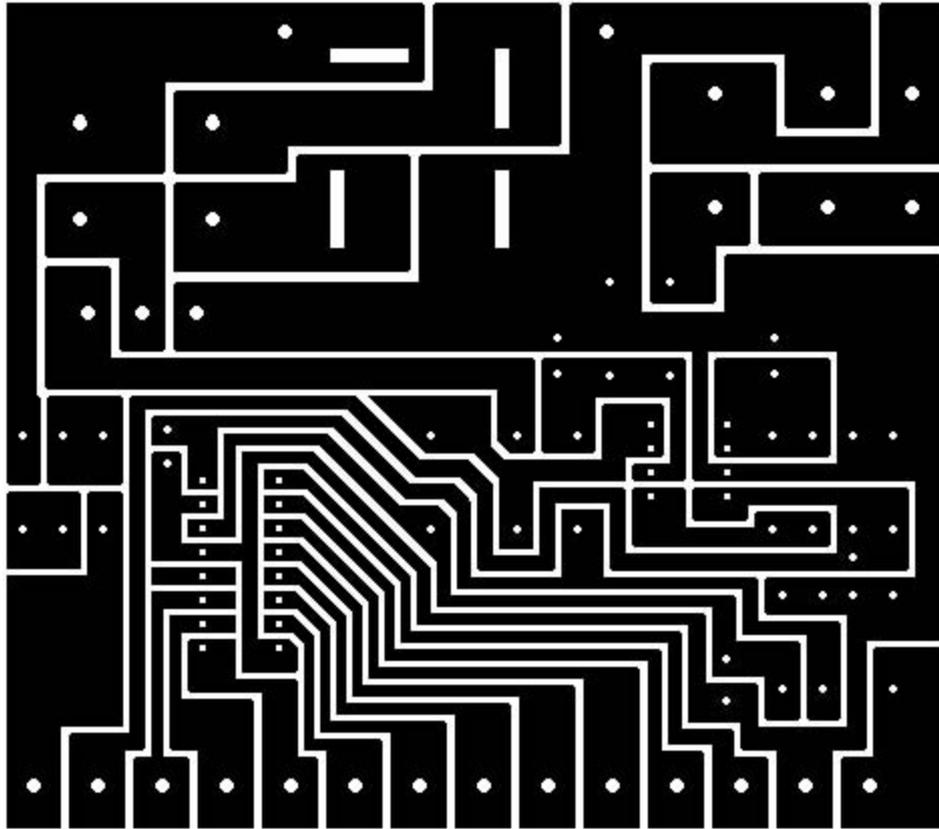
And component packaging is:

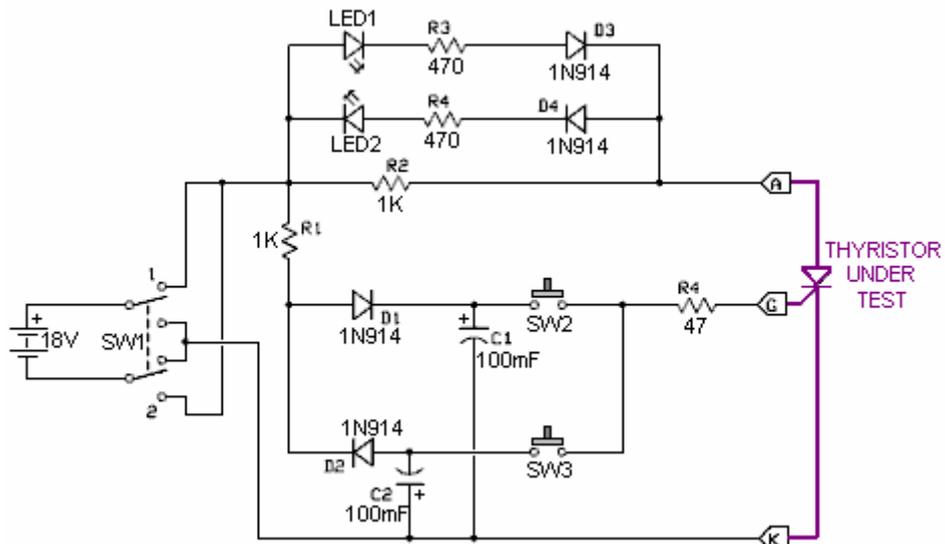**HEF4017B**

n-channel

IRG4PH40UD

17
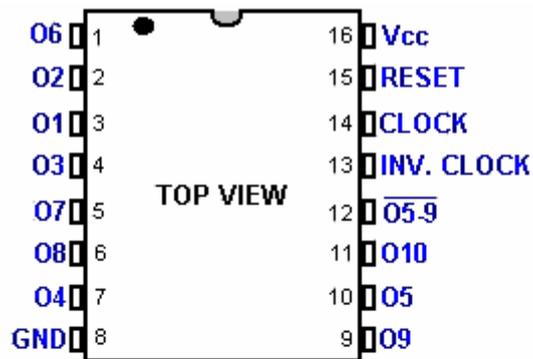
Phil's build of his circuit was implemented like this:

Thyristor testing:

The components needed to construct the thyristor testing circuit shown below can be bought as Kit number 1087 from www.QuasarElectronics.com

The circuit is operated by operating SW1 several times so as to get capacitors C1 and C2 fully charged. LED1 and LED2 should both be off. If either of them light, then the thyristor is faulty.

Next, with SW1 at it's position 1, press switch SW2 briefly. LED1 should light and stay on after SW2 is released. If either of these two things does not happen, then the thyristor is faulty.

With LED1 lit, press SW3 and LED1 should go out. If that does not happen, then the thyristor is faulty.

As mentioned before, even if the thyristor passes these tests it does not guarantee that it will work correctly in any circuit as it may operate intermittently and it may trigger spuriously when it shouldn't.

Component List:

Component	Quantity	Description
10 ohm resistor 0.25 watt	1	Bands: Brown, Black, Black
100 ohm resistor 0.25 watt	2	Bands: Brown, Black, Brown
1K ohm resistor 0.25 watt	2	Bands: Brown, Black, Red
2.2K ohm resistor 0.25 watt	1	Bands: Red, Red, Red
4.7K ohm resistor 0.25 watt	1	Bands: Purple, Yellow, Red
10K ohm resistor 0.25 watt	1	Bands: Brown, Black, Orange
22K ohm resistor 0.25 watt	1	Bands: Red, Red, Orange
10nF capacitor	3	
5mF 440V (or higher) capacitor	1	Polypropolene
20mF 440V (or higher) capacitor	1	Polypropolene
47mF 25V capacitor	1	
330 mF 25V capacitor	1	
1N5819 Schottky barrier diode	1	
10-volt zener diode	1	
15-volt zener diode	1	
18-volt zener diode	1	
75-volt zener diode	2	
400-volt, 40 A rectifier bridge	1	
35-volt 1 A rectifier bridge	1	
MC34151 IC	1	
HEF4017B IC	1	
IRG4PH40UD transistor	1	
LEDs	10	Any type or alternatively, an LED array
100K ohm variable resistor	1	
Plastic knob for variable resistor	1	
240:18 volt mains transformer	1	150 mA or higher rated
10A switch 1-pole 1-throw	1	Toggle type, 120-volt rated
Veroboard or similar	1	Your preferred construction board or pcb
Wire terminals	4	Ideally two red and two black
Plastic box	1	Injection moulded with screw-down lid
Mounting nuts, bolts and pillars	8	Hardware for 8 insulated pillar mounts
Rubber or plastic feet	4	Any small adhesive feet
Sundry connecting wire	4 m	Various sizes

Patrick J. Kelly
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