SIMPLE ADAMS MOTOR CONCEPTS (Hoptoad)

(The original 14 web pages collected in one single pdf)

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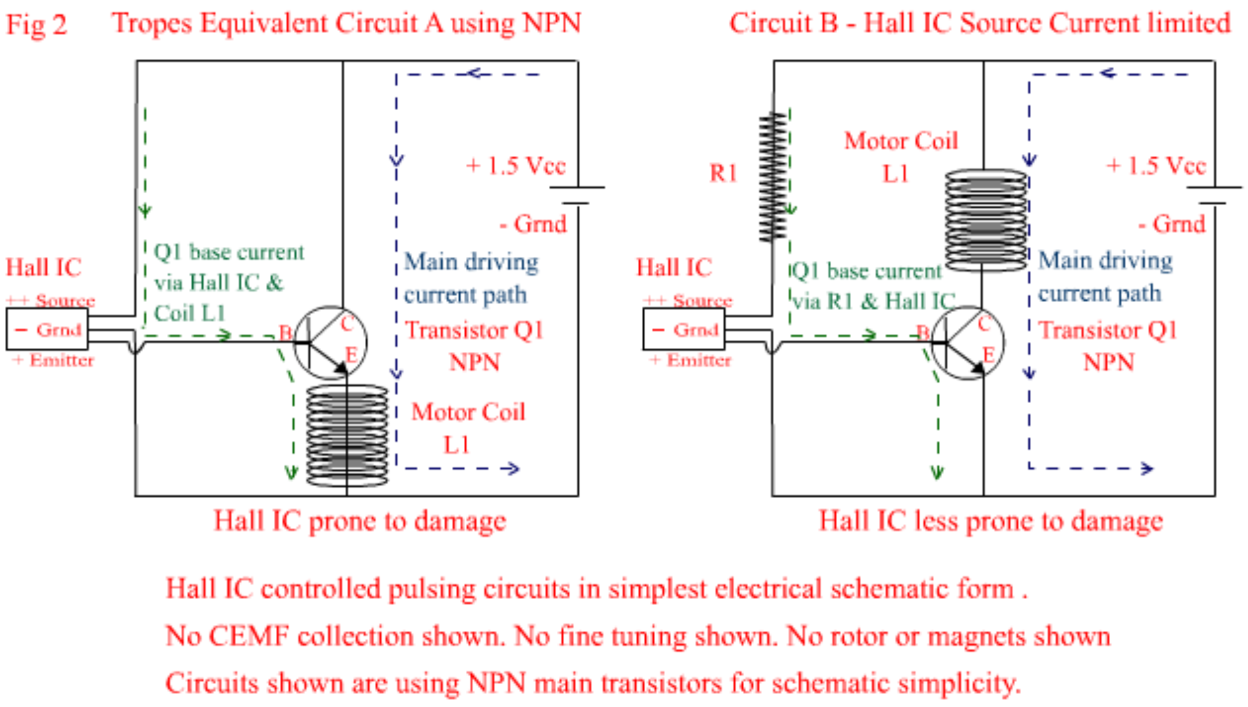
Page 1 : Simple Circuits

These first simplified circuits are here to show and explain some fundamentals pertaining to Hall IC's, Transistors and the reactive characteristics of Induction coils in pulsed motor systems. In particular, they are designed to show a couple of simple steps that can be taken to prevent components from "blowing" due to current surges and over voltage problems. This site was started to help experimental enthusiasts to keep their component budgets within acceptable limits.

This site is dedicated to electronics beginners and I will try to keep all explanations as simple as possible. If you have an intermediate to advanced knowledge of electronics then you will already be familiar with the circuit concepts and explanations presented here.

Fig 1- This first circuit was posted by "Tropes" on the Overunity.com forum. It is a very simple and workable circuit, but it is very prone to instability and component damage. See Fig 2 following with similar simple circuits with explanations for minor changes that lead to slight improved performance and stability

Fig2- The following circuits are based on Tropes above, with Circuit A representing an NPN version of Tropes posted circuit. Circuit B shows the same simplicity but with a Resistor R1 placed in series with the Source connection of the Hall IC and Coil L1 moved to a placement between the +ve supply voltage and the Collector of Q1 (Transistor) instead of the Emitter and Ground of Q1. See below Fig 2 for an explanation of the circuits and why I've done these minor changes in Circuit B



In relation to Fig 2 above, first lets examine the characteristics of the Hall IC. Whilst it looks very similar to a transistor, there are significant differences in its mode of operation. Like transistors though, they come with varying degrees of recommended maximum voltage and current ratings. Most Hall IC's are designed to operate on voltages between 5 + 10 Volts. And most have Source to Emitter junctions that only allow up to 100MA current flow before they are strained beyond their operating parameters. **At this stage, we will neglect the internal resistance of the Hall IC and the voltage drop across the Transistor Q1 Base to Emitter junction and concentrate on the Hall and the Motor Induction Coil only.**

In Circuit A, when the motor is first connected and a magnet passes by the Hall IC for the first time to activate the Hall IC's "on" state, the only limiting factor on the current flowing through the Hall IC's Source to Emitter junction is the actual DC resistance of the motor coil.

Lets assume that the supply voltage is only 1.5 volts, and the DC resistance of the motor coil is 10 ohms. This means that 1.5V divided by 10 ohms resistance gives us an initial maximum current of 150 MilliAmps. Already, the circuit is in potential trouble because we are 50 MilliAmps above the nominal current rating of the Hall IC. Now even if we subtract the .6V (for silicon) drop across the Transistor Q1 base to emitter junction, we are left with .9V divided by 10 ohms, giving us 90 MilliAmps current flow. Which would still be too much for some Hall Ic's which are often only rated at between 30 to 50 Milliamps. Fortunately there is an internal resistance in the Hall IC, even when it is in the "on" state, and some of the voltage drop in the whole circuit is also actually across the Motor Coil.

At just 1.5 Volts supply, the Hall IC will probably survive the surge from the initial turn on. As the motor starts to run, and picks up speed, the likelihood of the Hall IC blowing will actually decrease. Why? Well now we have to look at the characteristics of the motor coil, which has not just a DC resistance due to the length of wire, but also exhibits a characteristic called Inductive Reactance. When a coil is subjected to straight out DC, it only has DC resistance. But when it is subjected to Pulsing DC or AC, it also exhibits Inductive Reactance, (also known as impedance), and this is also measured in Ohms. As the motor spins faster and faster, the frequency of the pulses increases, and while the DC resistance of the coil remains steady, the impedance increases with the frequency. So the coil exhibits an ever increasing total Ohmage which reduces the current flow through it and every other component which is in series with it. Because the coil is in series with both the Transistor base to emitter junction and the Transistor Collector to Emitter junction, the current will be reduced in both current paths through Transistor Q1.

On top of that, normally, the fast rotating magnets that sweep past the coil, also induce an ElectroMotive Force back into the coil which is in the opposite direction to the incoming supply current. This opposing direction of EMF is what is known as Back EMF and happens in all conventional motors regardless of motor type. In the circuits shown above however, this BEMF has no extra ability to reduce the incoming current, but I will explain on Page 2 why this is so. It is suffice to say the increasing impedance of the coil due to the increasing pulse frequency will be enough to lower the running current to acceptable component limits.

Now imagine the initial starting current in the Hall Ic's Source to Emitter junction if the supply is 3 Volts or 4.5 Volts or 6V or 12 Volts. Remembering that Current is Volts divided by Ohms, it is easy to to see that the currents in the Hall IC may well go beyond their recommended maximum range and blow out the Hall IC before the rotor has a chance to reach a speed that provdes enough Inductive Reactance to lower the running current to acceptable levels.

In Circuit B, when the motor is first connected and a magnet passes by the Hall IC for the first time to activate the Hall IC's "on" state, the only limiting factor on the current flowing through the Hall IC's Source to Emitter junction is the Resistor R1, because the Motor Coil L1 is actually now isolated to the circuit path formed in the Collector to Emitter junction of the Transistor Q1. **Again we will initially neglect the internal resistance of the Hall IC in the "on" state and the voltage drop across the Transistor Q1 Base to Emitter junction and concentrate on the Hall and the Resistor R1.**

Again lets assume that the supply voltage is only 1.5 volts and the Resistor value is 100 ohms. Remembering that Current is Volts divided by Ohms, this means that 1.5V divided by 100 ohms resistance gives us an initial maximum current of 15 MilliAmps. Now this a much more acceptable current flow through both the Hall IC and the Transistor Q1 Base to Emitter junction. Now the transistor base current allows a much higher current to flow through the Collector to Emitter junction of Transistor Q1, due to the current amplification characteristics of all transistors. But the initial current through the motor coil at startup will once again be limited by the the DC resistance of the coil itself which is 10 ohms. So the startup current through the Motor coil and the Collector to Emitter junction of Q1 will be 1.5 V divided by 10 ohms which is 150MA. This is perfectly acceptable to the transistor because the Collector to Emitter junction of Q1 is designed by its very nature to handle higher currents. That is exactly why transistors are used to amplify and what they were designed to do; use a small current in one junction to control a larger current in the other junction.

Once again, as the motor spins faster and faster, the frequency of the pulses increases, and while the DC resistance of the coil remains steady, the impedance increases with the frequency. Again the coil exhibits an ever increasing total Ohmage which reduces the current flow through it and the Transistor Q1 Collector To Emitter junction. But the Transistor Q1 Base to Emitter junction now has no Inductive Reactance component, consisting only of the Resistance R1, so the current flowing through it will never exceed 15 mA during running, nor will it constantly decrease with the rising impedance of the coil.. The advantage of this is that a cleaner, squarer, more consistent controlling pulse will be delivered to the Transistor Base to Emitter Junction, regardless of the increasing impedance of the coil at rising frequencies.

Now imagine the initial starting current in the Hall Ic's Source to Emitter junction if the supply is 3 Volts or 4.5 Volts or 6V or 12 Volts. Remembering that Current is Volts divided by Ohms, it is easy to to see that the currents in the Hall IC will still be within the recommended maximum range up to 3 Volts for Halls rated at 30 mA and 5 Volts for Halls rated at 50mA and 10 Volts for Halls rated 100mA and so on. By Changing R1 to a value of 200 Ohms, most Halls will still be within their rated nomimal current range.

I usually use a value of 1000 ohms for the Hall IC's in my circuits running on 12 Volt supplies, and use what is known as diode clipping in conjuction with "bias" resistors to ensure that the base to emitter voltage and current is maintained at the right levels of the Transistor Q1 for proper operation. I will explain this further when I introduce you to slightly more sophisticated circuits in the upcoming pages.

I hope this information is understandable to you "the reader", as there is a balancing act between brevity and simplicity of explanation and the need for enough information for you to envision what I am trying to impart to you.

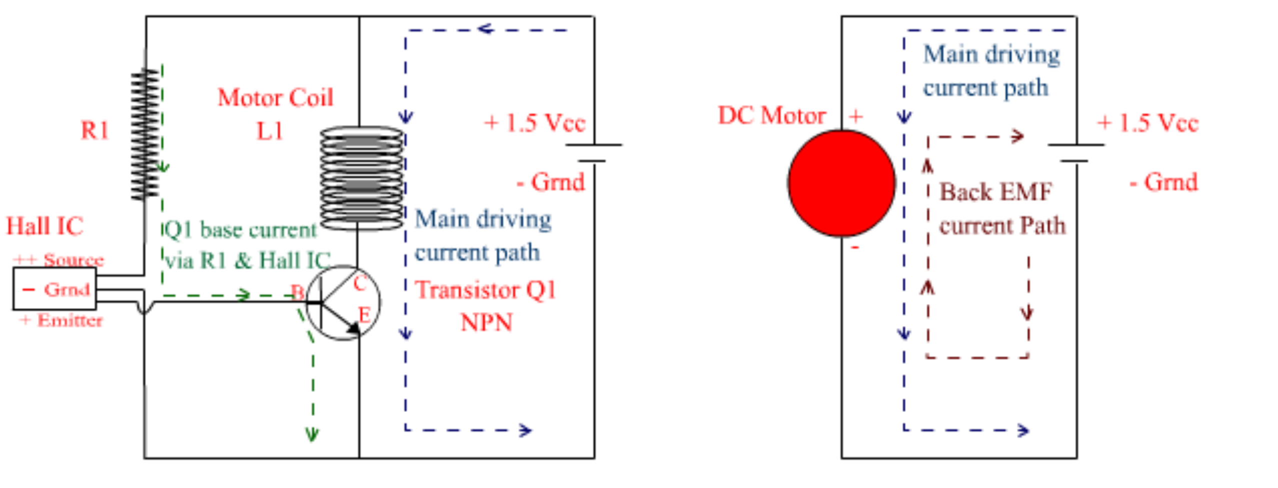
Page 2 : Simple Circuits – Continued

First I need to explain some things about Back EMP (BEMP) and Back Emf (BEMF). BEMP is Back Electromotive Potential while BEMF is Back Electromotive Force. What's the difference? Force is a measure of mass x acceleration. This implies that a movement of mass is an integral part of Force. In an electric circuit, this movement of mass is "current". Whilst there is a lot of debate about whether electrons actually move, or whether their electron "charge" is the only movement in the form of charge energy transfer from atom to atom, the notion of movement is still paramount to the formula of calculating force. For simplicity sake, we will assume that there is movement of some sort and leave it at that. So when we talk about BEMF, it is implied that there is a movement of charge which arises in opposition to the Forward EMF (FEMF supply current). BEMP is Back Electromotive Potential. In order for any BEMF to occur, there must be a BEMP, but the reverse is not always true. I will discuss Collapsing EMP (CEMP) and Collapsing EMF (CEMF) later on in following pages.

On page 1- I wrote : – "On top of that, normally, the fast rotating magnets that sweep past the coil, also induce an ElectroMotive Force back into the coil which is in the opposite direction to the incoming supply current. This opposing direction of EMF is what is known as Back EMF and happens in all conventional motors regardless of motor type. In the circuits shown above however, this BEMF has no extra ability to reduce the incoming current, but I will explain much further down the track why this is so."

In Fig 3 below I have shown a Circuit from the previous page (Circuit A below), and next to it Circuit B which is representative of a conventional DC motor. See below Fig 3 for an explanation of the differences in the current pathways shown.

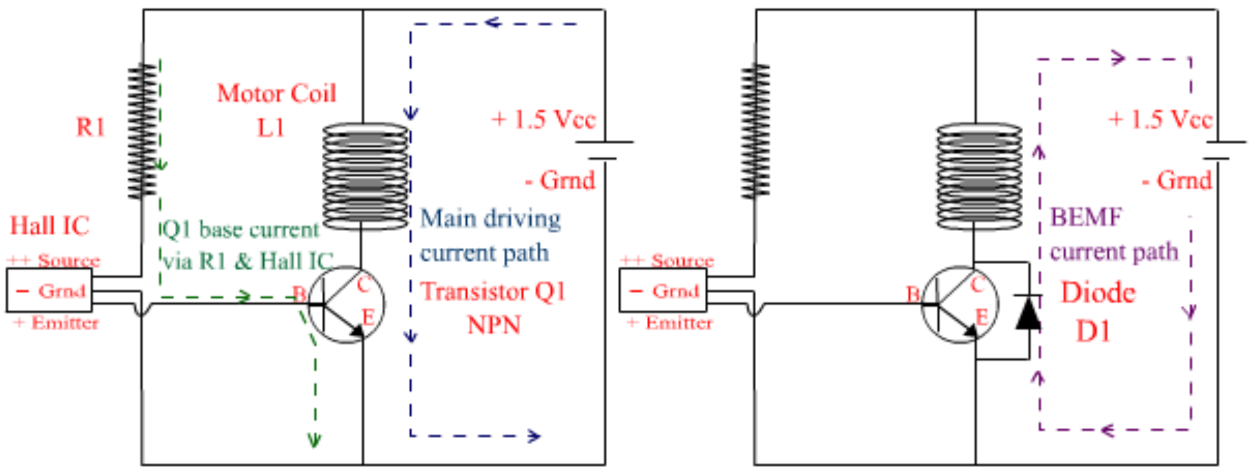
Fig 3



Circuit A - Hall IC controlled pulsing circuit in simplest electrical schematic form .
No CEMF collection shown. No fine tuning shown. No rotor or magnets shown
Circuit A uses NPN main transistors for schematic simplicity.

In Fig 3 Circuit B above, a normal DC motor is connected to a supply and promptly increases its speed until it reaches top speed. As it does so, a BEMP arises which produces a BEMF. The BEMF is just like the Forward EMF (FEMF), in that there is a complete loop in the circuit for it to flow. It is never as strong as the FEMF and so the net current flow measured will always be in the direction of the supply current. But in Fig 3 Circuit A above, a BEMP arises, but does not result in a BEMF, because the Transistor Q1 which is forward biased to the supply current, is reversed biased to the BEMF thus effectively blocking any potential current flow in the reverse direction. Because of this, only the increasing impedance of the coil due to pulse frequency is responsible for lowering the supply current through the coil. Now lets move on to Fig 4 below which shows how to incorporate the BEMF into the circuit to lower the supply current even further. See below Fig 4 for circuit differences and explanation.

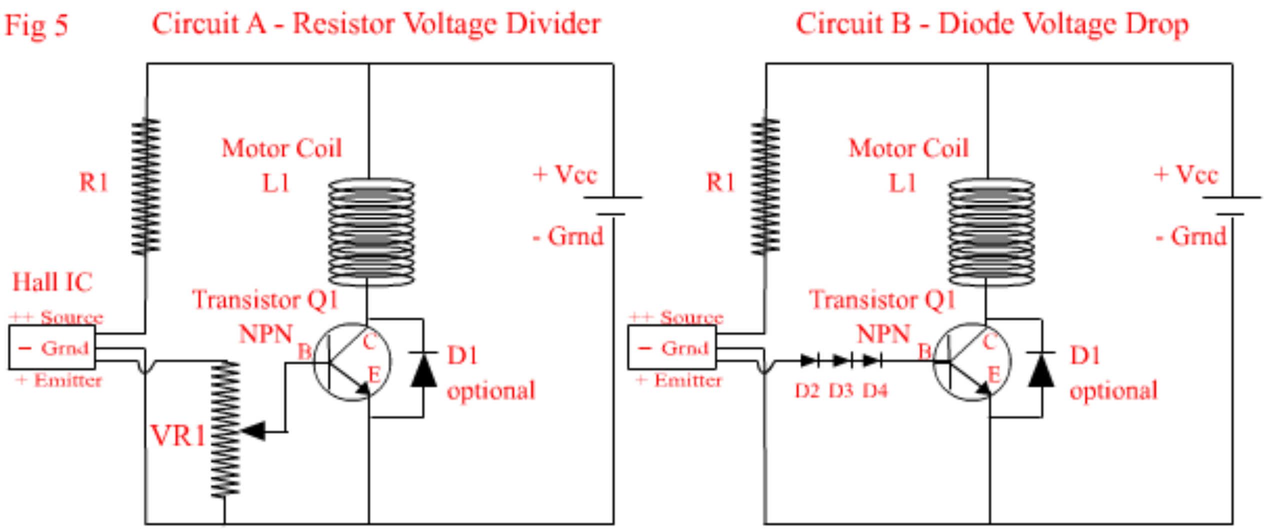
Fig 4



Circuits - Hall IC controlled pulsing circuit in simplest electrical schematic form .
No CEMF collection shown. No fine tuning shown. No rotor or magnets shown
Circuits use NPN main transistors for schematic simplicity.

In fig 4 above, both circuits are identical except for the addition of Diode D1 across the Collector to Emitter junction in Circuit B. This diode now provides a circuit path for the BEMF, and can effectively help to lower the supply current a little bit more. In high impedance coil motors you may not notice a significant change because current draw will already be quite low, but in motors designed to produce a lot of torque by using low impedance coils, the added diode can signifantly contribute to lowering the supply current in conjunction with the coil impedence. Now it also must be said, that the addition of Diode D1 will also effect to some degree the amplitude of voltage "spikes" occuring in the system which are due to the Collapsing EMP of the coil from the pulsing it receives. Normally this is a good thing, because these spikes are generally considered to be bad news, and in conventional systems, they are usually "bled out " of the system in one way or another. If however, these spikes are what you want because of the nature of the experiments you are performing, then simply leave the diode out. Now if you are basing your circuit on the very simple ones shown thus far, and you are not getting high voltage spikes (and you want to), it is likely, that the control circuit needs a bit of fine tuning, to ensure that when the Hall IC is in the "off" mode, your transistor is completely turned "off" and not just switching between states of "slightly on" and "completely on". In Fig 5 below some basic methods of transistor bias control are shown. See below Fig 5 for the circuit explanations.

Fig 5

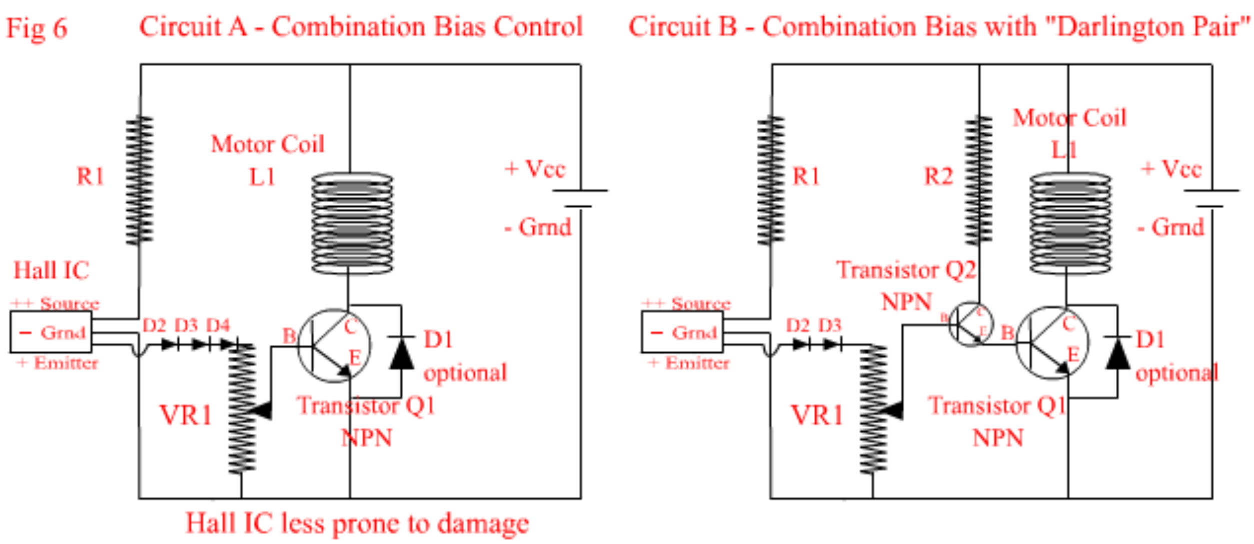


Circuits - Hall IC controlled pulsing circuit in simple electrical schematic form .
No CEMF collection shown. Adjustments to Q1 bias shown. No rotor or magnets show
Circuits use NPN main transistors for schematic simplicity.

In Fig 5 Circuit A above, a variable resistor has been placed between the switched output of the Hall IC and base of Transistor Q1. This allows some degree of flexibilty in "tuning" the voltage that is applied to the base of Q1. The VR1 **(linear** Pot – lets say 1000 ohms) as shown, acts as a voltage divider, and the value of the voltage that feeds the base of the transistor is proportional to the position of the the wipe contact in relation to the resistive track of the VR1. If the voltage from the Hall IC output to the top of the VR is 1Volt and the wiper contact is exactly halfway, then the voltage fed to the base of Q1 would be .5 V and Q1 would not turn on. If the wiper is moved towards the top of VR1 the voltage will increase towards 1 Volt and Q1 will turn on when it reaches above .6 Volts(for silicon Transistors). This method offers some flexibility but has the disadvantage that some control circuit current will be shunted to Ground via VR1 and some current will be lost to Q1 even if the VR1 wiper is as the top of the VR1 resistive track. If the current loss is too high due to the value of VR1, then Q1 may still not turn on when required, even when the voltage available is high enough, because transistors are current driven and require a minimum amount of current to "turn on". However, this method should suffice for most experimental purposes, and is very simple to implement. I will address the current loss problem associated with the VR1 in Fig 6.

In Fig 5 Circuit B above, small Signal Diodes are placed in series with the output of the Hall IC. Each diode causes a voltage drop of either .6 Volts for Silicon Diodes or .4 Volts for Germanium Diodes. A combination of both types may be used to achieve the desired voltage range required. The actual number of Diodes used will be dependant on the amount of Voltage dropping that is needed to make Q1 turn off completely when the Hall IC is in "off" mode. The advantage of this method, is that no current is shunted to ground, and there is minimal current loss through the diodes when the voltage rises above their total threshold conducting voltage when the Hall IC is switched to the "on" state. The disadvantage with this method is that it lacks runtime flexibility, and if the motor has been running for some time and the supply voltage begins to drop, there will be a point at which the forward bias voltage is no longer sufficient to turn Q1 on. In Fig 6 below, the advantages of both circuits are incorporated together to offer greater flexibility and increased stability, while an extra transistor is inserted (Fig 6 Circuit B) to address current loss problems associated with VR1. See Below Fig 6 for an explanation of the circuit modifications.

Fig 6



Circuits - Hall IC controlled pulsing circuit in simple electrical schematic form .
No CEMF collection shown. Adjustable bias to Q1/Q2 shown. No rotor or magnets shown
Circuits use NPN main transistors for schematic simplicity.

In Fig 6 Circuit A above, the previous circuits in Fig 5 have been combined to produced a more stable circuit which offers a degree of flexibiliy in controlling the amount of bias to Transistor Q1. However, depending on the type and characteristics of Q1, the voltage supplied to the base may be sufficient, but the available Base to Emitter junction current may now be too small to operate Q1 efficiently. In Fig 6 Circuit B, an extra smaller NPN transistor (Q2) has been added to the circuit to form a configuration known as a "Darlington Pair". Because the added Transistor Q2 will add a .6 Volt drop to the base current circuit, one of the signal Diodes has been removed, so that the effective voltage dropping due to "silicon junctions" is effectively the same in both circuits. The advantage of adding Q2 however, is that when it turns "on" due to sufficient bias voltage, it allows extra current to flow to the base of Q1 via R2 and the Collector to Emitter junction of Q2. The amount of extra current available to the base of Q1 will be mostly determined by the value of R2. Circuit B now offers a stable and variable controlling circuit which protects all the controlling components, whilst allowing a greater "turn on current" to Q1, which in turn allows a greater current availability to the motor coil via the Q1 Collector to Emitter junction.

If your experimental motor circuit is hooked up in the any of the above configurations, but you are not getting the results you expected, e.g. the rotor is running slower, fairly high constant current consumption regardless of rotor speed, etc, you may require higher resistor values (R1) or more signal diodes, to ensure that your transistor is actually turning off completely.

One simple test you can do to see if your transistor (or Mosfet) is turning off properly, is to:

1… Connect your circuit.

2… Put a volmeter across the collector and emitter. (doesn't matter whether its NPN or PNP or which leg you have your coil connected to.)

3… Stop the rotor from turning by hand, then manually turn it until the switching magnet is in front of the Hall IC to turn the Hall IC on.

4… Measure the voltage across the collector and emitter. – If the Hall IC is in the "on" mode, then you should only see .6 Volts across the collector to emitter junction.

5… Now turn the rotor so that the switching magnet is away from the Hall IC and the Hall IC should now be in "off" mode.

6… Measure the voltage across the collector and emitter again – If the transistor is turning off properly, you should now see almost the full supply voltage minus a small drop due to the presence of the coil. If the voltage is not nearly that of the supply (or very close to the supply voltage), then your transistor is not turning off completely. – Remedy put a variable resistor anywhere from 1K – 5K in series with the existing resistor (R1) and repeat steps 3+4 to test for "turn on" and 5 +6 to test for "turn off". Vary the pot until the transistor turns off. – You will know it's off because the voltage will read nearly that of the supply.

In the above circuits I have concentrated on describing the fundamental operation of the circuits and have mostly omitted any actual component values. This is because the values of VR1 and R1/ R2 or the number of Signal Diodes used, are really dependant on the type and characterics of the Hall IC and Transistor/s Q1 and Q2 used.

In following page, I will discuss Collapsing EMP/EMF, and how to tap it for charging Capacitors or another Battery or increasing the motor torque. I will also discuss Voltage Regulators and "Mosfets" and the advantages they offer for switching, and will introduce a more practical and more stable controlling circuit.

On this page, we finally get to collecting CEMF from the drive coil. Fig 7 below introduces a more sophisicated controlling circuit utilizing a Voltage Regulator and Mosfets to do the switching. The circuit also introduces a CEMF output and two different paths in which it can be connected. One path is often referred to as "Fly-Back" and the other path can better be described as "Fly-Forward". Fly-Back is essentially a method of recapturing some of the energy stored in the drive coil when the drive coil circuit is turned off. Generally speaking, if the Fly-Back circuit is connected to another Battery , the motor will continue running without any loss of Torque or running speed, but it will only charge the secondary Battery at a smaller charging rate than the discharging rate of the supply Battery. The most Current you will be able to recover is around 25-30 % of the drive Current. However this is a true recovery path and will not cause the drive circuit to consume more Current than it would if you didn't connect it.

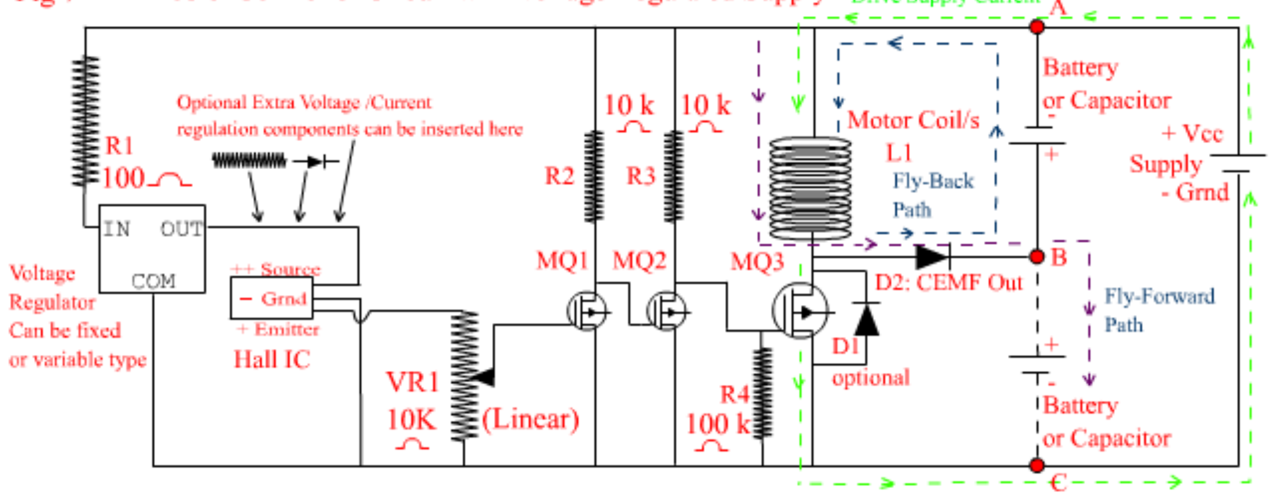
If you use this Fly-Back path to charge an Electrolytic Capacitor which has zero charge in it, then initially the motor will slow down and consume more Current until the Voltage in the capacitor climbs to the same level as the forward Voltage measured across the coil. Actually this is also true of a secondary Battery if the Battery is really very flat and its Voltage is significantly lower than that of the supply Battery. Once the Voltage in either the Battery or Capacitor reaches the same Voltage as the forward coil Voltage, there will be no more negative impact on the drive circuit and you will be recovering Current at no drive expense.

Many people think that if a really high Voltage spike is produced by their circuit, then surely they must be able to recover more Current than they put in. The answer is no. If they were measuring really high Current spikes then they would really be onto something fantastic!!!; and I would really love to know about it !!! But collapsing magnetic fields which produce CEMP do not produce high Current spikes, they only produces high Voltage spikes. These high Voltage spikes generally have a greater negative impact on Batteries and circuit components than any positive usefulness.

Fly-Forward is simply a different way of directing the CEMF through the circuit. It acts like a current pump because it adds the CEMF to the supply battery EMF in series with each other and can be used to charge a secondary Battery (or Capacitor) at a much higher rate than Fly-Back. But it will severely inhibit motor running speed and torque, and the Current drawn from the supply will increase dramatically. In essence Fly-Forward is a method of stepping up DC to a higher DC value without the use of Transformers and the need to convert DC to AC before stepping up through a transformer can occur. When connecting the circuit to utilize Fly-Forward, the coil doesn't actually experience a time when there is no Current flowing through it, (unless the operational duty cycle(on time) is very low) even when the drive Transistor or Mosfet is turned off. Instead the coil experiences a state of "low Current" when the drive circuit is "on" and a state of "high Current" when the drive circuit is "off". In both Fly-Back and Fly-Forward cases, no extra free energy is obtained.

Utilizing Fly-Back can be considered as a method of lowering the overall power consumption of the motor because it re-collects stored energy from the coils between pulses, and dumps it into a secondary Battery for later re-use. With the aid of bi-filar windings on the drive coil, it can also dump the stored energy directly back into the supply battery in between forward Current pulses. I will discuss various coil designs in following pages. Note that if a Battery is connected to the Fly-Forward path, there is no longer any CEMF available for the Fly-Back path. In other words, you can't collect Current from both paths at the same time. See below Fig 7 for an explanation of the Mosfet circuit operation and the Fly-Back and Fly-Forward paths.

Fig 7 Mosfet Controller Circuit with Voltage Regulated Supply



CEMF collection shown. Adjustable bias to Mosfet MQ1 shown. No rotor or magnets shown

Circuit uses NPN style Mosfets for schematic simplicity.

CEMF Fly-Back + Fly-Forward current paths shown

In Fig 7 above, the Hall IC supply circuit is fed via a Voltage regulator that can be a fixed output voltage type or a variable output voltage depending on the type of regulator used. If using a fixed output type, it still may be necessary to incorporate a resistor or diodes in series with the Hall IC supply to achieve the desired voltage range necessary (in conjunction with VR1) to turn the Mosfet MQ1 on and off. In this circuit there are three Mosfets which are hooked up in a "flip flop" arrangement to turn the drive circuit on or off. Why go to all this trouble of adding extra components? Well Mosfets are Voltage controlled not Current controlled, though they do still require a small amount of current to turn on. Like Transistors they will turn on at at .6 Volts but if the Gate to Sink junction (equivalent to base-emitter junction of a transistor) is fed a voltage of 10Volts or more, then the Source to Sink junction (equivalent to collector-emitter junction of a transistor) will have a resistive value of .001 or less ohms, which is very nearly zero resistance. This makes Mosfets ideal for pulse generating and DC motor control circuits, and indeed, is generally what they are used for.

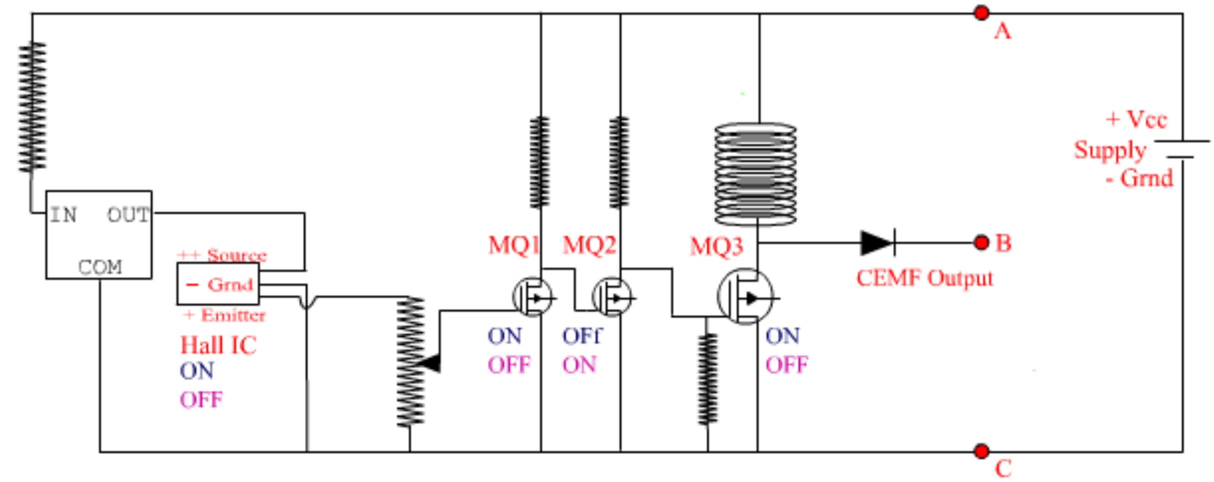
If Mosfets are fed 10Volts or more to the Gate (base), they will have almost nil voltage drop across the Source to Sink junction, and very little heat will be created within the Mosfet, and hence miniscule heat losses are incurred. Because the Gate to Sink junction current requirement is in the high micro-amp range (below milli-amp range), then a few extra components will only introduce micro-amp Current losses. Now lets look at how the circuit achieves the switching and provides a higher Voltage to the Gate of the drive Mosfet MQ3.

When the Hall IC is "on", MQ1 will also be on, but MQ2 gets its Gate Voltage from the Source connection of MQ1 via R2 which is 10,000 ohms. This voltage will be no greater than .6V because MQ1 Source to Sink Junction is on. The current available to the Gate of MQ2 is now only 60 micro-amps, so effectively, MQ2 remains off. The drive Mosfet MQ3 Gate, likewise gets its Voltage from the Source connection of MQ2 via R3. Since MQ2 is off, then the Source to Sink junction of MQ2 is effectively open circuit, and the Voltage at the Source of MQ2 which is connected to the Gate of MQ3 is nearly the full Voltage of the Supply, but the current is limited by R3 which is also 10,000 ohms. If the MQ3 Gate voltage is 10V, then the current will be 10V divided by 10,000 ohms(R3), which is 1 milli-amp or 1000 micro-amps, which is enough to ensure MQ3 turns on.

When the Hall IC turns "off", MQ1 turns off, which raises the Voltage to the MQ2 Gate to nearly the full Voltage of the Supply and MQ2 turns on. When MQ2 turns on, the Voltage to the Gate of MQ3 drops to .6V with a current of 60 micro-amps, and thus turns off. Because the turn on/off time of Mosfets is so quick, the pulses generated are very sharp and clean. Note that there is a 100,000 ohm resistor (R4) between the Gate of MQ3 and ground. Because Mosfets have a very high Gate to Sink impedance, they can be destabilised and affected by sudden and high voltage variations in the Source toSink (driving) circuit feeding back into the supply as high voltage spikes.. Resistor R4 absorbs any such fluctuations and keeps the pulse produced by MQ3 clean and sharp, without bleeding away too much current because of it's high resistance value.

You will notice in Fig 7 that I have included Diode D1 in the circuit as optional, but some Mosfets have a Sink to Source reverse biased diode already built into them, which takes away the option of not including it in the circuit. See Fig 8 below for a pictorial representation of the various "ON/OFF" states of the Hall IC and the Mosfets.

Fig 8 Circuit showing relative "on / off " states of controlling Hall IC and Mosfets



In Fig 7 above, there are 3 points on the circuit labeled A,B and C. If you connect a Battery or Capacitor across points A and B. then you are utilizing Fly-Back. If you connect a Battery or Capacitor across points B and C then you are utilizing Fly-Forward. Make sure that whichever points you connect to, you place the Battery or Capacitor in the right polarity direction as shown in the circuit. If you don't connect the polarity correctly, you will experience BIG problems!! Also you will notice the addition of Diode D2. This Diode (D2) is essential for the collection of CEMF, and also to prevent short circuits occurring when adding a secondary battery to the CEMF output. Without a diode, the secondary battery will be permanently connected across the coil if used in the Fly-Back arrangement, and will short circuit itself when the Mosfet MQ3 is turned on if it is connected in the Fly-Forward arrangement.

You may notice also, that whether you are using the Fly-Back or Fly-Forward paths, the current through the coil is always in the same direction as the main supply current The circuit in Fig 7 is very stable and very useful, but while VR1 offers some flexibilty in controlling the duty cycle ("on" time), said control is still largely limited and determined by the width of the triggering magnets ("on") versus the width of space between them ("off"). Once again I have only given specific values for some components. Namely the resistors. If you are an experimenter such as myself, then you are likely to be cutting costs by cannibalising old circuit boards. The circuit I have shown with resistor values given, will work with a large variety of Mosfets with different characteristics without causing component failure. As before, use this circuit as a guideline rather than a gospel.

Also note that any of the previous simpler switching circuits on page 1 + 2 have the same capability of supplying CEMF by the addition of the diode (shown as D2 in the diagrams on this page) on the appropriate side of the coil and providing a Secondary Battery or Capacitor to charge in Flyback or Flyforward mode: Note:* Flyback recommended .

Before continuing with any more circuits, lets examine the coil. After all, without the coil, there is no "motor " in a pulsed coil motor! And "In short", there is also NO "In Short", when it comes to talking about coil design. Especially when we are talking about pulsed motors, and even more importantly when we are talking about open magnetic system pulsed motors. Throw into the mix different requirements, e.g low speed high torque, high speed low torque etc, and the party really gets cranking! Coils! who's got coils?

When talking about "Adams" motors it is very important to understand that there is only one significant difference between an "Adams" motor (and for that matter, a "Bedini" motor), and any other so called conventional pulsed motor (and there are plenty! – just how do you think your computer hard drive is spinning?) and that significant difference is the magnetic circuit. In conventional systems, the magnetic "circuit" or "field " is closed. In a sense, it is almost short circuited, with only the air gap between the rotor and stator offering a small degree of magnetic insulation to an otherwise would be closed magnetic system.

The logic behind this has always been two fold. One is the assumption that, by bending the flux from the rear of the magnet or coil by way of metallic form work, (the side of the magnet not directly facing the coil and vice verse) to an area where it will be productive, this will increase overall torque. Which it definitely does (usually in well designed systems). But at a price!! (the reasons for which I will elaborate much later on.)

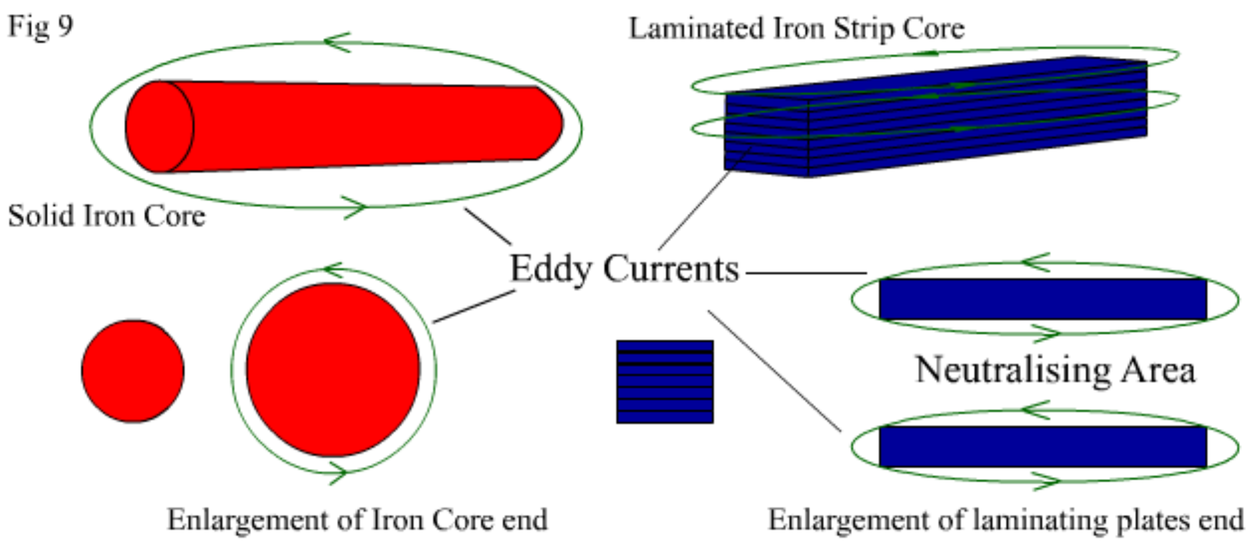
The other assumption is that by using a closed magnetic system, the imperfections in the system, such as sparking brushes (which are common in series wound motors used for most work tools), will not create undue RF interference, because the Closed Magnetic System allows the entire motor to be encased in an iron shroud without affecting its performance, and it is effectively encased in a "Faraday Cage". This is also a good thing for this very reason alone.

Imagine if every brush driven electric drill, saw, etc, were not effectively shielded to some degree by their inherent design. I know some cheap brands on the market, and they are not sufficiently shielded, but from my inspection of the goods, I dont think they will last long enough to be a persistent RF problem!

After many years of experimenting with "Adams" motors, I can say two things for certain. An Open Magnetic System acts and reacts differently to a Closed Magnetic System and "Adams" motors/generators are a challenge to design for a specific purpose, because, by their very nature, they are "Dynamic". Dynamic in the sense, that, by varying just one parameter of an operating motor, all other parameters change in response. As such, their behaviour is not "Linear" but instead conforms to a set of rules drawn from existing electrodynamic laws, but exhibit anomolous results just the same. The Anomolous Behaviour of Open Magnetic Systems is, I believe, an area of ElectroMagnetic Theory which needs some serious investigation, research and rethinking.

If you persist long enough with your "Adams" motors, I personally still doubt that you will ever achieve overunity (I'm quite skeptical in fact! – Please prove me wrong!), but you will definitely witness certain phenomena which are not covered in your average Technicians text book. And yes, I will discuss at great length, in another page, an anomoly which can be put to good use. Now lets talk cores and coils! Because thats where all the goodness happens!

In Fig 9 below, we have a pictorial representation of two core types. See below Fig 9 for an explanation of the relevance of the two different cores types.



In Fig 9 above, there is a (Red) picture representing a solid soft iron core. There is also an enlarged front end view. Around the pictures are green lines. Next to the solid core is a (Blue) picture representing a core made by stacking or "Laminating" strips of soft flat iron.. The green lines are representative of the fact, that when a magnet is constantly passing in front of the end of the cores, electric currents are set up within the cores themnselves. These currents are called Eddy Currents. They can be running in more than one direction at a time. They can run from one end of the core to the other, and they can run around the circumference of the iron material. According to accepted electrical theory, these Eddy Currents reduce the efficiency of the coil as both a transmitter and recevier of power via directed induction, by interfering with the preferred induction path. I agree.

However it is also accepted electrical theory, that these eddy currents can be minimised by using laminated plates. Notice on the lower right of Fig 9 I have shown a blow up of the iron strips (which are all covered in an insulating film) and an area titled "Neutralising Area". Theory says that ordinarily large Eddy Currents which may be produced in solid cores, can be reduced by laminating, because by laminating you break up singular large eddy currents into numerous smaller ones, and also, these then counteract each others influence due to the oppositional fields they produce. Effectively they self cancel as indicated by the arrows facing in opposite directions in the area between the two plates. I also agree. Please Note, that the solid red circular iron core, could be made into a type of laminated core, by substituting a single large core, with muliple smaller diameter cores (e.g soft iron nails), packed into the same area.

From my agreement to the above two statements regarding eddy currents you might be thinking, AHAH, so I should use laminated cores for my coils then! Well lets just talk a little bit more about coils/cores and what makes one better than the other, depending on requirement.

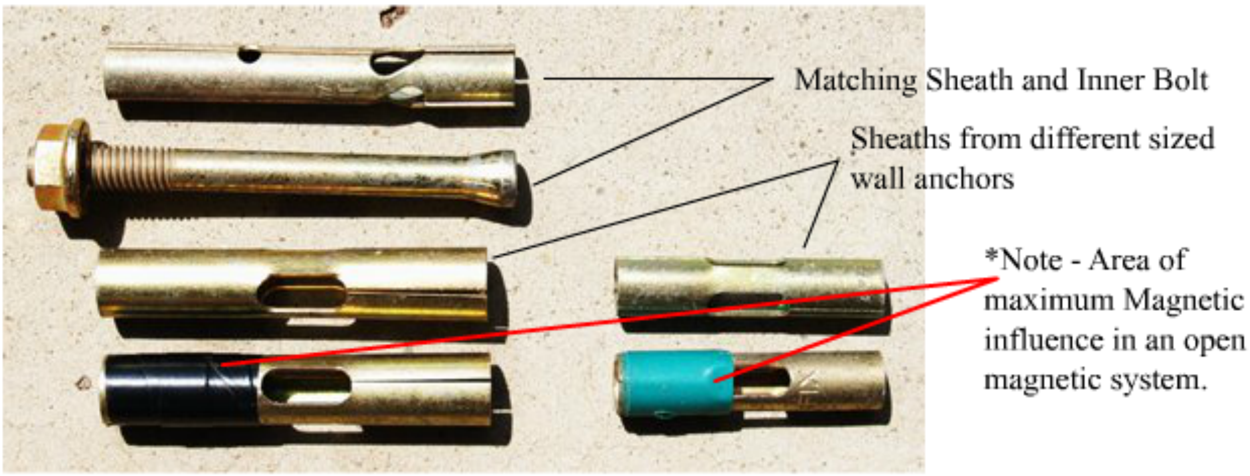
First, what about air cored coils? They have no iron content at all! And do not suffer from eddy current problems!. So maybe I should use those. Well maybe, maybe not. You see, no matter which coil core you use, there will be an upside and a downside. See the Table Below for a quick rundown on the pros and cons of each sort.

	Pros	**Cons**
Soft Iron Solid Core	Cheap and easy to resource, easy to wind if round. Easy to scale to any size core. High magnetic permeability. High induction capability. Magnetic field when energised cannot be easily distorted. High inductive reactance capability.	Can rust, can retain magnetism. High eddy current losses. High magnetic drag. High energy requirement to overcome attraction from magnet (especially if using neos)
Non Retentive Magnetic Stainless Steel Solid Core	High magnetic permeability, High induction capability. Resists magnetisation. Easy to wind if round. Resists oxidation. Magnetic field when energised cannot be easily distorted. High inductive reactance capability. Lower magnetic drag.	Expensive, High eddy current losses. Uneconomic in large scale. High energy requirement to overcome attraction from magnet (especially if using neos)
Laminated Soft Iron Core	Cheap and easy to resource. High magnetic permeability, High induction capability. More resistant to magnetisation than solid core due to eddy cancellation – Lower Eddy Currents. High inductive reactance capability. Magnetic field when energised cannot be easily distorted.	Hard to wind coils onto without preformed bobbin. Can sometimes be difficult to source the right size and number. High magnetic drag if not made from non retentive alloy. High energy requirement to overcome attraction from magnet (especially if using neos)

Air Core	Zero Eddy Currents. Zero Magnetoreactive drag. Great for achieving very high speed but low torque motors. Small low powered air core coils are readily available. Available in flat pack windings. Great for planar designs.	Hard to wind without bobbin, require great number of turns to achieve any inductive reactance making them potentially costly. Low induction and reactance at low frequencies. Magnetic field when energised can be easily distorted. No heat dissipation via metal core. Easy to burn out unless they have a very high winding count.

So which coil core do I prefer from the above as the most effecient coil for driving the rotor?, and which do I prefer as a standalone generator coil ? – Answer = NONE OF THE ABOVE ! It's a trick question really because there's one (or more) core/s. I hadn't mentioned. But one in particular. Its a Hollow Iron Core, or much more specifically in a generalised sort of way (LOL!) Its a Hollow Iron Alloy Core. And the best thing is, the perfect piece of metal and core design are already easily available from any Hardware and Building Supplies. They are common and are manufactured by a number of companies all over the world. You're gonna say Huh? when you look at Fig 10 below, so read beneath Fig 10 for a further explanation of these cores, for both energising and generating purposes.

Fig 10 Hollow Cores derived from the outer sheath of common masonry wall anchors.



The photo in Fig 10 above is of common masonry anchors which come with an outer sheath which is made of a particularly nice alloy, which, though I actually don't know what its composition is, I know what its composition can do! I tried on numerous occasions to get details of the composition of the alloy, so I could get some specific cores custom made from it, but you'd think I was trying to extract a good tooth from a dentist! Stonewalled for no real known reason. But no matter, I didn't chase it too hard, and if you want to, you can chase up that information yourself. The ones I used were marketed as "Ramset" and I got them from Mitre10 Hardware (Australia). I am sure they are manufactured to an international standard specification as a requirement for general commercial building use. I know they are an alloy of some sort, they are slightly lighter than soft iron, but exhibit high rigidity. I suspect they are made from a mixture of iron, tin and nickel. By the way, you don't need the Nut and Bolt! But it'll come in useful for something else, so don't throw it out!

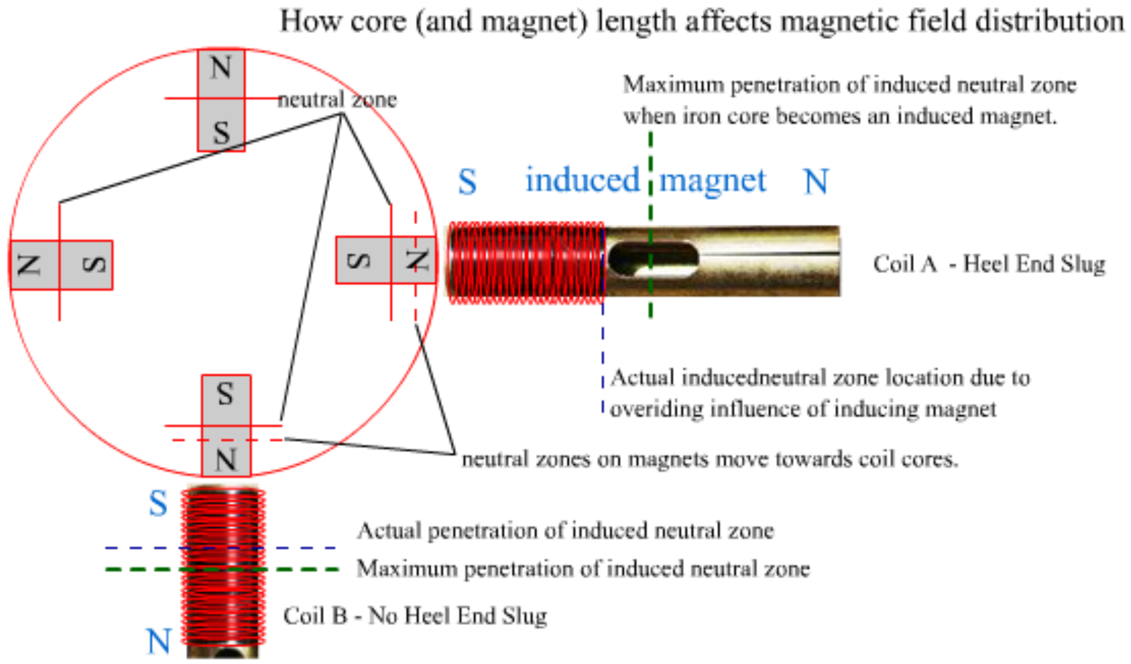
Now what's so special about hollow iron alloy cores and their shape? Well I completely stumbled onto the unique magnetic properties of the alloy and the already-made shape by total accident. Well actually I have to put a bit of "stubbornness" into the picture as well. Either way, it was a case of "necessity is the mother of invention". I had decided during one set of experiments that I wanted to try a hollow iron core, based on the idea, that 90% plus of the induction from the core to the coils happened in the outermost region of the core, because changing magnetic fields would take the path of least resistance and follow the "skin" of the core. Much the same as electrons follow the skin of a conductor in greater numbers than the centre. The only thing I had available to experiment with at the time that even vaguely resembled a hollow core (in my thinking) were wall anchor outer sheaths leftover from home renovating.

Thank goodness for the luck of the Irish! Serendipity Rules! I used them initially as generator pickup cores and went WOW, thats Reeeeeally Freaky! I spent the next 10 months investigating every aspect of the cores with their precut shape. This particular core type will be referred to again later on and its unique qualities explained in greater detail. I will also explain in detail the previous "anomoly" I mentioned that can be used to advantage, but I will reserve that for much later down the track. For now I will stick to some conventional theory and concentrate on cores and coils. It's early days yet before we start exploring "anomolies".!

Now you will notice that two of the sheaths in Fig 10 above have tape wrapped around a segment of them and it says "Area of maximum Magnetic influence in an open Magnetic system". I have to assume somewhere along the line that you've made your rotor, and you are mounting your coil in front of the rotor. In an open magnetic system, the Neutral Zone of the magnetic interaction will shift from the magnets own center to a point between its own center and the centre of the influenced body. That is, the coil core. See Fig 11 below. **The Neutral Zone is where the forces of the magnet's attraction to an external element is equal from each pole and therefore has a net attraction of zero on that element.**

It usually lies at the centre of the magnet depending on the directional influence of another magnetic/reactive body.

Fig 11

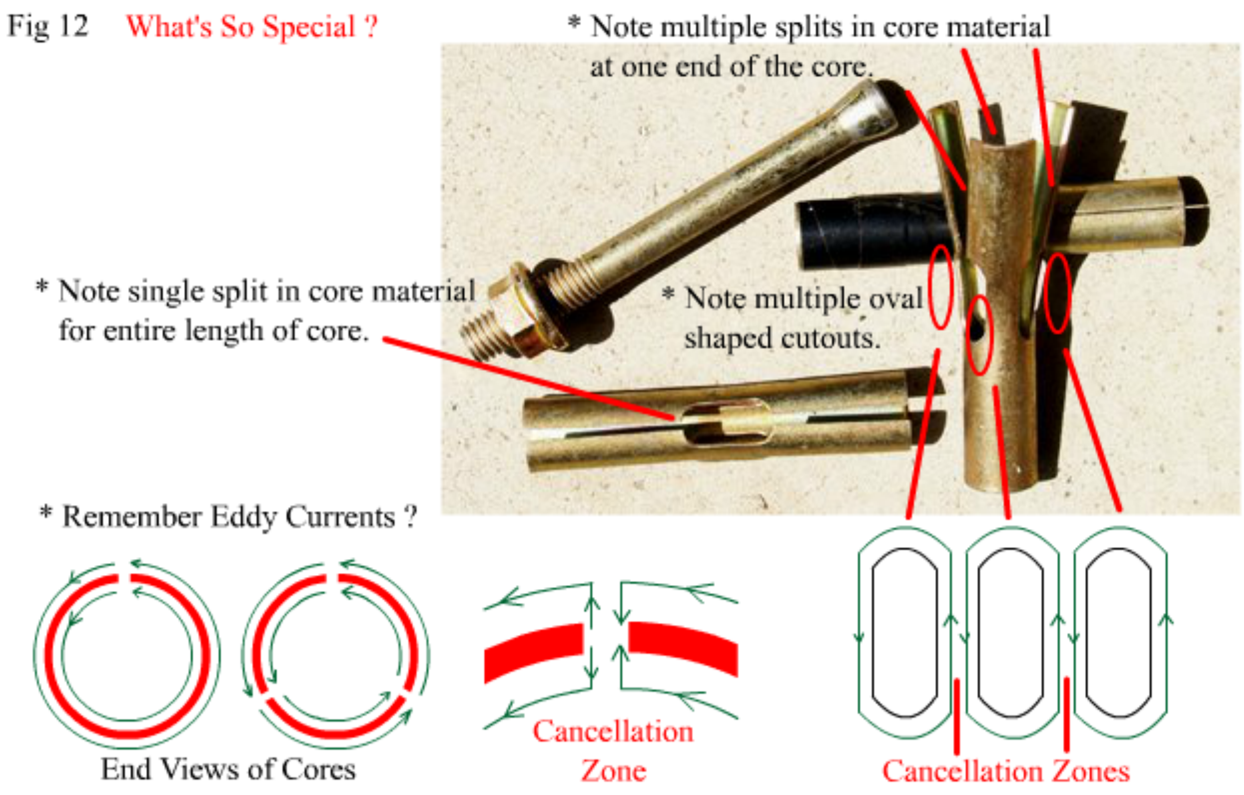


In Fig 11 above, we have two hollow iron alloy cores with identical coils wound on them.. When approached by a magnet they become magnets themselves, and form their own Neutral Zone. This induced Neutral Zone wants to establish itself near the centre of the core, with its own South pole facing the North pole of the magnet, and its own North pole facing away from the magnet . Coil A has a long core and is wound in what is known as Heel End Slug Configuration. Coil B is on the same hollow core material, but it has been cut down to the same length as the coil winding. A standard practice in most cases.

What, if any, advantages does Coil A have over Coil B and vice versa?

Well that depends on your requirements. If you want to use Coil B for a drive coil, it will be marginally superior, delivering a slightly higher torque availability, due to its lower inductive reactance (because it has less core material). But if you want to use the coil for a generator pickup then Coil A is far superior. This is because the Neutral Zone in the core of Coil A extends out beyond the area of the coil windings, while in Coil B the Neutral Zone maximum extends only to half the coil area.. In both instances the Neutral Zone tries to extend towards the middle of the core as normal.. But because the core in Coil A is long, then more of the coil is exposed to the "same magnetic polarity" of the induced magnetism of the core. The voltage produced by Coil A will be significantly higher than Coil B though the maximum current availability will be almost the same into a given low impedance load. The higher voltage stems from 2 influences. The greater amount of coil windings appearing on the "*same side of the induced Neutral Zone*" in Coil A, and the greater inductive reactance caused by the extra metal in Coil A which is not present in Coil B.

Now what about those core shapes? Whats so special?. Fig 12 below shows the sheaths exposed for analysis. See below Fig 12 for explanation.



Remember Eddy Currents? The bane of power transformer and inductor designers! An analysis of the pre-formed shapes of these cores, reveals that they have their own built in Eddy Current Suppression. The slotting and cut out areas form "skin paths" for counter running eddy currents to cancel each other out. Neat Hey! Its like using laminates, but without the hassle of bundling the plates together. And if you're winding your coils directly onto the sheaths (with a paper insulation wrapped onto the sheath first), their round shape makes winding easy. In fact the nut and bolt that you shouldn't have thrown away can be used as part of the jig you create to wind your coils!

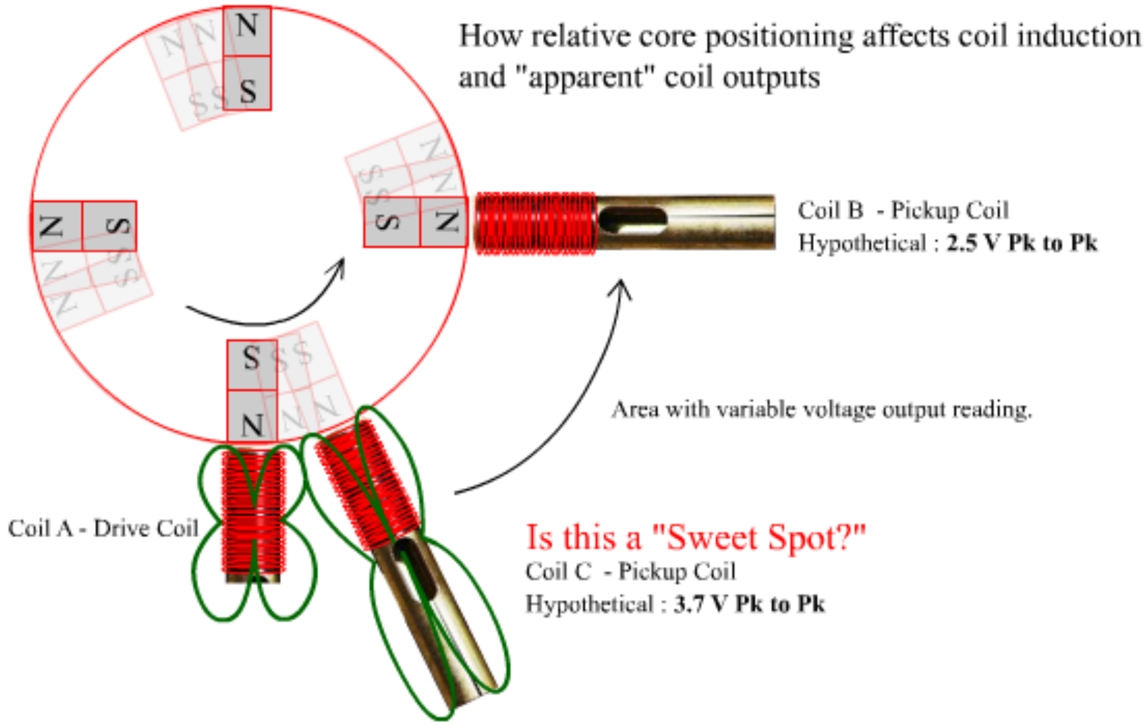
On top of that, the alloy itself has high permeability, low magnetic retention, resists oxidation, and is cheap and easy to source. The hollow alloy core is more efficient than a solid core or laminated core in translating magnetic induction in the core to useful electrical output from the coil. It has the advantage of a solid core, in that it produces a high permeability environment for maximum induction, creates a strong magnetic field not prone to distortion, yet it offers considerably less magnetic drag and a higher electron yield per unit of core mass than a soft iron solid core or laminated core.

Summary: The hollow alloy core achieves this superior translation through 3 main causes. 1.) The "skin effect" which concentrates the magnetic flux into a region which is very close to the actual coil windings. 2.) The actual core material has superior magnetic coercian and induction properties to that of soft iron alone. 3.) The core structure minimizes rampant Eddy Currents, thus maximising positive induction potential. This makes it suitable for use with high torque motor designs, and also for generator designs**

Page 5 : Cores and Coils – Continued

On this page we begin to discuss coil arrangements and magnetic properties. This will eventually lead us to rotor design; since how or what you want your motor to do will dictate the design of your rotor as well. In Fig 13 below we'll look at various coil locations, and discuss some observations. Lets go MYTHBUSTING !

Fig 13



In Fig 13 above, there is a single drive coil and two pickup coils. With the motor turned on and spinning merrily we take measurements of the voltage in Coil B and Coil C. We notice that, although the coils are identical in every way, Coil C has a much higher Voltage than Coil B. Is this the "Sweet Spot" you dreamed about last night ? (LOL). As you move Coil C away from Coil A towards Coil B you notice the voltage drop until at the halfway mark you notice its nearly the same as Coil B. But as you get closer to Coil B, both Coil C and Coil B may increase their Voltage together. But they wont go as high as the Voltage was on Coil C , when it was near Coil A (the drive coil).

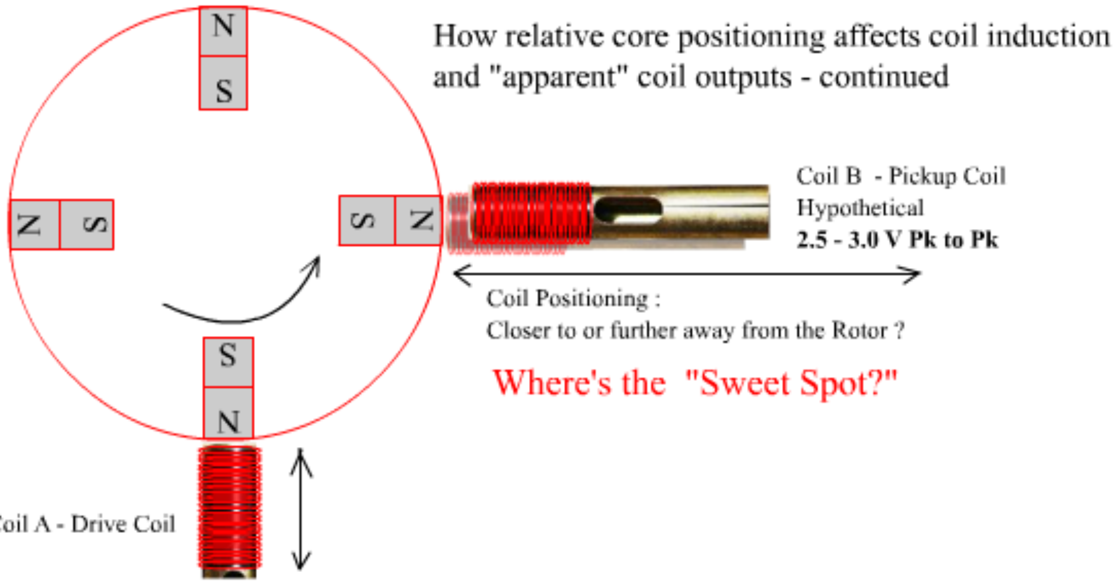
Whats going on here ?? Simple induction, that's all: – represented by the green lines around Coils A and C. *Theres no Punch without Judy!* You cant stick one core near another, without shielding, and not have something happen between them when one or more is energised. Especially when the magnetic path between them is constantly changing due to a magnet swinging past at high speed. The magnet, as it passes from Coil A to Coil C is imparting some of the EMF and

CEMF from Coil A on the leading and trailing edges of the pulse. Remember Coil A is turning on and off which is inducing a changing field exchange with Coil C . All the while this process of induction by proximity is happily facilitated by the closing of one end of the magnetic circuit between them by the magnet as it passes between them. So the higher Voltage reading is due to the Magnet and EMF/CEMF of Coil A combined. When Coil C is shifted right around to close proximity to Coil B, a field becomes shared between them which is induced by the magnet, and a similar sharing of Induced EMF occurs. Though not as profound, because neither coil is externally energised by a power supply like Coil A.

But what comes in goes out. If you connect the ouputs of each coil to a load, then, when Coil C is near Coil A (the drive coil) it will deliver a higher power to the load. But the extra power will be drawn directly through induction from the drive Coil A, whilst Coil B will only deliver what it gets from the rotating magnet. When Coil C is near Coil B, they will both only deliver the same amount of energy as each other and the total energy combined will be less than the combination of Coil C and Coil A. This is because they are both now only receiving induced current from the magnet and not from Coil A. **There is no "Sweet Spot" here without a sticky end. The higher power combination of Coil A and C together, fed into a load , results in higher current consumption from the driving source.** In this case a battery supply.

In Fig 14 below we look for another, **different sort of "Sweet Spot ".** See below Fig 14 for an explanation of this "Sweet Spot".

Fig 14

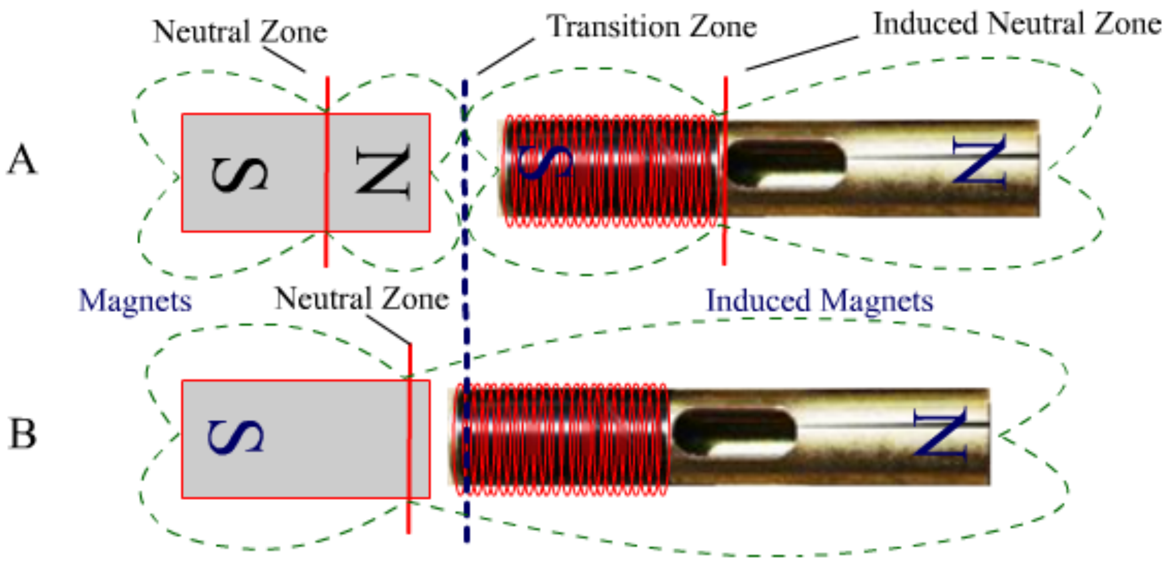


In Fig 14 above, we move the pickup Coil B towards and away from the moving rotor. All the while we are measuring the AC Voltage output of Coil B. Starting at about 1.5 centimetres away from the rotor, we notice we have a 1Volt peak to peak AC signal, and as we slowly push the core closer to the rotor we witness the voltage increase steadily until we are about 2-3 mm away from the rotor, and reach a Voltage of about 3.0 Volts. As we were moving the core closer to the rotor, we also noticed that the rotor slowed down just a "little bit".

At 2-3 mm distance, we continue to push the coil closer to the rotor, and at first notice a slight increase in Voltage, but then all of a sudden the rotor begins to slow down significantly and the Voltage suddenly starts to drop off. As we slowly pull back on the coil and return it to the point where it was about 2-3 mm away, we notice the rotor regains its speed and the Voltage climbs back up to 3 Volts. Is this the "Sweet Spot" you dreamed about last night? (LOL). Well it might be, because it is a "Sweet Spot" in a sense. **It is not a magical "OU" realm, but it is *the right spot*** for your particular setup. The actual distance will depend on both the magnet strength and length and the nature of the core being used. But this particular "Sweet Spot" is present in all open magnetic systems. It does not affect Air Cored Coils until those coils are delivering current into a load. Even when that is the case, the effect is minimal on Air Cored Coils.

To understand it we need to discuss the "Neutral Zone " and the "Transition Zone" which has not been discussed. Fig 15 below presents a diagramatic view of the Transition Zone

Fig 15



In Fig 15 above there are two groups of magnets to the left and cores to the right, which have become induced magnets. But there is a difference in the two groups A and B.

In Fig 15 A the magnet and induced magnet are still acting as two individual magnets. The induced magnet's existence depends on the magnet, but it is a mirror image in every respect except absolute strength. As the magnet and core get closer, there is a movement in the Neutral Zones towards a common centre which is the Transition Zone. The neutral and transition zones only exist between two or more magnets or a magnet and a reactant core. They don't exist at all when a magnet is all alone and has no one to play with! **"Or when two magnets become one!"**

In Fig 15 B the core has moved so closely to the magnet, that it has breached the mutual transition Zone, and has now fallen entirely under the domain of the magnet's overwhelming influence. The two separate bodies, for all magnetic intents and purposes, have become "like one"! The induced Neutral Zone disappears as the entire core changes to a single magnetic polarity, and the Neutral Zone of the magnet plunges forward to assert it's new found dominant position. Prying the core and magnet apart now becomes harder work.. And they haven't even physically touched yet! This change is a quantum change that requires a leap in driving power to maintain rotor speed. The coercian factor involved in separating the two pieces is now affected by a change in magnetic state.

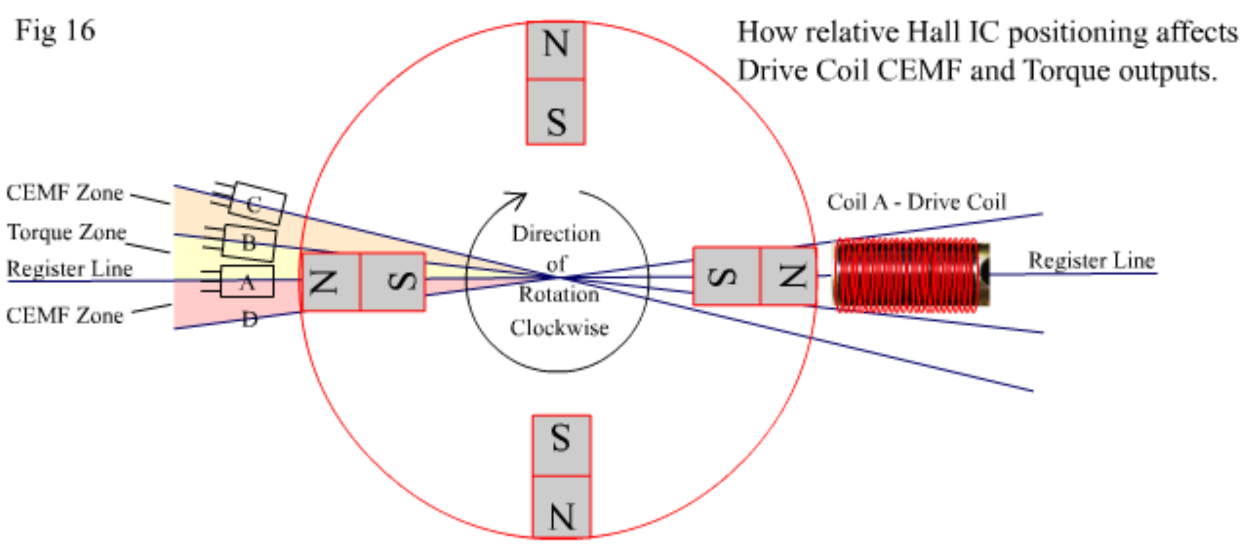
When water changes to ice there is a quantum change in state to the individual water molecules. Think of the way that water has a "latent" heat quota, which must be extracted before it will turn to ice, (relate to creating electrical Coercian). Once it does turn to ice, that same latent heat quota must be filled (relate to creating Drag) before it will turn back into water again. All the while, you could have just left it alone, and you would have had a drink of water a whole lot quicker!

Tuning in your pick-up coils to the "Right Spot" is strongly recommended. You will get the maximum Voltage and Current without paying a greater price than you need to. I also recommend, that you start off your construction by mounting your Drive Coils first. Play around with the Drive coils to "tune them in" to the "Right Spot", which is the best distance from the rotor. The best distance in this case, will be when you are getting the **Maximum desirable RPM from a Minimum Current Draw for that given Maximum desirable RPM.** Then, mount your pick-up coils and tune them in to the best distance that suits them. If the Drive Coils and Pick-Up Coils are identical, then the best distance will be the same for both coil types.

Standard Electrical Induction Generator Theory says you should put the cores as close as possible. In this instance I strongly disagree. I say put them where you get the most Voltage before your rotor slows significantly. And remember – This is an Open Magnetic System and We Play by Different Rules here! What can appear to be a weakness can be a great strength. There is a "yet to be discussed anomoly" which makes good use of the changing Bloch and Transition Zones.

Before moving on to working models using both Singular and Bi-Filar Coils, we will look at one more "Sweet Spot". Fig 16 below shows different results to be expected when the firing "pulse angle" changes due to shifts in the location of the Hall IC which is responsible for switching your pulses on and off at the correct time.

Fig 16



In Fig 16 above, there is a single drive coil mounted on one side of the rotor, and a Hall IC which provides the switching on the opposite side of the rotor. This alignment is for the ease of showing the different "Zones" created by changing the firing angle of the Hall IC. At point A the IC is in line with the "register point" of the magnet and coil. As you move away from the register point to point B, you will find that the RPM of the motor doesn't fall, or falls only very slightly, but the driving current also reduces slightly. When you go past point B and continue to approach point C you will notice the RPM will fall more rapidly, and driving current will begin to increase more rapidly. If you proceed past point C, RPM will fall dramatically and drive current consumption will increase dramatically.

For maximum RPM and true Torque, the motor will run best if the Hall IC is just past the register point and no further than point B. Within that small angle range will be the optimum angle for your motor. The ACTUAL angle or angles are not predictable as a mandatory angle for all motors, but will vary according to other factors such as the width of your magnets with respect to the distance between them (duty cycle), and the strength of the magnets, the biasing of the Hall and so on. All you need to do, is measure your current consumption while you are varying the position, and you will find the angle which delivers the most RPM and torque for the minimum drive current.

Between point B and C, there is a shift in the dynamics of the motor which translates torque availability to CEMF availability. Now there is always going to be a level of CEMF available while the coil is pulsing on and off. But the maximum level of usable CEMF (note* – current: not just potential) can be found when the motor is slightly "de-tuned" and your Hall IC is somewhere in the zone between B and C. But as mentioned, there will be a slight increase in current consumption, and a decrease in true torque.

You will also notice point D. If the Hall IC was in this position before startup, then the rotor would turn anti-clockwise when the circuit was connected. But what happens in this area between point A and D, when you already have the motor spinning clockwise? For a small number of degrees past register in the opposite direction, a running motor can be quite forgiving and still run at high RPM. One thing to be noticed here, is that in this small region, the effect is the same as that between points B and C.

By now, you should be starting to see that there's more to designing an "Adams" motor than first expected. Exactly what is it that you want from this motor? As I have previously mentioned, it is a very "Dynamic" motor, in every sense of the word, and what you design will be predicated by what you desire from it. But they are a great type of motor to experiment with due to the relative ease with which they can be made. A lot can be learned about motors in general by experimenting with them, and they also have the capability of introducing the beginner to simple semi-conductor electronic theory.

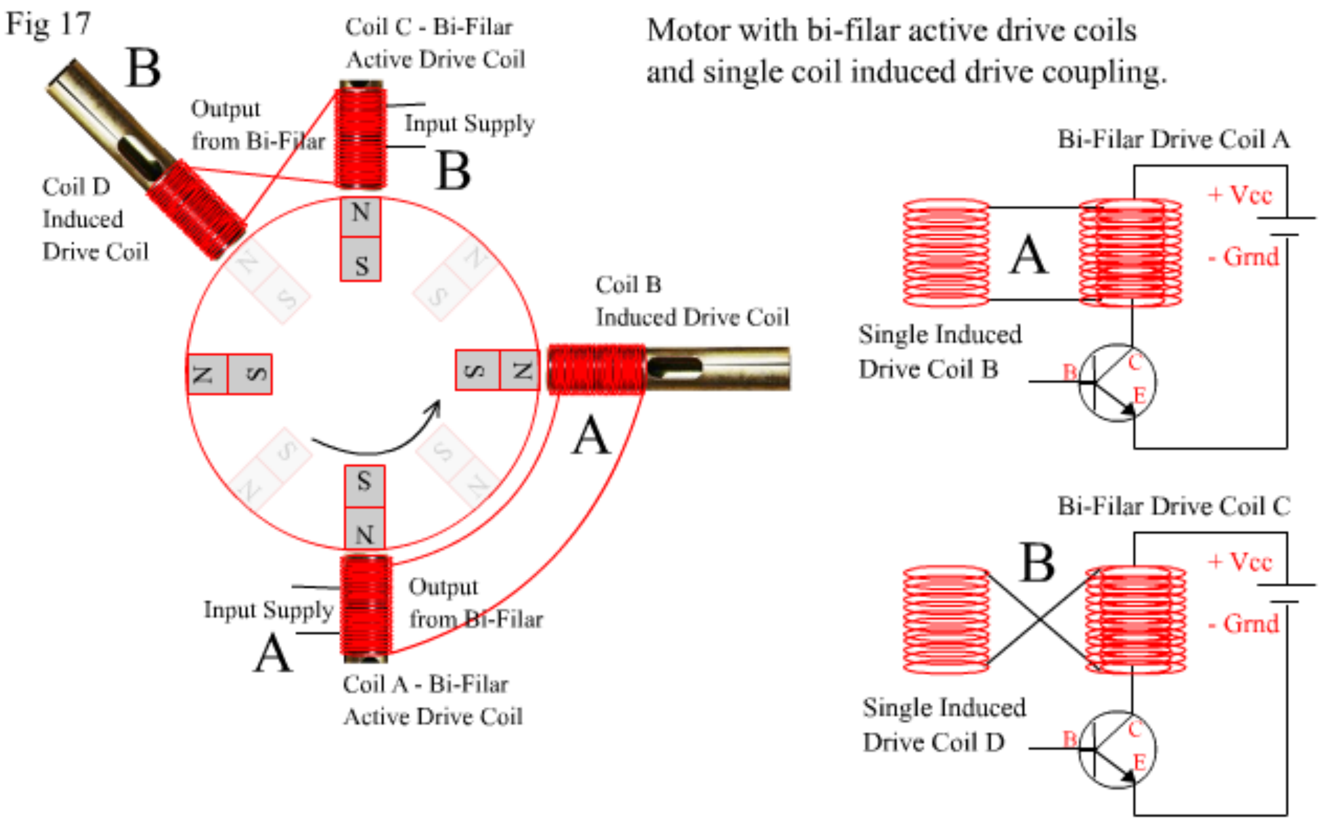
Page 6: To bi or not to bi

that is the question Horatio! Bi-Filar that is. Do you wind single or double (bi-filar) coils for your motor. Its six of one or a half a dozen of the other! Once again, it depends on your requirement. But I'll assume that you want to wind bi-filar, because you've read all sorts of things about them. We'll throw in a few single wound coils just for the sake of it. After all, we need to compare things to ascertain whether an advantage or disadvantage has occurred. Before we go too far, lets talk about Duty Cycle. What is it? How does it affect the motor running.?

Percentage Duty Cycle is a term used to describe the amount of time something is "turned" on compared to the time it is "turned off" before being "turned on" again. So if a rotary machine receives a burst of power at Point A for 1 second and takes another 3 seconds before it gets back to point A (or another burst point B) where it is ready to be given another burst of power, then 1 second out of a total of 4 seconds (1 on plus 3 off) , is 25% of the time of the total cycle. Thus, it will be referred to as a 25% Duty Cycle machine. If it was on for 2 seconds out of the 4 seconds, it would be 50% and if it was on for all 4 seconds it would be 100%. In a machine that uses magnets to trigger Hall IC's, the on time will usually be be the width of the triggering magnets (roughly) and the off time will be the space between triggering magnets (roughly).

The On Time + Off time = Total Cycle Time and the % Duty Cycle is the On Time / Total Cycle Time. A conventional shunt wound DC motor is on all the time when connected, thus it's Duty cycle is 100%.

See Fig 17 and below Fig 17 for an explanation of the diagram and how Duty Cycle can affects the circuits shown



In Fig 17 above there are two active Drive coils which are bi-filar wound, which means two identical lengths of wire have been wound into a coil at exactly the same time together. In this way each coil has exactly the same influence on the core or is influenced by the core in the same way. It is a different method to winding one coil first and then winding the other one over the first, which is very common in ordinary tranformers and inductors. A Bi-Filar coil shares the same induction capabilities as other winding methods including the ability to act as a transformer. In many instances it is the preferred way to make windings. And like a transformer there can be more than just two windings. Tri-Filar and Quad-Filar etc……

The two active drive coils have one set each of their bi-filar windings connected to a single wire induced drive coil. They are divided into Groups A and B. The two groups are wired differently and are spaced differently with respect to the distances between the active drive coil and its associated induced coil. The Drives Coils A and C are active drive coils, meaning that they are connected to the pulsed supply. The drive coils B and D are both "reactive" induced drive coils which derive their power from the transformer effect occurring in Coils A and C. Remember that Bi Filar Coils A and C will be pulsing on and off, and by doing so are acting like a transformer with a primary coil connected to a supply (the pulse) and a secondary coil connected to a load, which in this case are the induced drive coils B and D.

When the primary winding of Coil A is pulsed on, the other winding sends induced current in the opposite direction out to Coil B which is also opposite a magnet at the same moment of pulse. The current entering into drive coil B is in the same direction as the primary current in coil A and so it induces into the core the same magnetic polarity as coil A. Both coils will be North pole (in the above example) and the rotor will be repelled away by two synchronous electromagnetic cores.

When The Pulse in Coil A turns off, the collapsing field reverses the secondary current pulse and coil B will become a South Pole which is now attracting the magnet which was previously repelled by it. If the pulse is less than 50 % duty cycle, then the rotor magnet will still be less than halfway between the first core (active) and the next core (induced). This will cause some loss of the benefit of the initial Pulse when Coil B was a north pole because the magnet on the rotor will be attracted back to it while its trying to continue its journey to the next core.

As Coil C is being pulsed "on", the same induction process is occurring between Coil C and Coil D as between Coils A nd B. But the connections of the output from Coil C have been twisted 180 degrees and the position of Coil D has changed to a place corresponding to the midway point of the pulse cycle. Now when Coil C is pulsed on, it becomes a North Pole repelling the rotor (magnet), and at the same time Coil D becomes a South Pole attracting the rotor (magnet).

When the pulse in Coil C turns off, the collapsing field reverses the secondary current pulse and coil D will become a North Pole which is now repelling the magnet which was previously attracted by it. In this instance, if the pulse is less than 50 % duty cycle, then the rotor magnet will still not have passed Coil D before Coil D becomes repelling. This will cause some loss of the benefit of the initial Pulse when Coil D was a South pole because the magnet on the rotor will be repelled back while its trying to continue its journey to and past Coil D.

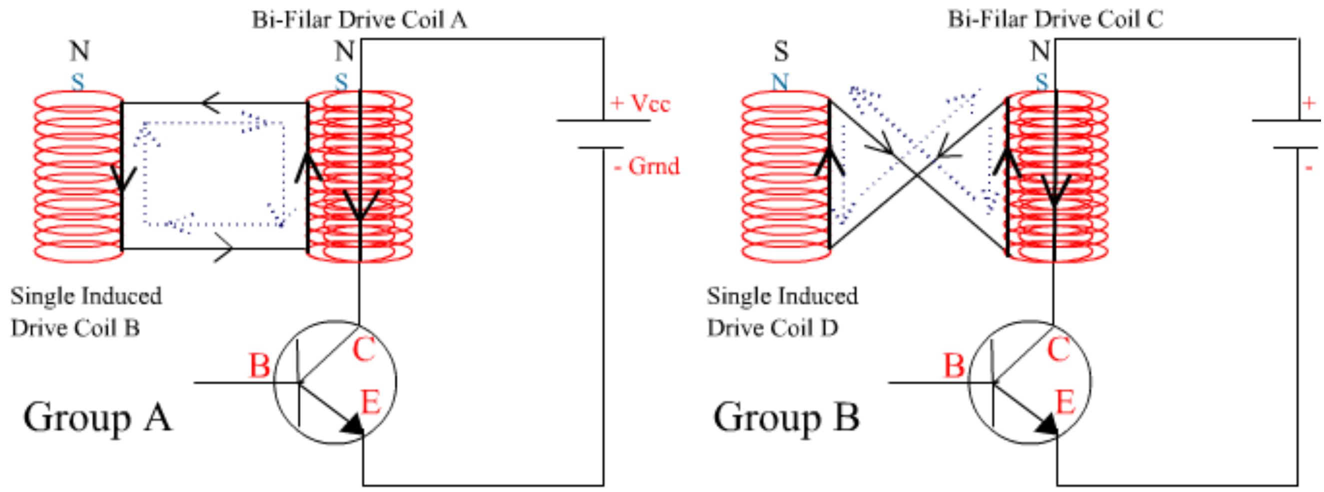
In the example above, if the pulse is exactly 50 % Duty Cycle, then Group A and B will both act in perfect unison and each set of cores will contribute to the overall positive torque of the motor. Group A will provide more additional torque than Group B on the leading edge (turn on) of the pulse while Group B will produce more torque on the trailing edge (turn off) of the pulse. This is due to the relative distance of all cores from the nearest magnet at each edge of the pulse. Both configurations will yield the same net amount of torque. Note that the placement of the induced drive coils above shows the best possible position for 50% duty cycle only. As soon as you change the Duty Cycle to something like 20-25 % then the current phase within the coils will change with respect to the magnet position and firing positions, and this will effect the location at which the coils will give their "maximum perceived benefit", and also the amplitude of that "maximum perceived benefit". Incorrect placement for a given duty cycle will have a negative impact on torque and current consumption.

In all pulse motors, *50% duty cycle per phase* is the maximum beneficial, usuable, active percentage. Applying power for more than 50 % of the time causes severe loss of torque through to complete motor stall, high current consumption, excessive heating and unnecessary energy waste. It is also rare in most multi-phase pulse motors to run on Duty Cycles of more than 30% per phase as it is not necessary. Correct use of "Timing Factor" can extend the "Virtual Duty Cycle" of each phase in a positive way by recirculation of CEMF, but only below Duty Cycles of 50% and preferably in the region of 20-25 %. This is one of the core benefits of pulsed motors.

We will discuss "Timing Factor" and "Virtual Duty Cycle" on a following page, especially as it relates to the collection of CEMF in the drive coil and translation to torque or regenerative charging.

Fig 18 below shows more clearly the phase relationship between the active and induced drive coils of Groups A and B from Fig 17 above.

Fig 18



NS ———— Represents Magnetic Polarity, Main current flow and current from secondaries of Coils A and C during leading edge of pulse beginning "on" time.

NS .... Represents Magnetic Polarity and current from secondaries of Coils A and C during trailing edge of pulse and beginning "off" time. CEMF period of propulsion.

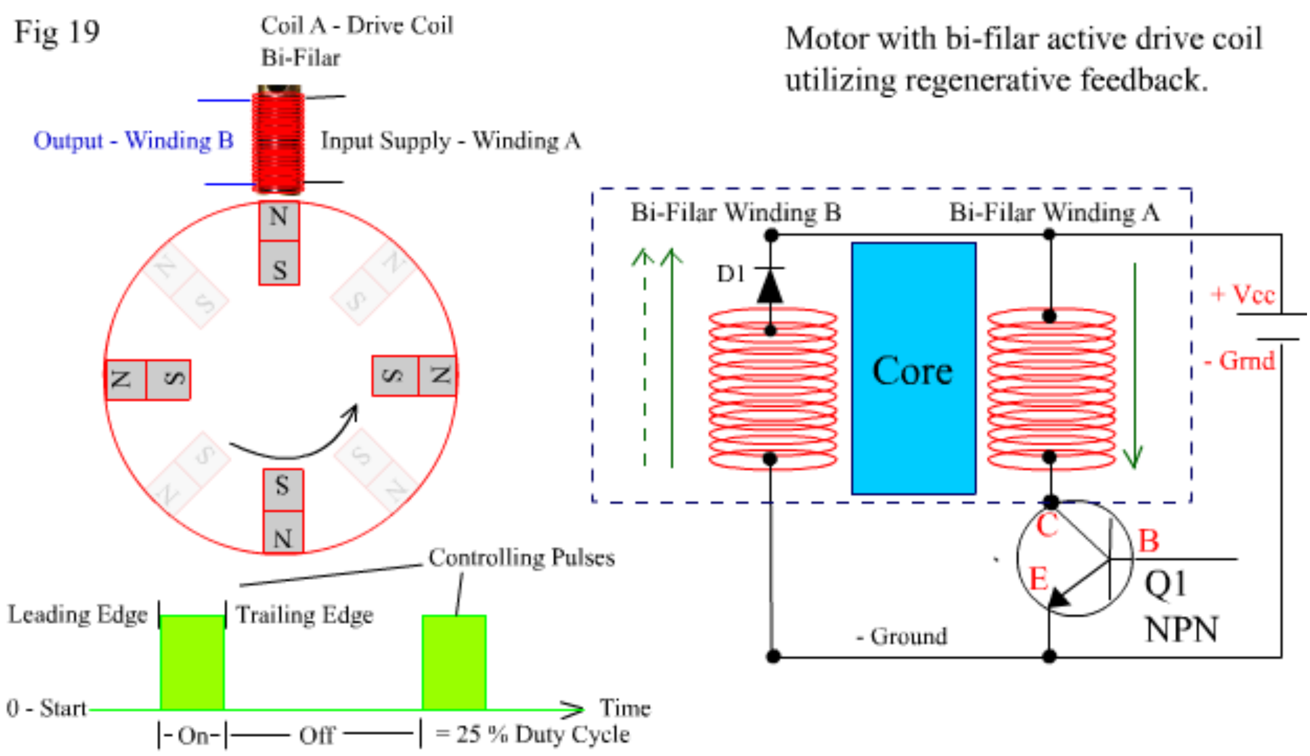
Now after all this, a question begging to be asked is; what advantages, if any, do either of the above two coil configurations have over just using two single wound drive coils A and C only. Why bother with bi-filar coils and the induced coils B and D.

The answer is; for not much really!. Especially if you are using solid iron cores!

Technically both configurations do increase torque marginally without increasing drive current consumption much, if at all. The small advantage they offer, is that they directly translate the CEMF which arises in Coils A and C into the rotor as added torque. The downside to this arrangement is simple. The extra cores introduce extra magnetic drag. Remember that nasty price you have to pay from drag. Theres always a price, so it isn't all win. The added torque is greater (when using low impedance coils) than the magnetic drag that is introduced, so there is still a small net gain in medium to high power motors. Not Overunity, just a gain in overall efficiency.

Bi-Filars can be used in a simpler even more efficient arrangement, which introduces no extra drag at all yet adds to available torque and reduces consumption by translating the BEMF and CEMF of the windings. See Fig 19 below and after Fig 19 for the explanation.

Fig 19



In Fig 19 above, a single Bi-Filar wound coil is shown. One side of Winding A is connected directly to the positive of the supply while the other side is connected to ground via the Collector to Emitter junction of the controlling transistor Q1. Winding B has one side connected back to the positive of the supply via a diode (D1). The diode prevents it from receiving any input power directly from the supply and provides a return path for regenerative energy. The other side of winding B is connected to the negative (ground) of the supply.

When the transistor turns on due to a pulse, the bi-filar coil acts briefly like a transformer. During the leading edge of the pulse, the current in winding A shown by the green arrow to the right of winding A, induces a BEMF into winding B. This BEMF normally arises within winding A, but is blocked by transistor Q1. However, the diode D1 is forward biased to the BEMF in winding B, and so current is allowed to pass in the direction as shown by the solid green arrow on the left of winding B. This BEMF current forms a loop * (see note at end of page) between winding B and winding A whilst transistor Q1 is turned on, and has the effect of maintaining a higher supply voltage to winding A by contributing recycled current (BEMF) in conjunction with the supply current to winding A. This in turn, translates to a slightly higher torque, with less total supply current required.

Once the leading edge of the pulse passes, this transformer recycling effect disappears until the trailing edge of the pulse occurs. When the pulse collapses (the trailing edge), a CEMF is produced in the same direction as the preceding BEMF and it also is recycled. But its energy goes directly back into the supply as charge, because when Transistor Q1 turns off, there is no path through winding A for current to flow in a circulating loop. The CEMF direction is shown by the dashed green arrow to the left of winding B.

This coil arrangement is very simple and has a positive impact on total efficiency over a wide range of duty cycles. When using low impedance coils with a short "Timing Factor", duty cycles can go as high as 45 % before the dynamics change from a positive impact to a negative one. As mentioned previously, I'll discuss the term "Timing Factor" in more detail later. Next we'll look at a few more simple methods of capturing CEMF as regenerative energy.

Note from above – "This BEMF current forms a loop between winding B and winding A" . This is a neat little trick! Especially when the statement is followed by "This in turn, translates to a slightly higher torque, with less total supply current required. " Lets examine these statements more closely.

In a conventional DC motor as outlined already on page 2 with the following statement "In Fig 3 Circuit B above, a normal DC motor is connected to a supply and promptly increases its speed until it reaches top speed. As it does so, a BEMP arises which produces a BEMF. The BEMF is just like the Forward EMF (FEMF), in that there is a complete loop in the circuit for it to flow. It is never as strong as the FEMF and so the net current flow measured will always be in the direction of the supply current."

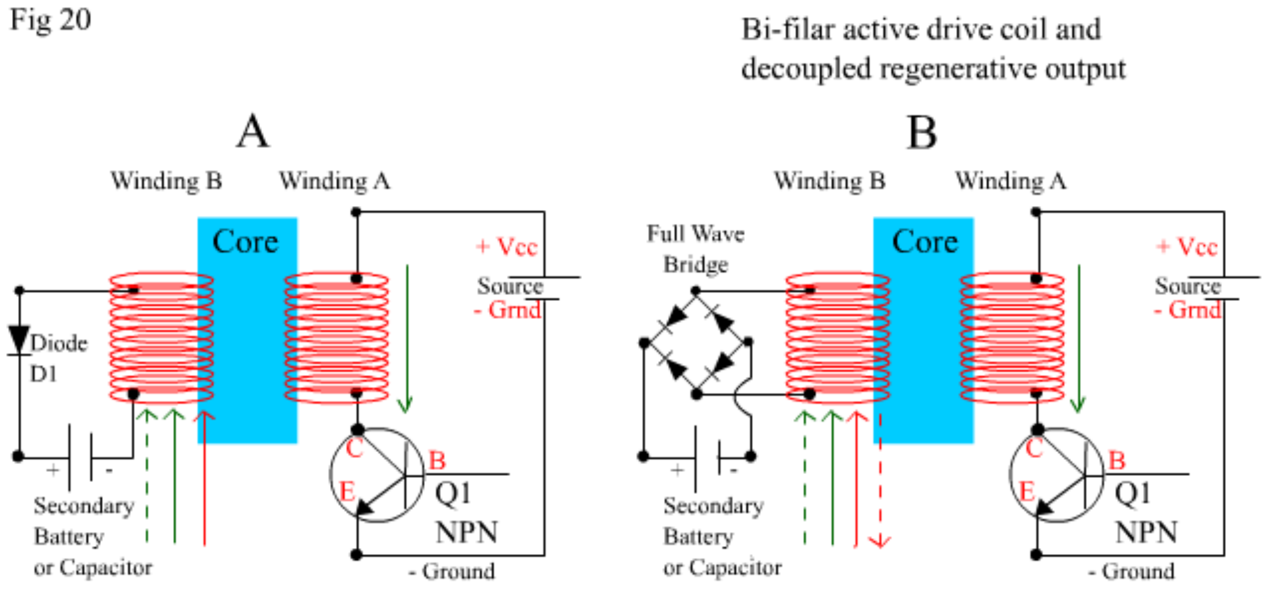
When the BEMF arises in the DC motor to its maximum, then current draw will be at its minimum, due to the opposing EMF's, RPM will be at a maximum, and actual torque will be at a minimum! Don't take my word for it. Check out the torque characteristics of any Permanent Magnet DC motor. Their maximum torque is at Zero Rpm. (maximum Current draw!) Have you noticed that when you hook up a high speed Permanent Magnet DC motor without a load for just 5 minutes, they still get quite warm to hot. After thirty minutes of continuous running they are definitely hot. Think about the Forward and Back EMF fighting it out against each other in the coil wire. Forward Current wins after battling its way against this BEMF the whole time. So where do you think most of the heat is coming from! Is it just from driving current. No, not when the motor is free wheeling with zero load. Thats when the "apparent" supply current is at its lowest! Yet still they run hot. It's because two big opposing currents are playing "push the other guy", and only one is winning by a small amount!. The "apparent" low current we measure.

The statement "This BEMF current forms a loop between winding B and winding A" reveals a wonderful trick of the circuit in Fig 19, whereby, an induced current which normally opposes the inducing current, is re directed to assist the current it normally opposes. In doing so it acts cohesively and unidirectionally, with the inducing current. A quick re-glance at Fig 19 above, shows both the supply current through winding A, and the CEMF from winding B (when followed around the circuit) wind up in the **same direction** through winding A. **The currents are not fighting each other, they are mutually co-operating with each other!**

Result – more torque, less supply current! less heat!

On page 6 we looked at how using bi-filar coils can minimize current demand and slightly increase torque. On this page we'll look at a few circuits that off-load their regenerative energy to a secondary battery or capacitor. We will discuss using the secondary winding of the bi filar as a charging source versus tapping directly into the supply winding. This will eventually lead us to discussion of the stand alone "passive" pick-up generating coils, and will open the door to an "anomoly" for us to examine!

Fig 20



In Fig 20 above Groups A and B are two identical bi-filar wound coils. Group A has winding A connected to the pulsed supply and winding B connected via a Diode D1 to an external Battery (or Capacitor). Group B has winding A connected to the pulsed supply and winding B connected via a Full Wave Bridge to an external Battery (or Capacitor)

In Fig 19 on the previous page, the example and description only took into account, the actions and reactions of the core to the supply pulse. Because diode D1 and transistor Q1 were blocking to any reverse currents in their respective coil windings, then we neglected to examine any influence that the high speed changing magnetic field had in creating its own induced AC or Varying DC current into the coils. I tried to keep the explanation within the bounds of supply current only to KISS. (LOL)

In Fig 20 above, the secondary winding B in both groups, is electrically de-coupled from the supply of winding A, and is connected to its own load Battery or Capacitor. Each winding B is also de-coupled from its load by either a diode or a full wave bridge. They cannot receive current back from their load.

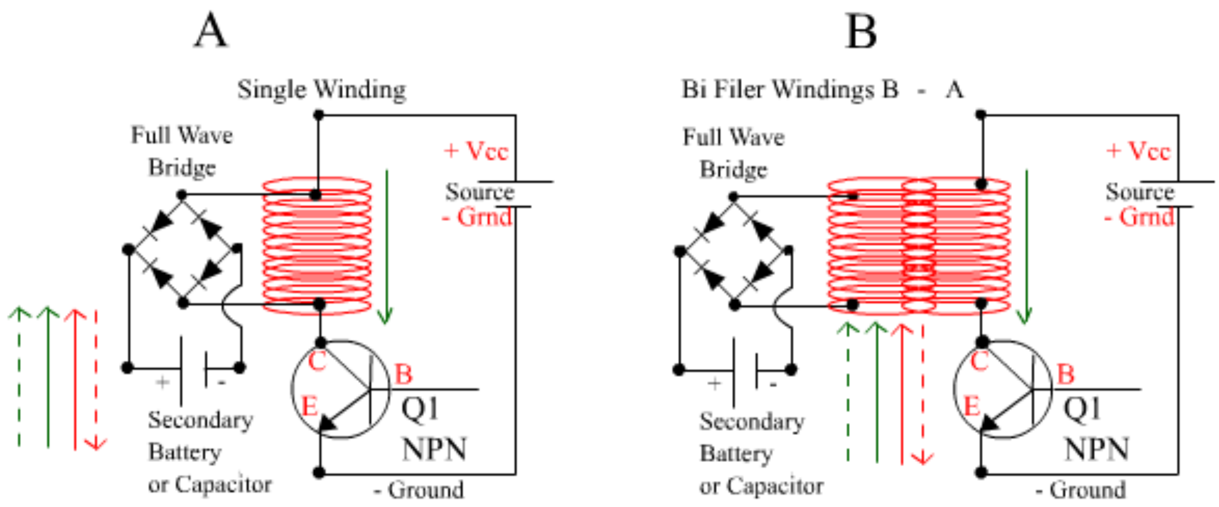
Group A will always take advantage of the pulsed supply, but it will only be influenced by the rotating magnets, when the current induced by the rotating magnets is in the same direction as that shown by the red arrow below winding B. This is because diode D1 only allows current through winding B in one direction. But Group B has a definite advantage as a generating coil because it will receive **current from both directions *induced by the magnets*, shown by the red arrows below winding B**, due to the full wave bridge, which allows this.

Once again however, "*There is no punch without Judy*", and in both circuits there will be losses. The regenerative energy is no longer available to the rotor as torque, or the supply as charge, but will instead be off-loaded out of the system. There may be a slight increase in supply current demand in both cases. And the generating capability advantage of Group B, can be quickly offset by supply demand, if too much load current is used from winding B. Also in both cases, the battery being charged has its own internal resistance (so does the supply) and therefore a small amount of the charging energy will always be lost within the battery itself.

In Fig 19 on page 6, we were feeding a small amount of energy back to the system as torque, and a small amount as charge. In Fig 20 we are translating all that energy out of the system into another storage area for later use. In both instances we are not making more energy than we put in, we are just using different methods to use the total input energy as efficiently as possible by recycling some of it. And succeeding! Personally if I were using bi-filars for a drive coil, I would be hooking it up as in Fig 19 on page 6, then using the extra torque to power stand alone pick-up coils. Before moving on to examining pick-up coils (where the real lesson is), lets look at other examples as shown in Fig 21 below.

Fig 21

Direct coupled and decoupled regenerative output



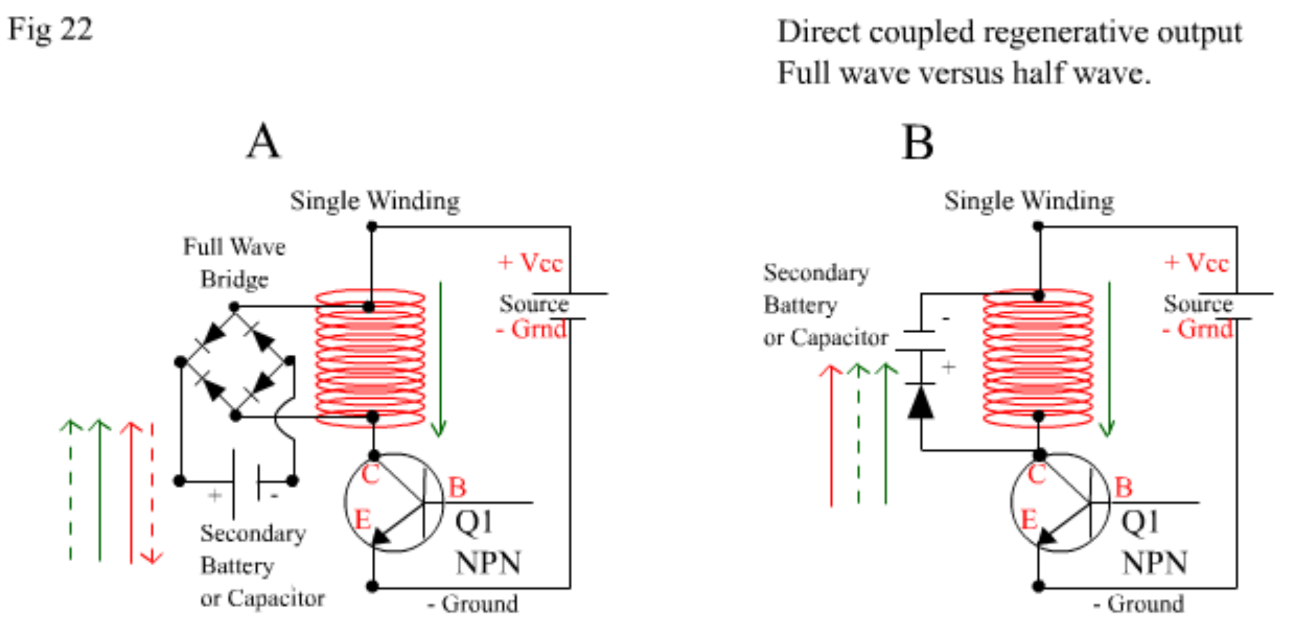
In Fig 21 above, diagram A shows a directly coupled full wave bridge across a single wound active drive coil. Diagram B shows a full wave bridge across winding B which is de-coupled from winding A, which is the active drive coil connected to the supply.

Besides electrical isolation in the circuits, what's the difference? Is one more efficient than the other?

Coil A has no transference loss between two coils when utilizing the BEMF and CEMF of the leading and trailing edges of the pulses. In Coil setup A, there is a direct loop of all arising current from the pulse within the load and coil, while in Coil B, the load loop and supply loop are isolated but mutually reacting through the inductive core they share. Both Coil A and Coil B will charge a Secondary Battery, but when utilizing BEMF and CEMF there will be less loss in Coil A due to direct coupling. **Both coils will experience the same Induced EMF from*the magnets*.** Both circuits will suffer from supply current increase if the load is too great. E.G a really flat battery or a capacitor with zero charge in it.

Please note also that Coil B doesn't have to be-filar. It can be wound like a traditonal transformer, with a secondary coil wound first over the core, then a primary coil wound over the top. In this way you can step the output up for higher voltage, or down for greater currents. Read some basic transformer theory and apply it to your motors. Play around with the following parameters and you'll have fun. High Current, Low Voltage, High Voltage (be careful), Low Current. If ever there was a way to learn about what works and what doesn't in induction systems, an open system pulsed motor will surely be it!

Fig 22 below shows a single active drive coil with either a full wave or half wave rectification. See below for explanation.



In Fig 22 A above a single coil with a full wave bridge can be seen as influenced by four possible current direction sources. Two from the supply in the form of BEMF and CEMF due to the pulse, and two from the magnets. Fig 22 B shows a single coil with diode can be seen as influenced by three possible current direction sources.

Now you might think that four is better than three, but you'll notice in this instance (and in fig 20(B) and fig 21 (A+B)) that the dashed red line in circuit A which represents one half cycle of the Induced Emf from the magnets is shown in opposite direction to all the rest. Thats because it arises at the same time as the "on" pulse, but it is in the opposite direction and is thus an oppositional vector not a complimentary one. If it is too great , it will negate some of the gains already made by the other three vectors and thus be counterproductive.

Across a wider range of load and duty cycle, circuit B will be more efficient than circuit A due to the fact that all induced *flowing* currents are complimentary and unidirectional with the supply current. Proving that KISS is the best in the end!

In summary, for absolute maximum torque with minimum supply current draw, over a wide range of duty cycles, use a bi-filar coil connected as shown in Fig 19 on page 6. For maximum charging of a secondary battery with minimum torque loss and minimum supply current draw, use circuit B as shown in Fig 22 above.

For anything else use your imagination! and let your understanding unfold! Also remember that the efficient operation of the above circuits is affected by duty cycle, and dwell angle and thus "Timing Factor", which will be discussed later in Optical-Switching. Now I keep referring to "Timing Factor" but really thats just because the terminolgy fits in with the way I have been discussing matters here. Simply – I hope! What I really should be referring to though is "Time Constants".

The following links are a must read in order for you to get a good understanding of "Time Constants" and how they will relate to your experiments with different impedance coils.

1. Particular reference to "heel end slugs" in relays.

http://books.google.com/books?id=OtlKBAcFBQAC&pg=PA274&lpg=PA274&dq=heel+end+slug+relay&source=web&ots=3uupcv-0EV&sig=L2pXZupMkAmkODcaCFzJHx7PW6w

2. Discussing time constants

http://www.ibiblio.org/kuphaldt/electricCircuits/DC/DC_16.html

http://www.d.umn.edu/~snorr/ece2006s5/Lab8b.doc

On the next page we will discuss passive pick-up generator coils, heel end slugs, and that "anomoly" I keep talking about. That "anomoly" is the very thing that makes these motors so controversial! But it may not be what you expect !

Page 8 : Pick-up Coils and Bending Lenz's Law

Please don't take a single word I have to say on this page as explicit "truth ". PLEASE reproduce your own motor/generator experiments as outlined on this page. Please Verify Effects For Yourself!!!

Hopefully you've already digested some of the complicated stuff, and in keeping with the KISS principle, you've decided to stick with single wound drive coils for the time being and see what single wound "pick-up coils" can do. They are a so called "passive" component of the circuit , so it should be straight forward to set them up and use them, shouldn't it ???. Yeah right! The accepted theory says: place a pick-up coil near the rotor and hook up a full wave bridge to it, and wallah! instant DC power, but with a price. The price is due to **Lenz's Law** as it applies to generators.

Lenz's Law states that: the magnetic field of *any* induced current *opposes* the change that induces it. Heres a quick link to Wikipeadia for a cross reference: http://en.wikipedia.org/wiki/Lenz's_law

That means the moment you start using any current from your pick-up coils, that same current will oppose the motion of the magnets! That's what**Lenz says.** So much for being passive coils! Now in almost all instances I would pay complete homage to a great man like Lenz and agree with everything he says. How dare I say it, but, in the instance of an "open magnetic system" he is only partly correct!. He is not wrong, he's just not completely right.

Lenz's Law probably needs a little post editing to say **" the magnetic field of *most* induced current *opposes* the change that induces it, *most* of the time** ".

Whew!, I'm really going to get into trouble with the "establishment" over that statement. I only changed one word and added a few more, but it's a BIG change for the parameters of motor/generator construction. You've already seen how the circuit in Fig 19 on page 6 can redirect an oppositional current to a complimentary unidirectional one, thus aiding the inducing force instead of opposing it.

So you've already seen a principle at work in pulsing which "bends" Lenz's Law. Try the bi-filar arrangement in Fig 19 yourself! Keep impedances low, under 5 ohms, and duty cycle to 25% or less. But even a so called "passive" coil, which is one that is not connected to any power supply, will bend Lenz's Law in an open magnetic system

You will be able to prove this yourself because Robert Adams the inventor of the Adams motor published a complete simple coil and rotor layout diagram for you already.. Unfortunately, Robert Adams misinterpreted what it revealed to himself. I believe that he was no fraud, and "he honestly believed" that extra energy was entering into the system, when in fact there was less *out of phase* ***"oppositional"*** energy created which hinders a motor system.

You ***can prove this yourself***, if you do a few experiments. Adams shows you how to bend Lenz's Law in Fig 23 below.

Fig 23

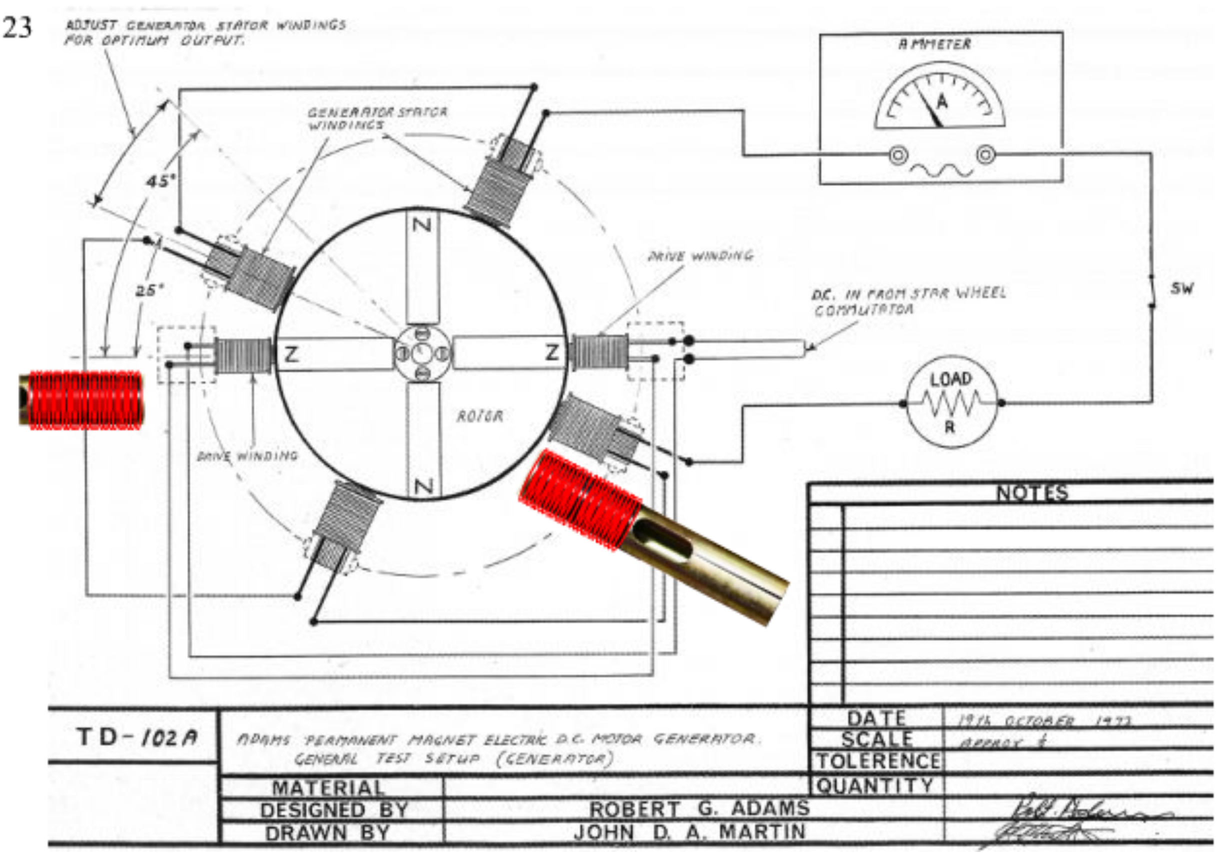


Fig 23 above, shows Robert Adams now famous "Golden Ratio Motor Generator". Superimposed , are two pictures of unconnected coils simply to draw attention to the coils in Adams original diagram. You will notice that his **pick-up coils have a "heel end".** And his drive coils do not. I explained this difference in core usage and operation on Page 4 / Fig 11. Don't argue with Adams on this feature. What I hadn't previously explained, was that the "heel end" also exaggerates the effect you will create. You may also notice that in Adams diagram he shows an "Ammeter" for measuring current, yet on his ammeter is the ~ symbol which represents AC. There has never been an analogue meter built, which can measure AC current directly, so we'll have to assume that the meter has it's own inbuilt full wave bridge to convert the current to DC. **Always question what you see!**

Now, assuming you've got all the ingredients to make a motor.- What's important in this experiment is that your motor has *plenty of real torque*, so use quite low impedance coils for your drive. Approximately 150-200 turns of .6 mm wire for each drive coil on a core approximately 50-60 mm long and about 10-12 mm in diameter. Preferably use hollow cores if you can, because they also *exaggerate the effect* and minimize drag. But if you're an Adams purist, then make your drive cores from non-retentive magnetic stainless steel and use laminated soft iron for your pick-up cores.

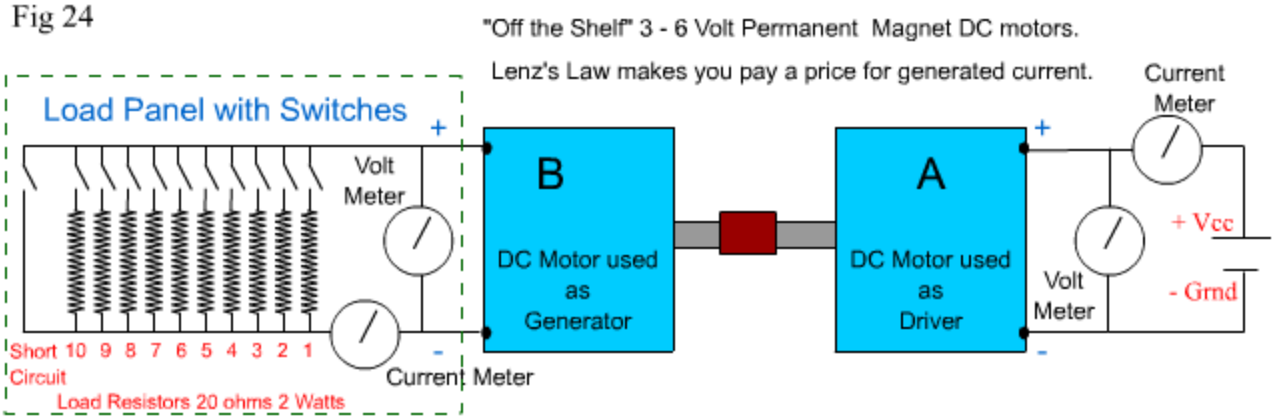
You will want a slightly higher voltage output than the supply, but still want a reasonable current from your output coils, so wind approx 200 – 300 turns of the same .6 mm wire on a core which is approx 70-100 mm long and 10-12 mm diameter. According to Adams diagram, connect the 2 drive coils in series, and the 4 pick-up coils in series also. Your rotor will probably be somewhere between 80 – 140 mm diameter, and you're probably using neodymium magnets which are around

10-15 mm diameter and 10-15 mm length. Desired rotor size, core lengths, diameters etc are *"Not Critical".* You just want your motor to have plenty of "grunt – real torque" so that it still spins at quite a high RPM after you have placed your "heel end" pick-up coils into position.

In Adams original description of this circuit, he claimed that "when you connect the output of the pickup coils to a load, the torque of the motor will increase". Why would he claim that? What happens when you connect the output to a load?. According to Lenz's Law, you **should**perceive a slowing of the rotor because the current induced into the coils opposes the movement of the rotor.

To understand the effect in an Adams motor, lets quickly prove that Lenz is ordinarily right, with a motor / generator that completely obeys his laws. You will need two small conventional DC permanent magnet motors. They don't have to be identical, but identical is better. See Fig 24 below.

Fig 24



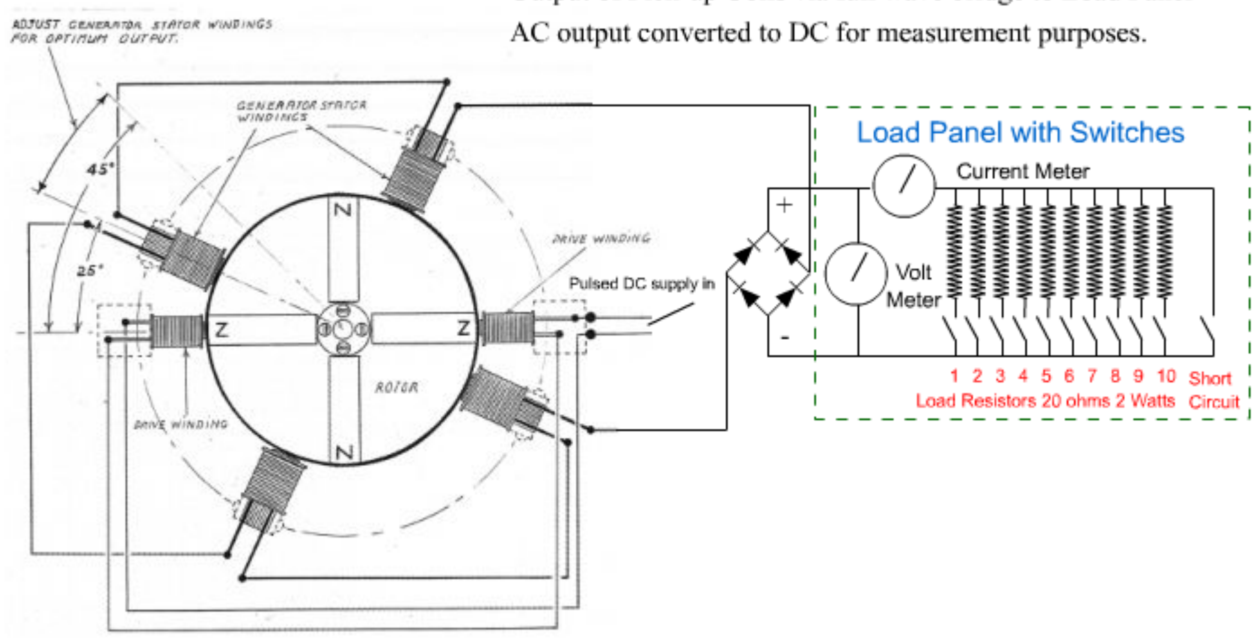
In Fig 24 above when motor A is connected to the supply, it turns motor B by common coupling at the shafts of each motor. Motor B is generating a Voltage produced by the Torque from Motor A, so we'll refer to Motor B as the Generator. The output Voltage from the Generator will not be quite as high as the input voltage to Motor A because of transference losses. All load switches are open and there is no load on the generator, so both the motor and generator will turn readily together at a high speed.

But as soon as you close the switch to R1, the generator circuit will provide current to the resistor, and this will cause a breaking effect due to Lenz's Law. This will cause the motor to slow down a bit because it has to work harder to maintain RPM against the oppositon created by the generator. Now switch on R2, then R3, R4, R5, R6, etc, until you switch on the short circuit at the end of the generator output line. Each time you switch on another Resistor, the breaking effect due to Lenz's Law will increase with increased current (shown by the current meter). At short circuit, the breaking effect within the generator will become so great that it will cause Motor A to stall and start "smoking" if you leave it connected too long! . As the breaking effect takes place you will see the supply current increase dramatically with each increase in load, as Motor A works harder to achieve continued rotation.

Now connect the Load Panel shown in Fig 24 above to the output of your Adams motor "Pick-Up Coils" as shown in Fig 25 Below. (Make your own Load Panel if you need to, and note meters are optional but recommended for this experiment.)

Fig 25

Output of Pick-up Coils via full wave bridge to Load Panel
AC output converted to DC for measurement purposes.



In Fig 25 the Adams motor pick-up coils are connected via a full wave bridge to the Load Panel for both measurement purposes and to compare like with like. The experiment with the two DC motors produces DC output because the DC motor coils are connected via commutator switches. So we'll make the Adams motor/generator output DC as well.

Now repeat the previous experiment. Be aware you are not trying to create a true comparison between the DC motors and an Adams motor per se, but a comparison in the way Lenz's Law affects or doesn't affect them. Turn on the supply to your Adams motor, let it get to top speed, then start switching the load Resistors on, one by one, from R1 to the Short Circuit.

To repeat what **should** be : "According to Lenz's Law, you **should** perceive a slowing of the rotor because the current induced into the coils opposes the movement of the rotor."

What actually happens ?????. If your motor is operating within the "realm of disbelief", as it likely will (LOL), you will notice something very strange!!.

You may notice the following:

___**********______________________________***********______________________________**********_________________

When R1 was turned on, the motor slowed a little bit, When R2 was turned on the motor may have slowed a little bit again, but not as much when R1 was turned on. Same when you turned R3 on, but **when you turned R4 on, there appeared to be no change in motor speed at all. You continue and find that when you turned R5 on there was still no change, but when you turned R6 on, the motor *seemed to speed up again*. Same with 8, 9 and 10. It's almost at the speed when you started. Then to your greatest surprise, you turn the short circuit on, and the**

motor goes to *full speed* as if there were no load at all.

___**********______________________________***********_______________________________**********__________________-

Now this is what I have personally observed in countless experiments and numerous different Adams motor Configurations. **Replicate it Please !!!!** Don't be discouraged if your coil setup doesn't do this. Try connecting the 4 coils into 2 parrallel circuits of 2 coils in series, or connect all 4 coils in parallel. Also try replacing the 20 ohm resistors on your Load Panel with 10 ohm resistors, so that the total load resistance is even lower, and therefore allows more generator current to flow each time you operate a switch. At some stage you will get it right. And if you just can't seem to get it right with your Adams motor, don't despair, because the effect can still be easily achieved. Read on.

At first it is easy to think that somehow you gained some free energy because the motor sped up to the same speed as if there were no load: – This statement is part of the puzzle and part of the answer. We will explore this phenomon again in a later page, where I will help you to prove that this "strange effect" not only exists, but exists in any open magnetic system. Proving it will be simpler than you think, because you will use an ordinary DC motor as the driving force. In fact proving it with a DC motor is more likely to yield successful results because of the great torque characteristics of Permanent Magnet DC shunt wound motors. Speed and "real" Torque matter!

On the next page we'll return to pulse motor design and address duty cycle and how to better control it using opto-switching rather than a hall device, or triggering coil.

I will also discuss how "Time Constants" can affect efficiency. But don't worry, I will try to keep things as simple as possible. Once again however, I repeat, Adams motors are "Dynamic" and there is a lot to learn from them. You may be having touble understanding, but I bet you've been having fun playing with them and trying to understand!

Page 9 : Controlling Duty Cycle and the advantage of using Optical Switching versus Hall Switching

When Robert Adams first introduced his motor to the world he also introduced a very unique but simple switch in the form of a metal star shape embedded in a disk. It was a mechanical switching system, which he later used to control a power transistor. See Fig 26 below.

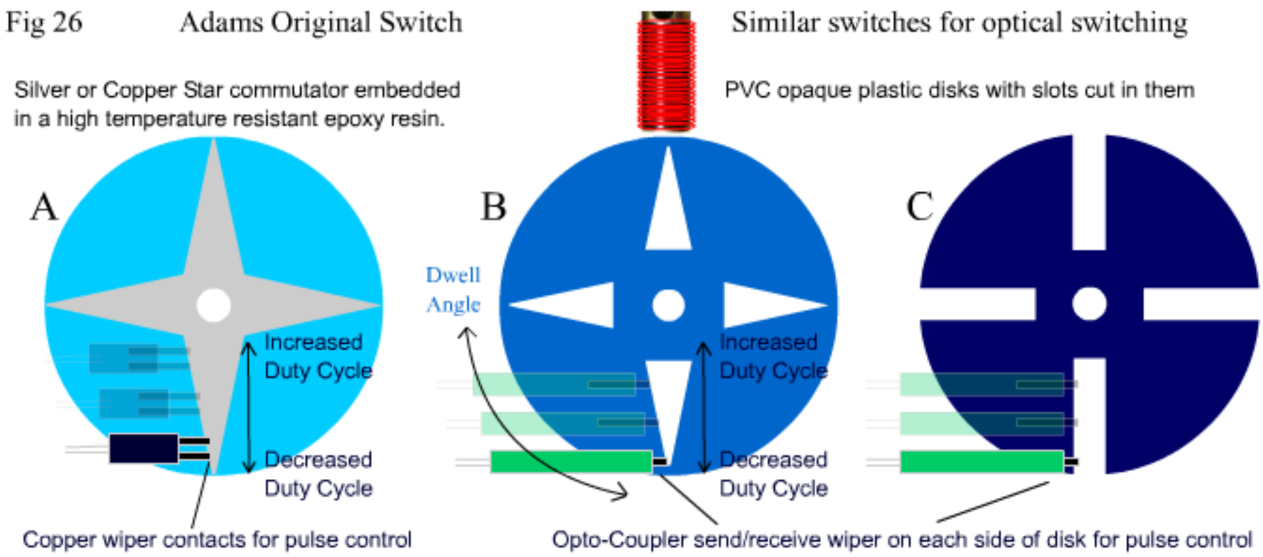


Fig 26 above shows Adams Original Star Switch Disk . The metal switching disk was mounted onto the shaft of the rotor, and would spin in unison with the rotor. There were associated copper wiper contacts to produce a pulse. Initially he controlled his drive coils directly with these contacts, but due to sparking problems which caused contact failure and commutator damage, he later used the switch to control a transistor, which in turn controlled the drive coils. By connecting the supply via the contacts to the base of the transistor through a 470 ohm resistor, the contacts switched less current, while the transistor switched the main drive current, the sparking of the contacts became less pronounced, and damage to the commutator and contacts was minimal.

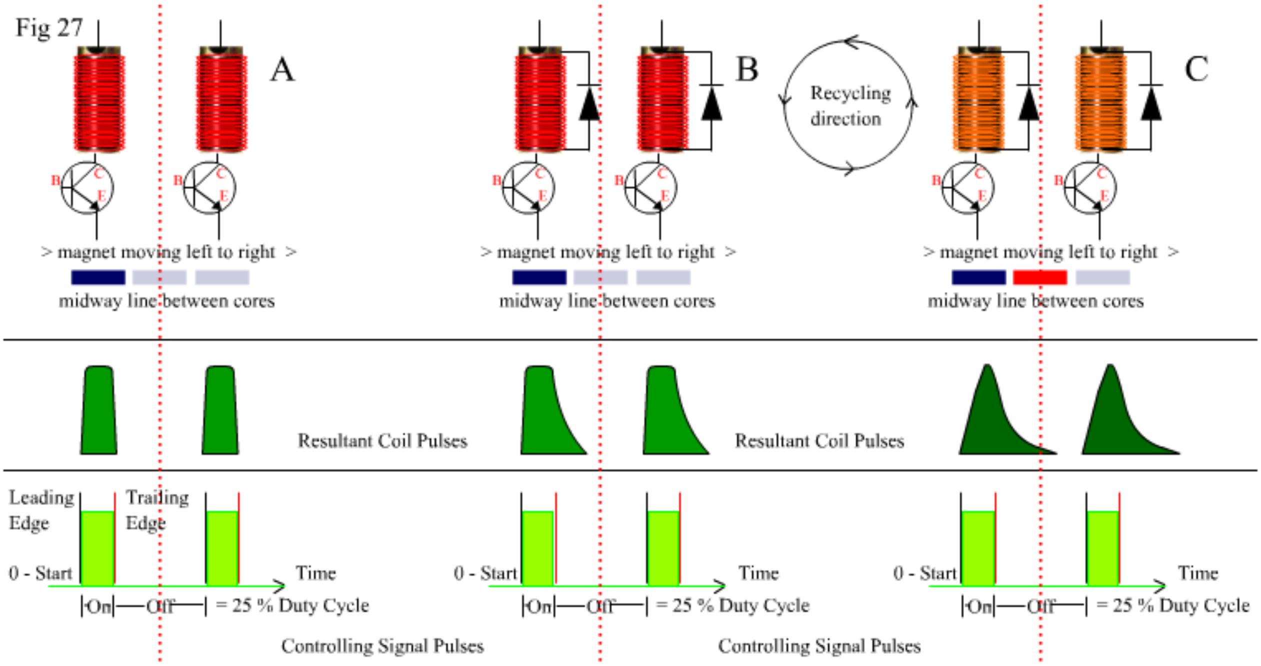
The actual design of the switch is classic KISS, and works perfectly for tuning or varying the dwell angle and duty cycle to any one desired. The Designs B and C replicate this design, but are simply made from opaque PVC sheet about 2-4 mm thick. Instead of using copper contacts on the same side of the disk, the contacts are subsituted with a sender (LED) and a receiver (photo sensitive:- transistor or diode or resistor). The sender is placed on one side of the disk while the receiver is placed on the other side. In this way, as the disk spins with the rotor, the disk will block the light (photon) path of the send / receive pair, or allow the light path through the slots or triangles which are cut into the disk. Disk B mimics Adams disk completely, except that it is imposible to overshoot the duty cycle above 50 %. Disk C works just as effectively, though its controllable duty cycle cannot go as low as A or B (in the dimensions shown). It is just much easier to make than A or B, and provided the slots are not too wide or too long you will achieve a desirable duty cycle range from approx 10% to

50%. To allow lower duty cycles make the slots narrower, to allow higher duty cycles make them longer (or wider, or both). Remember anything above 50% is counterproductive.

You can see that by moving the contacts up or down towards the centre of the disks or to the outer edge, you will vary the ratio of "on" time versus "off" time. That is, you will control the duty cycle. By changing the placement of the contacts around the circumference of the disk, you will change the dwell angle. This type of design gives very precise control over both switching parameters and is recommended for experimenters who want or require flexibility for both parameters. The advantage of using Optical Switching over mechanical switching is there are no sparks and no physical fatigue on the control sensors. The opto-switching method offers a more precise and flexible control over switching parameters easily. A Hall IC is not as precise, and although you can vary dwell angle easily, you can not increase duty cycle easily, or lower duty cycle precisely!

In Fig 27 below we look at duty cycle and how it is affected by "Time Constants". Hopefully you read some of the material regarding "Time Constants" that I provided links to at the bottom of page 7 and are a little bit familiar now with the concept. See below Fig 27 for an explanation of the circuit differences.

Fig 27



In Fig 27 above there are 3 groups of 2 coils, A, B and C. The distance between the middle of these sets of two coils represents the Total Pulse Cycle. From the first pulse to the next pulse, etc.. Between these two coils is the mid way point of travel of the rotor magnet/s moving according to the pulse.

Group A represents two **"low impedance"** coils which are used in drive mode only. There is no re-circulating path for the CEMF via a diode, so there is no recycling of current. Looking at Fig 27 you will see that at the bottom of each group, there is a light green square current pulse labeled "Controlling Signal Pulses". This is the desired shape of your signal to the base / gate of your drive transistor / mosfet. Notice how above them is a series of pulse shapes labeled "Resultant Coil

Pulses". These are the current pulse shapes actually formed in the coils according to the actual "Time Constants" of the circuit. They are the "Virtual Duty Cycle" of the motor.

Regarding Resultant Coil Pulses.

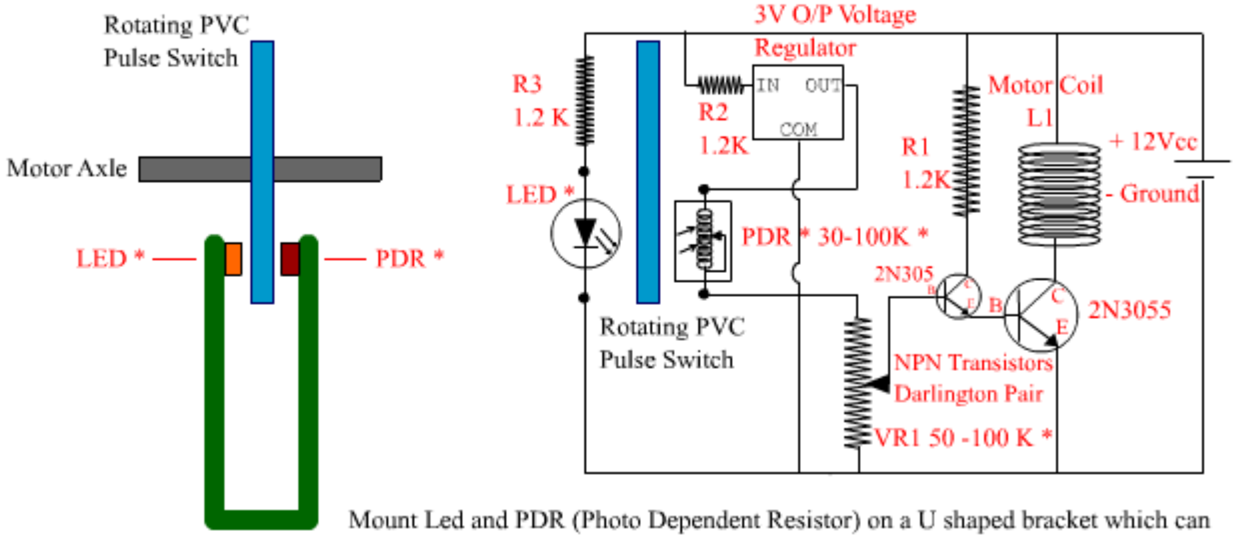
First and foremost, an Inductor Hates Current Change. It takes, what is known as a "rise time" before attaining its maximum voltage and current. In Group A you see that the square wave has been distorted on the leading edge, and is of equal distortion on the trailing edge. It no longer looks as square as the signal pulse, but its still roughly square. When the pulse in the coil collapses, there is no regenerative current circuit available, so the magnetic field collapses readily, taking the same time it took to attain maximum. In the mean time the magnet has been propelled to the midway point and is ready to be attracted on to the next core.

In Group B the same **"low impedance"** coils have a diode across them, so when the signal pulse is off, the CEMP in the drive coil/s creates CEMF which flows via the diode/s in a circulatory path back through the drive inductor/s. The leading edge of the pulse in Group B is the same shape as Group A but the trailing edge of the current is extended in time because of the recirculating current. Think of the coil/s and diode/s together forming a unidirectional resonant "ringing bell which takes a while to subside". By the time the magnet reaches the middle passover point, however, the "ringing" current has subsided and the cores are no longer active, and the magnet is now in attraction mode to the next core.

In Group C the coils are **"high impedance"**. They are made with larger cores, and have many more turns, giving them much *higher inductance and resistance*. The resultant drive pulse shape is nothing like the signal shape. It takes almost the entire length of the signal pulse for the drive voltage and current in the inductor to reach maximum. Then with the collapsing edge of the signal pulse, the drive current recirculation via the diode causes the magnetic field to collapse VERY slowly. If the time it takes is too long, then the core will still be inducing a repeling force on the magnet as it passes the middle crossover point. You can see in Group C that the red magnet is ready to move forward into what should be an attraction zone, but the core it should be moving toward would still be partially active and will be in repelling mode. This will cause torque and energy loss.

In Group C you can see why the ability to precisely control the length of the signal pulses is important. Especially when utilizing the recirculating current. Even more so when using high impendance coils. The circuitry that allows a recirculating current, also creates a "Time Constant" which is dependant on the Resistive and Inductive values of the coils themselves, and / or loads, which are in series with the regenerative loop thats produced. This "Time Constant" has a dynamic feedback effect on the actual duty cycle, producing instead a "Resultant Virtual Duty Cycle". As always, theres "No Punch without Judy"!. But with careful design, you can exploit this extended pulse time, as long as your resultant duty cycle pulse is no more than 50 % of the real total cycle. See Fig 28 below for a simplified layout of a photo-controlled switching circuit.

Fig 28 Simple Optical-Switching Circuit

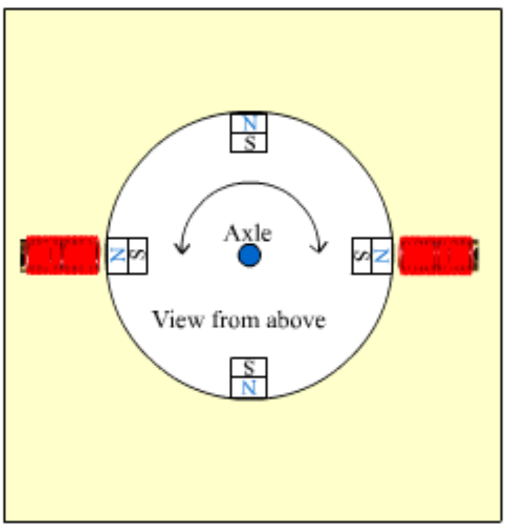


Mount Led and PDR (Photo Dependent Resistor) on a U shaped bracket which can be moved along the full length of the radius of the PVC disk, for duty cycle control.

In Fig 28 above, the pulsing signal is produced by a PVC disk with slots cut into it, rotating between a LED (Light Emiting Diode) and a Photo Dependent Resistor. When the LED shines through the slot of the PVC disk, the resistance of the Photo Dependent Resistor changes from 100 k-ohm to around 30 k-ohms. This will raise the bias voltage to the Darlington Pair of Transistors, and they will turn on and deliver current to the motor coil. Note the inclusion of a 3 V Voltage regulator to keep the signal supply voltage steady at all times. Variable resistor VR1 is included to give fine tuning to the bias of the Darlington Pair to ensure that the Darlington Pair turn off completely when they need to. The actual maximum value of VR1 is to some degree, dependent on the maximum and minimum resistances of the PDR.

Now we'll briefly discuss rotor design. See Fig 29 below.

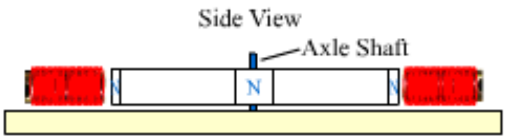
Fig 29



Rotor Design
Radial Layout

The magnets are placed on the the rotor with either North or South Poles facing outwards from the rotor perimeter.

Only one pole of each magnet is visible when looked upon from the side view below.

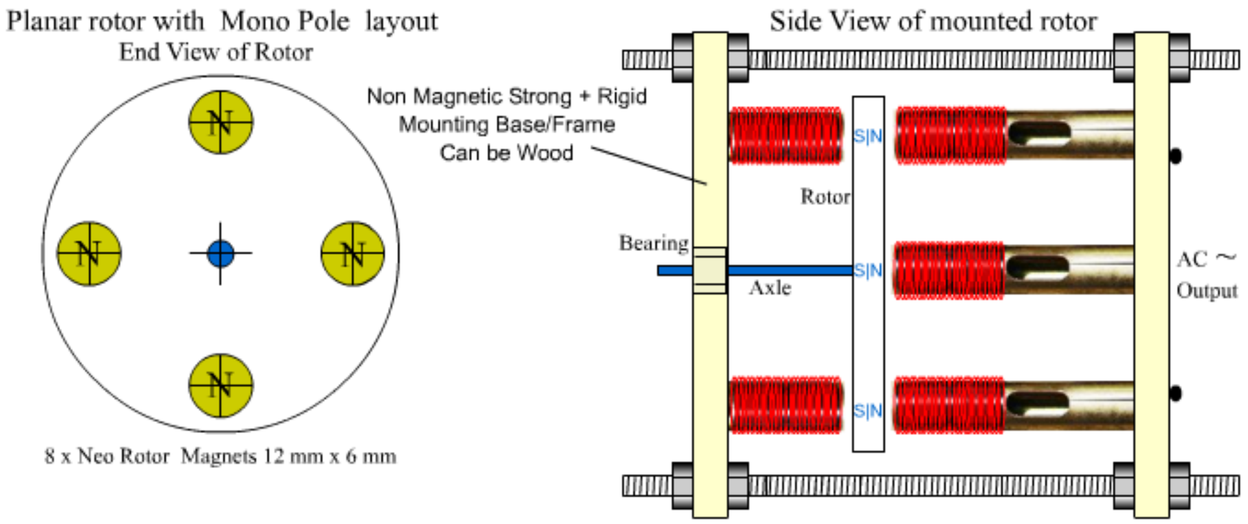


The coils are mounted around the circumference of the rotor perimeter facing the rotor magnets.

Fig 29 above shows a very simple beginners layout for an Adams motor. Its a typical Radial Design. It's a good design to start with as you learn the basics of operation. But it has a number of limitations, and can pose safety problems. In the above diagram, if the supply was 24-48 Volts, and the drive coils were low impedance coils (1-2 ohms), then the rotor would easily reach speeds between 5,000 to 10,000 RPM. At these speeds, the centrifigal force on the magnets can be so great, that there is a great risk of the magnets flying off the rotor if they are not bound to the rotor very well. **The magnets can be very dangerous if they fly off, and will easily cause serious injury.**

Other limitations include: limited number of coils you can place around the rotor whilst trying to keep the whole motor within respectable size limits, and only having access to one side of the magnet. In Fig 30 below we look at a Planar Design. See below for explanation.

Fig 30



The magnets are embedded into the rotor extending from one face of the rotor to the other. Both North & South Poles will be facing outwards from the face of the rotor. None of the magnets are visible from the rotor side view.

The coils are mounted in line with the face/s of the rotor and magnets, and can be mounted on either side of the rotor, as shown above.

Fig 30 above shows the rotor layout in a different manner. It shows the magnets inserted into the face of the rotor instead of the circumference or outer edge of the rotor. The magnet length and rotor thickness should be matched, to minimize wind drag and maximize safety. The rotor can be made from plastics, resins, or wood or even aluminium (O.K. but not recommended). High temperature epoxy resin, or a thermo-hardening plastic is best if you're confident with moulding it, and lathing it smooth afterwoods. The magnets are inset from the edge of the rotor, thus providing the magnet with a solid barrier of outer rotor material, preventing it from flying off when the rotor is spinning at high speeds.

It is a slightly more difficult design to set-up, often requiring two bearings instead of just one, and two (or more) mounting plates, but it is much safer when designing high powered, high speed rotors. It also has the advantage of allowing access to both sides of the magnets, which can increase greatly the total number of coil configurations used for a particular setup.

It is also easy to have multiple rotor disks on the same axle shaft, with 2 disks interacting with single drive cores between them. Why not 3 or 4 rotor disks? It's entirely up to you and how powerful a machine you want to build.

Note * Adjustment of the distance between the magnets and the cores in a planar design can be a little more difficult than in a radial design, but can be facilitated using 4 long threaded non-magnetic stainless steel or brass rods and nuts as adjustable frame guides. Soft Iron or Galvanised threaded rods will do, but will affect the rotor by proximity to it, because they are magnetically reactive metals. Same applies to your axle. Use something non-magnetic if possible. For most experiments, it will NOT BE CRITICAL to the success or failure of the experiment..

In Fig 31 on the following page, is presented a very simple experiment you can do to "Bend Lenz's Law" using an "open magnetic system" alternator (which you build yourself) driven by a conventional closed magnetic system DC motor.(which you dont need to build yourself!) (LOL).

I hope this general information and that on preceding pages has been of some help to you, the experimenter, and has not left you more confused than enlightened! This is the last page dealing with Adams Pulsed Motors…….. Happy motoring pulsars, I hope you discover what you think you're looking for. Keep Experimenting!

Page 10 : An Experiment in Bending "Lenz's Law"

This is a simple and straighforward experiment, but because of the high torque and speeds involved, YOU will have to build an alternator And for YOUR safety, YOUR rotor, bearings, framework and axle should be made as precisely and well balanced as possible. The materials you choose to make your rotor and frame should be solid and sturdy, and heat resistant. **All care should be taken to centre align the drive motor and alternator shafts. All safety precautions should be exercised, before running the combination motor driver and alternator as shown in Fig 31 below.** At the end of the page is a Printable Template of the frames and rotor which is scaled (true size) for use in this experiment. You will need to source 3 identical 12 Volt DC Permanent Magnet or DC Shunt Wound Motor/s. Whew! sounds hard – easy really. they're common as snails! You can get away with a minimum of 2 DC motors, but with three DC motors, the experiment is set up more easily, and offers comparisons of differing reactions in real time.

Fig 31

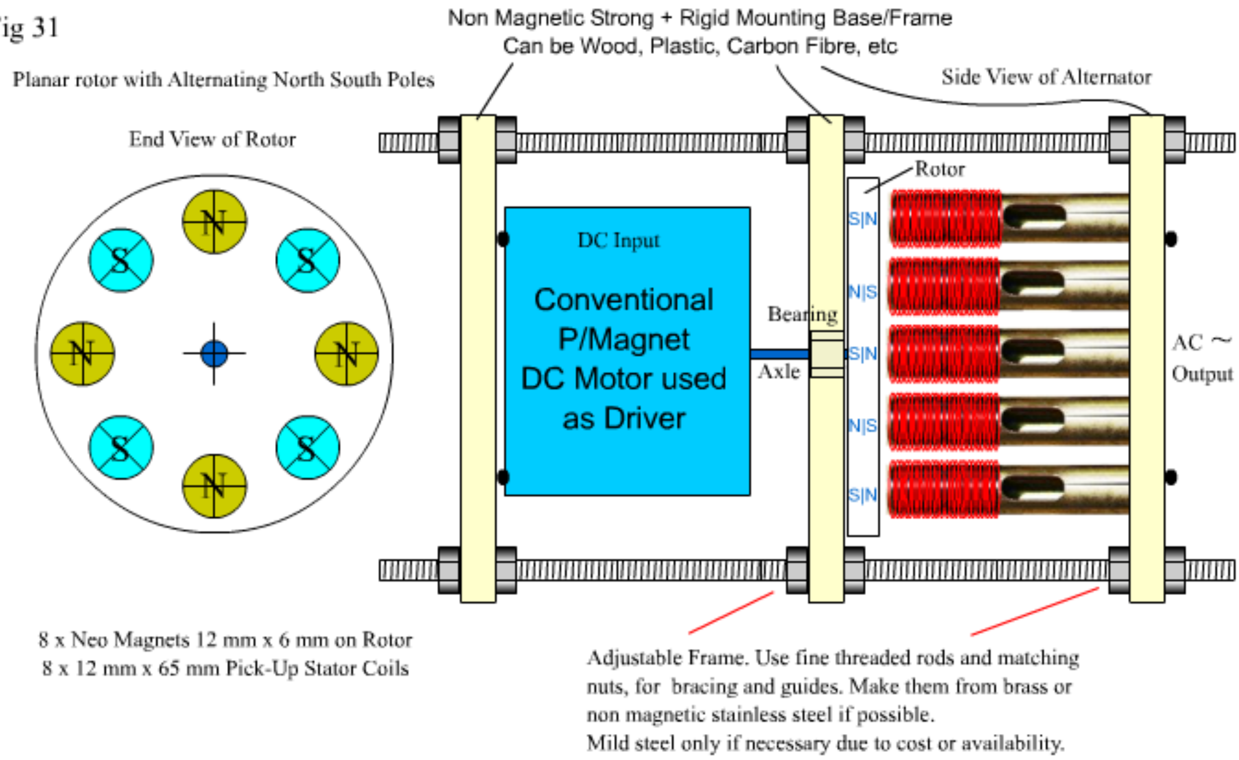
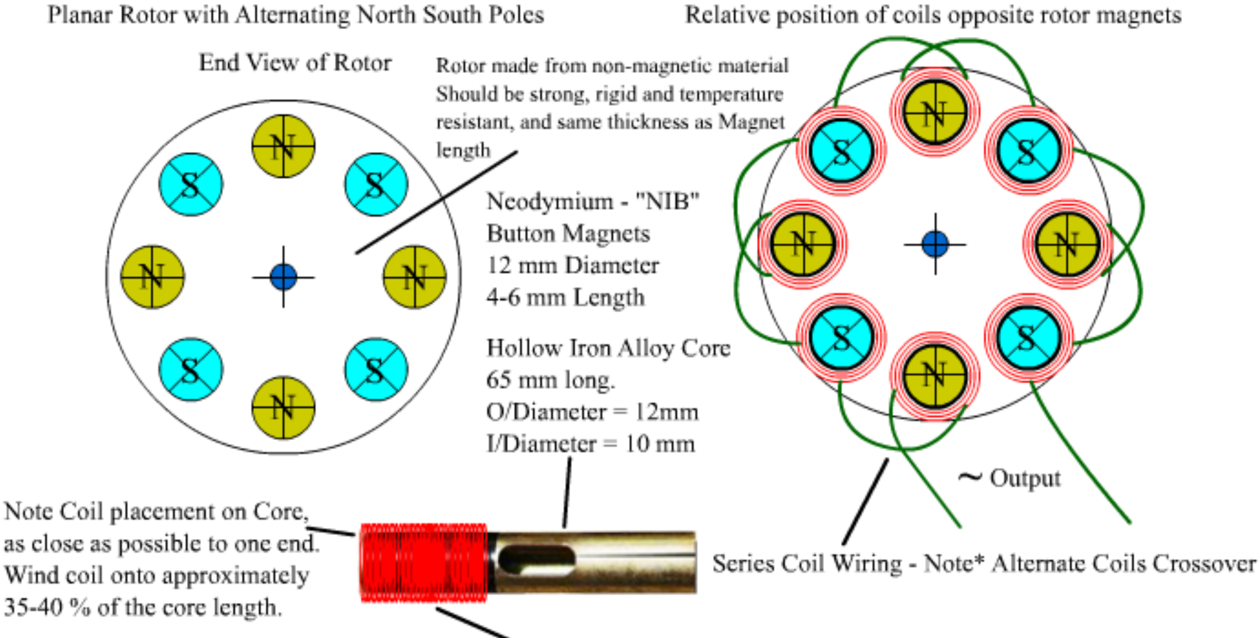


Fig 31 Above shows a planar rotor open magnetic systen alternator with 8 hollow cores (not all cores are shown), each core wound with 80-100 turns of 0.63 mm transformer wire. They are low impedance coils. The alternator is driven by an ordinary 12 Volts DC High Torque Permanent Magnet or DC Shunt Wound Motor. The perfect sizes and power ranges of the DC motor for this experiment are commonly found in good quality 12 Volt Cordless Power Drills. They are not very large, but they "pack a lot of throttle"! Common sizes range from 25-40 mm in diameter and 45-60 mm long. They can endure short periods of high current up to 10 amps, and will run nominally on 3 -4 Amps under a moderate load for a reasonable time. They are perfect for this experiment because it shouldn't take that long! The motors are cheap, easy to source, high speed and powerful for their size.

Not only are their torque characteristics good, but, because they are DC and Shielded, any "peculiar effects" noticed in your experiment will*not be falsely attributed* to any *"Pulsing Current" or "Pulsing Voltage".* Not-withstanding any voltage peaks introduced, if the brushes of the DC motor are exremely worn, and you are using Digital Meters. Other than that, the current supply will be straight, clean DC Especially if you use a 12Volt Battery for your supply. With no "Adams Motor" or other pulsing mechanism in sight, **You will prove in this experiment that Lenz's Law can be "bent" by ordinary AC with any "open magnetic system", and this "bending" does not rely on pulsing currents or pulsing voltage in any way.**

Fig 32 below shows how the alternator coils should be wired. Note that 4 coils have the wires crossed over and 4 do not. This is an alternator and the coils must be equal to and sychronous with the alternating rotor magnet poles. This is an ordinary AC coil arrangement!

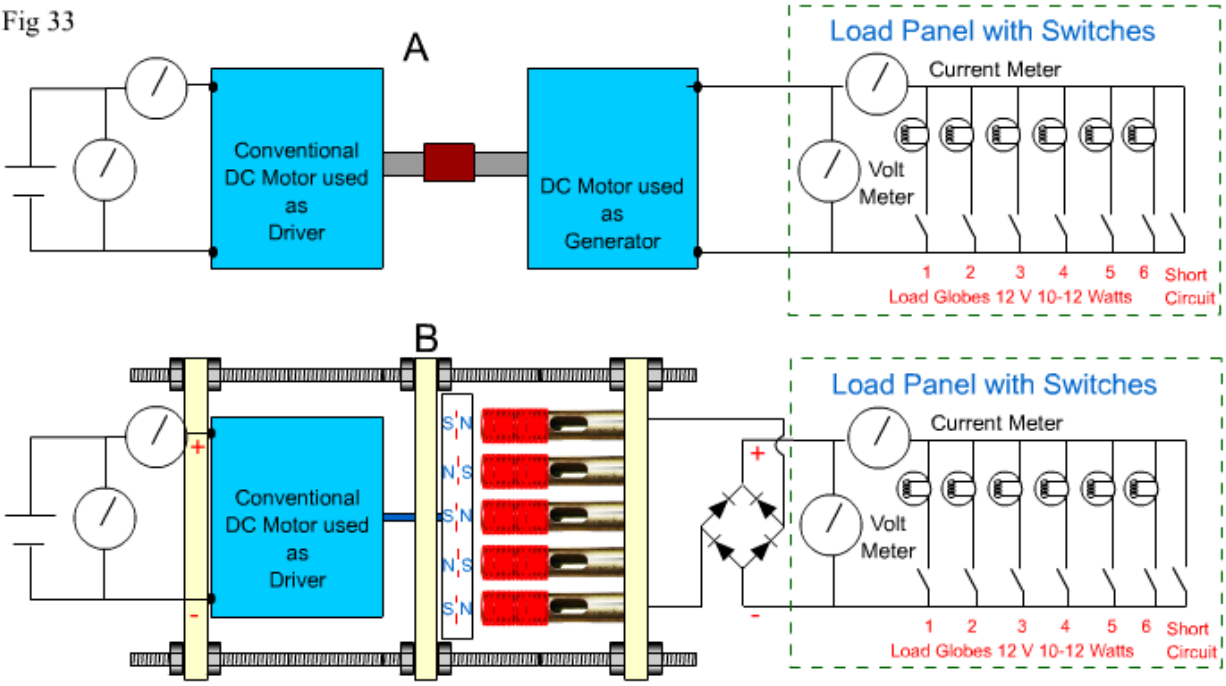
Fig 32



Remember the experiment on page 8 Figs 24 and 25? comparing a DC generator output with the Rectified output of the Adams Pick-up coils. We compared the differences in the "breaking effect" of an open and closed magnetic system. And if things went right for you, you noticed a "strange effect" with the open magnetic system. This following experiment is meant to exaggerate that effect, so that it is undeniable and unmistakable. The key factors here are torque and speed. And hence"frequency"!

Well here's the experiment again, with Fig 33 Below, except there is now an ordinary motor, driving the open magnetic system alternator. The alternator is a "true" alternator with an alternating North and South pole rotor, and alternately connected pick-up coils. The Resistor Load Panel has been replaced with an Incandescent Globe Panel. The Globe Panel does exactly the same thing as the Resistor Panel, but looks more Spectacular! (LOL)! Each globe has a measurable DC resistance of approximately 12 ohms. So thats 12 V / 12 Ohms = 1 amp per globe. Max globe power at 12 V = 12 V x 1 amp = 12 watts. Typical Automobile Globes from anywhere.You can use either sort of Load Panel as the result will be the same in both cases.

Fig 33



In the experiment on page 8 was Fig 24 with a subsequent explanation. It's repeated below, with edits, with the reference now relating to Group A in Fig 33 above:

" when motor A is connected to the supply, it turns motor B by common coupling at the shafts of each motor. Motor B is generating a Voltage produced by the Torque from Motor A, so we'll refer to Motor B as the Generator. The output Voltage from the Generator will not be quite as high as the input voltage to Motor A because of transference losses. All load switches are open and there is no load on the generator, so both the motor and generator will turn readily together at a high speed.

But as soon as you close the switch to R1/Globe1, the generator circuit will provide current to the resistor, and this will cause a breaking effect due to Lenz's Law. This will cause the motor to slow down a bit because it has to work harder to maintain RPM against the oppositon created by the generator. Now switch on R2, then R3, R4, R5, R6, until you switch on the short circuit at the end of the generator output line. Each time you switch on another Resistor/Globe, the breaking effect due to Lenz's Law will increase with increased current (shown by the current meter). At short circuit, the breaking effect within the generator will become so great that it will cause Motor A to stall and start "smoking" if you leave it connected too long! . As the breaking effect takes place you will see the supply current increase dramatically with each increase in load, as Motor A works harder to achieve continued rotation."

Then on Page 8 was Fig 25 with a subsequent explanation. It's repeated below, with edits, with the reference now relating to Group B in Fig 33 above:

"the pick-up coils are connected via a full wave bridge to the Load Panel for both measurement purposes and to compare like with like. The experiment with the two DC motors produces DC output because the DC motor coils are connected via commutator switches. So we'll rectify and make the alternator output DC as well. Now repeat the previous experiment. Be aware you are not trying to create a true comparison between the DC motors and your alternator per se, but a comparison in the way Lenz's Law affects or doesn't affect them. Turn on the supply to your alternators DC drive motor, let the whole assembly reach top speed, then start switching the load Resistors/Globes on, one by one, from R1/Globe1 to the Short Circuit.

To repeat what **should** be : "According to Lenz's Law, you **should** perceive a slowing of the rotor because the current induced into the coils opposes the movement of the rotor."

What actually happens ?????. If your alternator is operating within the "realm of disbelief", as it likely will (LOL), you will notice something very strange!!.

You may notice the following:

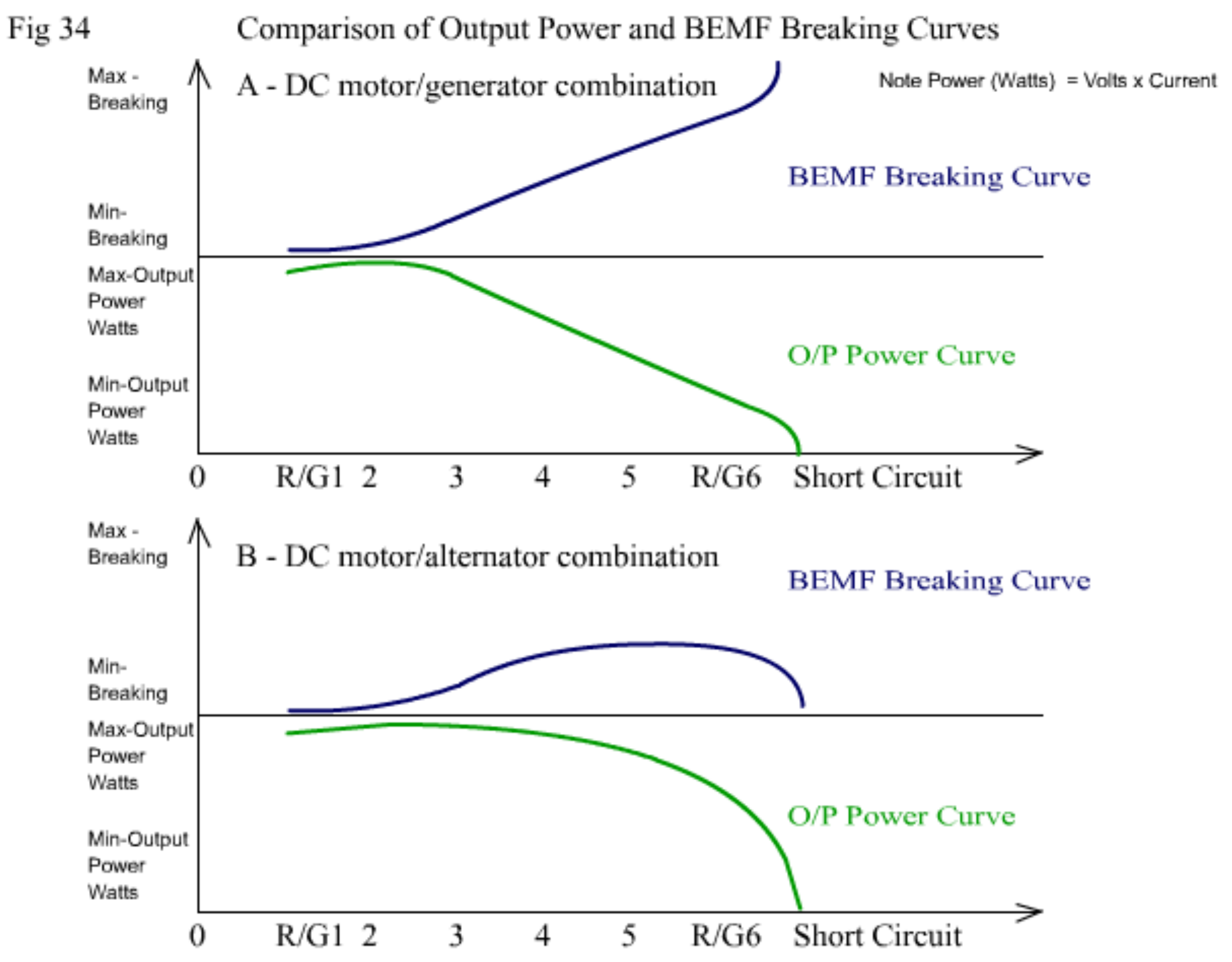
___**********______________________________***********_______________________________**********__________________

When R1/Globe1 was turned on, the motor slowed a little bit, When R2/Globe2 was turned on the motor may have slowed a little bit again, but not as much when R1/G1 was turned on. But **when you turned R3/Globe3 on, there appeared to be no change in motor speed at all. You continue and find that when you turned R4/G4 the motor *seemed to speed up again*. Same with 5 and 6. It's almost at the speed when you started. Then to your greatest surprise, you turn the short circuit on, and the motor goes to *full speed* as if there were no load at all.**

___**********______________________________***********_______________________________**********__________________

Now this is what I have personally observed in countless experiments and numerous different open magnetic alternating systems. **Replicate it Please !!!!"** "

See Fig 34 below and the explanation of the benefit of this "bending" effect.



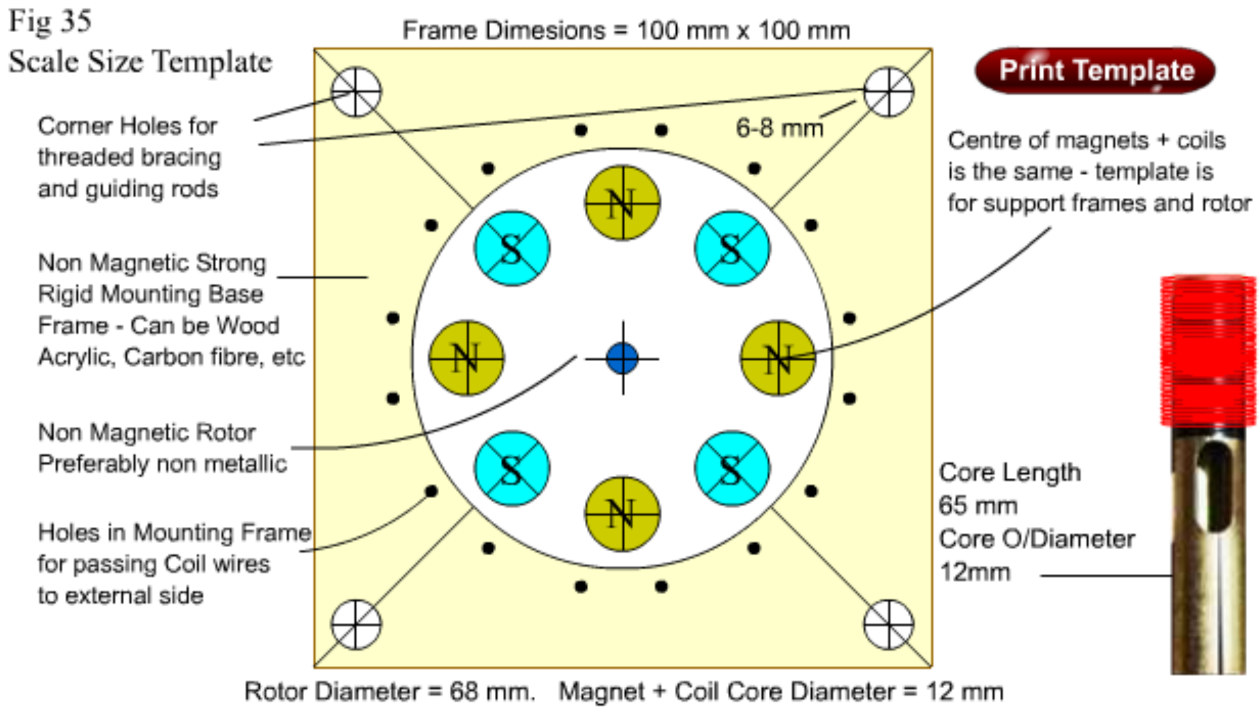
The ramifications of the effect produced in this experiment are not obvious at first, until you do the experiment and **take actual input and output voltages and current readings**. The load panels are designed to give you an indication of **true DC power** output, because it is necessary to measure current through a load and the voltage across that same load at the same time. P = E x I.

By taking current and voltage measurements of both the driving motor, and the generator/alternator outputs, **you can plot an input and output power curve for both Groups A and B.** *When you see the power curves,* you'll notice that **the alternator maintains a higher usable electrical power output for a much greater load demand.** And it produces minimal breaking effect when short circuited to the extent that, it acts like an open circuit.

If you do an Input Power Curve for each group you will see that the Input Power Curve for Group A will rise almost linearly like its BEMF does in Fig 34 A. But you'll notice for Group B that the Input Power Curve will look like the BEMF curve in Fig 34 B. It will rise at first, then it will curve back down – almost to the level it started before any load was placed on the coils!!! So, with short circuited output, you will be using no more power than open circuit output. With Group A, a short circuit is catastrophic. With Group B, it's a minor nuisance.

Because there is almost zero "breaking effect" at short circuit, there is minimal drag on the driver motor, and it will maintain a higher RPM than if it were under slight load !!

Below is a Printable Scaled Template for use in drilling, aligning etc, if you wish to make your own alternator based on the one shown above.



The 64 million dollar question, is, Why and how does this effect occur?? See Page 11 for an explanation

I have given you all the little pointers you need to exaggerate and see this effect for yourself, and know that Adams really did discover something useful and have something to offer, even if it wasn't really what he thought it was.

But hey, a really easy to make alternator, that outstrips conventional induction means of generation whilst using less iron and copper is something special isn't it ? Sure can help to save a lot of money all round. Wind generators would really benefit from this type of generating system. Now"bend" those power and bemf curves – yeh!

Happy experimenting to all !

Page 11 : A simple explanation for an apparent accelerative anomaly !

Or "why acceleration occurs when a passive generating output coil in an open magnetic system is short circuited or placed under a higher than nominal load".

This explanation is drawn from conventional electronics and focuses on the impedance characteristics of a coil wound on a ferromagnetic core. The driving motor in this explanation can be any sort of electrical motor. Passive generator output coils in an *open magnetic system* is the main topic of this explanatory review.

First, here's a list of simplified descriptions of events as they normally occur within a permanent magnet electrical alternator/generator system, where the magnets are moving with the rotor and the generator output coils are stationery.

1. A motor (of any kind) turns the generator rotor. The rotor has permanent magnets embedded within it.
2. The magnets of the generator rotor move past the passive generator pick-up coils, and as they do, they create a varying magnetic pressure upon the cores/coils.
3. This varying magnetic pressure results in a varying voltage in the coils. (It also results in eddy currents in the core – but I'm going to ignore them for this explanation)
4. If there is a load on the generating coil, current will begin to flow.
5. This coil current will, in turn, create its own magnetic field in the core.
6. The magnetic polarity of the core field will now act in opposition to the varying magnetic field of the passing magnets.
7. This opposition will cause a breaking effect, the magnitude of which is related to the amount of coil current and hence the induced magnetic field strength of the core.

It seems pretty straightforward, but the current in the loaded coil which produces the magnetic field of the core in opposition to the motion of the magnets, does not arise instantaneously. There will be a time lag which is dependant on the impedance and reluctance of the coil/core. To understand the following explanation, it is necessary to view the moving magnets as the actual AC power supply, and to treat the generating coil as an inductive load which, when coupled to an external resistive load, is in series with that external resistive load. It is also necessary to understand how the current in the inductor reacts to changes in the resistive load, because the coil current is responsible for the counter mmf (oppositional magnetic field), which is normally associated with the breaking effect of the generator load, in accordance with Lenz's law as it applies to generating systems.

An inductive coil has a constant resistance to a given DC voltage (provided excessive current is not creating high temperatures).
It also exhibits an inductive reactance (impedance), which arises in response to connection to a Pulsed DC or AC power signal.
Furthermore, it also exhibits some capacitance due to the accumulated inter-winding capacity between each full turn of a coil winding, and therefore, it also posseses a small amount of capacitive reactance.

Capacitive reactance in a coil is opposite in vector and response to inductive reactance. As frequencies rise (rotor speed increase), capacitive reactance decreases, while inductive reactance increases. Capacitive reactance and inductive reactance cancel each other due to vector opposition. But the value of capacitance and therefore capacitive reactance (Xc) is usually negligable compared to the value of inductance and it's XL in a coil with a ferromagnetic core. Consequently, the coil will still exhibit an overall inductance and inductive reactance (XL), after the vector sum of XL and Xc have cancelled out.

The amount of inductive and capacitive reactance (impedance) is determined by the frequency of the AC or pulsed DC and is not constant.
E.G., the impedance Z of a coil at 500 hz will be roughly twice the impedance Z than at 250 hz, yet the dc resistance will be the same.

The actual total impedance of a coil (Z) is the square root of the sum of the resistance (R) squared plus the (inductive reactance (XL) minus the capacitive reactance) squared. The actual total impedance of a circuit that comprises a coil in series with an external resistive load and or external inductors and capacitors in series, is determined by the same formula. The total resistance of a series Coil, resistor and capacitor circuit comprises the internal resistance of the coil plus the external resistance/s of the load.

Here are some links to a good site, explaining impedance Z in an AC or pulsed DC circuit.

http://hyperphysics.phy-astr.gsu.edu/Hbase/electric/imped.html#c1

http://hyperphysics.phy-astr.gsu.edu/Hbase/electric/impcom.html#c1

1. Regarding the reluctance characteristics of a ferromagnetic core*:

When a generating coil is connected to a load, there is a magnetic field produced around the wire that forms the coil (which is wound on a ferromagnetic core), and changes to this magnetic field are in phase with the current in the wire. But the reluctance of the ferromagnetic core causes changes to it's own magnetic flux to lag the changes in current produced by the coil, and also to lag the changing magnetic field of any passing moving rotor magnet. If flux induced into an inductive ferromagnetic core instantly reached the levels dictated by the current and/or passing magnet, and then instantly demagnitised when current ceases, and then instantly reached opposite polarity flux levels dictated by current in the opposite direction, then there would be no such thing as a hysterisis loop or BH curve/s. We would have perfect inductors. But ferromagnetic materials do not instantly change their magnetic flux in direct relationship with either current changes or inducing magnetic field changes, instead, they always lag behind to a degree which is determined by the reluctance / permeability characteristics of the core.

Now combine the natural ferromagnetic core lag characteristics with the total Z impedance characteristics of the coil/core combination, and together, there is an ample amount of already accepted electrical theory to account for the acceleration as being a result of negating both the core drag and the coil induced counter mmf.

2. Regarding the coil's Z impedance and it's relationship with induced <u>current phase</u> and counter mmf*, see the phasor diagrams at the site linked below:

http://hyperphysics.phy-astr.gsu.edu/Hbase/electric/phase.html

The voltage (electromotive potential- emp) in the coils is produced by the changing magnetic field strength from the passing magnets (magneto motive force – mmf) of the rotor, and will manifest as current (electromotive force – emf) in the coils, when there is a load connected. This load forms part of the impedance (Z) triangle of RLZ in the phasor diagrams shown at the site link above. When you increase the load (lower the resistance) the phase angle increases.

Counter mmf (counter magneto motive force) is produced by the current (emf) in the coil, and it also arises out of phase with the coil current that is producing it. Conventionally speaking, counter mmf is said to be 180 degrees out of phase with the inducing mmf and is therefore oppositional to the inducing mmf. In reality no inductor is perfect, and the phase is more likely to be between 170 – 179 degrees out of phase depending on the inductors characteristics. Bear in mind, that in a perfect inductor this phase opposition is theoretically a 180 degrees polarity vector difference, but a zero degree difference with respect to time. The time phase is where all the changes occur in this acceleration anomoly!

When there is an incrementally increasing load placed on the coil, the phase angle of the coil current (time lag) increases as the resistance of the load decreases towards S/C. The resulting counter mmf phase angle of the core (time lag) also then changes with respect to the original inducing mmf of the passing magnets. As the counter mmf approaches 90 degrees out of phase (time lag) with the inducing MMF it also approaches physical vector neutrality and thus zero opposition. Since The counter mmf is a product of both the current phase in the coil and the degree of magnetic phase lag due to reluctance of the core material, then the opposition normally produced by the coil current and core drag are nullified together. At short circuit, with maximum current and counter mmf phase angle change, the coil/core appear to magnetically "disappear" with respect to the rotor, and so the rotor accelerates.

Because the motor / drive coils experience less opposition, due to less magnetic drag being placed upon the rotor by the generator coils, it accelerates, resulting in an increased motor back emf and motor coil impedance.

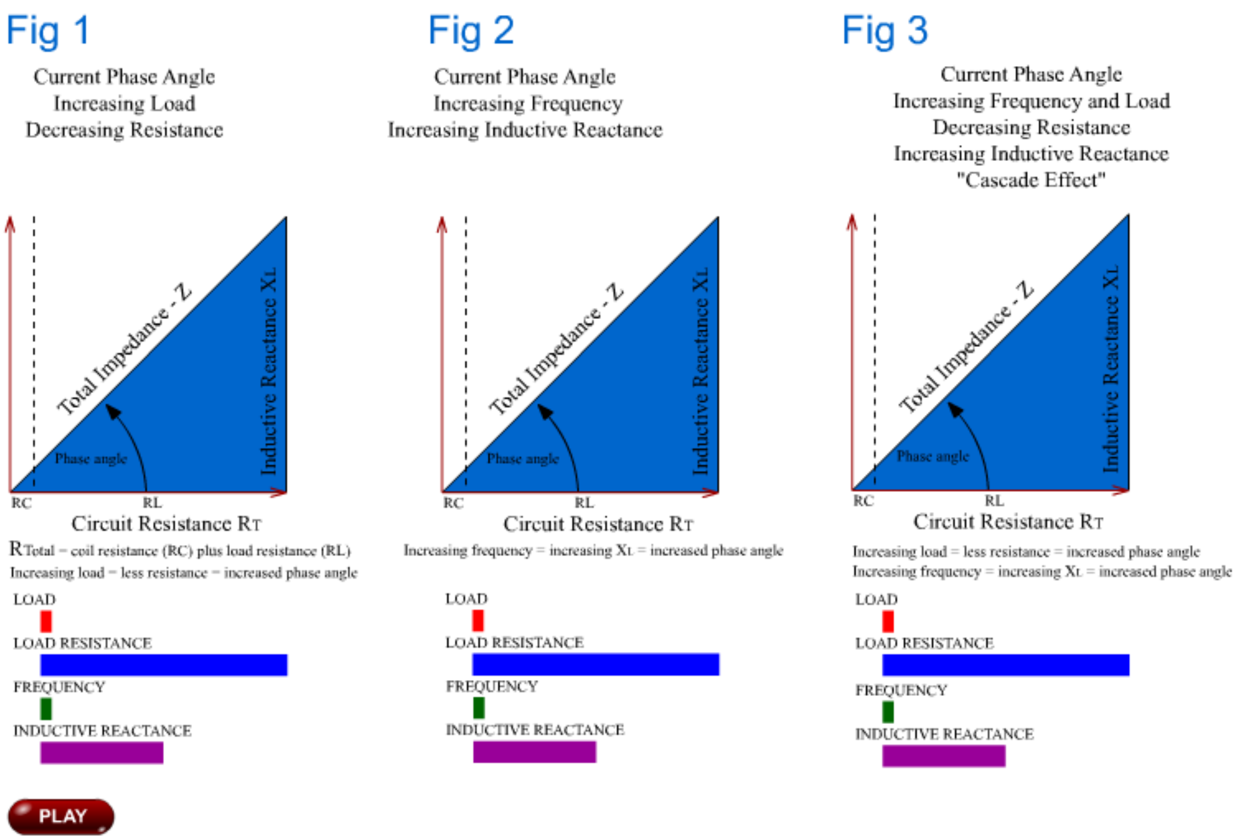
The increase in motor back emf and motor drive coil impedance results in a decreased current input from the supply, and a lower motor power consumption.

The (motor) rotor speed, combined with the number of magnets on the rotor, determines coil current frequency, and plays a very important initial role, because the inductive reactance (XL) of the generating coil increases with frequency. As a consequence, the current phase angle will be greater for a higher frequency coil output than a lower frequency coil output, into the same given load. The acceleration effect will occur at a lower rotor rpm when using high impedance pick up coils than the rpm required when using low impedance pick up coils.

Because the coils I showed on page 10 of my article are very low impedance coils, then a high rotor speed is required for the acceleration effect to occur. I indicated that high speed was desirable for that particular set of coils, but didn't explain why. I chose low impedance coils for the experiment shown because the majority of working generators that are in use, such as car alternators, are low impedance generators, with low voltage but high current output capability. (I was trying as near as possible to compare apples with apples.)

Below is an animation of inductor current phase changes occurring due to 1. Varying load. 2. Varying increased frequency and 3. Varying both load and frequency.

Note that because capacitive reactance is usually negligible, for the sake of ease, (mine) it is not included in the simplified visual representation below.



In my experiments with incremental loads placed on the output of the coils, the amount of acceleration increased non linearly with the load change. This actually makes sense to me, (within the context of this whole explanation) because as the load increases, it forces the current toward a critical phase angle, (where the drag and counter mmf are significantly diminished with respect to the rotor), the rotor (motor) begins to spin faster with less drag to oppose it, which in turn increases the power output frequency, which in turn increases the current phase angle. This cascading effect contributes to the rotor acceleration at each interval of increased load beyond the critical loading/frequency point, until maximum phase change occurs. (Theoretically, a 90 degree max phase angle at short circuit). Fig 3 above shows the cascading effect when both load and frequency are increased.

Put simply, IMHO, the acceleration effect is the result of negating oppositional forces associated with the generator core/current, and not the addition of extra energy into the system. This negation occurs due to a phase shift in the coil current and core counter-mmf, as a result of increasing frequency and /or higher than nominal output loads up to and including a short circuit.

Now I ask myself – why don't conventional closed system generators act like this, and accelerate under higher than nominal loading or short circuit? Can they be made to act in the same manner.? After all, even with Lenz's law applying, the coils of a conventional generator are bound by the same set of other accepted electrical rules which govern the Z impedance characteristics of an inductive power supply connected to a load.! And if they can't be made to have the same characteristics- then why not ?

Is it really a useful anomoly anyway, or just a curious thorn in the side of conventional wisdom.??

Hmmmmm! Another can of worms maybe….. I just love worms!……. Hoptoad

Page 12 – Dealing with Rotor Induced Counter (Back) EMF – Update/March/2012

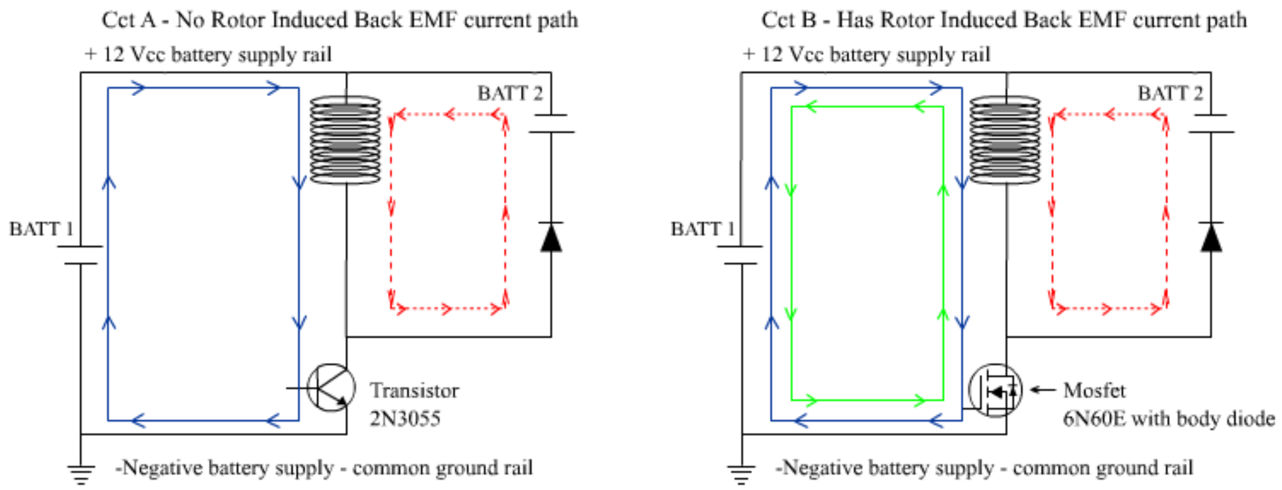
Recently, as I was going through some storage boxes, I came upon an old rotor and some air coil assemblies which had been destined for the junk heap years ago, but which somehow managed to escape their appointed fate. The rotor is bent and the magnets are poorly positioned, making the rotor severely out of balance. The rotor is made from a hardened aluminium alloy, and has 8 small (10mm diameter by 6mm deep) neodymium magnets embedded in a NSNS arrangement. The shaft bearings are badly worn, and the magnets are not really the optimum shape or size for use with the pancake air coils that the motor assembly uses. The hall sensor is hard glued to the assembly preventing adjustment of duty cycle (which is approximately 40%) and timing angle, but in spite of all these motor failings, it has performed well enough for the following presented experiments. First, some revision to put the experiments on this and following pages into context.

On page 1- I wrote : – " the fast rotating magnets that sweep past the coil, also induce an ElectroMotive Force back into the coil which is in the opposite direction to the incoming supply current. This opposing direction of EMF is what is known as Back EMF and happens in all conventional motors regardless of motor type. "

On page 2, I wrote the following: – "First I need to explain some things about Back EMP (BEMP) and Back Emf (BEMF). BEMP is Back Electromotive Potential while BEMF is Back Electromotive Force. What's the difference? Force is a measure of mass x acceleration. This implies that a movement of mass is an integral part of Force. In an electric circuit, this movement of mass is "current". Whilst there is a lot of debate about whether electrons actually move, or whether their electron "charge" is the only movement in the form of charge energy transfer from atom to atom, the notion of movement is still paramount to the formula of calculating force. For simplicity sake, we will assume that there is movement of some sort and leave it at that. So when we talk about BEMF, it is implied that there is a movement of charge which arises in opposition to the Forward EMF (FEMF supply current). BEMP is Back Electromotive Potential. In order for any BEMF to occur, there must be a BEMP, but the reverse is not always true. I will discuss Collapsing EMP (CEMP) and Collapsing EMF (CEMF) later on in following pages."

Below is a block diagram of two pulsed circuits. There are three possible types of EMF current flow that can manifest in a pulsed DC circuit. Clearly there is a major difference in the two circuits, even though they are used for the same function. The transistor circuit only shows Supply Forward EMF and Collapsing Field EMF (Flyback) because the transistor blocks any current flow (BEMF) from the opposite direction to the supply. But the Mosfet circuit, due to its conducting reverse body diode, provides a current path for Rotor Induced BEMF. This Rotor Induced BEMF is ever present in normal continuous DC motor circuits.

Page 12 - Fig1

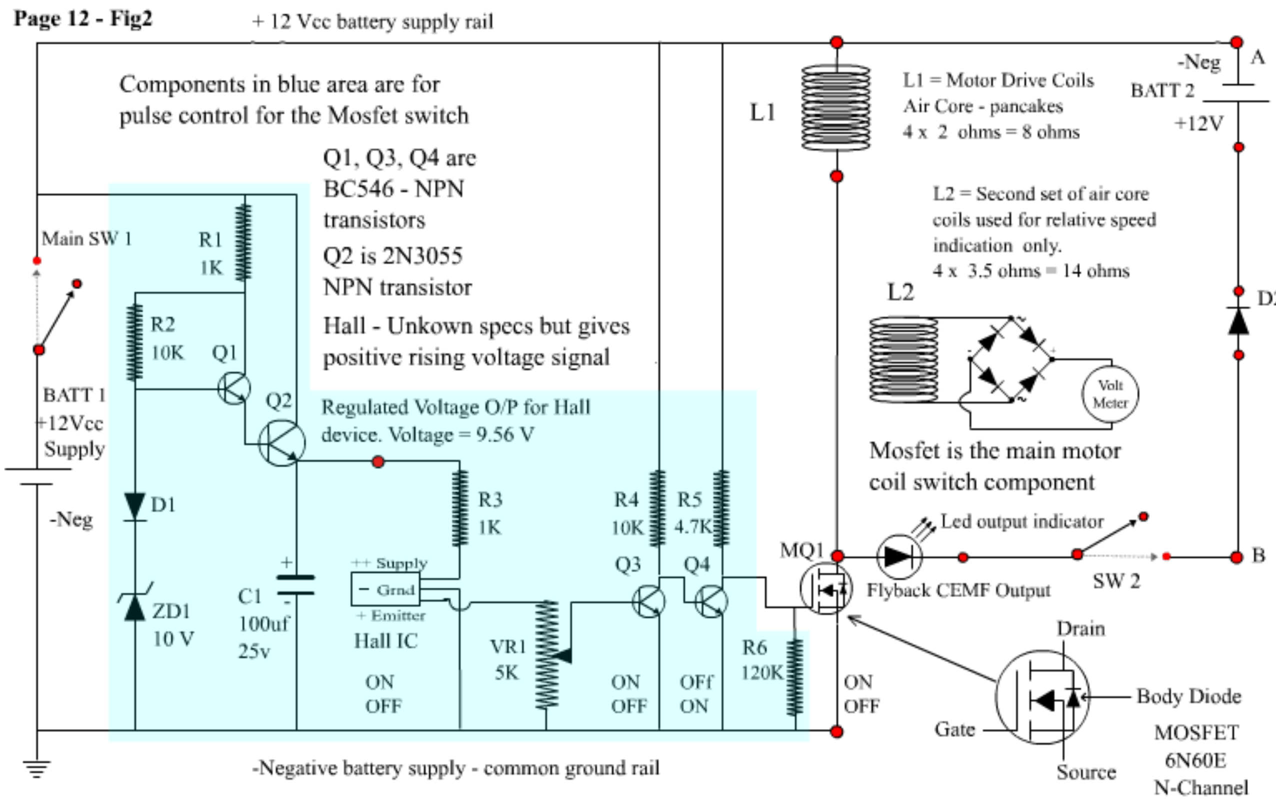


Blue Line Arrows = Forward Supply EMF current path. During on time of pulse. (EMF)
Red Line Arrows = Flyback C(ollapsing) EMF current path. During off time of pulse (CEMF)
Green Line Arrows = Rotor Induced Counter B(ack) EMF current path. Continuous path. (BEMF)

So what's the issue here ?. Is Rotor Induced BEMF in a DC motor a good or bad thing? Lets explore the idea.

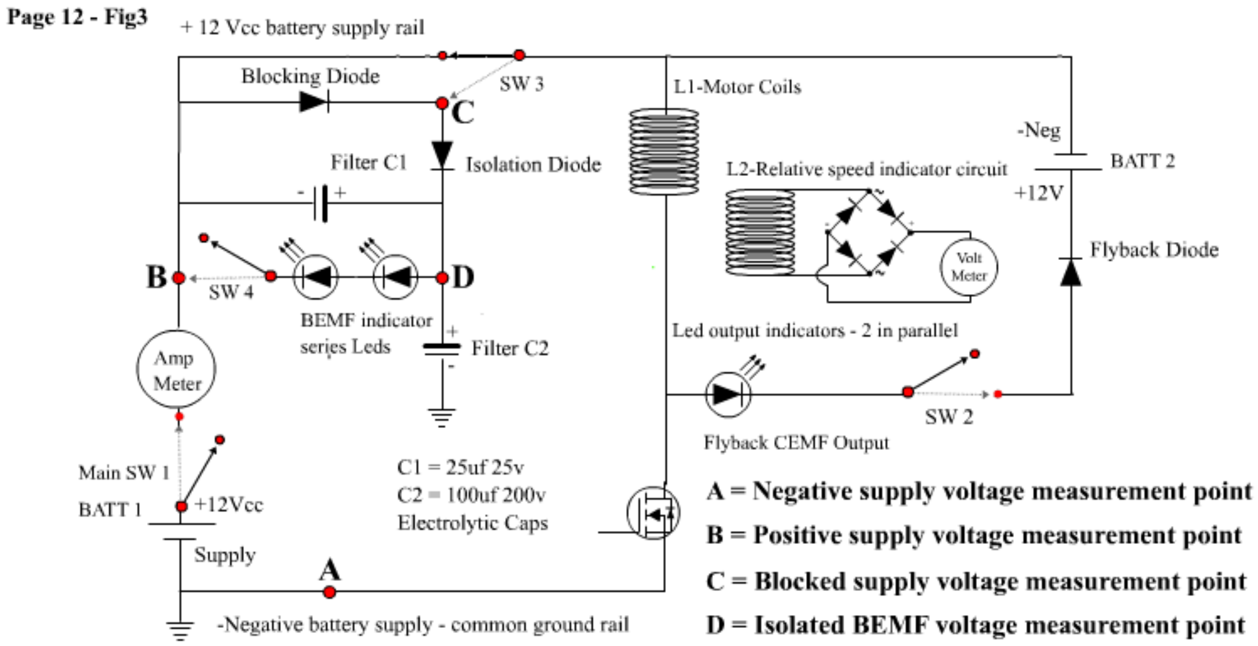
When I first started to learn about electric motors as an apprentice technician, the subject of BEMF with respect to continuous supply motors was presented. I remember my instructor saying that just because it (BEMF) is a force that emerges in opposite direction to the supply, doesn't necessarily mean its a negative thing. He explained that as the speed of a motor increases to working speed, the BEMF voltage arises in proportion to the motor speed and serves to limit the forward current by reducing the potential difference between the opposing voltages. At full running speed the two opposite electrical forces result in minimal forward current. Surely, that's a good thing ?. If you had to provide a constant high current to maintain your speed, electric motors would be very uneconomical. He also explained that the voltage of the back emf (rotor induced), never attains the same potential as that of the supply, which is why there always remains a certain amount of forward current to maintain speed. In fact, he explained that if the bemf voltage did equal that of the supply, the motor would begin to stall because there would no longer be any forward current to maintain rotation. He also informed us (his students) that the bemf cannot be stopped or diverted. We were guided through the various diagrams and explanations in our textbooks, and I believed him and the textbooks. It all seemed very logical and staightforward to me. So I filed that information into the "assumptions" folder in my head. That was a big mistake. I recently realized that this assumption may be erroneous with pulsed motors and it was time to investigate. The rest of this page is a presentation of circuits, data and information which challenges my filed away assumptions about back emf.

What's presented here is probably only news to me! (and possibly some of you readers) LOL. For all I know, the information I've gleaned may have been common knowledge amongst EE professionals for decades. Below is the basic simple starting circuit I used for my first bemf experiment, showing all the main circuit components. It is a Mosfet switching circuit controlled by a Hall sensor connected to a fixed regulated voltage supply and intermediate fine tuning transistor "flip flop"output stage to the Mosfet. A LED is connected in the flyback circuit to give a visual indication of flyback current flow when the flyback circuit is engaged by operating SW2. It's not necessary, as the power diode D2 already serves it's main function, the LED is just convenient for visual confirmation.

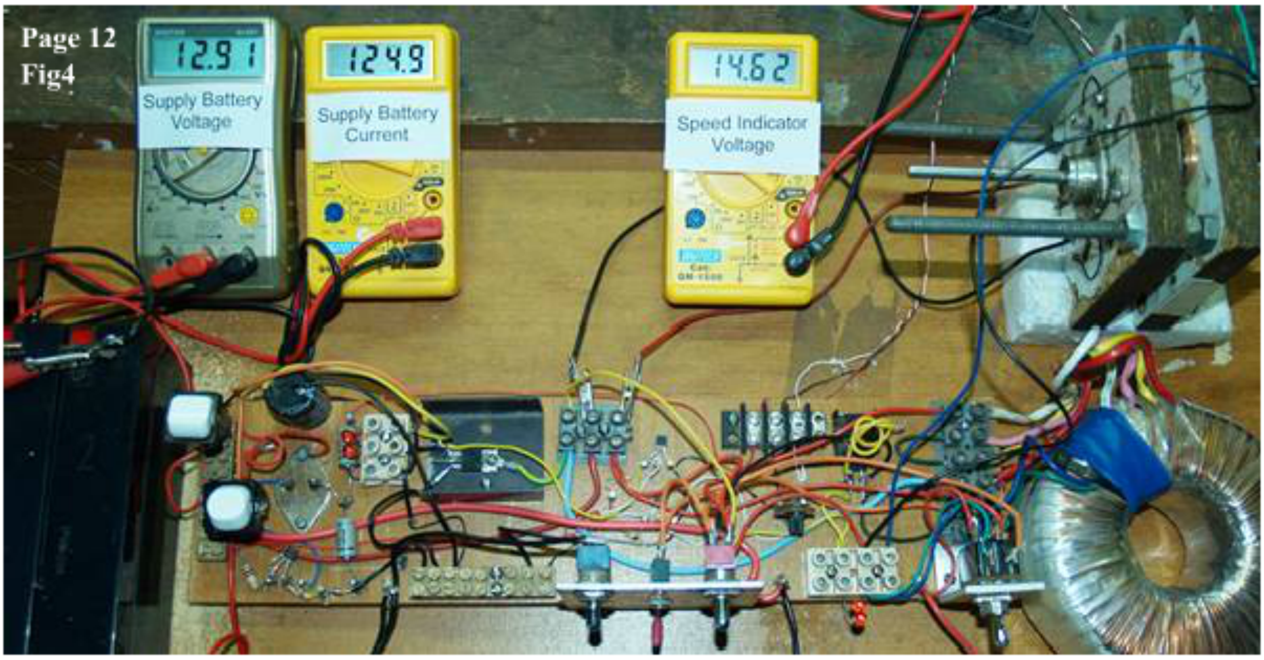


Circuit shows relative "on / off " states of controlling Hall IC and Transistors/Mosfets from left to right
Sw 1 and Sw 2 are shown as normally off.

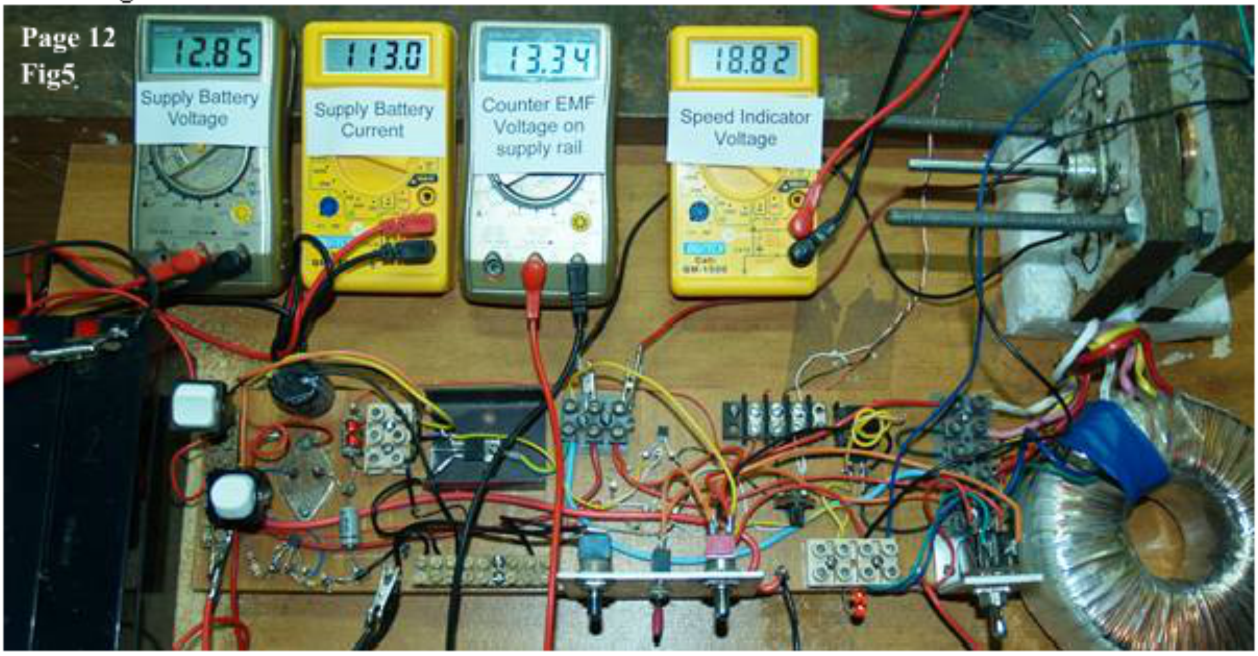
Below is a block diagram of the same circuit showing the introduction of a BEMF blocking diode, an isolating diode and some capacitors serving as a voltage ripple filter. This enables a more accurate BEMF voltage reading and redirection of the BEMF current (if there is any) through some series connected LEDS to the supply battery positive. Again, the LEDS are just for visual convenience to help show what's happening in the circuit. If the BEMF voltage never rises to a higher potential than the forward supply voltage then the blocking diode and all the other added components would prove to be of no use, requirement or benefit, and would also probably help to prove nothing at all in the experiments I've performed. LOL. Because I don't have a tachometer to measure rotor rpm, I have set up another 4 x series connected air coils on the opposite side of the motor, and have connected the output of these to a voltmeter via a full wave bridge. This at least gives me a visual relative rotor speed indicator, though I don't know the actual rpm of the rotor.



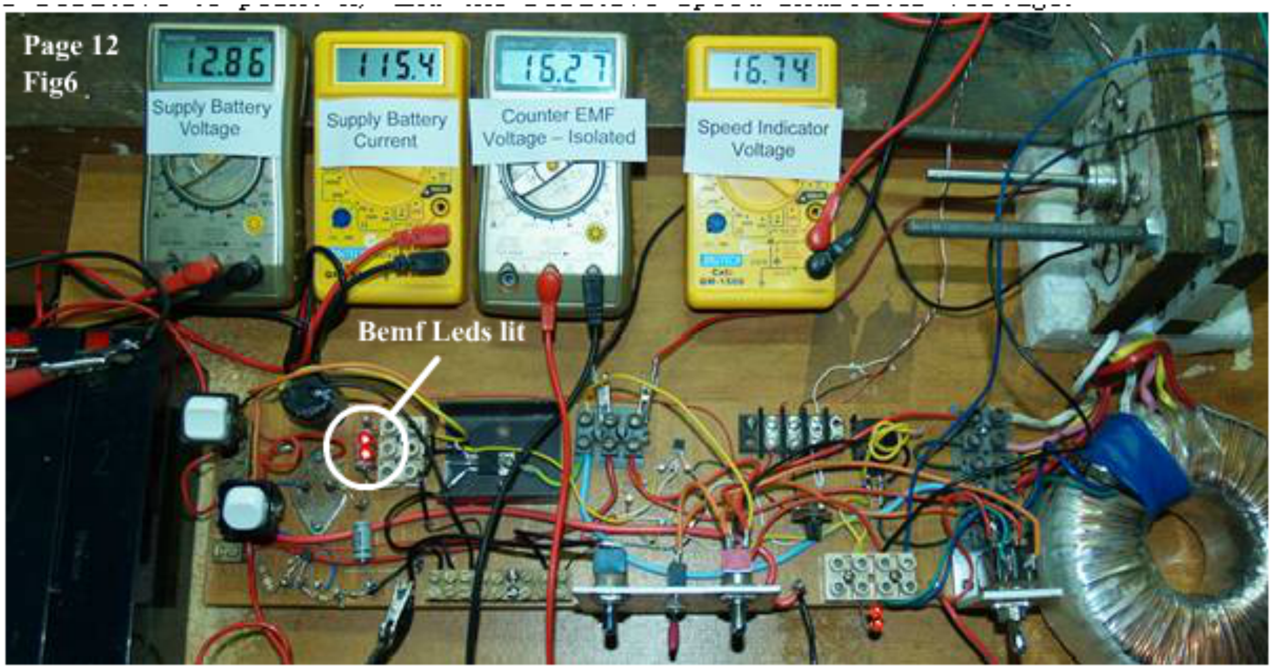
Below is a photo of my test rig. It is set up to allow for a number of different experiments. This photo below shows the basic device circuit running with only the main switch SW1 operated. There is no attempt to collect or divert the CEMF, and there is no blocking diode or other components in use to change the BEMF. The meters show the supply voltage, the supply current (in milliamps) and the relative speed voltage.



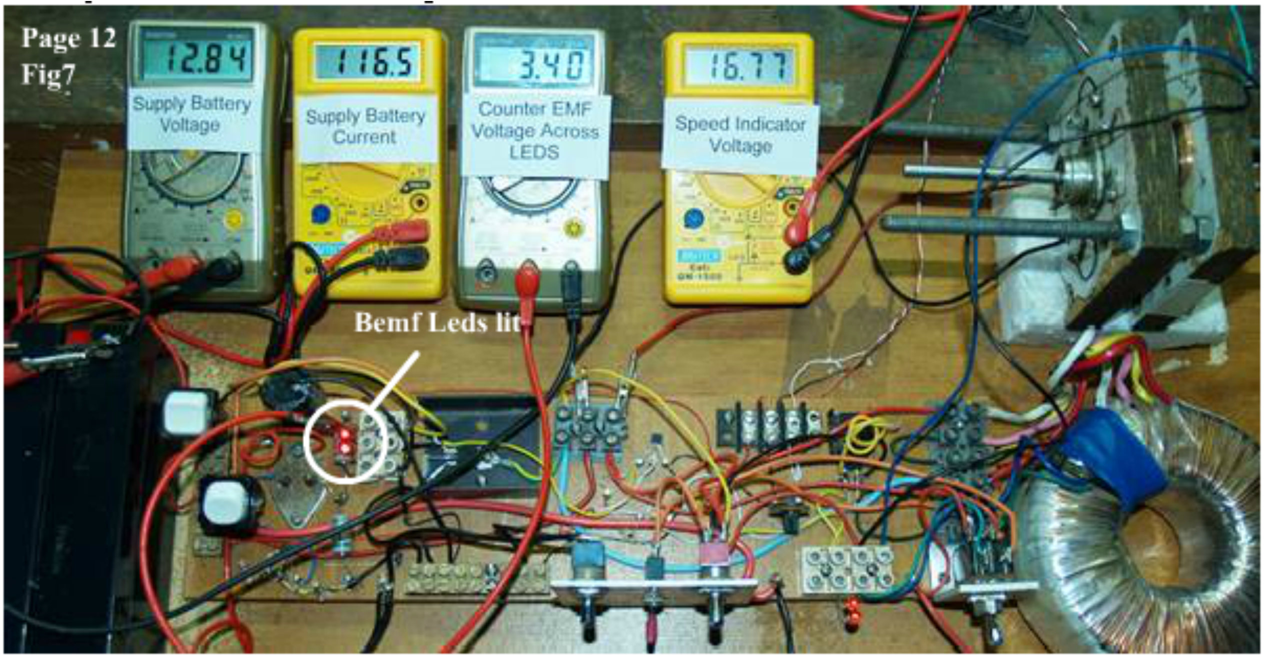
This photo shows the main switch SW1 operated and also SW3 operated, which puts the blocking diode in series with the supply rail. There is no attempt to collect or divert the CEMF, and the back emf is blocked only. There is no attempt to redirect or collect the bemf. The meters show the supply voltage (point B relative to point A), the supply current (in milliamps), the blocked supply rail voltage (point C relative to point A) and the relative speed indicator voltage.



This photo shows the main switch SW1 operated and also SW3 operated, which puts the blocking diode in series with the supply rail. It also shows SW4 operated which connects the Leds from the BEMF voltage to the positive of the supply. Note the Leds are lit. There is no attempt to collect or divert the CEMF. The meters show the supply voltage (point B relative to point A), the supply current (in milliamps), the isolated BEMF (Counter emf) voltage (point D relative to point A) and the relative speed indicator voltage.



This photo also shows the main switch SW1, SW3 and SW4 operated. There is no attempt to collect or divert the CEMF. The meters show the supply voltage (point B relative to point A), the supply current (in milliamps), the isolated BEMF (Counter emf) voltage across the Leds (point D relative to point B) and the relative speed indicator voltage.



In the photos above, note that Fig5,Fig6 and Fig7 show a reduction in current consumption and an increased rotor speed compared to Fig4 which has no blocking diode in the circuit. Fig5 in particular, which has only the blocking diode in circuit, shows the greatest current reduction and the highest speed increase. Also please note that the difference in the supply voltage in Fig4 compared to the Figs5,6,and 7 is largely due to the battery losing some surface charge after running for a few minutes, before settling into its running voltage.

So far, that's two of my "assumptions" discarded, with respect to pulsed motors. BEMF voltage can and does rise beyond the supply voltage. In doing so, however, "with this particular motor", it is counter productive to torque and efficiency. However, it can easily be blocked. If I had used switching Transistors, it would already be blocked, but by using switching Mosfets (with a body diode), it is not be blocked. If the bemf is blocked with a diode, it can be diverted, as shown by the lighted Leds in series with the battery return path.

In this pulsed system BEMF is not required as a supply current limiter, because the increased initial current from the supply in the absence of bemf, is offset by the increased speed that the motor attains. The current is then is limited by the increased inductive reactance of the coils due to higher frequency (rpm – speed). This can be observed on the meters, when the motor is already running without the blocking diode, then the blocking diode is switched into circuit. There is an initial increase in supply current as soon as the switch is operated, then the motor responds by increasing it's rpm (higher running torque), while the current reduces (higher effiency) to a level lower than previously, without the blocking diode.

Inversely, however, as soon as I switched the bemf LEDS into the circuit, this allowed some of the bemf current to flow to the battery. That initially resulted in a slight decrease of current, but was followed by a slight decrease in rpm (counter productive to torque), and then a slight increase in supply current (lower efficiency) above the previous level, as the motor speed decreased. The meter readings as shown in the table below reveal that even a small amount of bemf current into the battery such as that through the Leds, can result in a lowering of motor efficiency.

Table1	**Blocking diode**	**Bemf LEDS**	**SupplyVoltage**	**Supply Current – ma**	**BEMF Voltage**	**Speed Indicator Voltage**
Fig4	No	No	12.91	124.9	Not readable	14.62 * Lowest motor torque /efficiency
Fig5	Yes	No	12.85	113	13.34 on blocked unfiltered rail	18.82 * Highest motor torque/efficiency
Fig6	Yes	Yes	12.86	115.4	16.27 on isolated/ filtered rail	16.74
Fig7	Yes	Yes	12.84	116.5	3.40 across Leds	16.77

See Page13 for more information and additional experimental data.

The following experiment is intended to give visual confirmation that the BEMF and CEMF current paths take the routes shown on Page 12- Fig1, and are two separate forces that emerge independently, taking different paths in the circuit. In the photos presented below, one set of Leds (lower left) indicate the back emf path and one set (lower right) indicates the cemf path. In this experiment the bemf blocking diode is included in the circuit. The cemf path via the Led indicator also charges battery2 as can be seen on the load current and volt meters in Fig1-C

Fig1-A Shows only the motor running with a blocking diode in circuit. The meter readings in Fig1-A below provide a relative baseline for this experiment and also the next two experiments with respect to the rotor speed versus supply current. That is, the circuit efficiency in terms of motor running torque versus supply current. The bemf is diode blocked and there is no cemf external load on the circuit. Thus far this appears to be the most efficient configuration for this particular motor and circuit.

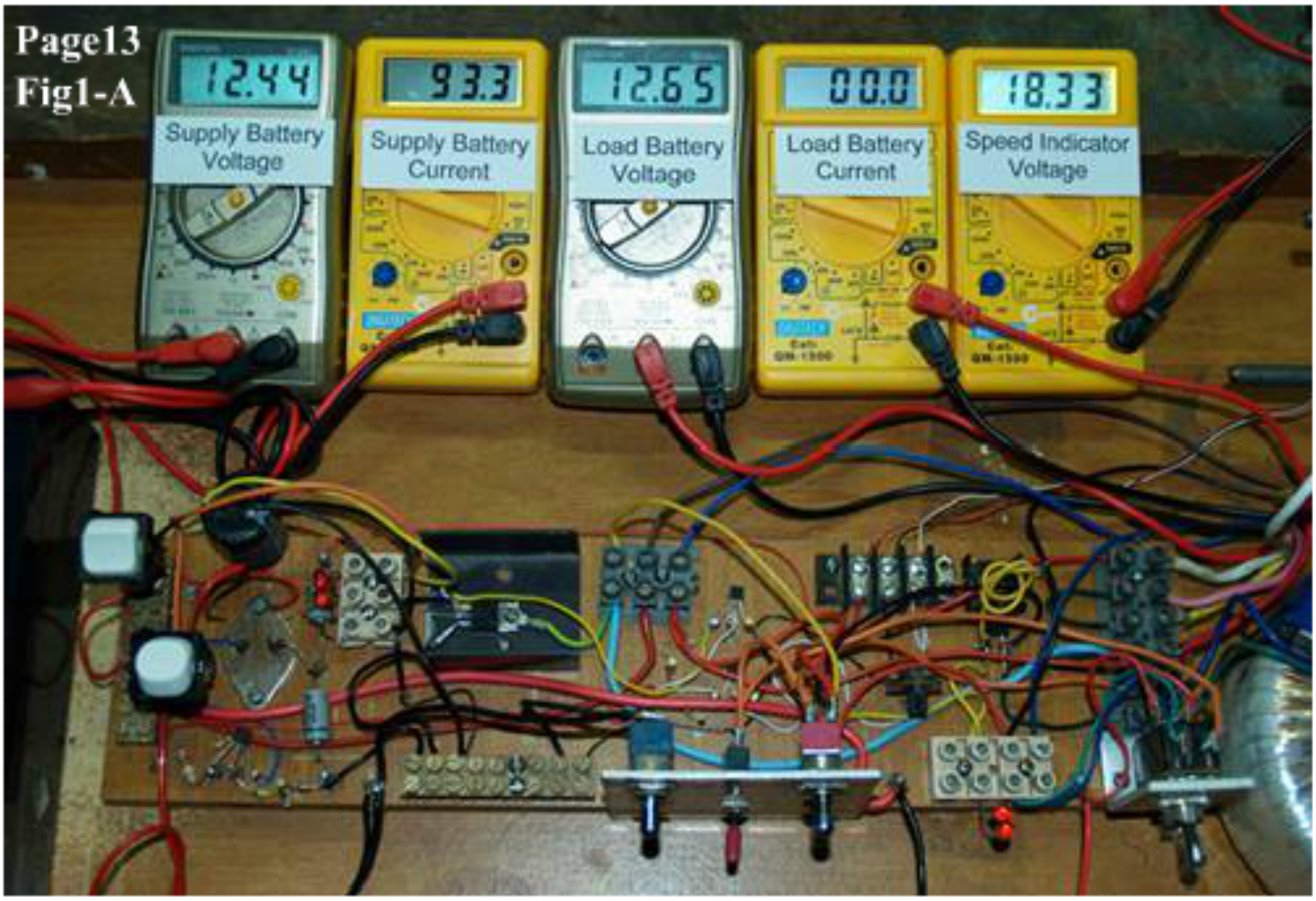


Fig1-B Shows the BEMF indicator Leds switched into circuit to show the bemf current flow. It also shows a loss of speed and increased supply current as a result.

Fig1-C Shows the CEMF (flyback) circuit switched on with CEMF indicator Leds and load battery meters showing current flow and increased battery2 voltage. It also shows a further loss of speed and increased supply current as a result.

In the above photos, the main purpose was to show that bemf and cemf can be diverted and used at the same time. One does not cancel out the other. However they can affect one another. In Fig1-C above, the BEMF Leds are not quite as bright as they are in Fig1-B, because the cemf output load caused the rotor speed to fall. The bemf voltage is proportional to rotor speed, so a reduced speed yields a reduced voltage. In the summary table1 below, it can be seen that direct harvesting of the CEMF via a diode across the coil, is counter productive to running torque/speed in this particular motor.

Table1	**Blocking diode**	**SupplyVoltage**	**Supply Current - ma**	**BEMF LEDS**	**Load Voltage**	**Load Current**	**CEMF Leds**	**Speed Indicator Voltage**
Fig1-A	Yes	12.44	93.3	Off	12.65	0	Off	18.33 * highest motor speed
Fig1-B	Yes	12.43	97.9	On	12.65	0.1 (meter flicker)	Off	16.29
Fig1-C	Yes	12.41	110.3	On	12.69	11.4	On	15.14

Judging from the experiments thus far, it would appear that the best thing to do with the bemf in this particular pulsed motor is simply to block it. But appearances like my assumptions are often misleading, and need challenging from time to time. A question I asked myself, "is this the best we can do with bemf – simply block it, or can it be manipulated to benefit like cemf". I showed on Page9 Fig27, the underlying principle of how harvesting cemf can be be either beneficial or counter productive to rotor speed depending on duty cycle, and coil impedance.

I asked myself a few other questions too, before embarking on these next two circuits and experiments, Questions, such as "Can I utilize or neutralise the bemf without just blocking it ? Can I make this motor go faster, on less current, in some other way. Can I make it go faster than when the bemf is blocked ? Can I make this existing motor circuit harvest cemf, charge a battery and produce a torque increase instead of torque reduction at the same time ? Just like a well tuned impedance/duty cycle cemf circuit combination will sometimes do. Even though I can't significantly change it's duty cycle? Sometimes I drive myself mad with all the questions. Get off my back Hoptoads LOL.

Of course, nothing is more satisfying than an answer to a question, even if it's not necessarily the answer you'd been hoping for. I've had plenty of results I hadn't hoped for ! LOL. In the next two experiments, there is a dramatic shift in circuit design, operation and motor response characteristics. In some aspects the circuit/s seem counter intuitive in their operation. The first of these experiments introduces a transformer into the circuit in a novel manner. It is a 300W continuous power rated toroid transformer, made for the Australian market, with a primary winding intended for 240v mains connection, and two 25V ac secondary output windings designed to give continuous 12A x 25V capability. The circuit in Fig2 below, shows the toroid transformer included in the circuit.

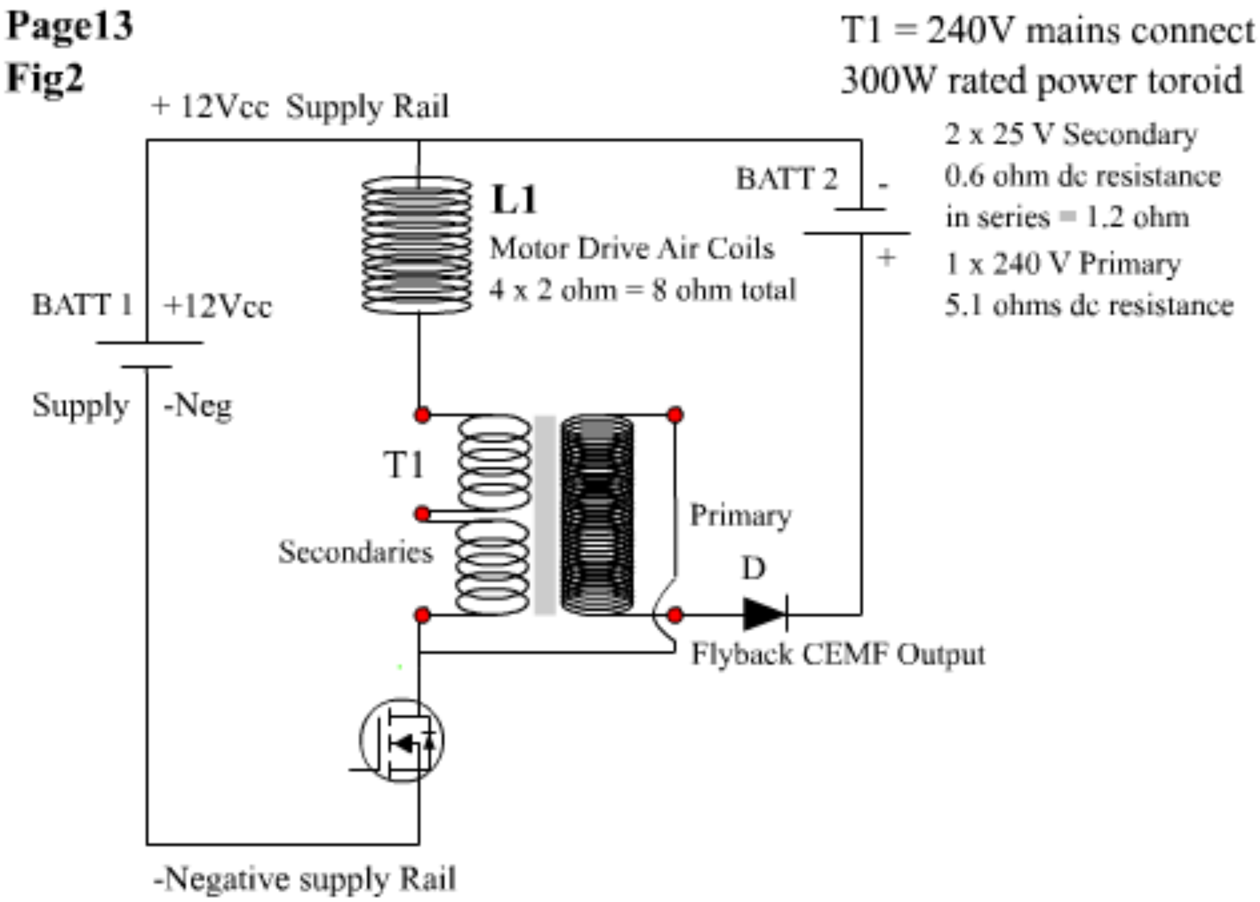


Fig 3 – In the photo below, the transformer secondaries are connected in series with the motor coils, and the flyback is in series with the transformer primary as shown in Fig2 above.

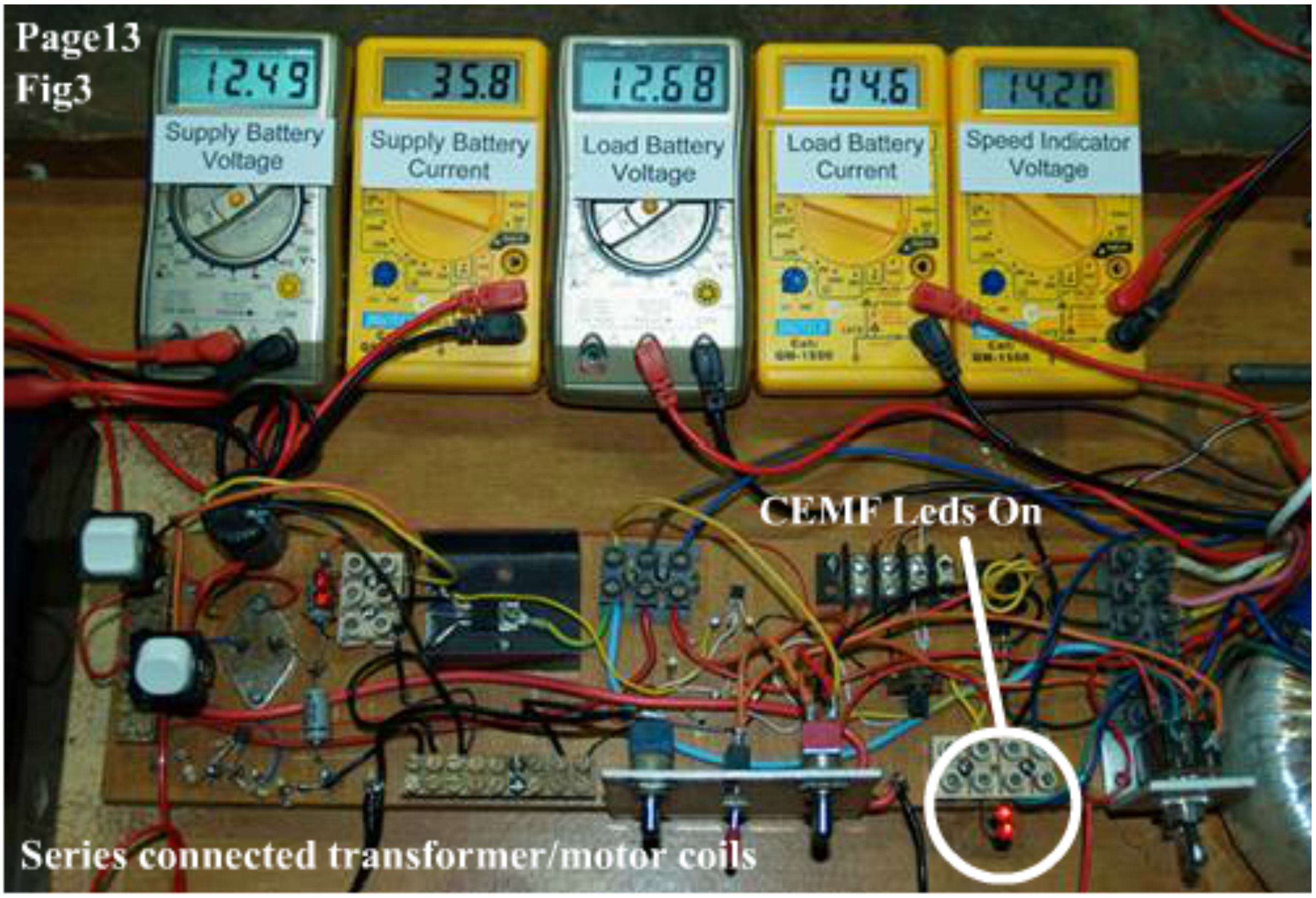


Fig3 above clearly shows a large drop in supply current, but also a significant drop in speed indicator voltage. It is charging the battery2, but at a reduced rate compared to direct diode harvesting (no transformer) as shown in the prior Fig 1-C. However, the relative speed decrease is much smaller than the relative decrease in supply current, indicating a better current versus rotor speed ratio, and thus a potentially higher efficiency. The battery2 is also being charged, and that's encouraging. Still, the speed indicator voltage is not greater than it would be without the transformer as shown in Fig1-A. But the results are encouraging. So what next.? To maximise the performance of the circuit by including another component! I think.? What ? won't that just add more losses?! The transformer should have increased circuit losses, which in turn should have lowered the relative efficiency, but the relative efficiency seems to contradict that. An extra component should just introduce more potential losses. Hmmnnn….Let's see.

Fig4 below shows the voltage indicator coils, which are normally passive, meaning they are not connected to the supply, or contributing to the motor circuit in any way. They have now been connected in series with the flyback circuit, to perform two functions. 1.To continue giving a visual indication of relative rotor speed, and . 2. To allow the flyback current to flow through the voltage indicator coils (now flyback coils), enabling them to positively contribute to the motor circuit by increasing rotor torque.

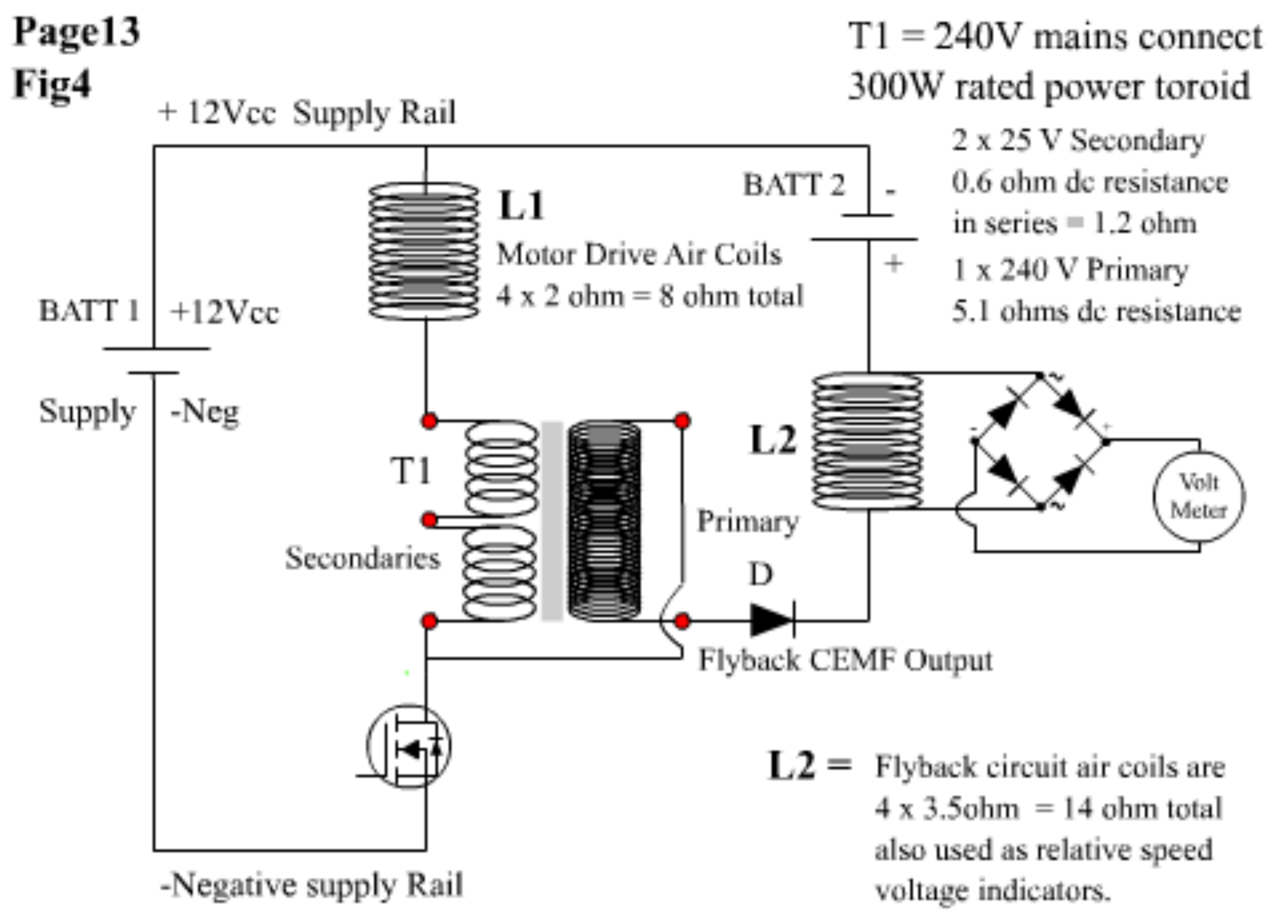


Fig 5 below shows the results of series adding the voltage indicator coil to the flyback circuit.

Table 2 below combines the data from table1 with the data from Fig3 anf Fig5 above, I can happily say yes to most of my previous questions. With this particular motor's air core coils and transformer arrangement, I can manipulate the cemf more efficiently in order to 1: increase motor speed (running torque), to a greater speed than an unloaded motor. 2: charge a battery load at the same time with cemf . 3: decrease supply current while increasing speed

Table2	Blocking Diode	Transformer	Flyback coils	SupplyVoltage	Supply Current Milliamps	BEMF LEDS	Load Voltage	Load Current Milliamps	CEMF Leds	Speed Indicator Voltage
Fig1-A	Yes	No	No	12.44	93.3	Off	12.65	0	Off	18.33 * prior max speed
Fig1-B	Yes	No	No	12.43	97.9	On	12.65	0.1 (meter flicker)	Off	16.29
Fig1-C	Yes	No	No	12.41	110.3	On	12.69	11.4	On	15.14
Fig3	Yes	Yes	No	12.49	35.8	Off	12.68	4.6	On	14.20 * min speed + current
Fig5	Yes	Yes	Yes	12.43	71.1	Off	12.71	12.7	On	18.44 * max speed

In the next experiments the transformer and flyback coil configurations will not incorporate a blocking diode in the main supply circuit, and all the experiments will not include Leds in the circuits as indicators.

See Page14 for more information and additional experimental data.

On the pages 12 and 13, I used Leds in the circuit to give visual indications of current flows. In the following experiments, the Leds are discarded in the CEMF circuit path. Without the 1.8 volt drop across the Leds, more current flows into the battery2. This means there will be a greater load on the flyback circuit (includes motor coils), than in the previous experiments. The purpose of the following experiments, is to explore the motor speed characteristics during higher cemf current loads. In this set of experiments, there is no blocking diode when the transformer/coil configuration is used. Once again, to establish a baseline for the experiment, the first set of figures below shows the motor running with just a blocking diode and no cemf load.

Fig1 Shows only the motor running with a blocking diode in circuit. – Baseline figures – Motor running with no cemf load connected.

Fig2 Shows motor running with a blocking diode in circuit and direct diode flyback circuit switched on, with battery2 as cemf load.

Fig3 Shows motor with no blocking diode, and a transformer in series with motor coils and flyback circuit switched on, with battery2 as cemf load.

Fig4 Shows motor with no blocking diode, and a transformer in series with motor coils and flyback circuit in series with voltage indicator coils with battery2 as cemf load.

See Summary Table1 below.

Table1	Blocking Diode	Transformer	Flyback coils	Supply Voltage	Supply Current /ma	Load Voltage	Load Current /ma	Speed Indicator Voltage
Fig1	Yes	No	No	12.43	93.9	12.60 No Load	No Load	18.23 *max no load speed
Fig2	Yes	No	No	12.38	124.9	12.67	20.9	13.82
Fig3	No	Yes	No	12.50	40.1	12.64	5.7	15.72
Fig4	No	Yes	Yes	12.44	80.9	12.67	15.2	20.30 * max speed with load

Results are interesting and encouraging, so the next experiment presents a heavier low impedance load to the flyback circuit. The battery2 in the flyback circuit has been drained to a lower voltage by a 12V 10 watt globe, which is still connected across it's terminals during the test, to maintain a low load battery voltage. The flyback circuit will therefore experience a greater load than in the experiment above. As before the first meter readings shown in Fig6 further below are the baseline readings with only the motor running with no load and a blocking diode is in circuit. Fig5 below shows the test rig with the globe across battery2 terminal nestled into the toroid and keeping battery2 at 10.23 Volts

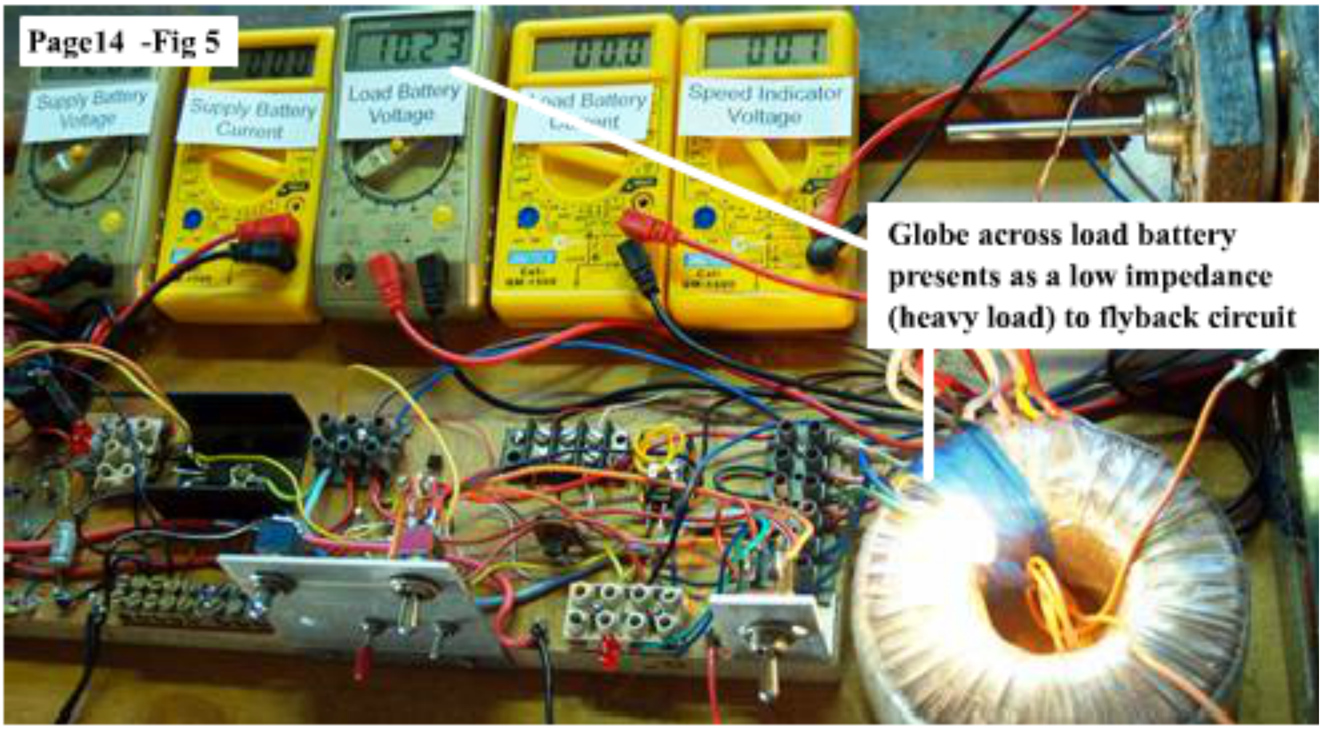


Fig6 Shows only the motor running with a blocking diode in circuit. – Baseline figures – Motor running with no cemf load connected.

Fig7 Shows motor running with a blocking diode in circuit and direct diode flyback circuit switched on, with battery2 as cemf load.

Fig8 Shows motor with no blocking diode, and a transformer in series with motor coils and flyback circuit switched on, with battery2 as cemf load.

Fig9 Shows motor with no blocking diode, and a transformer in series with motor coils and flyback circuit in series with voltage indicator coils with battery2 as cemf load.

See Summary Table2 below.

Table2	Blocking Diode	Transformer	Flyback coils	Supply Voltage	Supply Current /ma	Load Voltage	Load Current /ma	Speed Indicator Voltage
Fig1	Yes	No	No	12.43	91.2	10.23	No Load	18.23 *max no load speed
Fig2	Yes	No	No	12.35	139	10.25	32.6	12.16
Fig3	No	Yes	No	12.47	45.5	10.24	9.9	16.05
Fig4	No	Yes	Yes	12.38	85.4	10.24	16.8	20.90 * max speed with load

As you can see in the previous experiments, the higher flyback circuit load is very counter productive to rotor speed when only using the blocking diode and direct diode flyback output. However it can also be seen that the direct diode output consistently delivers a higher current into the load battery2 than the transformer/flyback coils circuits. The transformer and flyback coil configurations, do however, show a consistent increase in rotor speed (torque) accompanied by lower supply currents, even without the use of a bemf blocking diode.

With this particular motor assembly, when comparing rotor speeds versus supply current, it can be clearly seen that the transformer and flyback coil arrangements are beneficial, and are enhanced by increased loads on the flyback circuit. The efficiency of the transformer arrangements is greater with a flyback load and no blocking diode, than the diode blocking arrangement with no flyback load. This answers another one of my questions; Do I have to block the bemf to achieve better motor performance? The data suggests the answer is No, but I have to be imaginitive in dealing with it, because the data on page 13 shows that trying to use it directly will lower motor torque and increase supply consumption.

Just for the record, I haven't shown the transformer circuit performance without a flyback load connected, and I haven't shown direct diode ouput in series with the flyback coils without the transformer interface. So the two Figs below show these.

Fig10 below shows the readings with just the transformer connected in series with the motor with no flyback circuit connected. No Blocking Diode.

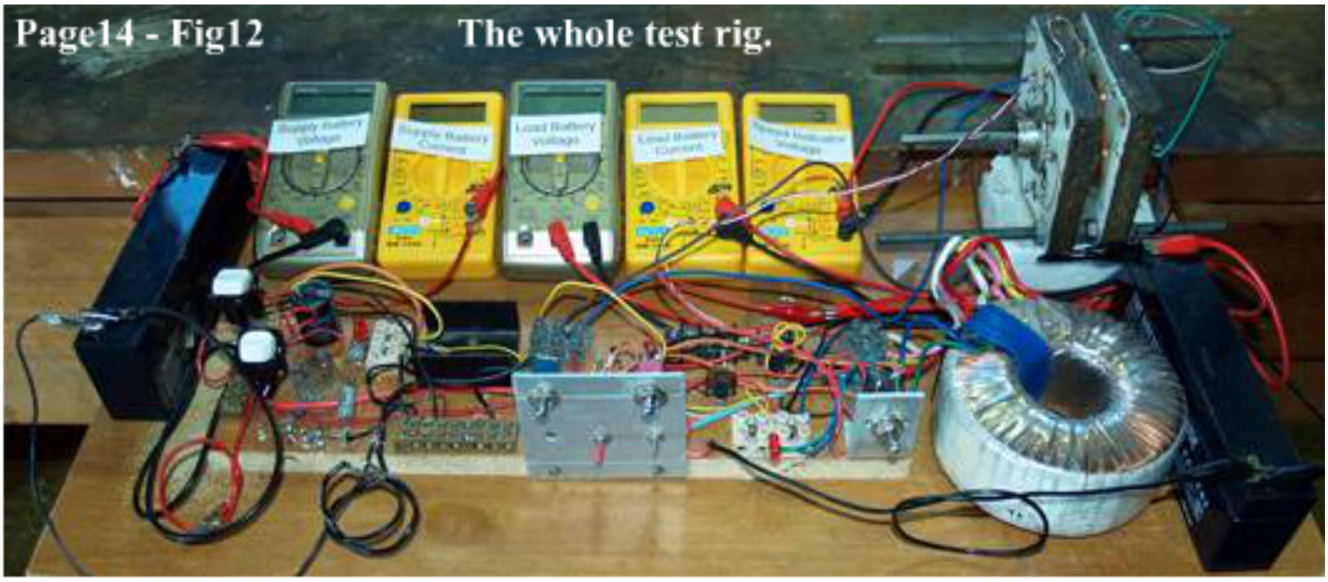
As can be seen by the meter readings, the current is low (23.7ma) but the speed is also very low. The transformer/coils arrangement will only produce its highest motor speed when the cemf circuit is connected and heavily loaded.

Fig11 below shows the readings with the motor running with just a blocking diode, and the direct diode flyback output is in series with the voltage indicator coils (flyback coils).

The result is catastrophic. The current consumption is very high (250ma), and the rotor speed is very low, however it can be seen that the maximum load current into battery2 is achieved. In terms of rotor speed versus current consumption, it is clear that directly connecting the cemf diode via the voltage indicator coils (flyback coils) is counter productive and very inefficient. Without the intermediate presence of the transformer, trying to use the relative speed voltage coils as flyback coils results in poor performance. This is true regardless of the polarity of the voltage indicator coil connections to the diode. A different physical relationship (angle) between the drive coils and flyback coils may yield very different results.

The fact that these experiments have been carried out using air coils is important to me, because they preclude any existence of core drag, and any speed/torque increase being attributed to neutralizing that drag. This leaves the experiments free from those considerations, and able to explore other mechanisms for increased efficiency.

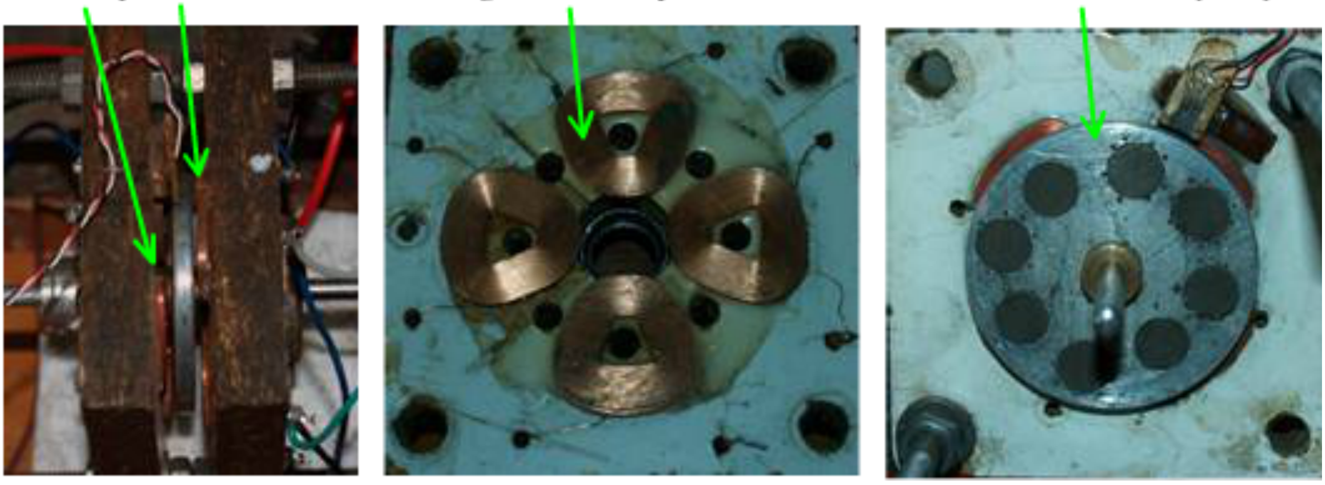
Another interesting aspect of the transformer/coils configuration compared to the motor coil only configuration is the relative characteristics of the cemf current into the load battery2 when there is a physical load put onto the rotor. In the instance of using motor coils only, with direct diode output, the cemf current reduces as the rotor speed reduces due to the physical load. The supply current also increases with the application of a physical load. But, while the supply current also increases with the application of a physical load in the instance/s of the transformer/coils configurations, the cemf into the load battery2 does not reduce as rotor speed reduces, but actually increases. Fig 12 below shows the whole rig used for these experiments and the rotor and coils.



Note* Drive coils and flyback/voltage indicator coils are 45 degrees out of physical alignment with respect to each other

Voltage Indicator/Flyback coils

Rotor /Drive coils/Hall pickup



You can see from the photo above, why the poorly made and badly balanced rotor was destined for the junk heap. Thank goodness it never made it there. It still proved itself to be useful for these experiments. Now if I can get such positive torque results with this novel tranformer/coil circuitry using a rotor assembly like the one above in Fig12, then I'm pretty sure a precision made rotor/motor will yield significantly better results.

The experiments shown on pages 12 to 14 were carried out using cheap and inaccurate Digital Multi-meters. I have in no way attempted to accurately measure power consumed, or torque delivered. I am not claiming OU or anything for that matter. I have just presented the actual test data for your consideration. The experiments are relative experiments only. The same "bad measuring sticks" have been applied to all configurations. LOL. This circuit is new to me, so I have not attempted to give a complete analysis. I do not possess scopes or even quality DM's for that matter, and I believe, that to fully understand the power phase relationships in the transformer/coils circuit, may require the use of some decent scope-ware. Hopefully, this series of experiments has ignited your own curiosity, and perhaps you will diligently set up your own test rigs and circuits to explore what may or may not be an inherently useful pulsed motor circuit. For me these experiments have answered a few questions and raised a few more.

Cheers and keep on motoring !