Bucking Coils produce Energy Gain

1. Introduction

There are many claims of overunity for systems that employ bucking coils. These are coils mounted on a common core and connected in series such that their magnetic fields oppose each other. This paper considers such coils to show that a magnetic propagation delay from one coil to the other gives the connected pair of bucking coils a clockwise flux v. current loop, and such a clockwise loop is known to deliver energy. By considering a fast transient current supplied to the loops the presence of the magnetic delay is seen to produce an inductance that reduces with time from which the clockwise loop can be inferred. The resulting simplified waveform is seen to compare favourably with that shown for example by Osamu Ide. The analysis is then extended to a general case for sinusoidal current through the two coils to show that the propagation delay creates a negative series resistor in the equivalent circuit.

2. Fast Transient Analysis

Osamu Ide's OU converter uses short pulses, which suggests that magnetic propagation delay may have something to do with its performance. The claimed "forward EMF" being in the same direction as the current is simply another way of saying negative resistance, i.e. it represents an energy source. The diagrams show this "forward EMF" region being a narrow spike within the waveform. Now it is well known that for inductive systems an energy sink (energy loss) is represented by an anti-clockwise BH loop (which is really a material characteristic) where the area of the loop represents an energy density (Joules per cubic meter). At the system level an anti-clockwise flux (Φ) v. current (I) loop represents that same energy loss where the area of the loop now gives energy (Joules) directly. A clockwise BH loop or ΦI loop represents an energy source that supplies power to the electrical circuit. It is shown here that bucking coils as used by Ide can produce that CW ΦI loop.

When the two bucking coils are energised simultaneously there will be a short period of time where the magnetic wavefronts propagate along the ferrite core but have not yet reached the opposite coil. This has been illustrated here by simply taking a FEMM plot and truncating it to represent the moving wavefront from one coil.

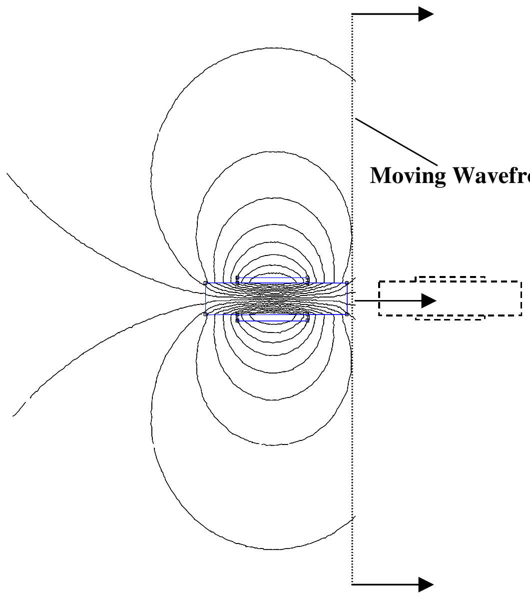

Figure 1. Magnetic Wavefront.

Of course the magnetic field from the RH coil also has a wavefront moving from R to L towards the first coil. The important thing to note is that during this time the drive source is seeing just two non-interacting coils. When the wavefronts finally reach the opposite coils then the combined inductance reduces because of their bucking interaction. This change of inductance during the applied pulse accounts for a CW loop as shown in the next figure. Here it is assumed that the coils are suddenly connected to a low impedance voltage source that enforces a constant $d\Phi/dt$ and dI/dt where the values are determined only by the voltage and the inductance. Thus when the inductance changes value then so does the slope of the flux and current waveforms. Initially these rates are low according to the initial high value of inductance, then the rates increase when the inductance becomes lower. Upon removal of the voltage the inductor discharges into the load resistor, again initially at high inductance then followed by low inductance. It is seen that the ΦI chart traces a CW loop.

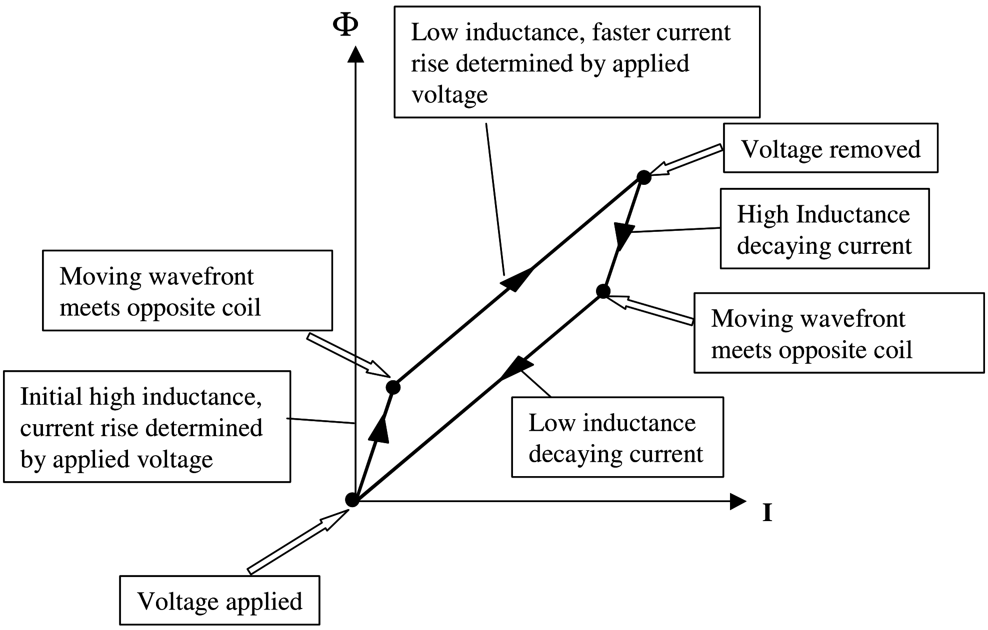

Figure 2. Φ v. I Loop

If we construct simplified voltage and current waveforms we obtain the waveforms shown in figure 3.

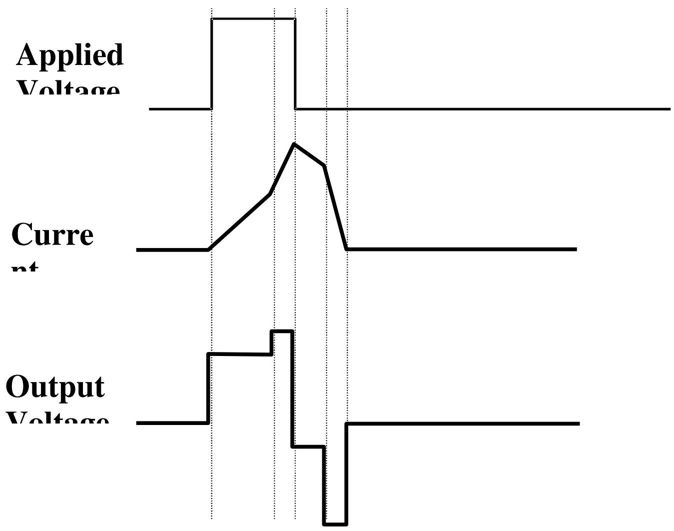

Figure 3. Voltage and Current Waveforms.

For comparison here is the waveform as given by Ide at the 2012 SPECIF conference.

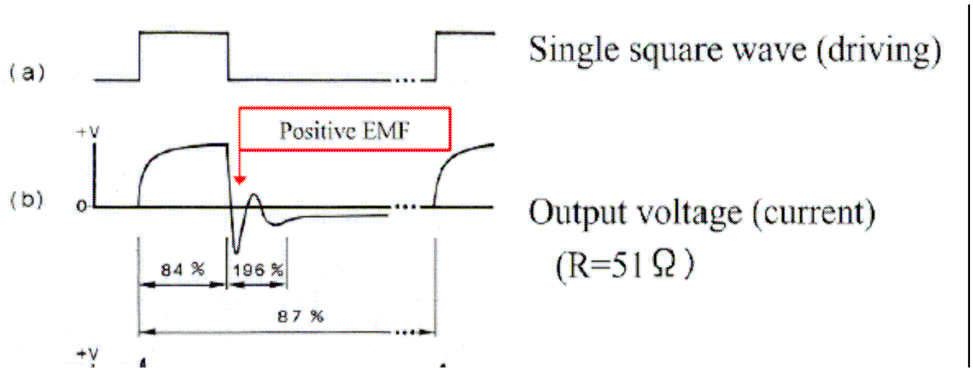

Figure 4. Ide's Waveform

Ide's claim is that the fly-back spike is "positive EMF" whereas it represents the excess energy gained from the CW loop.

3. Sine-wave Considerations

The above analysis assumed fast transients, however the OU characteristic from bucking coils is not limited to this case. Even for smooth waveforms the time delay in the magnetic path coupling the two coils will show itself as a CW Phi v. I loop. This can be demonstrated by the following analysis.

The inductance for two coils in series is given by the well known formula

$$L = L_1 + L_2 \pm 2L_{12} \qquad (1)$$

where L_1 and L_2 are the inductances of the two coils when isolated from each other (e.g. at great separation) and L_{12} is the mutual inductance between the coils. For bucking coils the negative sign applies. Now to a first approximation we can say that there are no time delays affecting the values of L_1 and L_2. However there could be a significant time delay concerning the coupling between the coils hence affecting voltage induced into the L_{12} term. Taking the current through the two coils to be of value $i\sin(\omega t)$ and using the classical voltage across an inductor as $V = -L\frac{di}{dt}$ we get from (1) the voltage across the series combination as

$$V = -\omega i[L_1\cos(\omega t) + L_2\cos(\omega t) - 2L_{12}\cos(\omega t + \phi)] \qquad (2)$$

where we have introduced a phase delay ϕ for the mutual coupling. Expanding the third term yields

$$V = -\omega i[L_1\cos(\omega t) + L_2\cos(\omega t) - 2L_{12}\cos(\omega t)\cos(\phi) + 2L_{12}\sin(\omega t)\sin(\phi)] \qquad (3)$$

Rearranging (3) to gather the $\cos(\omega t)$ and $\sin(\omega t)$ terms gives

$$V = -\omega i[\cos(\omega t)\{L_1 + L_2 - 2L_{12}\cos(\phi)\} + \sin(\omega t)\{2L_{12}\sin(\phi)\}] \qquad (4)$$

The phase angle θ between voltage and current is then

$$\theta = -\tan^{-1}\left(\frac{2L_{12}\sin(\phi)}{L_1 + L_2 - 2L_{12}\cos(\phi)}\right) \qquad (5)$$

This phase is perhaps more readily understood by dividing (4) by the current $i\sin(\omega t)$ to get the impedance of the series-connected bucking coils as

$$Z = \frac{V}{i\sin(\omega t)} = j\omega[L_1 + L_2 - 2L_{12}\cos(\phi)] - 2\omega L_{12}\sin(\phi) \qquad (6)$$

where j is the imaginary operator $j-\sqrt{-1}$. It is seen that the equivalent circuit of the series connected bucking coils is an inductance $L = L_1 + L_2 - 2L_{12}\cos(\phi)$ in series with a ***negative*** resistance $R = -2\omega L_{12}\sin(\phi)$. This is illustrated in figure 5.

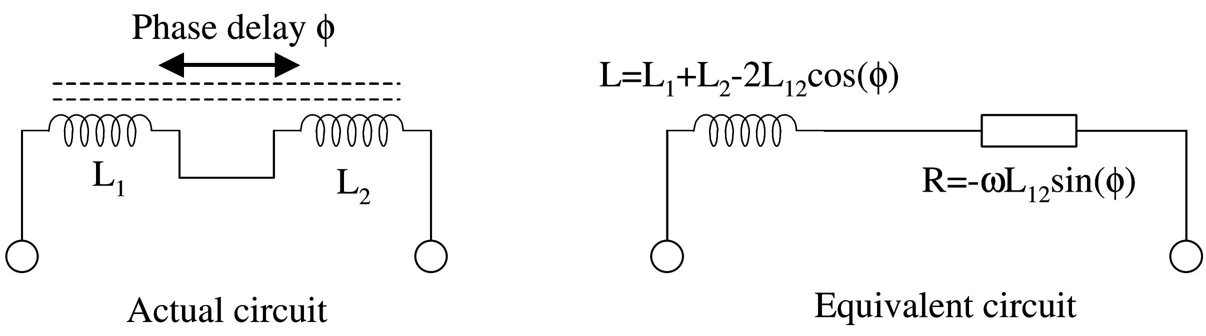

Figure 5. Series opposing coils and their equivalent circuit.

Note that value of the negative resistor increases with frequency. Unfortunately positive real losses associated with the core and the conductor also increase with frequency, so the presence of the negative resistance is not always readily discernible.

4. Discussion

If the coils were in series-aiding the resistance R would be positive representing an energy loss. It is well known that the magnetic propagation delay through ferromagnetic cores does generally result in a loss, and the delay has been given the name *magnetic viscosity* invoking the perception that friction causes the loss. The above analysis could be extended to the coupling between adjacent turns of a single coil to show that with a magnetic propagation delay between turns the mutual coupling between turns will produce a loss. However that only applies to the situation where the mutual coupling is aiding and not opposing. *When the opposing case is considered there is an energy gain*. This reasoning can apply to bifilar-wound opposing coils wound on magnetic cores that have significant magnetic propagation delay. The fact that series-aiding turns produce a loss but series-opposing turns produce a gain should tell us that there is more to magnetic propagation than the name *viscosity* implies.

5. Optimum Conditions for obtaining Energy

Maximum anomalous power is delivered by the induced negative resistance at maximum current flow, but for a given voltage this current is limited by the series inductance $L = L_1 + L_2 - 2L_{12}\cos(\phi)$. Thus to obtain maximum power we need coils that are

- separated by a large distance so as to maximize the negative R
- tightly coupled so as to minimize L

These conflicting requirements are met by having a closed magnetic path of significant length such as a large toroidal core, then using small coils placed diametrically opposite to each other. A load resistor in series with the coils will receive the anomalous power. Voltage drive can be applied directly to the series circuit, where power taken from that voltage source may be less than that delivered to the load. In exceptional circumstances the device could feed power back into the voltage source, there is evidence of researchers having their power supply damaged. Alternatively the voltage can be induced by transformer action. One method for doing this uses a primary coil on a core placed across a diameter as shown in figure 6.

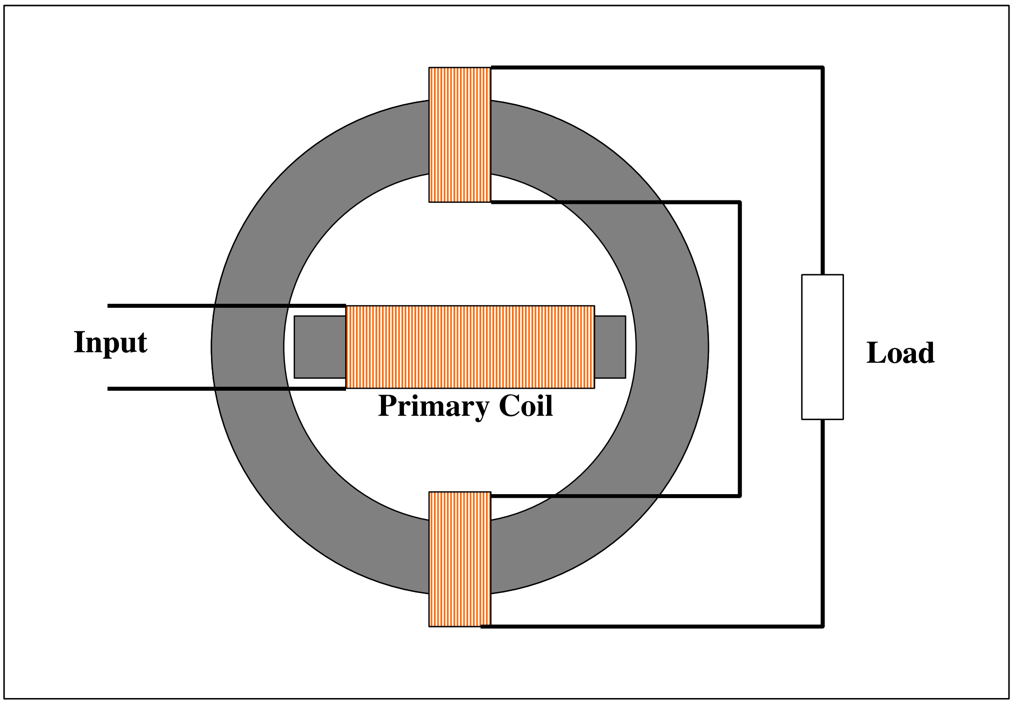

Figure 6. Bucking Coil Transformer

There are a number of transformer systems having magnetic path configurations similar to this, all claimed to create OU. These use **E I** transformer laminations or ferrite cores to create a rectangular version. But no account is taken of the need for maximum propagation delay, so either all three coils are wound on the center limb or the outer coils occupy the entire length of the outer limbs. So their OU performance is not significant enough to persuade the scientific establishment. The above configuration should improve that performance.

6. Effect of Coil Self-Capacitance

To maximize the negative *R* it is desirable to operate at the maximum frequency that the core material will allow, and to use the maximum number of turns. However more turns increases effects due to the inter-winding capacitance of the coils. When this capacitance is taken into consideration equation (1) becomes

$$L = \frac{L_1}{1-\omega^2 L_1 C_1} + \frac{L_2}{1-\omega^2 L_2 C_2} \pm 2L_{12} \tag{7}$$

where C_1 and C_2 are the self capacitances of the two coils. The third mutual coupling term is not affected. Hence when magnetic delay is considered (6) becomes

$$Z = j\omega\left[\frac{L_1}{1-\omega^2 L_1 C_1} + \frac{L_2}{1-\omega^2 L_2 C_2} - 2L_{12}\cos(\phi)\right] - 2\omega L_{12}\sin(\phi) \tag{8}$$

The presence of the capacitances causes the inductive impedance to rise with frequency, tending to infinity at resonance, thus severely limiting the ability to drive current. Thus for optimum performance inter-winding capacitance should be kept to a minimum.

7. Conclusions

It has been shown that the presence of a magnetic propagation delay along a ferromagnetic core will create an energy loss for series-aiding mutual coupling between coils, and an energy gain for series-opposing. The loss or gain can be accounted for by a series resistor in the equivalent circuit of positive or negative value. The formula for this resistor is given for two separated coils on a common core. Optimum arrangements for obtaining anomalous energy from this negative resistance are considered.

The analysis can be extended to the mutual coupling between adjacent turns of a single layer coil to show that the presence of magnetic propagation delay in the core will produce the well-known loss associated with that phenomenon. That same analysis would show that a single layer bifilar coil where the current is reversed between adjacent turns would exhibit an energy gain, hence the usual assumption that loss in cores all goes as heat can be disputed. It appears that cores can both consume and deliver energy by the presence of magnetic delay.