<u>Gotoluc's Recirculating BEMF Video #3</u>

The following is in response to your video test #3 where you compare the magnet lift and resistor heating with the pulsed DC source vs. the straight DC source. In both cases you adjust the intensity of the input bulb to be the same level.

In short, I have obtained very similar results to what you have shown in the video, and I will attempt to show why the results are how they are with some analysis.

To get a better picture of what's happening in the two scenarios and why they produce different results, we have to do the following:

1) Get the RMS power dissipated in the input bulb when in pulsed DC mode (as a baseline). For the straight DC mode the DC supply is adjusted to obtain the same power dissipation (light intensity) in the input bulb as was in the first case (this is what you have done).

2) Get the RMS power dissipated by the two 22 Ohm series resistors (modeled as one 44 Ohm Rsense) (heat is proportional to dissipated power in the resistor).

3) Get the RMS current in the coil (magnetic field strength is proportional to coil current).

4) Get the RMS power taken from the power source.

Note: I have chosen a bulb (hot) resistance value of 10 Ohms as this is probably close to what you have, and it does not really have too much impact on the final results if it is off a few Ohms.

<u>Pulsed-DC Results (RMS):</u>

1) Pbulb = **70mW**
2) Prsense = 2.82W
3) Icoil = 267mA
4) Psource = 3.78W

<u>Pure DC Source Results (RMS):</u>

A pure DC source was connected and all loads placed in series, i.e. DC Source=>Rbulb=>Rsense=>Rcoil=>Gnd. The DC source was adjusted in voltage to obtain the same 70mW dissipation in Rbulb which is the same dissipation (light intensity) measured in the pulsed-DC test. Note that for this pure DC test, only the 8.3 Ohm DC resistance of the coil need be considered, as the inductance will not come into play to alter the circuit current.

1) Pbulb = **70mW** (DC source adjusted to 5.2VDC to obtain this value)
2) Prsense = 306mW
3) Icoil = 83mA
4) Psource = 434mW

By comparing the results for both tests we see that even though the dissipation (bulb intensity) in Rbulb is the same for both tests, the total power going into the rest of the circuit is quite different for each. It is evident from the numbers why the magnet had no lift (much less coil current "Icoil") and why the wirewound resistors (rsense) had much less heat (~ 9x less power dissipation) in the test with pure DC as the source.

At this time I need to explain my response to your question regarding the use of the input bulb as an indication of the amount of power used in the circuit. Perhaps I was not precise enough in my explanation and I apologize for that, but on the other hand there were several other points made in that post (and others), which taken together as a whole would paint a slightly different picture than what came out by focusing only on the one response of main interest. Also, part of the question of interest was: ***"do you really believe that we now have more Energy at the bulb because the voltage was raised 10 time higher then before?"***. The answer was given with respect to the bulb; it would be the same power in the bulb if adjusted to the same intensity. Unfortunately I said "in the circuit" rather than specifying the bulb only, and I suspect that this is where the communication was interpreted differently.

Please take into consideration the complete post linked here: http://www.overunity.com/index.php?topic=7713.msg190619#msg190619 and hopefully it will become clearer now.

The Rbulb intensity (or heat) can not be used reliably to indicate the total amount of power used by the entire circuit! (as confirmed by the results above). IF the bulb is the ONLY element in the circuit, i.e. it is placed across the power source alone, then YES it will indicate directly how much total power is being taken from the power supply by the "circuit", but the circuit in this case only consists of the bulb, the battery, and the connecting wires.

When there are other components in the circuit (such as resistors and coils) and the bulb is in series with them and the power supply, the bulb's intensity is only indicative of the power being dissipated in the bulb itself. It does not indicate how much total power is being taken from the power supply and being used in the whole circuit.

Actually what the bulb intensity DOES indicate is the RMS CURRENT (and only current) from the supply (ask me about this if you do not understand how or why). But as I mentioned before, current is only one half of the power equation, and without taking power supply RMS VOLTAGE into account, you can not know how much total RMS POWER is being taken from the supply and being used in the circuit.

Again, $\mathbf{P_{RMS} = V_{RMS} \times I_{RMS}}$.

I have mentioned this before and it will be stressed here again in upper case (not yelling, I just want it to stand out a little):

THE ONLY WAY TO PROPERLY MEASURE OR INDICATE HOW MUCH TOTAL POWER IS ENTERING A CIRCUIT IS TO MONITOR THE POWER BEING SUPPLIED BY THE <u>POWER SOURCE</u> ITSELF. BY MEASURING THE CURRENT-THROUGH (BY USING A CURRENT SENSING RESISTOR) AND THE VOLTAGE-ACROSS THE POWER SUPPLY (TAKING INTO ACCOUNT DUTY CYCLE), IT IS POSSIBLE TO CALCULATE THE RMS POWER BEING TAKEN FROM THE POWER SUPPLY BY MULTIPLYING THE TWO VALUES TOGETHER, I.E. $\mathbf{P_{RMS} = V_{RMS} \times I_{RMS}}$. "**V**" IS THE CALCULATED DC SUPPLY RMS VOLTAGE, AND "**I**" IS THE PULSED CURRENT (PULSED VOLTAGE ACROSS THE CURRENT SHUNT) MEASURED AND CONVERTED TO RMS BY A GOOD VOLTAGE METER.

If that is not clear I will be happy to try and expand on it for anyone.

If one wants to know the total *energy* being used by a circuit, then we simply multiply the instantaneous power by time to get Watt-seconds, or Joules. I have built a component in PSpice that allows me to measure Joules as well as Watts.

Now, I imagine the million dollar question in many minds right now might be: "WHY then does the energy in the coil (amount of lift) and the sense resistors (amount of heat) decrease so much with the straight DC supply compared to the pulsed-DC supply?". [Keep in mind here that the straight DC voltage setting was determined by matching the bulb intensity (power dissipation in Rbulb) to what it was with the pulsed-DC supply].

The answer is fairly simple and becomes more obvious when the two circuits are simplified and examined. We have the *Pulsed-DC Case* and the *Straight DC Case* to look at and compare. See **Figures 1a** and **1b** below**.**

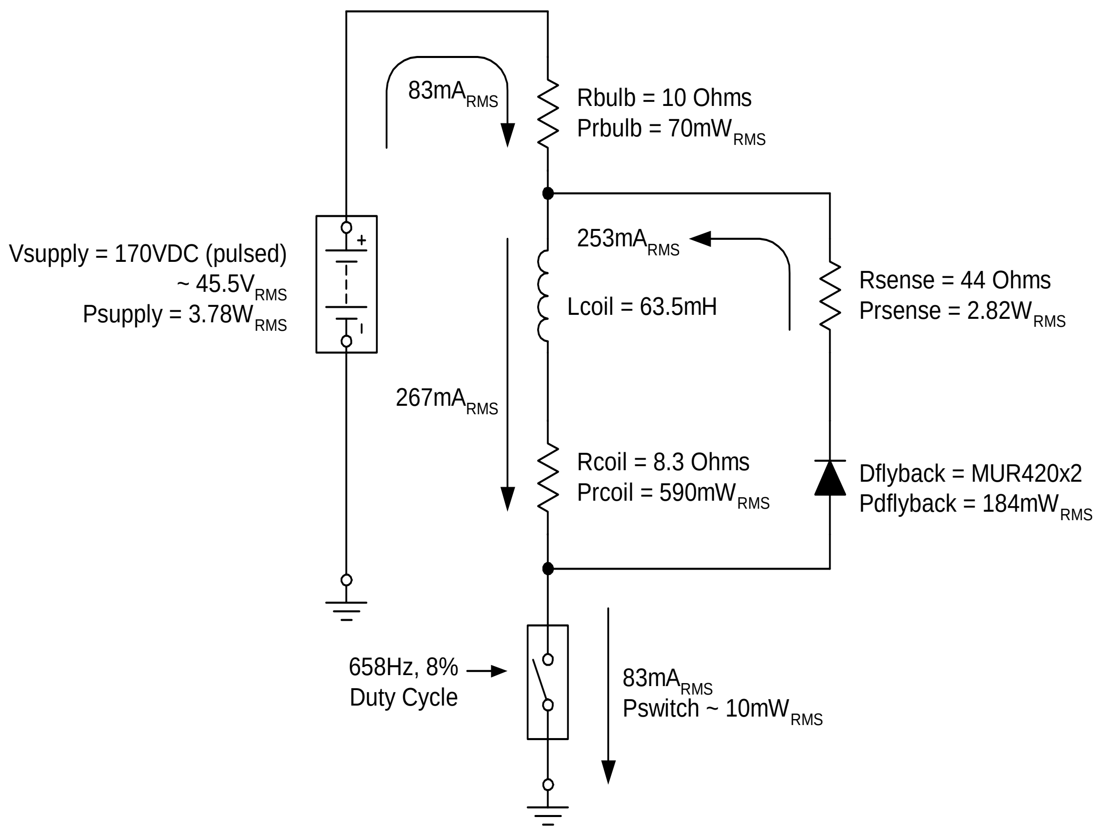

Figure 1a

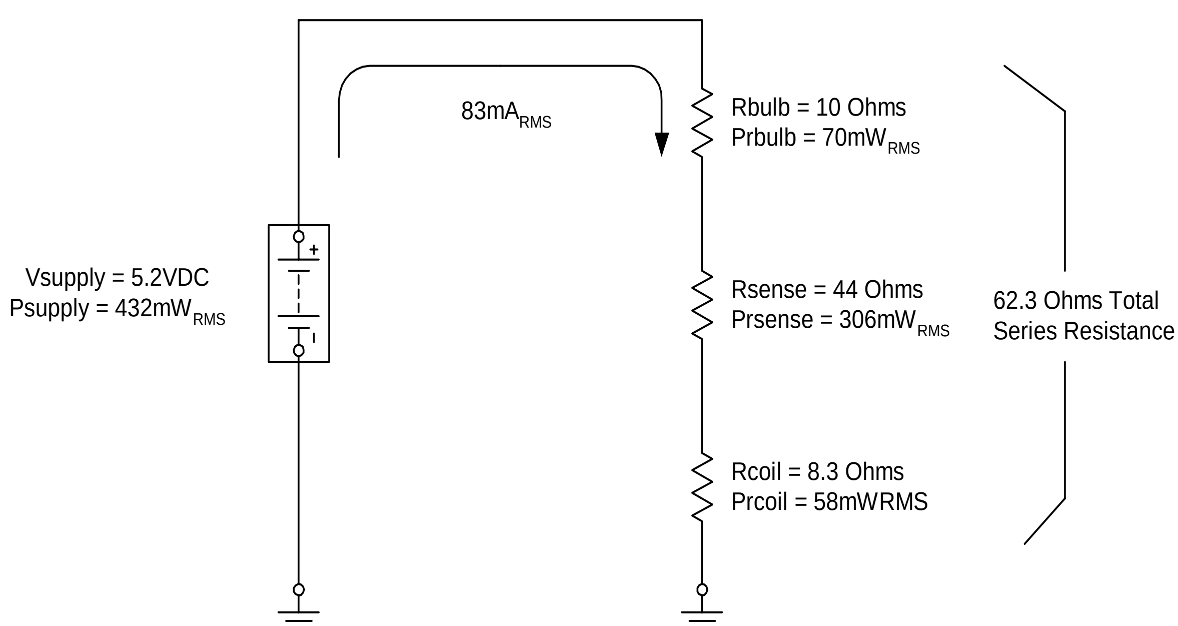

Figure 1b

Pulsed-DC Case (Figure 1a)

One of the first things that may be immediately obvious from looking at the simplified pulsed-DC circuit is the absence of the Rsense resistors in the direct path of the switch and voltage source. The two 22 Ohm resistors (shown as one 44 Ohm) are in fact in parallel with the coil and only partake in the circuit during the period of time the MOSFET switch is OFF and the coil is in its “kickback” phase of the complete “energize/de-energize” cycle. This of course is possible by use of the flyback diode, which acts as an automatic switch when the voltage across the coil reverses.

Intuitively, this may appear to put the Rsense resistor in a disadvantageous position compared to the straight DC circuit where it is clearly in series with all the other components. In fact with the pulsed-DC circuit, the Rsense resistor experiences a greater current through it because of the flyback effect. The flyback diode acts like a switch and current rectifier, and allows the coil current to build and sustain a value with a much increased RMS factor than without it. The coil, diode, switching, and flyback effect create a current amplifier if you like, or as mentioned before a voltage down-converter. Voltage and current are being converted during the flyback cycle in the coil.

One oddity does stand out and that is with the value of the labeled currents in **Figure 1a**. Anyone that knows or remembers their “Kirchhoff’s Current Rule” should recognize that something strange is happening at the coil terminals: that is we don’t have an equal amount of current entering the top terminal as we do leaving the top terminal (similarly for the bottom coil terminal). So what’s happening there?

Keep in mind that the labeled currents are RMS currents that establish themselves over a number of operation cycles, and this does not indicate what is happening at any particular snapshot in time.

As this circuit involves two switches (the MOSFET and the Diode) and the circuit operates in two phases, Kirchhoff’s circuit rules still apply but they must be evaluated in two phases.

In the ON phase (MOSFET ON, Diode OFF), we see 83mA entering the coil and leaving the coil through the MOSFET. That is as it should be. We may also assume that during the **first** ON phase the RMS coil current is also about 83mA.

During the OFF phase (MOSFET OFF, Diode ON), inductive kickback begins and the coil/flyback circuit becomes essentially floating on its own until the MOSFET again turns ON. The kickback causes the RMS coil current to increase by a factor of about 3 times up to 253mA. Because of the diode and LR time constants, the coil current is rectified and “accumulates” (is smoothed out) to a much larger RMS value which accounts for the increase magnetic field and associated force on the neo magnet.

Combining these two phases together over time produces a slightly larger constant RMS current in the coil as indicated (267mA). This is caused by LR time constants and imperfect/overlapping switching speeds of the MOSFET and diode. Note: If Rsense was replaced with a short, the RMS coil current would substantially increase to about 1.25A (but so will the RMS power from the power supply to about 16W from 3.78W). As it stands, the current through Rsense is about 3 times higher than that measured/calculated in the straight DC power circuit, and this 3 fold current increase amounts to a RMS power dissipation increase of **9 fold** in Rsense.

Note: Adding together the displayed values for the RMS power dissipated by each device in the circuit, closely equals the total RMS power being delivered by the power supply, i.e. ~ 3.78W_{RMS}.

Straight DC Case (Figure 1b)

For the pure straight DC supply test, the circuit is a simple series chain of: DC supply, the bulb (Rbulb), the sense resistor(s) (Rsense), and the coil resistor (Rcoil). See **Figure 1b**.

The total resistance across the DC supply is 62.3 Ohms. The setting for the DC supply (5.2VDC) was worked backwards from the power dissipation (70mW) value in Rbulb (as determined by measurement in the pulsed-DC setup). Again, with this test, Rbulb is set to the same power dissipation (light intensity) as was measured in the pulsed-DC setup.

Using Ohm's law and basic power equations, the current in the circuit which results in Rbulb dissipating 70mW was determined to be 83mA (same as in the pulsed-DC circuit, which it should be). The resulting DC voltage setting is 5.2VDC (62.3 Ohms x 83mA). Note here that the Rsense resistor *is* placed **in series** with the DC supply (contrary to the pulsed-DC circuit). This largely limits the current that can exist in this circuit to less than half it would be with only the bulb and coil in series.

Rsense being the highest resistance is where the majority of the power is dissipated (resulting in heat) because $\mathbf{P = I^2 R}$, but with only 83mA through the circuit the power dissipated by Rsense is only 306mW compared to the 2.82W dissipation in the pulsed-DC circuit.

Again, with a RMS coil current of only 83mA, the coil's force on the neo magnet will be one-third that as the pulsed-DC case, and hence why there was no movement of the magnet. In theory, the voltage would have to be increased to about 16.6VDC to levitate the magnet to approximately the same height as with the pulsed-DC setup. Of course if a real bulb is used in place of my "Rbulb", the voltage would have to increase even above this value of 16.6V due to the increasing bulb resistance as it heats up.

Summary

In both cases above for Video #3 it was shown that although the bulb intensity was matched with different power supply types (pulsed-DC vs. DC) and voltages, the actual RMS power delivered by the connected power supply is in fact not the same for each case.

Bulb intensity (Rbulb) or power dissipation is only an indication of current through the bulb (and power dissipation in the bulb only), and it can not be used to indicate the total power (nor energy) delivered by the power supply to the rest of the circuit.

<u>Gotoluc's Recirculating BEMF Video #6</u>

In step with the analysis from Gotoluc's video #3, a similar analysis will explain the results obtained from the setup and changes made in video #6.

In video #6, frequency, pulse width, and voltage changes were made to see the effects they had on power dissipation in Rsense and coil lift on the neo magnet.

For this analysis, I am going to stay with the frequency of 658Hz and vary only the pulse width and voltage to illustrate the same effect of increased power dissipation in Rsense and lift in the neo magnet, all while maintaining a constant intensity in Rbulb.

Since a supply voltage of 170VDC and duty cycle of 8% has already been shown above, I will add one test at a supply voltage of 50VDC (and it's associated duty cycle to retain the 70mW dissipation in Rbulb), and one at a supply voltage of 350VDC (and it's associated duty cycle to retain the 70mW dissipation in Rbulb). **Figure 1a** above is the test circuit with noted voltage and duty cycle changes to follow.

<u>VDC = 50V; Pulse Width = 270us; Duty Cycle = 17.7%</u>

1) Pbulb = **70mW**
2) Prsense = 1.17W
3) Icoil = 183mA
4) Psource = 1.70W

<u>VDC = 170V; Pulse Width = 120us; Duty Cycle = 7.9%</u>

1) Pbulb = **70mW**
2) Prsense = 2.82W
3) Icoil = 267mA
4) Psource = 3.78W

<u>VDC = 350V; Pulse Width = 74us; Duty Cycle = 4.9%</u>

1) Pbulb = **70mW**
2) Prsense = 4.65W
3) Icoil = 335mA
4) Psource = 6.13W

Comparing the above 3 tests we see again that maintaining the intensity of the input Rbulb (70mW) does not account for the total RMS power being used in the rest of the circuit. We also see that increasing the supply voltage magnifies the effect of the inductive kickback and power dissipation in Rsense, as well as creating a stronger magnetic field at the coil, but all at the expense of drawing more power from the power supply.

<u>Conclusion</u>

A better way needs to be found to monitor/measure/indicate the total power being used by a circuit. Using an input resistor's temperature or bulb's intensity only tells us something about the current through, and hence the power dissipation of that component alone. Also, in-circuit power dissipation gains can not occur without a corresponding increase in power drawn from the power source.

The only sure way as previously stated, is to measure and calculate the power delivered by the source.

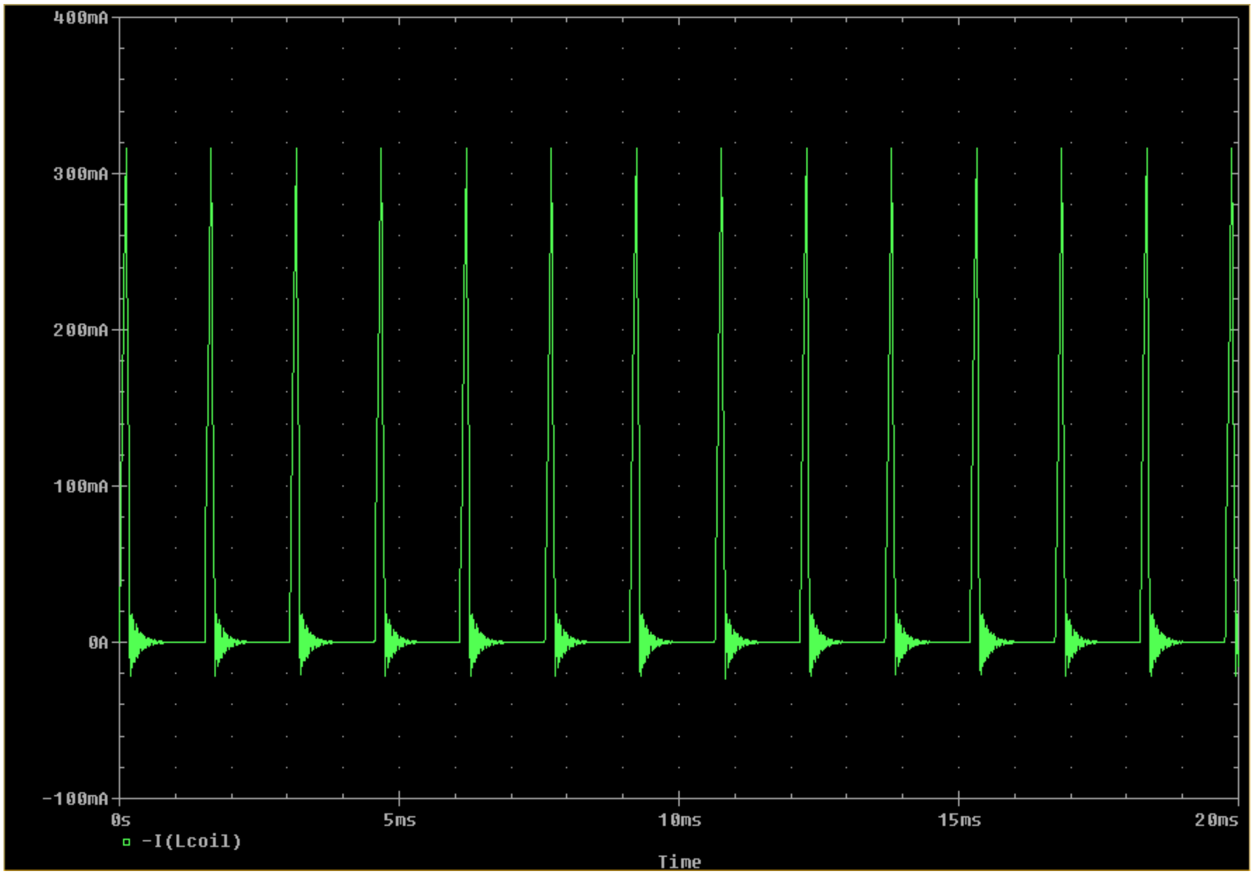

Figure 2 – Coil current without flyback diode connected
RMS current = 65mA

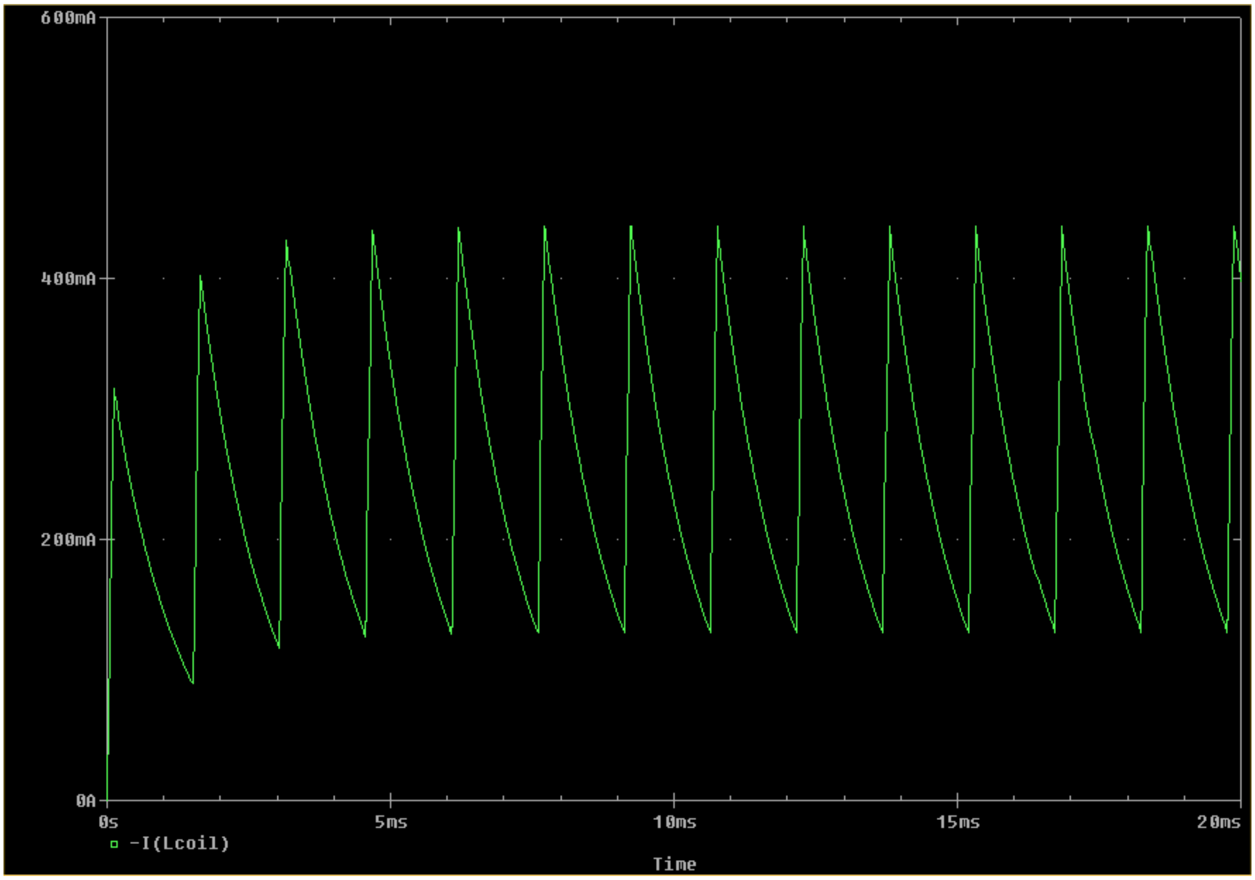

Figure 3 – Coil current with flyback diode connected (same settings as in Figure 2)
RMS current = 267mA

$$Vrms = \sqrt{\left[Va^2\left(PWa/T\right)\right] + \left[Vb^2\left(PWb/T\right)\right]}$$

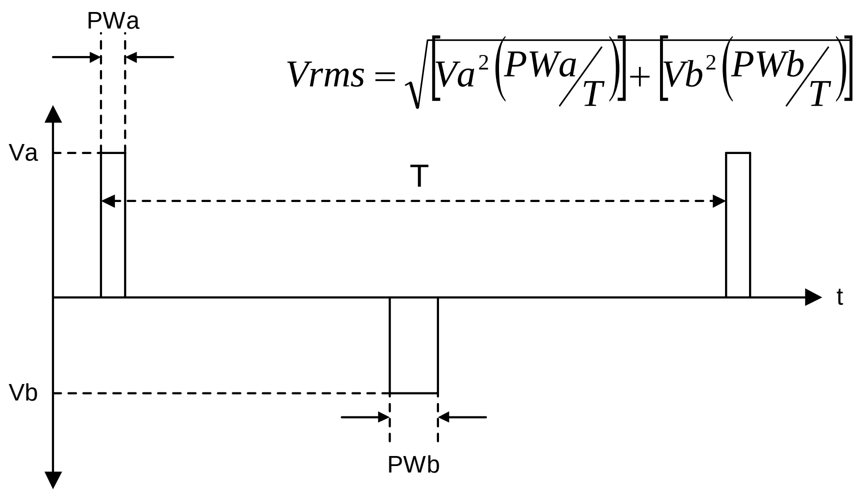

Figure 4 – How to calculate RMS voltage with pulse wave forms