Phase Relationships and Harmonics in the Steven Mark Toroidal Power Unit

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For the longest time, I have been confused about the relationship and interaction of the input frequencies in the TPU. We know from Steven Mark's letters that the 'kick' phenomena was what initially got him interested in the subject, as well as two out of phase transformers. In later letters, he then talks about harmonics (or harmonic components to be more precise, more on this later) as an integral part of his device. He said in yet another letter that the devices could put out great amounts of power once they reached harmonic perfection. But what does this all mean?

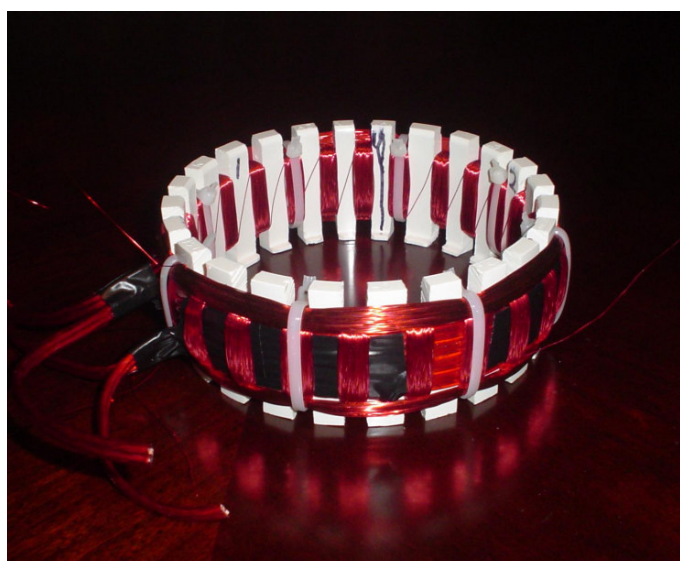
How do sharp kicks, slightly out of phase transformers, and harmonics all tie together? Oh, but there is one more thing to throw into the mix…. The rotating 'field' with inertia. How is this all working together in the TPU to produce power?

The question that I have sought to answer is ***Why*** all this works to produce power.

So let's start at the beginning with the 'kick.'

We pretty much know from many different sources from Tesla to Bearden that sharp, quick impulses create interesting 'effects'. But how does this apply in the case of a TPU specifically? To answer this question, I must turn to the experiment I did last week.

Part of my investigation into the fundamental concept of the TPU involved understanding the characteristics and behavior of high speed rotating magnetic field. We know from the letters that these things produce this field, so my goal was to determine how to make one with the least amount of input power.

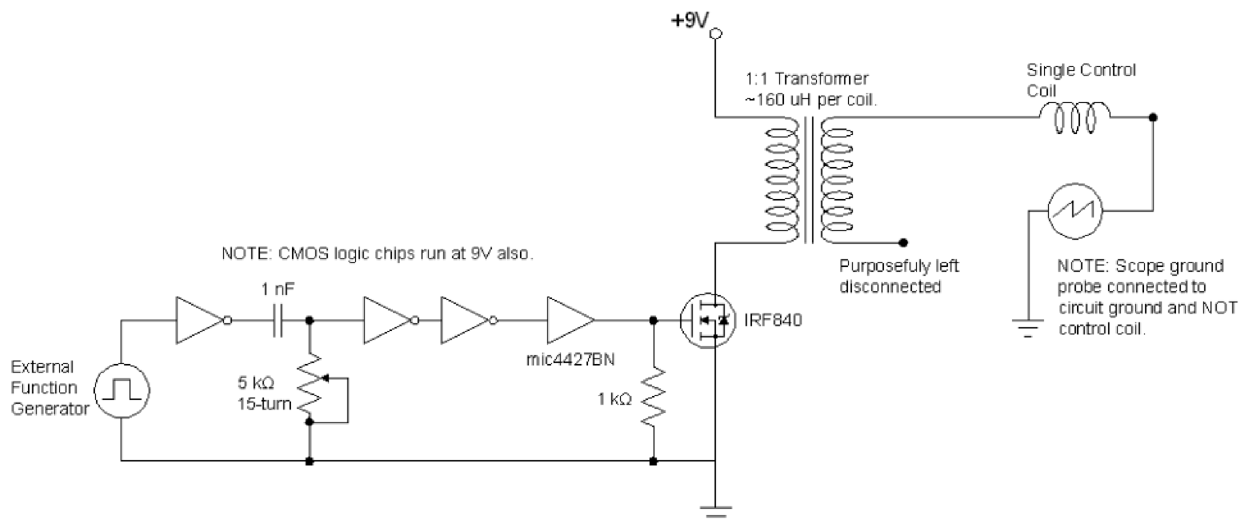


So I started with my latest TPU which is wound on a hacked 5" diameter PVC cuplink.

It turned out to be a great candidate for this test because each of the three control coil, which were wound in eight segments, contained exactly 200 feet of 30 gauge magnet wire (basically, the whole spool from RadioShack) and had an inductance of exactly 3 mH! This very high inductance value (for an air-cored coil) allowed me to bring the natural resonant frequency of the coil down into the kHz range without the need of adding a capacitor to the coil to artificially lower it.

My goal for this test was simple. First I modified one channel of my old control board (which used an external function generator to drive some mic4427 MOSFET drivers for IRF840 MOSFETS), and I added a few extra components to decrease the pulse width of the input going to the MOSFET driver chips down to about 400 ns (which was about the minimum pulse width that the driver chips could handle).

Next, I connected my circuit as shown in the following diagram:



As you can see, the significant feature of this circuit is the ungrounded transformer secondary and control coil! This is part of what I believe is the secret…

I found in some earlier experiments I did that you can actually transfer power from the primary of a transformer to the secondary of a transformer without the circuit on the primary being closed-looped. We are speaking strictly electrostatic induction here (or longitudinal induction if you will).

So I tried the same method here. When I put the short pulses into the primary, I found that the circuit operated very efficiently and drew no more than 30mA throughout the entire frequency range from 1 Hz up to about 800 kHz (where the driver chips started to mis-trigger from extra capacitance on the signal lines).

The most remarkable thing I found was that I could pulse this one-wire control coil into <u>sine wave</u> resonance simply from these pulses of potential that came from the open circuited primary! But wait there's more! When I attached the coil to the transformer, the input current did not change at all! (or if it did, the change was negligible considering the current draw of only ~10-30 mA).

When I found the resonant frequency of my control coil, the control circuit was drawing only 20 mA at a frequency of about 480 kHz. The 50V spikes that entered the coil at this point turned into a +200V pk/pk sine wave in the coil once it reached the ‘sweet spot’ and if I tuned it higher, I could also hit other harmonics of this fundamental frequency.

Next, I scoped across the circumferentially-wound collector coil of this device (which was composed of six turns of 18 gauge speaker wire) and I was able to see sinusoidal oscillations so I connected a bridge rectifier and a 330 Ohm resistor across the DC side to take some output measurements. The RMS voltage across the resistor came out to be 2.5V for a total output of 7.5 mW. Now this may not seem like much but the fact is that I managed to produce this minuscule output from a resonant sine wave that was generated from free potential!

So the next step now is to repeat the same process for the other two control coils to produce a three-phase rotating field!

So from this first experiment, I learned that by using sharp ‘kick’ potentials, it is possible to pulse a coil into resonance using little to no extra power from the driving circuit. The final amplitude appears to be a function of the rising and falling edges of the impulse that induces the effect. The higher the pulse voltage, the better!

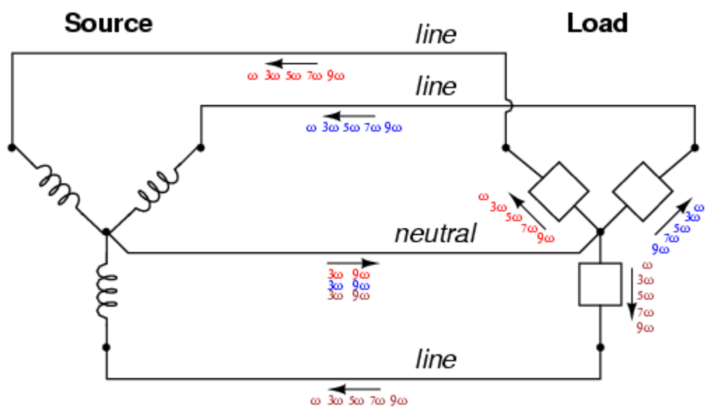
This answered my question about how the many little kicks combine into one big kick (resonance), but what about the out of phase transformers and the harmonics?? Now we can make a nice smooth rotating field virtually for free, but how does this other information fit in?

For the answer to this, I make reference to the following two articles from http://www.allaboutcircuits.com. The first article is called “Harmonics in Polyphase Systems” and the second article is titled “Harmonic phase sequences.” Here are the links to both below:

http://www.allaboutcircuits.com/vol_2/chpt_10/7.html
http://www.allaboutcircuits.com/vol_2/chpt_10/8.html

Please read these first before continuing onto the rest of this article as I will make references to specific information from the above sources.

Below are some highlights from the first article that I want to turn your attention to.



*"What should be surprising here is the analysis for the **neutral conductor's current**, as determined by the voltage drop across the $R_{neutral}$ resistor between SPICE nodes 0 and 7. (Figure above) In a **balanced** 3-phase Y load, we would expect the neutral current to be **zero**. Each phase current -- which by itself would go through the neutral wire back to the supplying phase on the source Y -- should cancel each other in regard to the neutral conductor because they're all the same magnitude and all shifted 120° apart. In a system with no harmonic currents, this is what happens, leaving zero current through the neutral conductor. However, we cannot say the same for harmonic currents in the same system.*

*Note that the fundamental frequency (60 Hz, or the 1st harmonic) current is virtually absent from the neutral conductor. Our Fourier analysis shows only 0.4337 µA of 1st harmonic when reading voltage across $R_{neutral}$. The same may be said about the 5th and 7th harmonics, both of those currents having negligible magnitude. In contrast, the 3rd and 9th harmonics are strongly represented within the **neutral conductor**, with 149.3 mA (1.493E-01 volts across 1 Ω) each! This is very nearly 150 mA, or three times the current sources' values, individually. With three sources per harmonic frequency in the load, it appears our 3rd and 9th harmonic currents in each phase are adding to form the **neutral current**."*

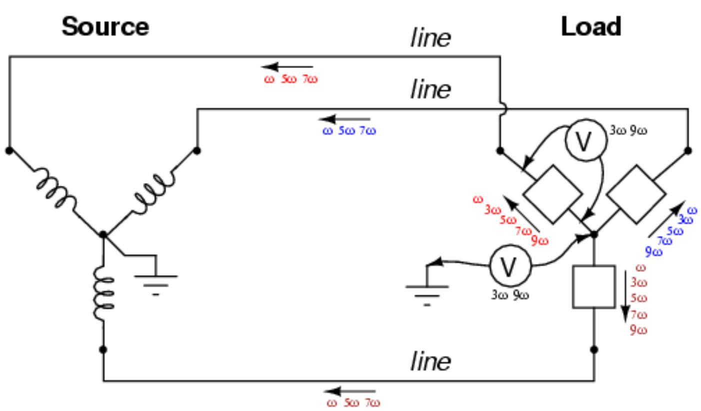
AND….

*"Due to their abundance and significance in three-phase power systems, the 3rd harmonic and its multiples have their own special name: **triplen harmonics**. All triplen harmonics add with each other in the **neutral conductor** of a 4-wire Y-connected load. In power systems containing substantial nonlinear loading, the triplen harmonic currents may be of great enough magnitude to cause neutral conductors to **overheat**. This is very problematic, as other safety concerns prohibit neutral conductors from having overcurrent protection, and thus there is no provision for automatic interruption of these **high currents**."*

OK, can anyone see where I am going with this!? I believe that it is these **Triplen Harmonics** showing up in the three-phase neutral lines that are the source of the anomalous energy output! Even the author admits that these currents are "strange" and explains that people try their best to kill them! But the fact is that these harmonics are producing power and lots of it apparently if it is enough to overheat and burn out the otherwise neutral line of the system!

Now for this next point, envision the three-phase Y connection as the three control coils for a TPU and see what they say happens if we cut the ground line…

Here's another diagram again for reference:



*"Strange things are happening, indeed. First, we see that the triplen harmonic currents (3rd and 9th) all but disappear in the lines connecting load to source. The 5th and 7th harmonic currents are present at their normal levels (approximately 50 mA), but the 3rd and 9th harmonic currents are of negligible magnitude. Second, we see that there is <u>substantial harmonic voltage between the two "Y" center-points, between which the neutral conductor used to connect</u>. According to SPICE, there is **50 volts** of both **3rd** and **9th** harmonic frequency between these two points, which is definitely <u>not normal in a linear (no harmonics), balanced Y system</u>. Finally, the voltage as measured across one of the load's phases (between nodes 8 and 7 in the SPICE analysis) likewise shows strong triplen harmonic voltages of 50 volts each."*

So we can see that leaving the three control coils <u>floating</u> between each other increases the triplen harmonics that appear even more! What this all adds up to is a large potential difference building up in the TPU which will create a stronger and stronger field <u>the closer you get to the harmonic resonant frequencies of the system.</u>

Now, this is all good, but guess what? The harmonics also do something else in addition to strengthening the field. They add rotation to the field!

Check out this quote from the second link I posted:

"If we extend the mathematical table to include higher odd-numbered harmonics, we will notice an interesting pattern develop with regard to the rotation or sequence of the harmonic frequencies:

Fundamental	**A** 0°	**B** 120°	**C** 240°	**A-B-C**
3rd harmonic	**A'** 3 x 0° (0°)	**B'** 3 x 120° (360° = 0°)	**C'** 3 x 240° (720° = 0°)	*no rotation*
5th harmonic	**A''** 5 x 0° (0°)	**B''** 5 x 120° (600° – 720° - 120°) (-120°)	**C''** 5 x 240° (1200° – 1440° - 240°) (-240°)	**C-B-A**
7th harmonic	**A'''** 7 x 0° (0°)	**B'''** 7 x 120° (840° – 720° + 120°) (120°)	**C'''** 7 x 240° (1680° – 1440° + 240°) (240°)	**A-B-C**
9th harmonic	**A''''** 9 x 0° (0°)	**B''''** 9 x 120° (1080° = 0°)	**C''''** 9 x 240° (2160° = 0°)	*no rotation*

Harmonics such as the 7th, which "rotate" with the same sequence as the fundamental, are called positive sequence. Harmonics such as the 5th, which "rotate" in the opposite sequence as the fundamental, are called negative sequence. Triplen harmonics (3rd and 9th shown in this table) which don't "rotate" at all because they're in phase with each other, are called zero sequence.

This pattern of positive-zero-negative-positive continues indefinitely for all odd-numbered harmonics, lending itself to expression in a table like this:"

Rotation sequences according to harmonic number

+	1st	7th	13th	19th	← Rotates with fundamental
0	3rd	9th	15th	21st	← Does not rotate
-	5th	11th	17th	23rd	← Rotates against fundamental

The first point I want to make here is that we are literally creating fields that will rotate with and against each other at harmonic speeds of the original! Remember this quote from Steven Mark?

*"Rotation of field. . . How many people think about that? If you could have a field that you could think of as a big ball, and you could **rotate it in two directions**, what would the ramifications be?"*

Steven's "big ball" analogy could possibly mean that two of the three rotating magnetic fields are rotating against each other.

However, there is still one unanswered question left to tackle. If the TPU will make harmonics simply by applying the pulses in a three-phase fashion, then why do we need to input harmonics into the system? If you remember the article, it states that the 3rd and 9th harmonics (which are stationary) are the strongest, while the 5th and 7th harmonics (which rotate) are the weaker ones that show up naturally. So… If we want to intentionally make these weaker harmonics show up, we simply apply pulses at those two frequencies into the coil. This will strengthen the harmonic rotating fields (if that is what we want to do), But then again, if we simply want to strengthen the stationary harmonics, we can input the 3rd and 9th harmonic frequencies. But either way, this definitely offers a lot of freedom for experimentation.

In Summary

1. By using sharp, high voltage impulses, it is possible to stimulate a coil into resonance using one-wire and virtually no power consumption.

2. If we connect three of these open-ended control coils together in a Y-configuration and send three-phase pulses into the other ends, we can produce **Triplen Harmonics** at the neutral point where the three connect.

3. This effect is enhanced even more if the Y-connection is left ungrounded.

4. The most significant harmonics that show up in the system are odd (3^{rd}, 5^{th}, 7^{th}, 9^{th} etc…).

5. The 3^{rd} and 9^{th} harmonics are stationary and add to each other to form the current at the Neutral point while the 5^{th} and 7^{th} harmonics rotate with and against the fundamental frequency.

6. Once properly tuned to Harmonic Resonance, it may be possible to extract large sums of energy from the collector coil.

Quote From Steven:

"If you know how to find the circuit potential, tune into the frequency, and you have enough short pieces of wire, you can convert as much power as you wish in a given space."