One of our recent tinaja quest winners was D.C. Cox from Resonance Research. This firm is the leading supplier for the bigger Tesla coils and Van De Graff generators you find in science centers, museums, and planetariums.

He is also newly offering his free do-it-yourself reprint on building up your own smaller Tesla machine.

Thoughts on Tesla Coils

A Tesla coil is nothing but a huge resonant transformer. One intended to make high voltage, high frequency electricity. Otherwise known as "lots of sparks". Sparks which literally can stand your hair on end. Or light up an unconnected fluorescent tube you are holding in your hand.

The key secret to Tesla coil design is a quite high Q air core transformer having precisely the right amount of input source coupling. The resonance buildup does a "Q-multiplier" effect to generate the high voltage.

The ultra high voltages are usually safe because they are high frequency alternating current. That skin effect tells us that ac currents travel only on the outside of conductors. The higher the frequency, the less will be your skin effect depth. The output from a Tesla coil can often be routed along a person (or a chain of people) without significant shock hazards.

Amazingly, most of the Resonance Research machines still use a spark gap for their input switching. Above a certain power level, spark gaps still do have compelling advantages over tubes or solid state devices.

Needless to say, a Tesla coil is one really horrendous generator of radio frequency interference. These can be a most blatant violator of FCC Part 15 regs. All Tesla coils are illegal.

There are several persistent urban lore type myths that Tesla coils are in some manner a "suppressed" or "lost" source of "free energy".

The original myth can be traced to one of two sources: Either his really bad misunderstanding of differences between resonance stored energy and source converted energy. Or as something between too much hype and an outright scam involved in seeking lab funding.

Do careful and objective research and you will discover there is not one shred of either actual or theoretical evidence that this sort of hogwash is even remotely possible.

Tesla coils are closely related to color tv flyback transformers and to all the UHV ultra high voltage power line transmission research. In spite of countless hours of formal research in these fields, not the least hint of any over unity energy has emerged.

Another good source for hands-on Tesla stuff is Lindsay Publications. The Tesla Bookstore is another useful resource. But you'll be way better off limiting your readings to those books and the reprints by Tesla, rather than errant ramblings about him.

If you really want to get into all of the free energy Tesla hogwash, check High Energy Enterprises, or else that International Association for New Science, that International Guild of Advanced Science, or Borderlands.

Check out that KeelyNet BBS for a mesmerizingly outrageous source for late-breaking pseudoscience info.

And, of course, for a back-to-earth reality check, be certain to read the
A three phase delta load is normally driven by three "half bridge" drivers. These usually require a total of six power switching devices...

When using digitally switched unipolar inputs, there are only eight possible bipolar motor winding current results...

Just as there are delta-wye transforms, we can list these eight pairs of unipolar delta input to bipolar motor coil forward and reverse transforms...

Further analysis easily proves that any motor winding magic sinewave bit sequence which has a zero third harmonic will end up fully delta friendly.

Fig. 2 – THREE PHASE "DELTA FRIENDLY" magic sinewaves require only simple input switches. Yet they produce positive, negative, or zero winding currents. Provided you use carefully chosen sequential commands.

Skeptical Inquirer instead.

I’ve been thinking about gathering all my pseudoscience info into a new book. Give me a call if you have any interest in this.

Watch that Q!

A recent caller had a brilliant but flawed idea on how to simplify his Tesla coil. He wanted to use a Slinky for his main coil. Eliminating most of those messy winding hassles.

The only tiny oint in the flyment is that Tesla coils must be high Q and nearly lossless. A steel Slinky won’t hack it. But a gold plated one or a beryllium copper version may work.

In another time, long ago and far away, this student came to me hours before his Theremin project was due for a course final show-and-tell. The bright silver colored coils sure were pretty. It seems that the story he was copying clearly said to use #30 wire in his oscillator coils. While he found lots of #28 and #34 copper wire, the only #30 he could find seemed to be made from Nichrome.

Three Phase Power Basics

Most of your utility electricity gets generated as three phase power. And pretty near all larger industrial and ag motors are three phase.

Ever wonder why? Figure one shows us a three phase waveform. Three windings get spaced out 120 degrees around a generator’s stator. Thus producing three identical sinewave waveforms whose electrical phase is also 120 degrees.

Your first great advantage of three phase is that all three phase power is continuous. Go through the math, and you’ll find that the instantaneous sum of the power on all three phases will always add to the same value.

In a single phase system, there are times when very little power is being delivered to you. Other times, much more than average is delivered. Thus, three phase power is more efficient and has lower line losses.

Three phase motors also start a lot easier than single phase ones. Most of them are easily reversed, simply by swapping phases. Because of the continuous power, most vibration and noise can end up a lot lower.

Three phase power sources can be easily rectified for dc. Your ripple is much lower and the ripple frequency is way higher. Which is one of many reasons that a car alternator is a three phase ac generator.

It turns out there are two standard ways of connecting a transformer or motor or whatever to any three phase power line. With a delta connection, one winding goes between phases a and b. A second goes between phases b and c. And the last one routes from phases c and a.

In the wye connection, one end of each motor winding gets connected together. And usually brought out to a fourth line called a safety neutral. The free end of each winding will get connected to phase a, b, or c.

Under balanced loading, you have a safety neutral current of zero. Even with some major unbalance, the safety neutral current still stays low.

Delta and wye both feature unique advantages and disadvantages. Both do see a lot of use. Note that voltages are 1.732 times higher in wyes and currents are 1.732 times higher in deltas. With 1.732 being the square root of three.

Thus, you could easily overload or underpower any load by making your incorrect choice of delta or wye. But that’s what power engineering is all about in the first place.

It is simple to show that any delta has a wye equivalent. And vice versa.
This is called a delta-wye transform or else a wye-delta transform. I have also shown these in figure one.

Your major disadvantage of three phase power is that three times the wiring is needed, combined with far more expensive switches.

Plus, you need three times as many transformers. Thus, single phase gets used for home, shop, and other "low power" uses. While the advantages of three phase power are reserved for the industrial and ag users.

Much more on three phase in any college power textbook. Such as my utterly ancient favorites of Skilling’s Electrical Engineering Circuits or Fitzgerald and Kingsley’s Electrical Machinery.

Three Phase Magic Sinewaves

As all you regular readers already know, I have been doing bunches of unique magic sinewave research. Magic sinewaves are rather carefully chosen and ultra long sequences of repeating ones and zeros. Sinewaves of precisely controlled amplitude and amazingly low distortion.

Compared to classic PWM, these brand new magic sinewaves can offer elegant simplicity along with superb efficiency. For such diverse apps as induction motor speed controls, solar panel inverters, electric auto drives, power factor correctors, home energy efficiency improvers, or for reliable uninterruptible power supplies.

A participant at one of our magic sinewave seminars did ask me a very embarrassing question, though. A real scary back-to-the-drawing-board one: "How can magic sinewaves get used with three phase loads that use only half bridge drivers?"

The original magic sinewaves used individual "H-bridge" drivers. These needed access to both ends of each winding phase. For the three winding currents of (+), (0), or (-).

All of which is just fine for single and two-phase users. But in the real world of big time three phase power, we rarely have access to both ends of each winding. Especially doing some of precisely controlled amplitude and repeating ones and zeros. Sinewaves of normally equal and ultra long sequences of repeating ones and zeros. Choosing the more interesting examples.

Thus, to be three phase friendly, a magic sinewave's length should be a multiple of three. Such that our three phases happen on bit boundaries. For simplicity and compact files, we’d also want a multiple of four. For that way, we’ll need only work with and store one of four quadrants.

Next for something a tad subtle: Another factor of eight sure would be nice. But in the real world of big time three phase power, we rarely have access to both ends of each winding. Especially doing some upgrade or retrofit. And we’d sure like to get by using a mere six active power devices. Instead of the twelve the full H-bridge route needs.

Well, for openers, the length of our magic sinewave sequence should be a multiple of three. Such that our three phases happen on bit boundaries. For simplicity and compact files, we’d also want a multiple of four. For that way, we’ll need only work with and store one of four quadrants.

Here are three of the more interesting examples.

<table>
<thead>
<tr>
<th>Hexadecimal</th>
<th>Fundamental Amplitude</th>
<th>Distortion 3-17</th>
<th>Transitions</th>
<th>Filter:</th>
<th>Relative Harmonics 3 through 17</th>
</tr>
</thead>
<tbody>
<tr>
<td>$8122B36E7EF</td>
<td>0.866208</td>
<td>0.00739%</td>
<td>22</td>
<td>secondorder2.0</td>
<td>0.0, -0.000591363, -0.00042485, 0.0</td>
</tr>
<tr>
<td>$203153B3EDFB</td>
<td>0.814612</td>
<td>0.0445%</td>
<td>21</td>
<td>secondorder2.0</td>
<td>0.0, 0.00053564, 0.00052628, 0.0</td>
</tr>
<tr>
<td>$20261AD3EB7E</td>
<td>0.781196</td>
<td>0.0739%</td>
<td>22</td>
<td>secondorder2.0</td>
<td>0.0, -0.000198935, -0.000186813, 0.0</td>
</tr>
</tbody>
</table>

Fig. 3 OF THE 281,474,976,710,656 possible 192-bit quadrant symmetric magic sinewaves, a scant 43,046,721 end up three-phase "delta friendly". Here are three of the more interesting examples.

<table>
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</table>

Fig. 4 CORRECTED VERSION OF the PIC time delay generator.
What do we have to do beyond this to also become what I will call being delta friendly?

The delta friendly sinewave needs only three leads. And each of those leads need only get connected to a positive supply or ground. Figure two should get us started.

With simple SPDT or "half bridge" drivers on each line, there are only eight possibilities here. Namely, the binary combinations of 000, 001, 010, 011, 100, 101, 110, and 111. We might define a "clockwise" winding current as (+) and "counterclockwise" as (-).

We immediately see that the eight combinations can give us our choice of (+), (0), or (-) currents.

Now for the tricky part: For all of your possible input combinations, the winding currents always must sum to zero! You could have zero current on all three windings (cases 000 or 111). Or have zero current on one winding, positive current on one, and negative current on one (as in cases 001, 010, 011, 100, 101, 110).

Next, think about this really hairy concept: Not only do winding states a, b, and c have to occur together, but state b will occur in data stream a at one third of the way through the time sequence, and state c also happens in data stream a at two thirds of the way through the time sequence!

We already do know that our three states must sum to zero. But this also newly tells us that the three states are bits that are separated by one-third of their cycle distance in each sinewave sequence. Thus, the one-third spaced bits must also sum to zero.

Which tells us that a delta friendly magic sinewave must have a forced zero third harmonic!

And that is all there is to it. To be both three phase friendly and delta friendly, just select 96-bit multiple magic sinewaves that have their third harmonic forced to zero.

Most power books also tell us that there can be no third harmonic line current on any delta connected three phase load. Sort of an independent check on what we’ve discovered.

Several examples of 192 bit delta friendly magic sinewaves are shown in figure three.

You will find vastly more magic sinewaves than there are particles in the galaxy. Untold zillions versus a mere 10^70. So finding the good ones gets real tricky. Indeed, there are lots and lots of highly useful and delta friendly magic sinewaves. But magic sinewaves that are not delta friendly might perform better.

Just as there are delta-to-wye and wye-to-delta transforms, there’s also simple math which gets you from the “positive-ground-negative” winding currents to the "positive-ground" line currents. I’ve also shown these back in figure two.

When you want zero current on all three windings at once, you’ll have your choice of using 000 or 111 input states. At first glance, either would work just fine. But it turns out one or the other might be more efficient and needs fewer transitions.

For instance, if your previous state was 000 and your next state was 010, use of a 000 would require only one transition. But use of 111 would need five transitions instead.

Obviously, you pick the one with the fewest transitions. Because fewer switchings certainly means less high frequency losses. And usually means higher efficiency. Sometimes a 000 is clearly better. Other times, 111 is the only way to go. Other times (such as a previous 010 and a following 101), it doesn’t matter at all.

The bottom line: Magic sinewaves work just fine with half bridge delta drives. So long as you use only those which include (A) a forced zero third harmonic, and (B) bit lengths that are an integer multiple of 96.

As you may have guessed, this is a billion dollar new opportunity that is very much up for grabs. I’ll be happy to send you a free tutorial on magic sinewaves when you call or write.

You can also ask me for a formal proposal that explains in detail our seminars, PIC sourcecode, and the
new partners programs.
Both reprint and proposal are also available at www.tinaja.com

Time Delay Correction

Uh, the neat PIC time delay utility I showed you a few columns back had one bug in it. A PIC spends one cycle if a skip is not taken, and two cycles if an instruction skip is taken.

The corrected version is shown in figure four. Sorry about that.

Professional Audio Resources

I have just picked up a free new subscription to Pro Audio Review. A trade journal that more or less reports what its name implies.

It has detailed reviews of high end amplifiers, mixers, and microphones. For tv, video, CD, and radio.

For this month’s resource sidebar, I’ve tried to gather together some of the other pro audio resources.

A second major magazine is Mix, who also operate an outstanding Mix Bookshelf. Where you will find just about any book on audio.

The leading technical organization is the Audio Engineering Society.

The finest audio pub in the world seems to be that British Studio Sound and Broadcast Engineering.

Let me know if I’ve missed any of your favorites here. A free Incredible Secret Money Machine II if you tell me about any pro audio resource I don’t already know about.

New Tech Lit

A real fine new collection of PIC related data books is now offered by Microchip Technology. These include the PIC 16/17 Microcontroller Data Book; their PIC 16C8X Data Book; PIC 14000 Data Book; a PIC 16C7x
Tech Musings

Data Book; their PIC 16C62X Data Book; ECHV Update I; the MPASM Assembler Guide; Third Party Guide 1996; their Non-Volatile Memory Products Data; Embedded Controller Handbook; Serial EPROM Tutorial Series I-III; the Development Systems Ordering Guide; BBS System User’s Guide; MPSIM Users Guide; and the HCS300 Data Book.

Their PIC, of course, is the finest microcontroller. Nothing else comes remotely close. Other PIC resources include Scott Edwards Electronics, and the superb Basic Stamp products offered by Parallax.

A unique collection of PC-related books is offered by Coriolis Books.

A new CD Roms in Print 1996 is freshly offered by Gale Research. It reviews over 9000 titles.

Free copies of Acrobat Reader 3.1 are downloadable at www.adobe.com. This wonderment lets you view full technical reprints on line. Part of it plugs into Netscape Gold. Which you can find at netscape.com.

I often like to check out the hobby and craft catalogs. These can be a great source for products and ideas. One example is the Source Place for Creative Living "owner’s manual" by Loose Ends. Mostly on unusual handmade papers. Another is the Wood Parts Catalog from Lin-Wood. Who do make a bewildering array of small wooden items.

Or, just because it is there I guess, the neat free Things You Never Knew Existed catalog from Johnson Smith.

For typical individuals and small scale startups most of the time, any involvement whatsoever with patents is absolutely certain to turn into a net loss of your time, energy, money, and sanity. You find out why in my Case Against Patents package. It includes proven real world alternatives.

See my nearby Synergetics ad for more details. I’ve also got some great deals on Tek 1230A logic analyzers left over from my school buyout.

I’m still building my web site at www.tinaja.com. Eventually, globally searchable reprints for my previous columns should be available here.

Check this one out.

As usual, a no-charge tech helpline and online access is available per the Need Help box. Most of the resources mentioned appear in our Names and Numbers or Pro Audio sidebars.

Let’s hear from you. ✪