ExtraOrdinary Conference 2019

The “REAL” Tesla Electric Car Motor
(Part 3)

Mike Gamble

8/10/19

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For those of you that haven’t met me, I am Mike Gamble a retired electrical engineer; put in 30 years at (BR&T) Boeing Research and Technology (Seattle, Wa) where I ran an R&D Lab building all kinds of fun stuff. Would like to thank the conference chair (Steve) for having me back to talk more about Tesla’s resonate electric car motor.

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INTRODUCTION

This (Part 3) presentation of "TESLA'S ELECTRIC CAR MOTOR" is a continuation of my Tesla resonate motor research.

Part-1 Reverse engineered and confirmed Tesla's basic design.

Part-2 Concentrated on improving the system efficiency using a "Series Resonator".

Part-3 Continues using "Dual Resonators".

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HISTORICAL REVIEW (Part 1,2)

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For those of you that did not see the (Part-1,2) presentations; will start with a quick review so everyone is on the same page.

COFE8 (Part 1)

Conference On Future Energy

"Electrical power is everywhere present in unlimited quantities and can drive the world's machinery without the need for coal, oil or gas" – Nikola Tesla, 1892

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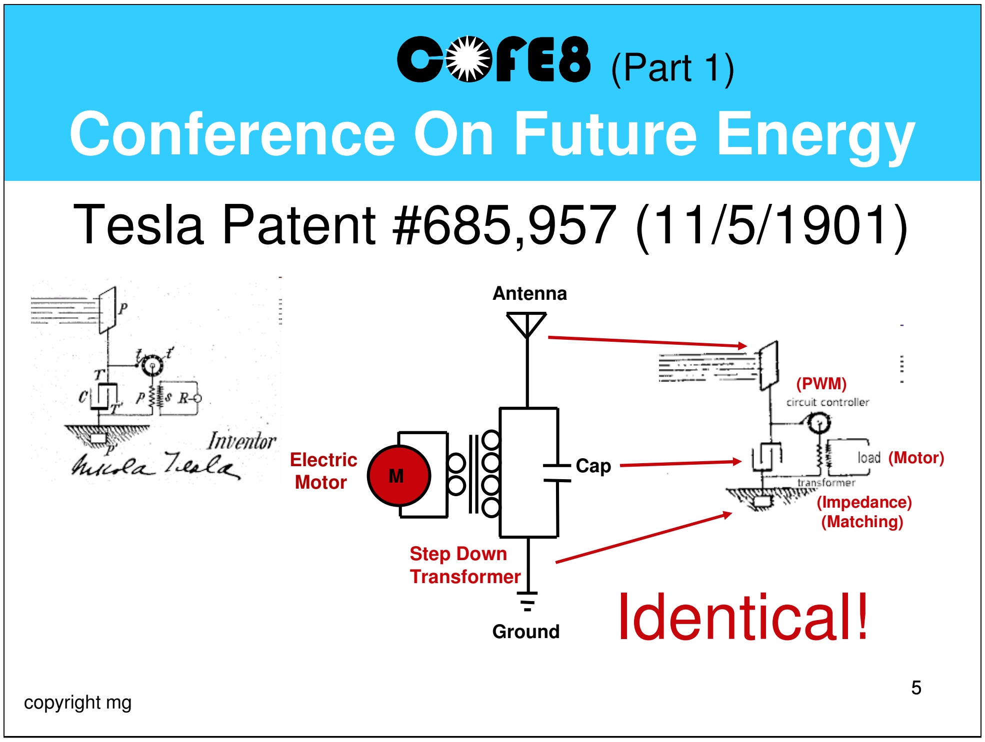
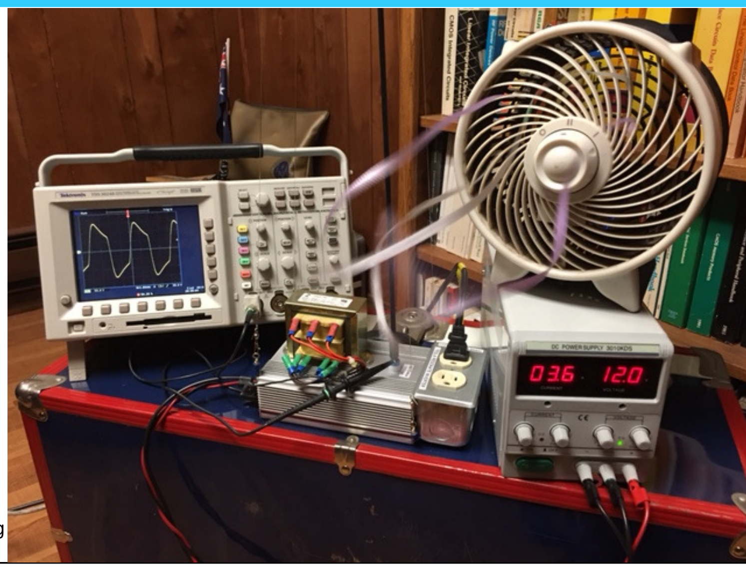
If you haven't heard the stories; It's rumored in books and on the web that Tesla built and drove an electric powered Pierce-Arrow car back in the early 1930s. In (part 1) I started by taking a few of those stories from the web and analyzing them to see if there was any truth in them and to correlate such data to see if it even came close to a "real" motor design. After building and testing a working demo model will state that Tesla's design is VALID!



This chart shows the schematics of Tesla's original patented resonate electrical device. The only difference between the reverse engineered one and Tesla's design is the nomenclature! The symbols and part names are different (antenna/ground, condenser/capacitor, interrupter/PWM chopper).

COFE8 (Part 1)

Conference On Future Energy



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This picture is a close up view of the running (part 1) demo model. Note: the AC wave shape and input power readings of 12V @ 3.6A.

COFE8 (Part 1)

Conference On Future Energy

Demo (Fan) Motor Conclusions

1) Demo **PROVES** an induction motor can run off a resonate power system
2) The (first cut) demo design showed only a small resonate current gain (low Q= 1.6)
3) which just about equals the inverter (losses) inefficiencies (89% circuit, 93% transformer)
4) Not enough resonate gain (Q) to achieve “standalone” operation
5) Need an inductor with a higher Q factor (Q= 5-10) and
6) Need a better tuned antenna (loading)
7) However, the demo **PROVES** Tesla’s resonate design was **VALID** (real) he did not break any electrical rules (no black boxes or black magic)!
8) Based on this research, my engineering experience, a working demo model and the many rumored accounts; would have to conclude Tesla **“ACTUALLY”** built and drove an electric powered Pierce-Arrow!

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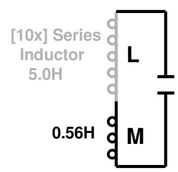
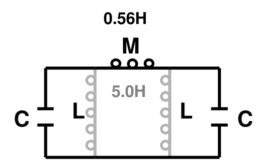
TeslaTech

1) **TWO (2) WAYS TO INCREASE THE RESONANCE "Q"**
   a) **Add a bigger [10x] inductor in series with the load (motor)**
   b) **Move the load (motor) out of the resonate circuit**



a) Series Inductor



b) Dual Resonators

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The (part 2) DESIGN GOAL 1: This chart shows two different ways to increase the resonance "Q" factor. Figure A) adds a large (10x) inductor in series with the load (motor). This increases the reactive component without significantly increasing the real resistance. Figure B) moves the load (motor) out of the resonate circuit. This reduces the real resistance without significantly reducing the reactive component. The motor current now becomes the input current of both resonate circuits.

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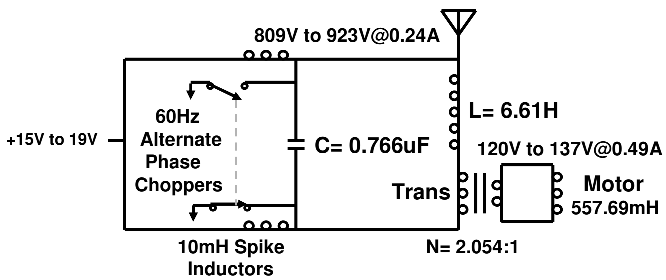
SERIES INDUCTOR "RUNNING" SYSTEM BLOCK DIAGRAM

MODs - Increased Input Voltage



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Block diagram of the "running" series inductor resonate system. Upon building and running the circuit it required an increased input voltage of 19Vdc to get the correct AC motor operation. This was higher than the calculated 15Vdc input as the output resonate wave shape is not a perfect 120V sine wave along with chopper power losses.

TeslaTech

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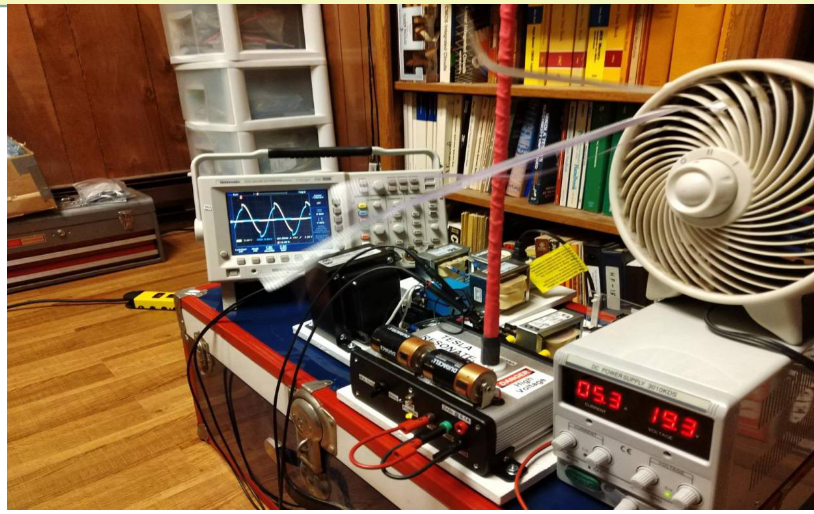

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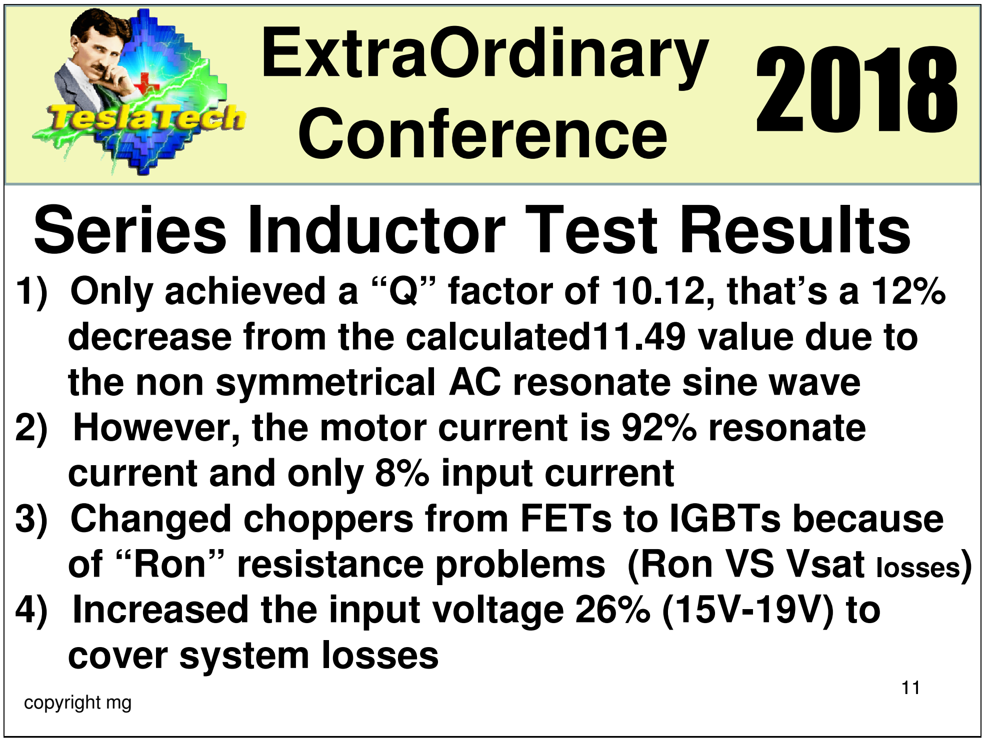
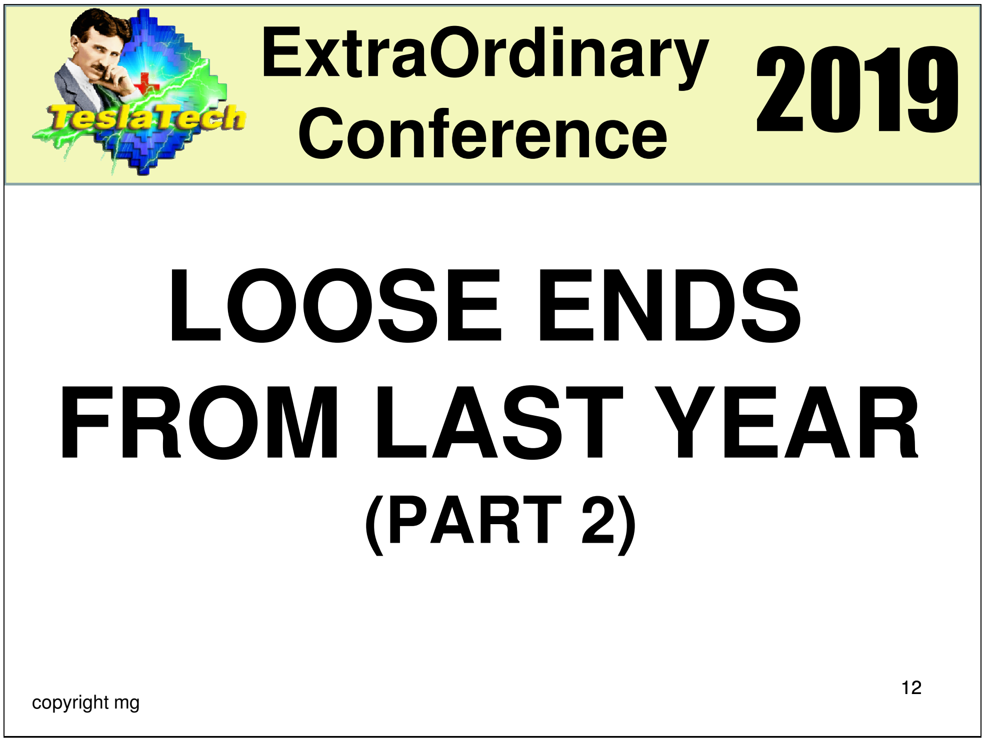
Close-Up View of the Running Demo Model

This picture is a close up view of the running (part 2) demo model. Note: the spiked AC wave shape and input power reading of 19.3V @ 5.3A.



The test results of the series inductor method:

1) Only achieved a “Q” factor of 10.12, that’s a 12% decrease from the calculated 11.49 value due to the non symmetrical AC resonate sine wave
2) However, the motor current is 92% resonate current and only 8% input current
3) Changed the choppers from FETs to IGBTs because of “Ron” resistance problems (Ron VS Vsat losses)
4) Increased the input voltage 26% (15V-19V) to cover system losses



Next we have a few loose ends from last year’s (part 2) presentation to discuss before proceeding to the (Part 3) design.

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FIFTH: TESLA PIERCE ARROW ELECTRIC CAR MOTOR STORY

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The first item; in surfing the web I found another (fifth) Tesla car story which gives more details and a block diagram.

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This is a crude block diagram of the Tesla device.... it's all I can remember these days so it is lacking important details that can be duplicated by an enterprising garage inventor. The main thing is that Tesla used a transmitter and not a receiver... his transmitter resembled a **Super Heterodyne system**; but, the difference is that each 6 tube assembly of the 12 tube total system [if that is really accurate] is for each 12"x12"x6" **reactive cavity** [2'x12"x6" total cabinet dimension making two 12"x12"x6" enclosures that need a **tuning rod that is 3" tall to tune a 6" deep cavity**!] and the propose of them is to provide a 50-100hz boosted oscillations [from the battery power through the tubes] into the mast antenna inductive coil. The invitation excitation comes from the frame reference which is biased to the other 2 phase motor tap. NOTE: the **motor has to be started via a standard electric automotive engine starter** that initially props over the system. All of these functions should be easily reproduced by frequency generators and amplifiers.

When **system is in phase the motor will spool up** until it explodes or melts down. Controlling it [taking them out of phase] is to take one system out of phase via a variable resistor [making it the throttle]. The beauty of this system is that it will always **need constant throttle corrections**; but, used in automotive applications that is done automatically, unconsciously by the operator/driver.

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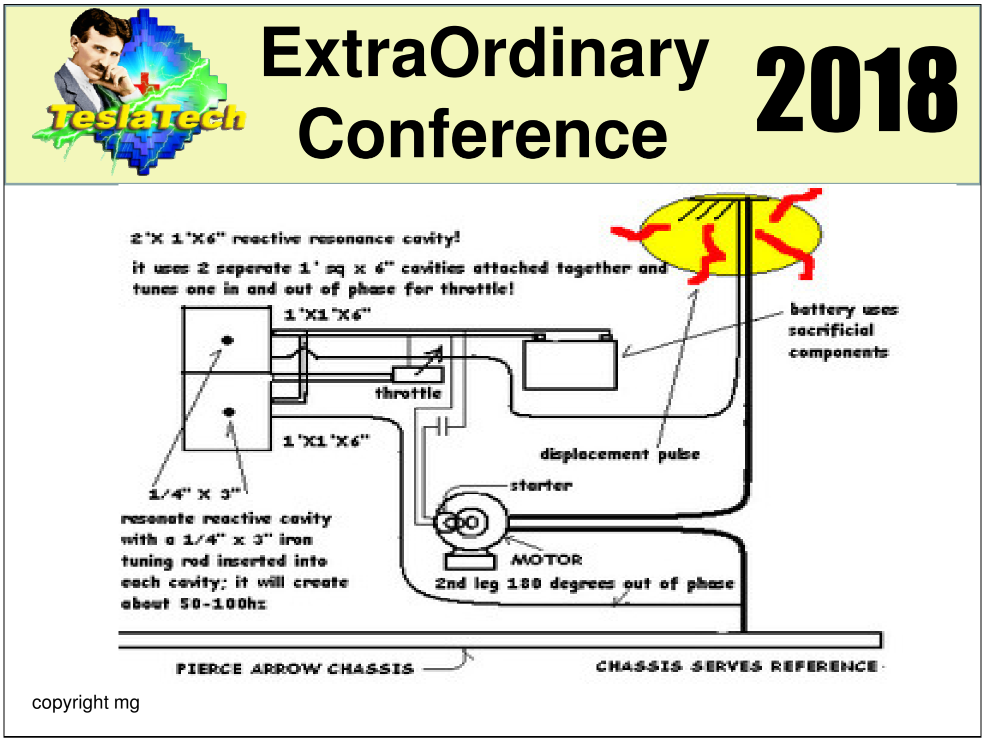
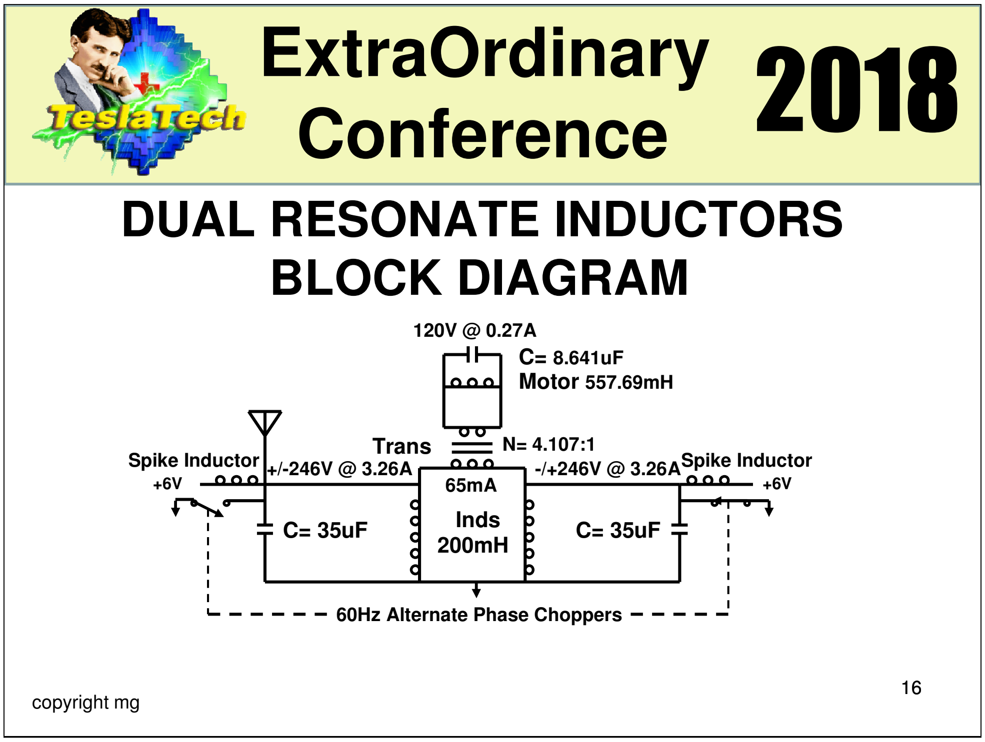
As with the other stories I used the same "red" highlighting format for any relevant technical specs. This fifth "Tesla Car" story gives more technical details.



Moving on to the block diagram it’s very similar to the proposed dual inductor resonate system. As you can see the motor is connected between two resonators with one phase to the antenna and the other phase to the frame (GND) powered from a regular car battery.



Block diagram of the proposed dual resonate inductor system using the 4.107:1 stepdown transformer. Each of the dual resonator circuits only supplies half voltage (246Vac @ 65mA) because the load is shared differentially. Note: The only difference Tesla's is direct drive and this design uses a step down transformer.

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Wikipedia Hoax

The second item; Wikipedia states that all the Tesla Electric Car stories are a hoax.

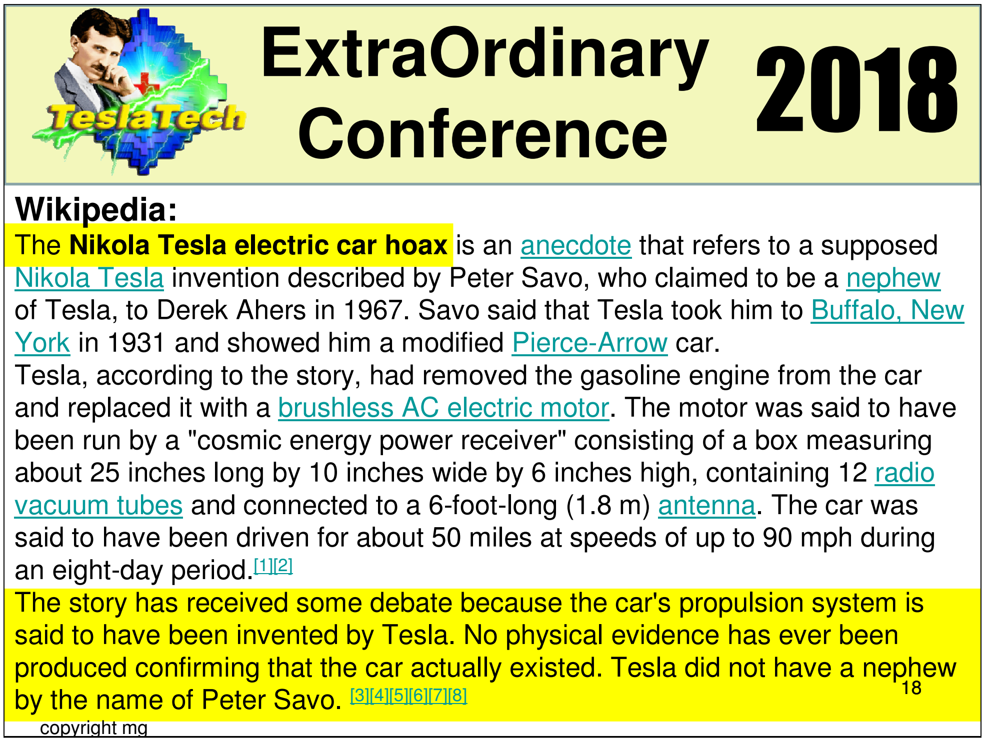
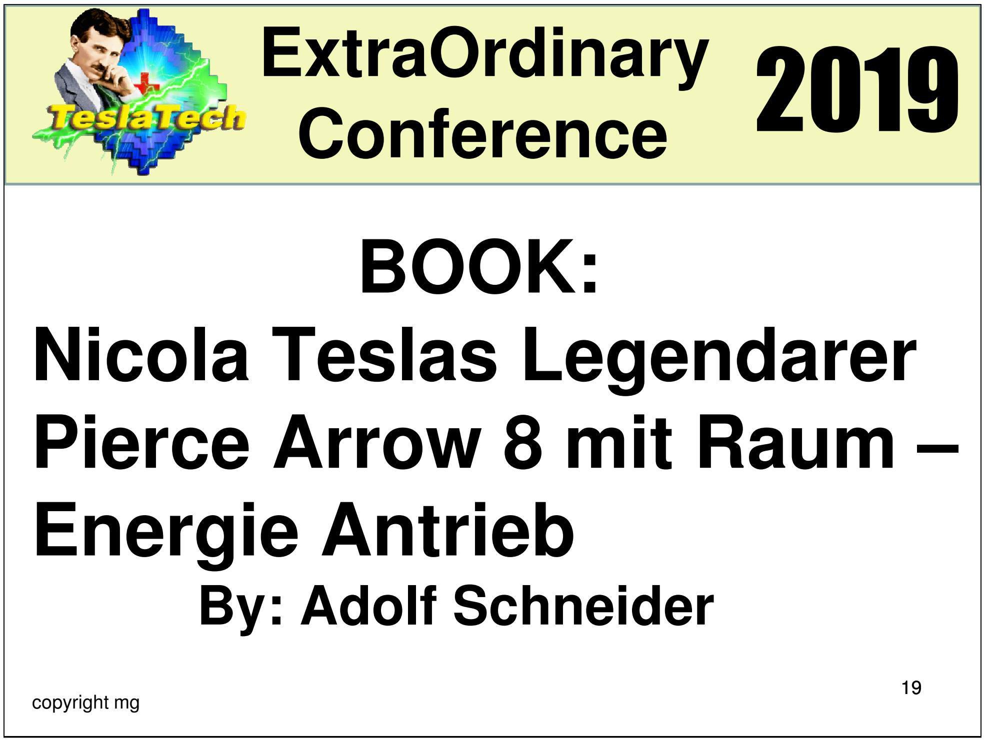


Chart highlighting Wikipedia's claim that the Tesla Electric Car story is a "Hoax". It's based on two points: 1) no physical evidence of the actual car and 2) no documentation of a Peter Savo nephew.



First, I would like to thank Dr. Thorsten Lugwig for sending me this “German” book on Tesla’s Pierce Arrow car by Adolf Schneider. I am happy to know I am not the only person interested in Tesla’s “Electric Car Motor” Design. Will to highlight a few items from this book which are relevant to today’s presentation:

1) I was shocked to see that it included some of my previous charts from my part 1 presentation a couple of years ago! (have to put in a plug) Word sure gets around; this conference defiantly has an international flavor.

2) The book sheds some light on Tesla’s Pierce-Arrow test car.

3) It also gives details on Peter Savo.

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Is the story of Petar Savo or about the Tesla car? (Pg 24)

Wikipedia states that the Tesla car story is undoubtedly a classic "hoax" as "No physical evidence has ever been produced confirming that the car actually existed". Since Wikipedia is based on the generally accepted scientific findings that make an "aether powered" car impossible, nothing else can be expected.

William H Terbo Tesla's grandnephew is completely sure that Tesla did not have a "real" nephew named Petar Savo. By the way, his father Nicholas J Trbojevich had been in constant contact with Tesla; who told him about the existence of the Pierce Arrow test car. He was advised to confirm this to all the people who heard the incredible story!

Despite William H Terbo statement; it cannot be ruled out that Petar Savo may have been a distant relative of Nikola Tesla. It is known, for example, that Tesla's father Milutin had five siblings, three of whom were brothers, hence Tesla's surname. Perhaps also Fanika Tesla, who wrote a letter to Nikola Tesla on June 9, 1931, was a descendant of Tesla's father or sister. **One week earlier, on June 1, 1931, a person by the name of Petar Savo did arrive in New York, which is officially confirmed by a ship's passenger list.**

Petar Savo and the Nikola Tesla family (Pg 25)

Nikola Tesla is the fourth of five children of Serbian parents, an Orthodox priest Milutin Tesla (1819-1879) and his wife Georgina (nickname Djuka, née Mandic, 1822-1892), in the rectory of St. Peter and Paul Church of Smiljan in the Lika shank. As can be seen from the family tree, Petar Savo is not in the direct relationship**. However, he may have been a descendant of one of Nikola Tesla's uncles.**

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At first the "German" was a bit of challenge, but Google translator sorted that out! This is the translated excerpts from pages 24 and 25 of the book. William Terbo (who has spoken at this conference) states that Tesla told his father (Nicholas Trbojevich) about the Pierce-Arrow test car he was working on and to spread the word. Tesla doesn't appear to me to be a PR type salesman; if he said he was working on a car it was fact. Also, the book lists Tesla's family tree and confirms that Petar (Peter) was not Tesla's "real" nephew, but a descendant of one of his uncles and that he actually did come to New York on June 1, 1931. Today we would just call him a "shirt tail relative".

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Gyrators

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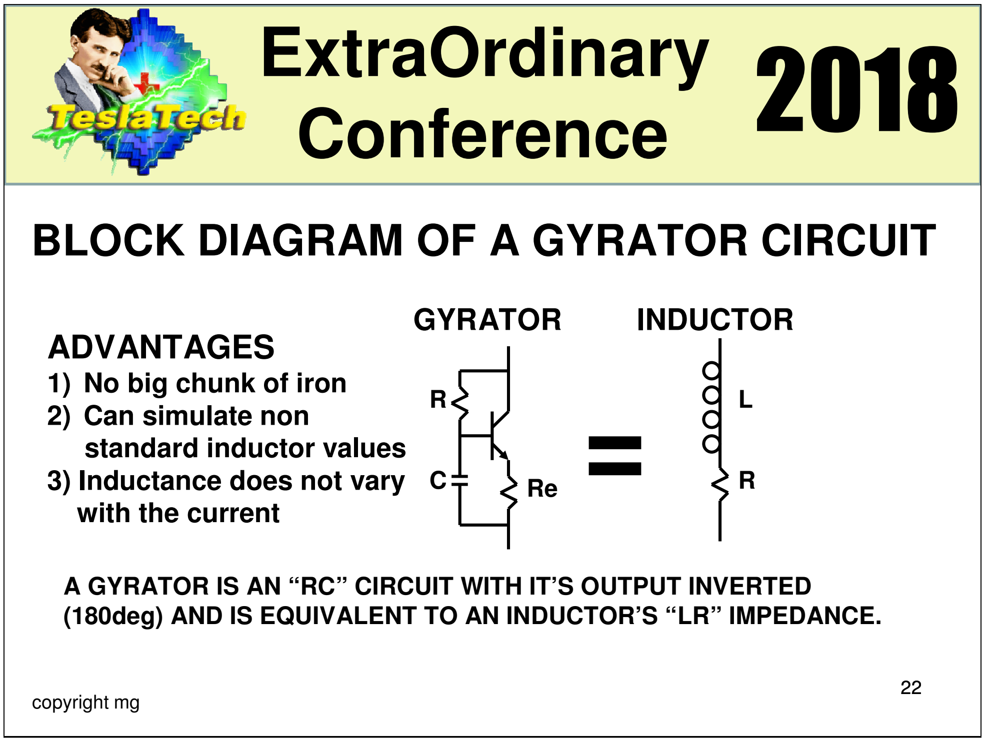
The third item; the topic of Gyrator circuits.



Block diagram of a gyrator circuit which is equivalent to an inductor. By inverting a capacitor's +90deg phase by 180deg it simulates the -90deg phase of an inductor. Also, this circuit has some advantages over "real" fixed inductors (size, weight, cost).

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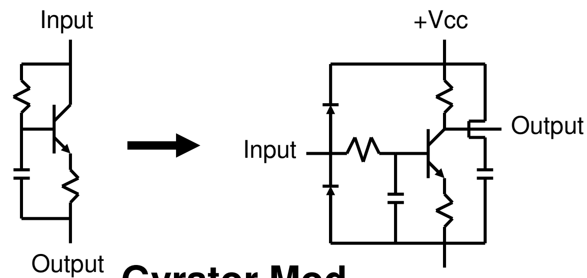
1) The basic (self powered) Gyrator circuit only operates in unipolar mode as the inverting transistor must run as a “Class A” amplifier.
2) A bipolar Gyrator may require (external?) differential (+/- V) power supplies for the transistor to run as a “Class A” amplifier.



Gyrator Mod

 23

This year I built and tested some gyrator circuits and discovered problems.

1) Only work in “Class A” configuration (unipolar)
2) May need external power supply to run in “Class B” configuration (bipolar)

Will need a little more R&D work to get them going. However, I still think they would work better as their specs are more stable. Also, they have a better form factor than “real” iron ones for high current loads.

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MOTOR DATA

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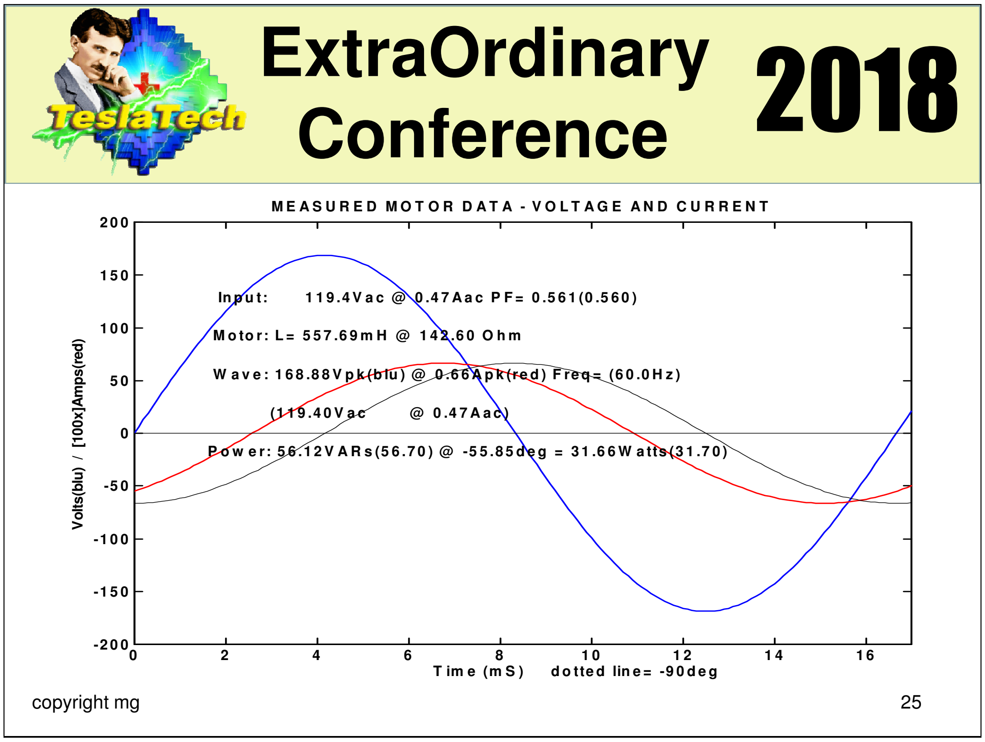
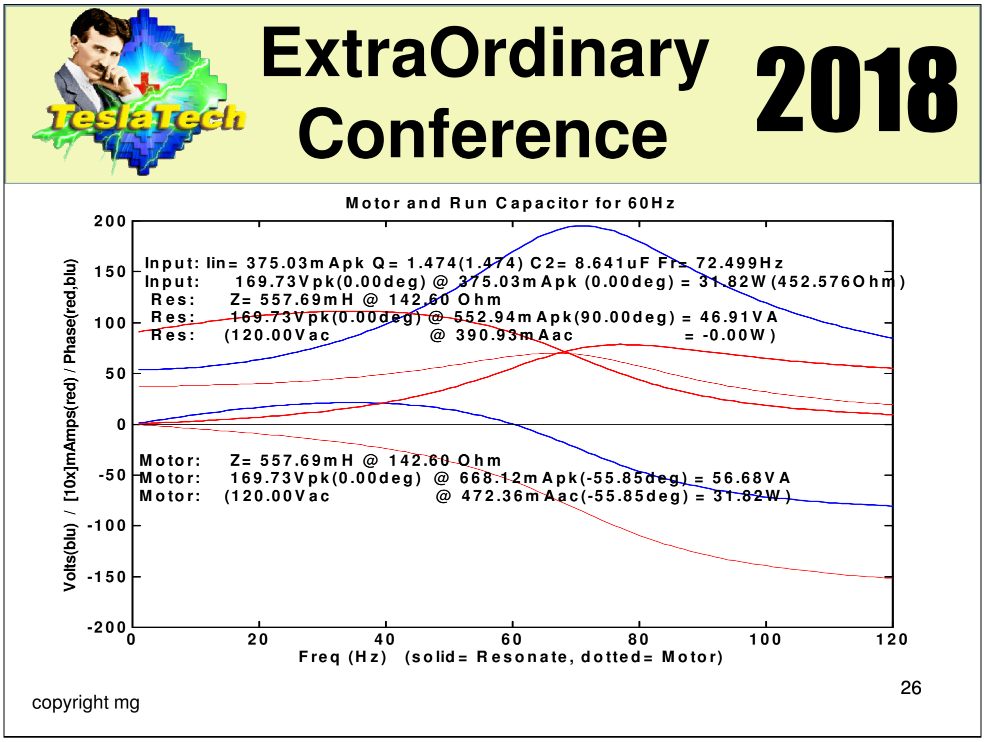
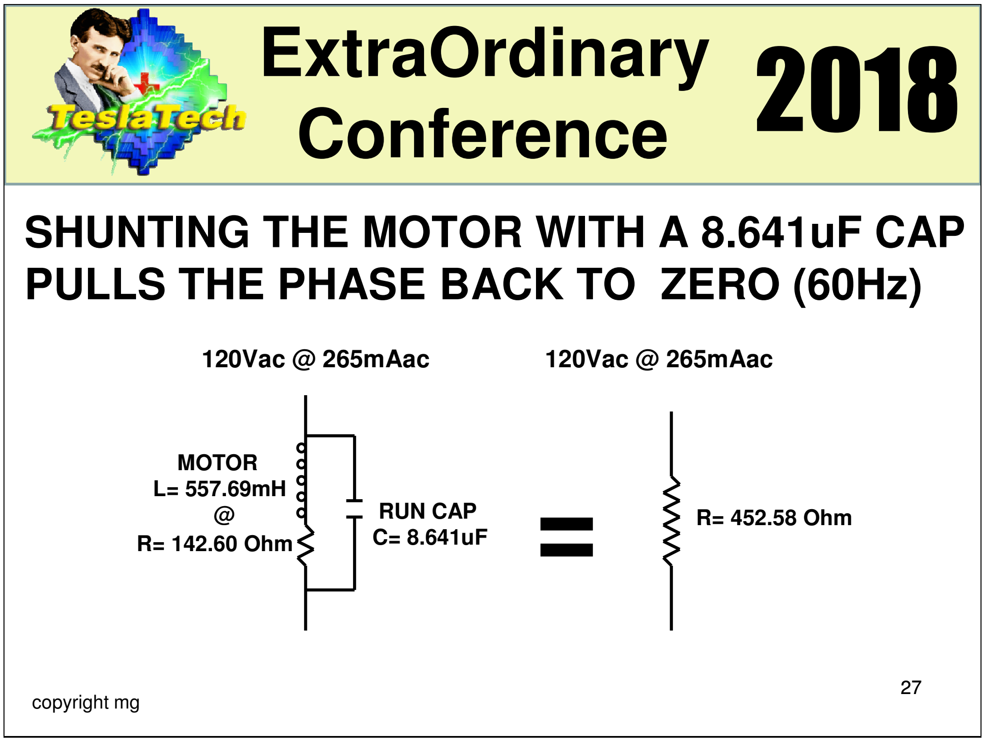
The fourth item; the fan motor data .



This chart shows the MatLab calculations for the motor load impedance (Zm) and phase angle given the measured input voltage and current values. Also, shown is the resonate 90deg phase curve (dotted line); the closer to 90deg the better.



MatLab calculations for the motor and run (shunt) capacitor. The simulation shows that the resonate motor/cap circuit equals the impedance of a fixed resistor at 60Hz – zero phase angle. Note: The resonate freq (72.5Hz) is much higher then the operating freq (60Hz) because of the low “Q factor”.



Block diagram of the motor and shunt (run) capacitor operating at 60Hz is equivalent to a fixed resistor with zero phase angle. The “Dual Inductor” resonate system requires a resistive load; as phase shift in the load decreases resonance.

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PART 3
SECOND METHOD: DUAL INDUCTOR RESONATE SYSTEM

[Detail Design]

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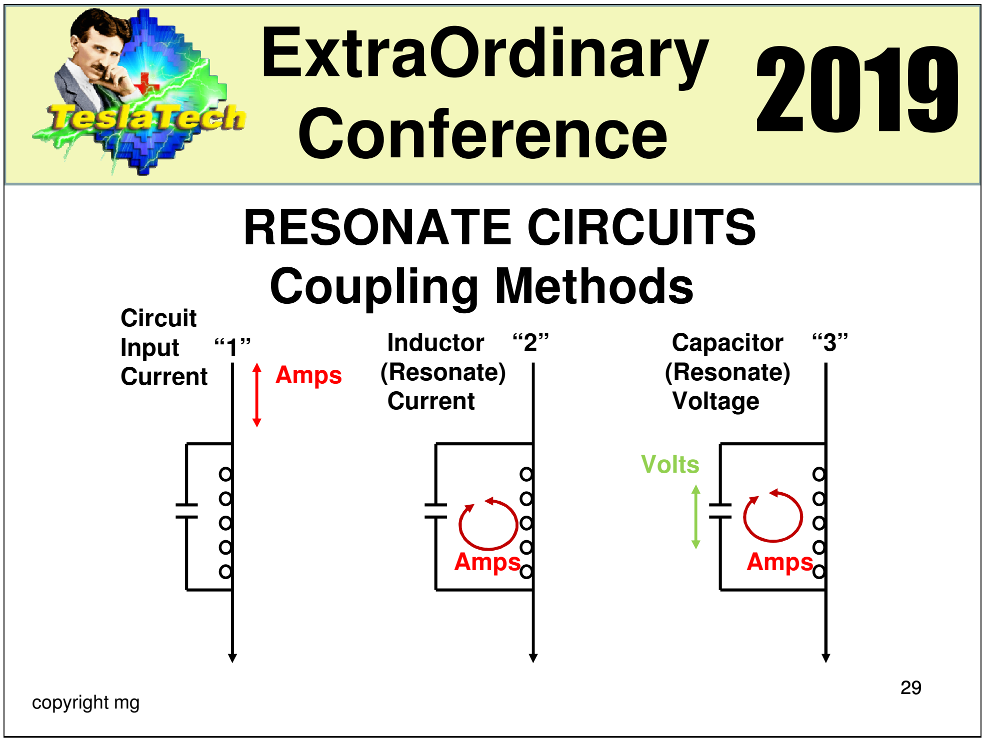
This starts the Part 3 “real engineering” of the detailed design of the “Dual Resonate” system.



There are three (3) different ways to couple into a resonate circuit:

1) Circuit Input Current

2) Inductor (resonate) Current

3) Capacitor (resonate) Voltage

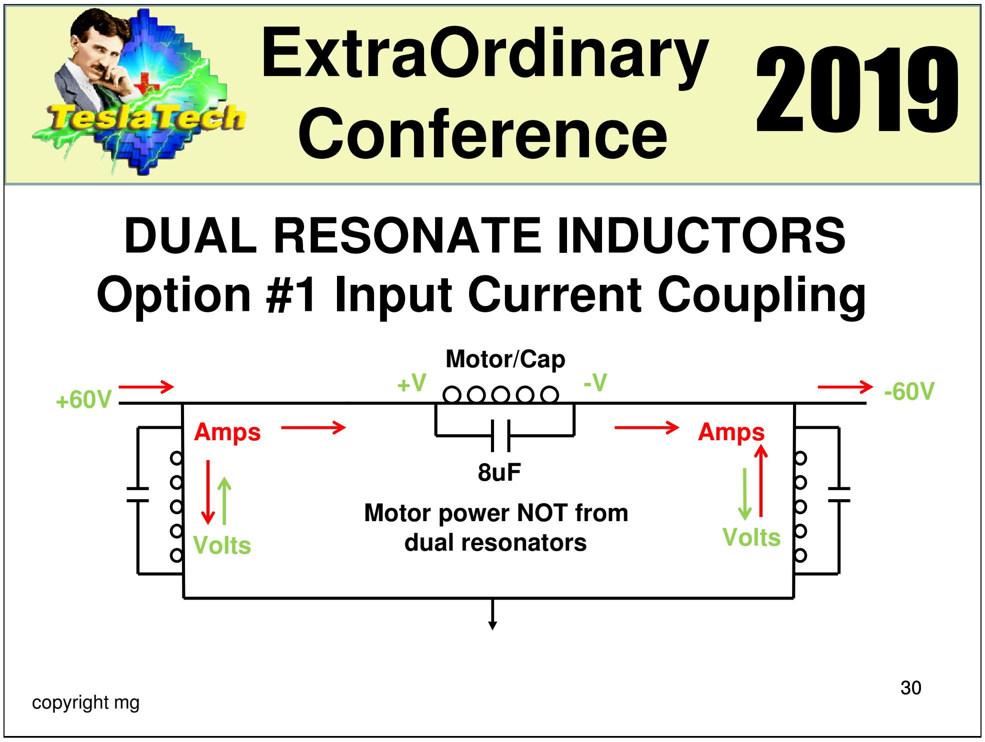
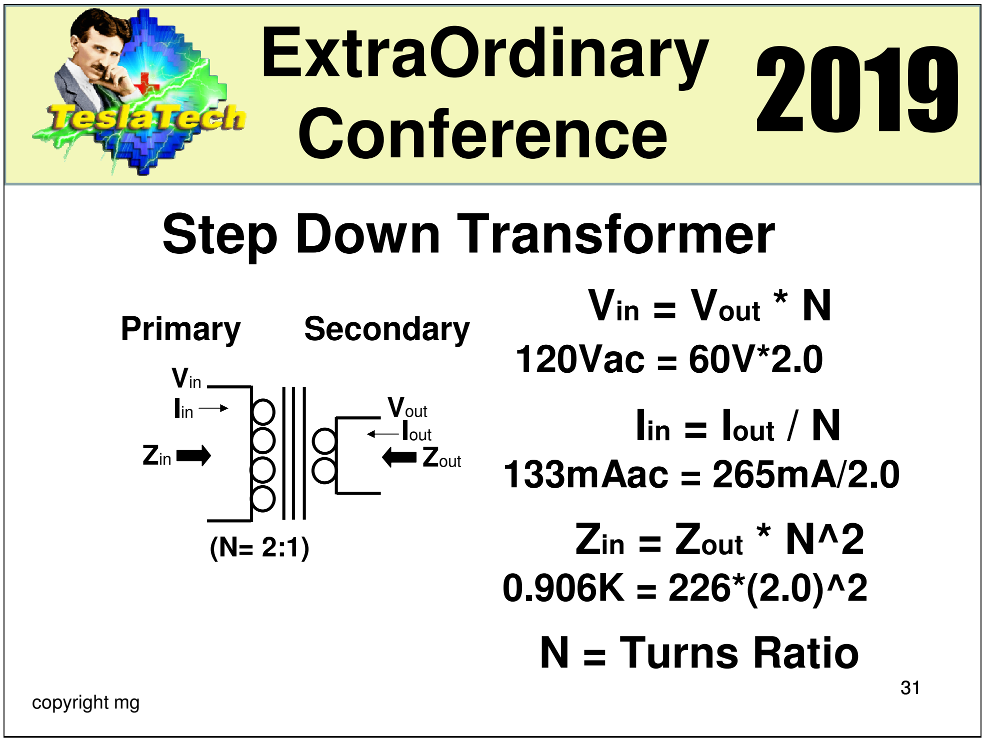
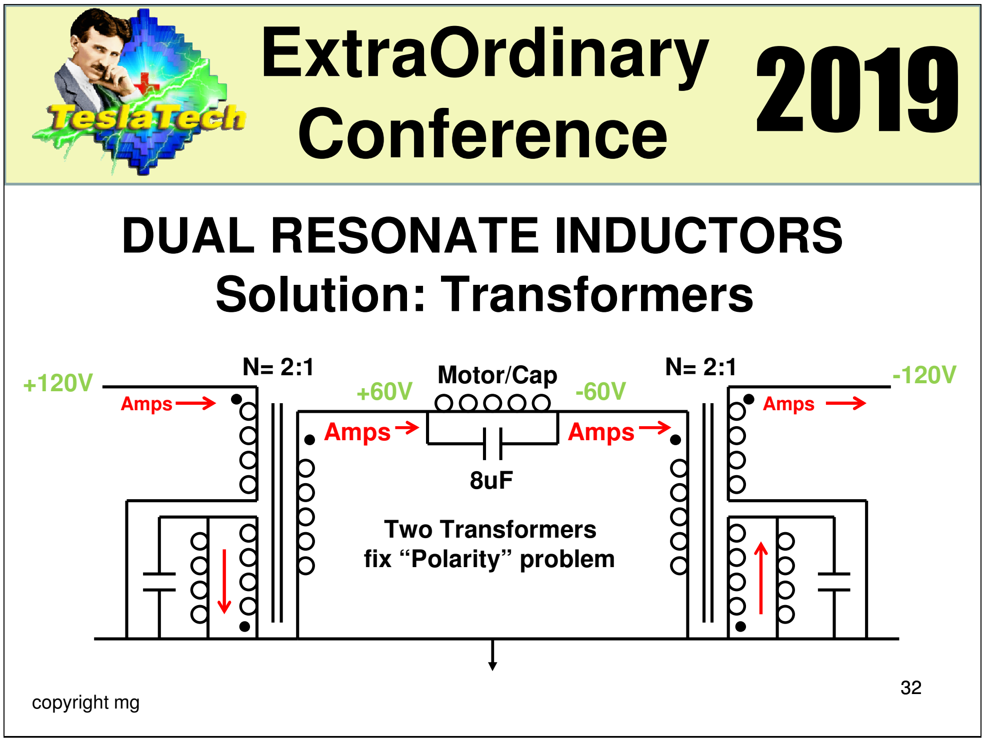


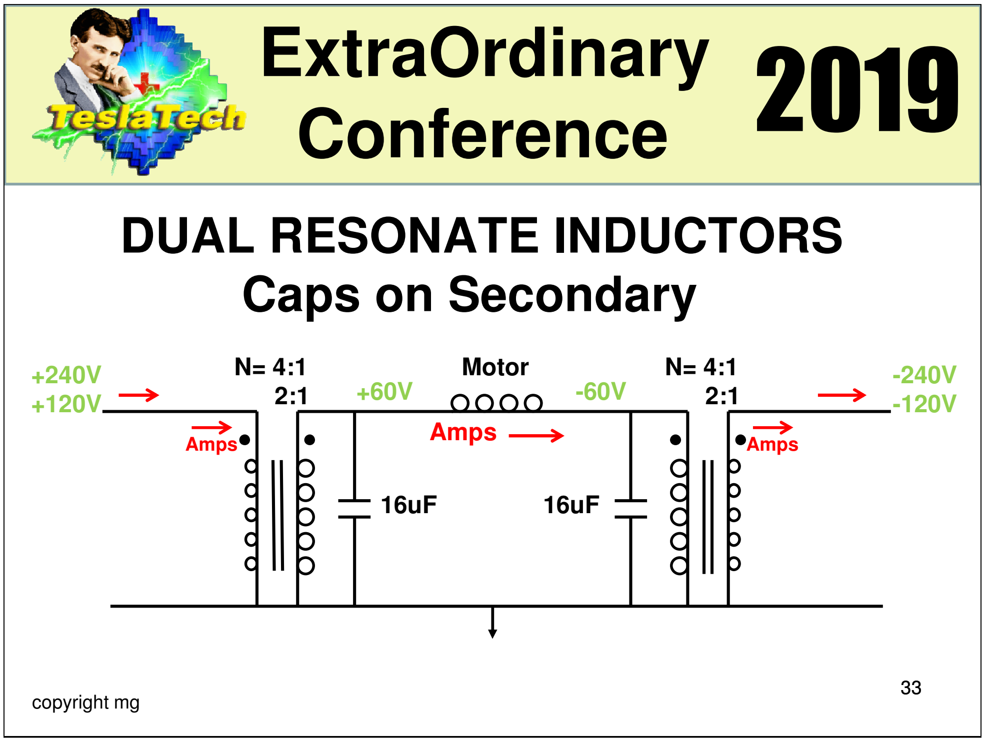
Diagram of method “1”; coupling through the input current. The problem is the motor current is just an additional power supply load as it’s not sourced from the dual resonator circuits.



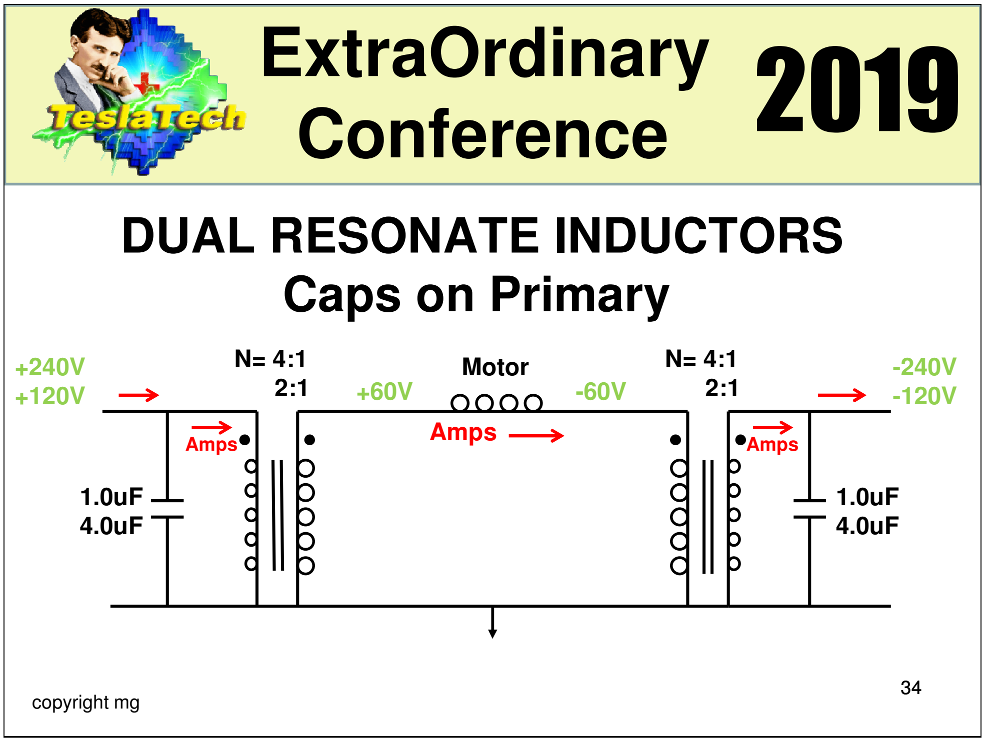
Going back to our friend; transformer’s not only step voltage down/up and impedance match, but they also do phase shifting.



Block diagram of the proposed dual resonate inductor system using 2:1 stepdown transformers. Each of the dual resonator circuits only has to supply half this voltage (120Vac @ 133mA) because the load is shared differentially. Note: Transformer voltage is reduced while the current is increased.



The next few charts show that all three of the resonate circuits are mutually coupled (interact). The single 8uF motor cap can be split into two 16uF caps placed across on the transformer secondary outputs.



The 16uF caps on the transformer secondary's can also be placed across the transformer primary’s with a corresponding decrease in value (1.0uF/4.0uF) depending on the square of the “turns ratio”.

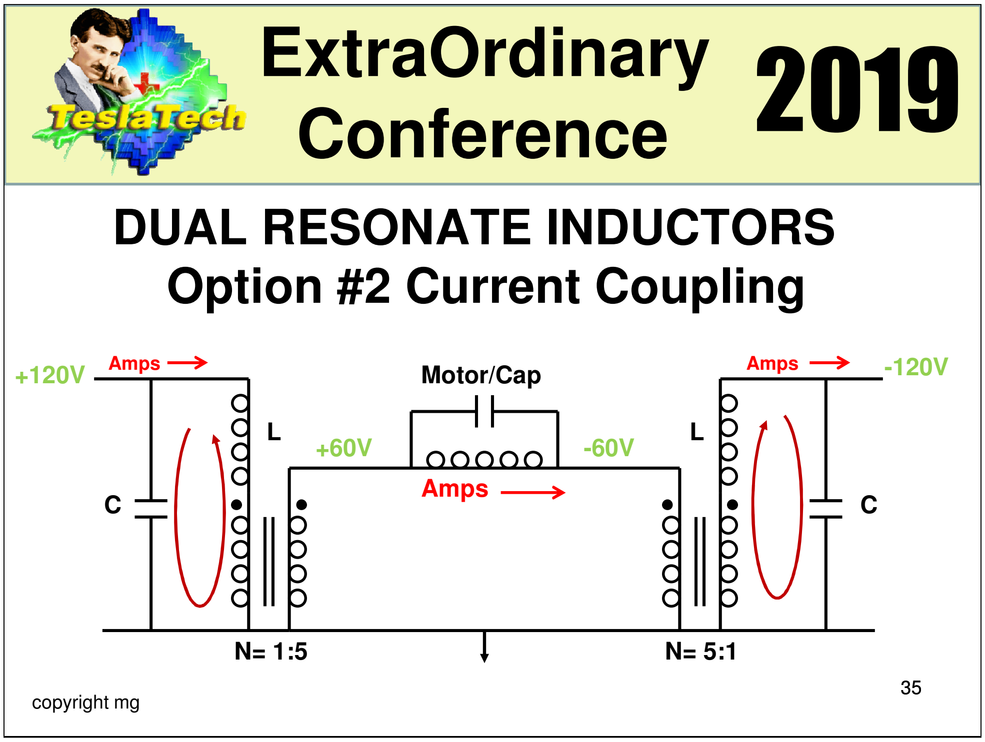


Diagram of method “2”; coupling through the resonate current. Using step up transformers to convert a 12V @1.8A resonate input to a 60V @ 360mA output. The problem is the motor current may detune (lower) the resonate “Q” some.

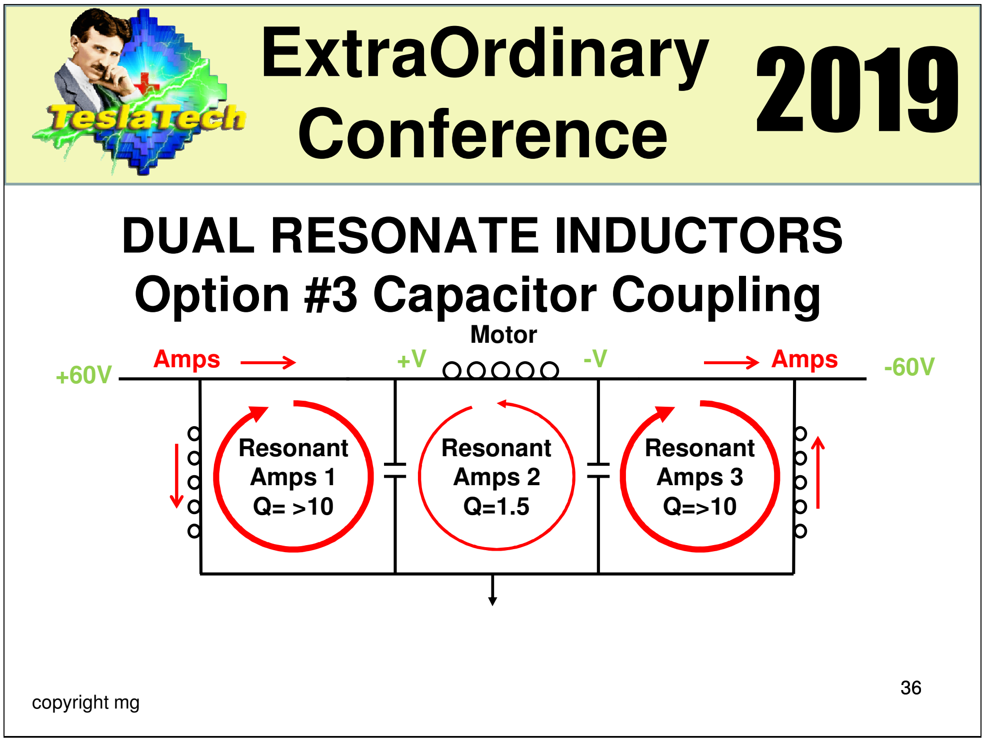
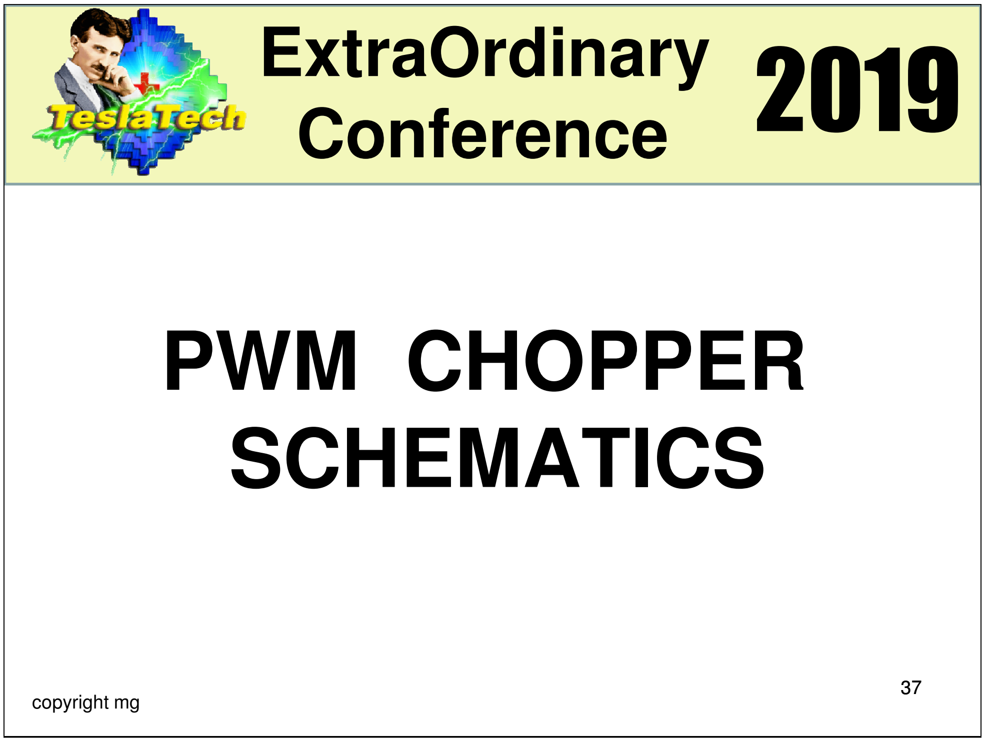
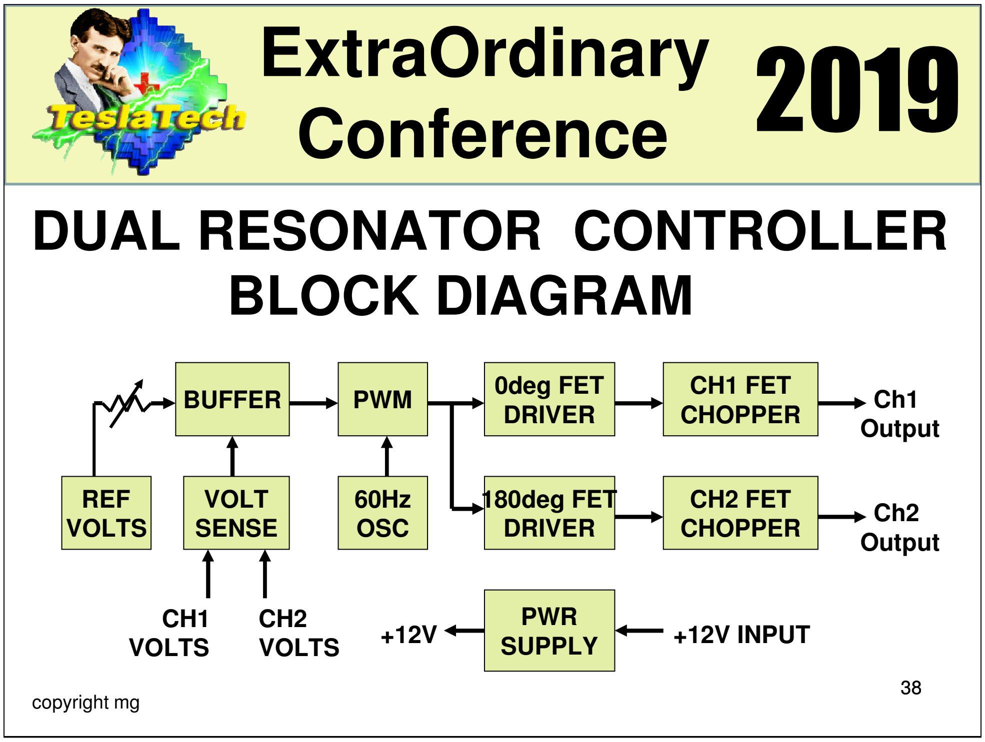


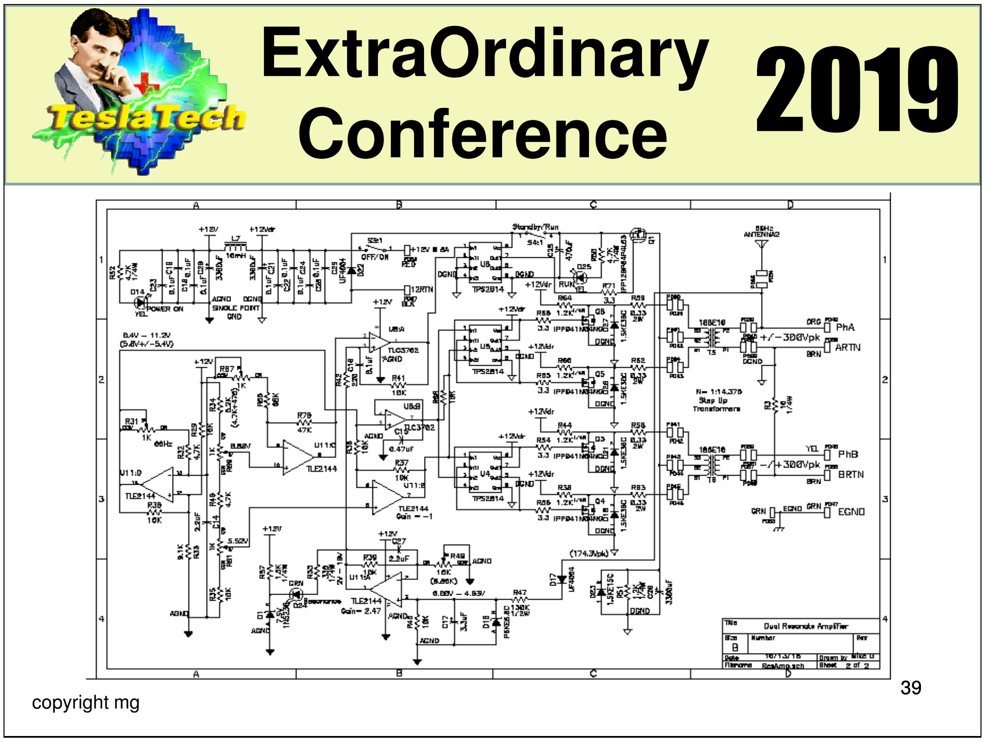
Diagram of method “3”; coupling through the resonate circuit’s capacitor voltage. This requires the resonators to have a very high “Q” with both the resonate and motor current passing through the same caps. The main point of these charts is to show that all three (3) resonate circuits are mutually coupled (interact).



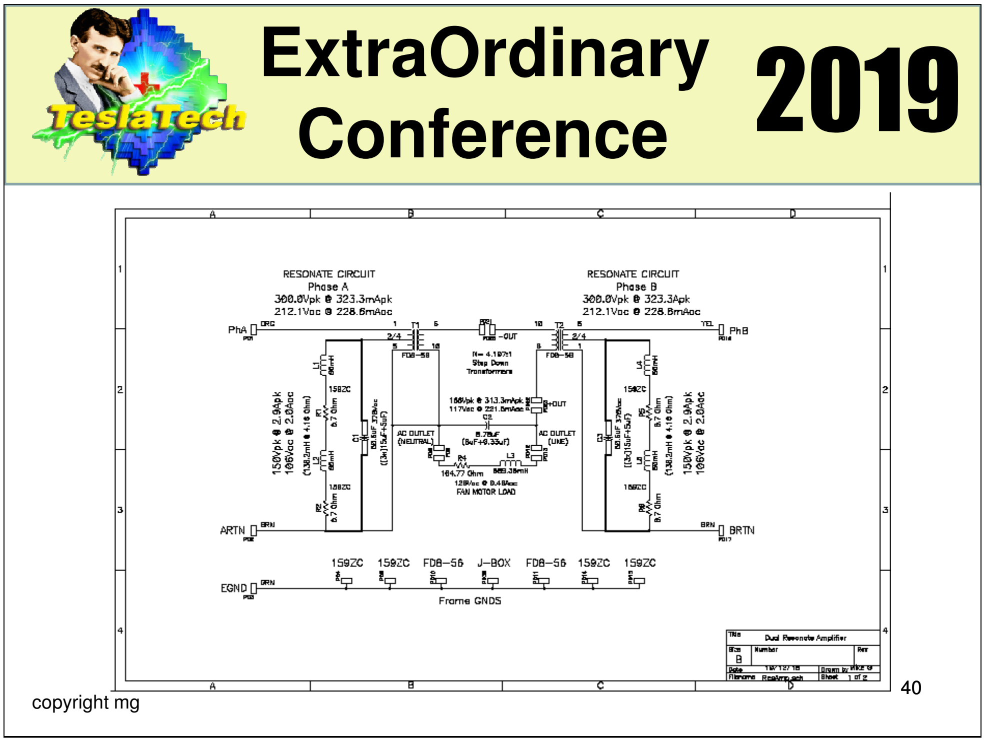
The following charts show the detailed circuit schematics of the “Dual Resonate” system and PWM chopper circuit.



Block diagram of the “Dual Resonate” inverter controller.



Schematics of the “Dual Resonator” PWM inverter controller circuit.



Schematics of the “Dual Resonator” phase A/B circuit boards. The following data is from the “running” demo model: Resonate Inductor [(2x)60mH] = 138mH, Cap [(3x)15uF+5uF]= 50.6uF. Motor: Inductance 689mH@ 104 ohm, Cap 8.78uF.

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PICTURES OF THE DUAL RESONATE DEMO MODEL

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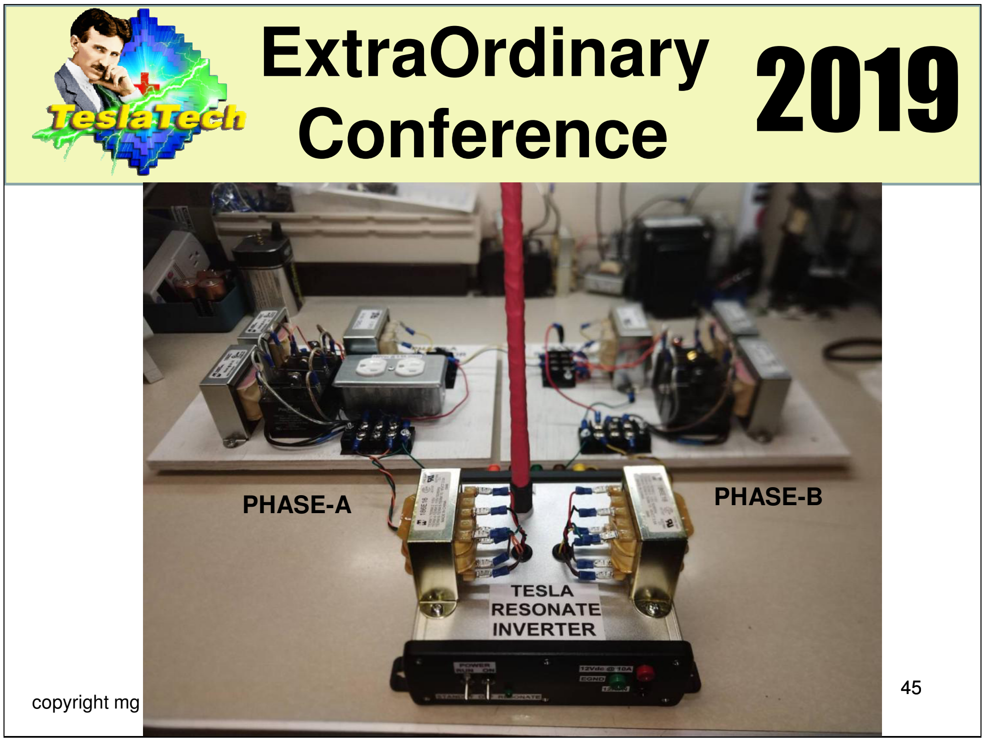
Pictures of the actual Tesla “Dual Resonate” demo model.

Close up picture of the Phase A Resonator Board showing LC resonate circuit and step down transformer.

Close up picture of the Phase B Resonator Board showing LC resonate circuit and step down transformer. It's basically a mirror image of Resonator A except for the J-box.

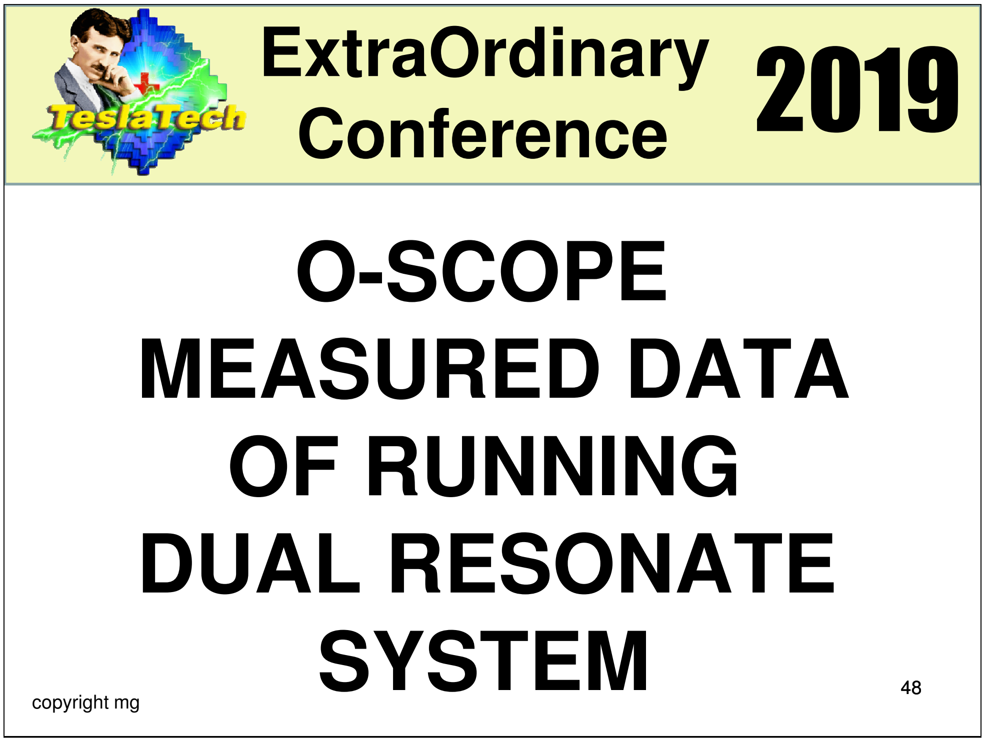
The front and rear views of the Tesla "Dual Resonate" Inverter driver. The inverter converts 12Vdc to 230Vac for both phase A and B "LC" resonator circuits.



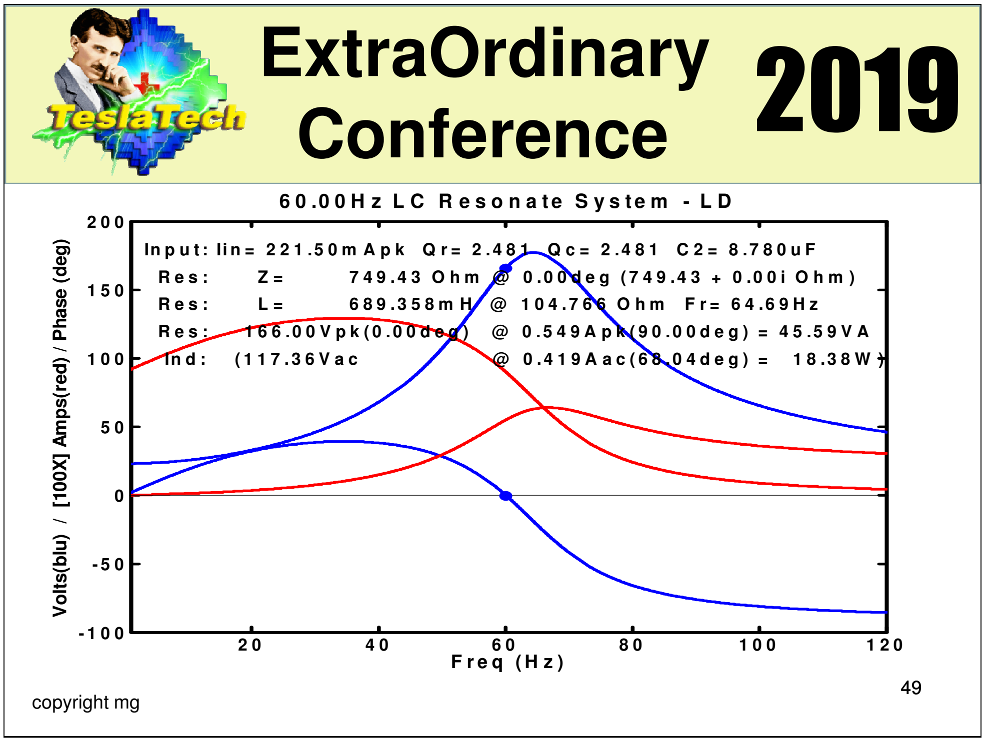
The completed Tesla “Dual Resonate” System assembled on the workbench. As you can see there is a lot of iron needed just to run a small fan motor. To run larger horsepower motors the iron only gets bigger – may need gyrators!

Picture of the Tesla “Dual Resonator” system powered up and running on the bench.

Close up of the Tesla “Dual Resonator” system running. The O-scope shows the three resonator voltages (Phase-A, Phase-B, Motor) all synchronized to 60Hz. The two paralleled DC power supply reads 12.2V @ 10.7A (5.8+4.9) input into the inverter.



The following charts are actual O-Scope measured data from the running “DUAL RESONATE” demo model.



MatLab plot of the actual running motor (load) in the "Dual Resonate" system, based on the measured data values of: resonate capacitance, input current and output voltage. The S/W calculates the resonate current, resonate frequency, "Q" factor, output current, phase angle and motor (load) inductance and AC resistance.

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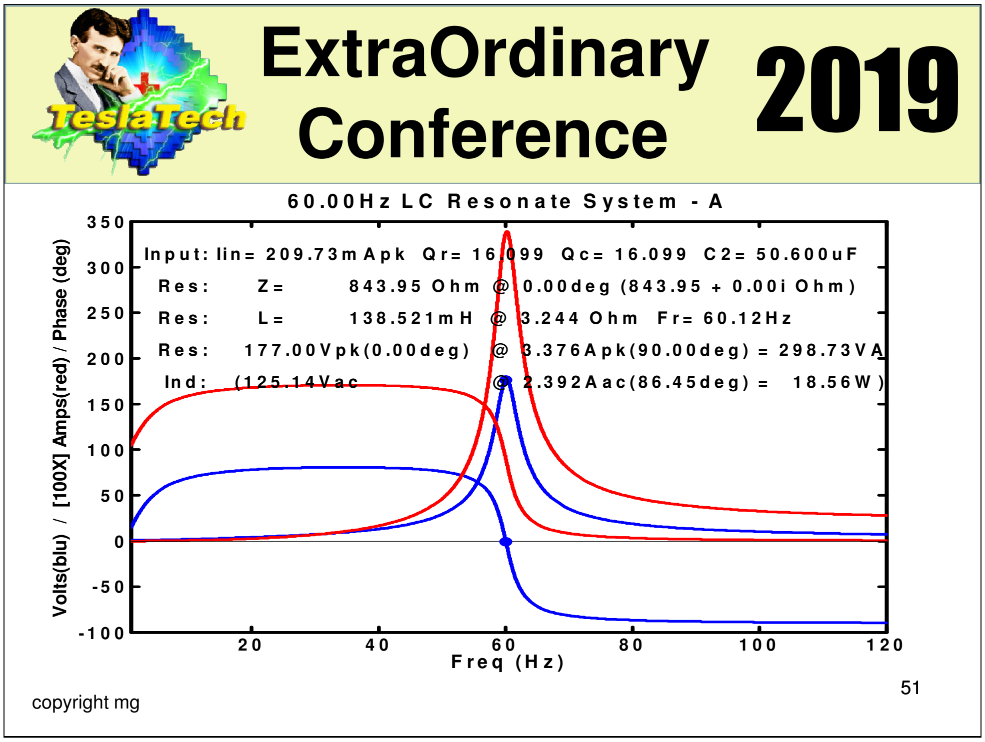
Motor Operation: LINE VS DUAL Resonance

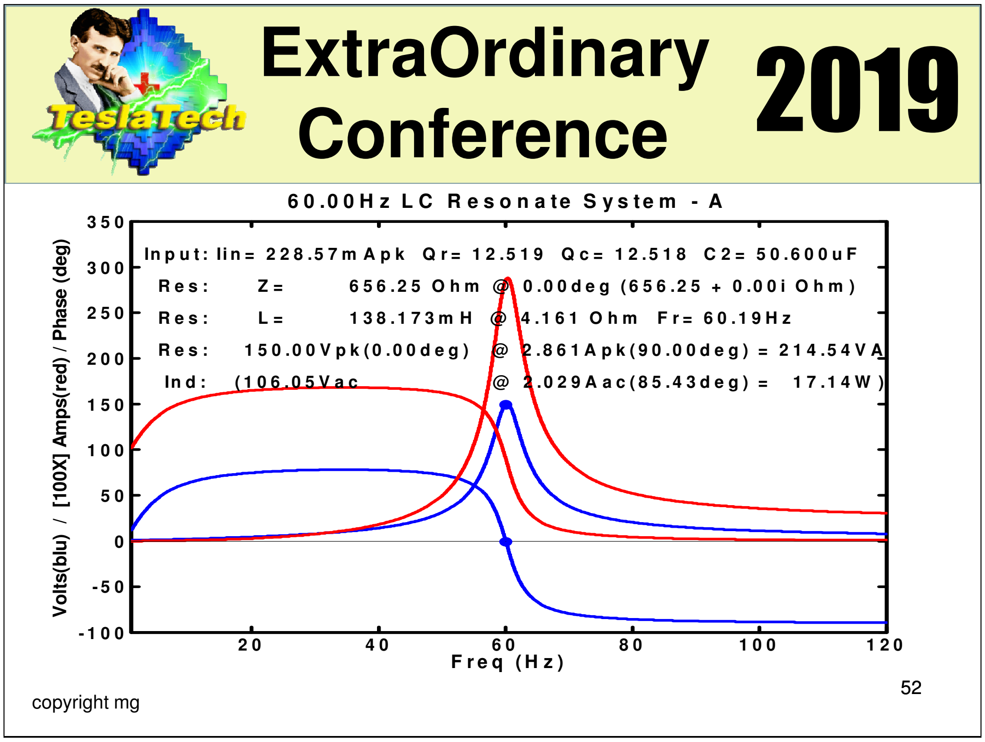
Increases “Q” Factor	by	+1.01	[1.47 – 2.48]
Increases Resonate Cap	by	+0.14uF	[8.64 – 8.78]
Increases AC Inductance	by	+131.67mH	[557.69 – 689.36]
Lowers AC Resistance	by	-37.8Ohms	[142.6 – 104.8]
Lowers Resonate Freq	by	-7.8Hz	[72.5 – 64.7]
Lowers Input Current	by	-153.5mA	[375.0 – 221.5]

50

Comparison of the Motor running “LINE” and “DUAL” resonance” shows the motor “Q” factor increases because of all the dual resonator’s mutual coupling (interaction).



MatLab plot of an actual “NO Load” running resonator circuit of the “Dual Resonate” system, based on the measured data values of: resonate capacitance, input current and output voltage. The S/W calculates the resonate current, resonate frequency, “Q” factor, output current, phase angle and resonator inductance and AC resistance.



MatLab plot of the actual “Motor Load” running the resonator circuits of the “Dual Resonate” system, based on the measured data values of: resonate capacitance, input current and output voltage. The S/W calculates the resonate current, resonate frequency, “Q” factor, output current, phase angle and resonator inductance and AC resistance.

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Resonator Operation: NO VS MOTOR Load

Increases AC Resistance by +0.92 Ohms[3.24 – 4.16]

Increases Input Current by +18.84mA [209.7 – 228.6]

Lowers “Q” Factor by -3.58 [16.10 – 12.52]

Lowers Operating Voltage by -27Vpk [177 – 150]

Therefore: 91.9% = [100*(470mA – 2*18.8mA) / 470mA] of the motor power is generated by the Dual Resonators and only 8.1% from the power supply.

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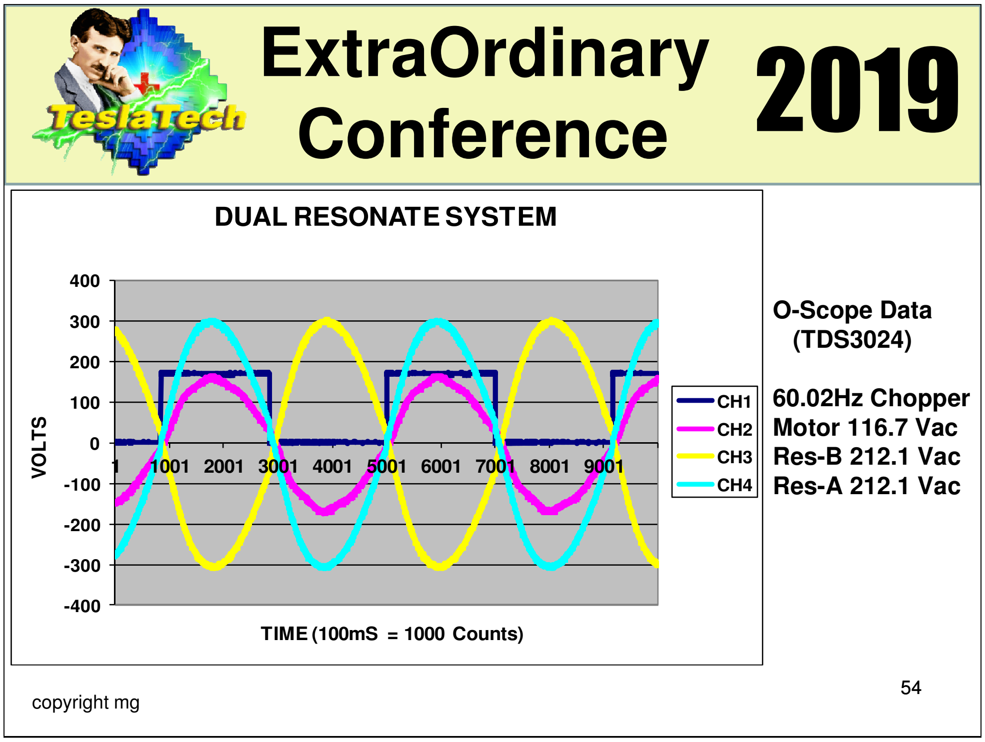
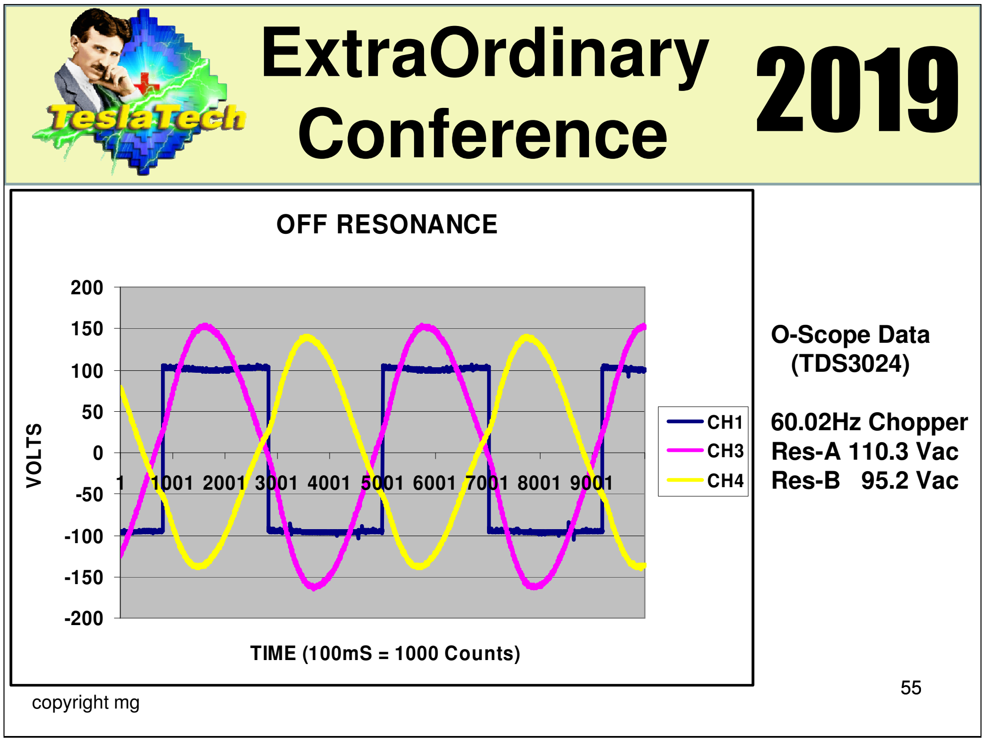
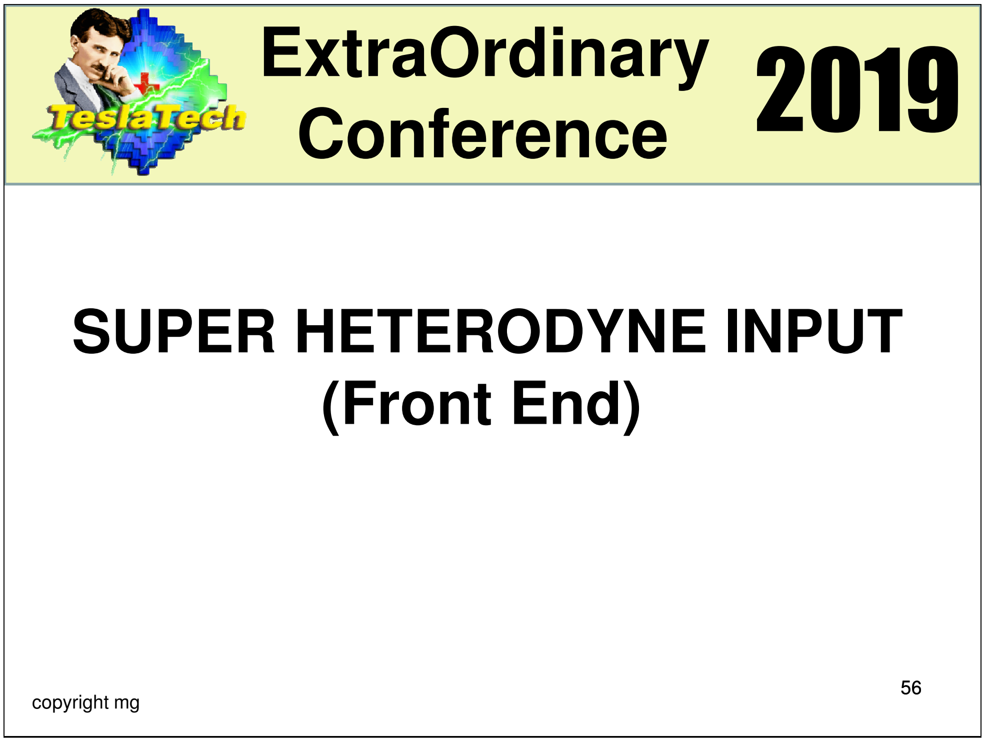
The comparison of the “LC” resonators running “NO” and “Motor” loads shows the Dual Resonators are providing 91.9% of the motor power with a slight reduction in the “Q” factor.



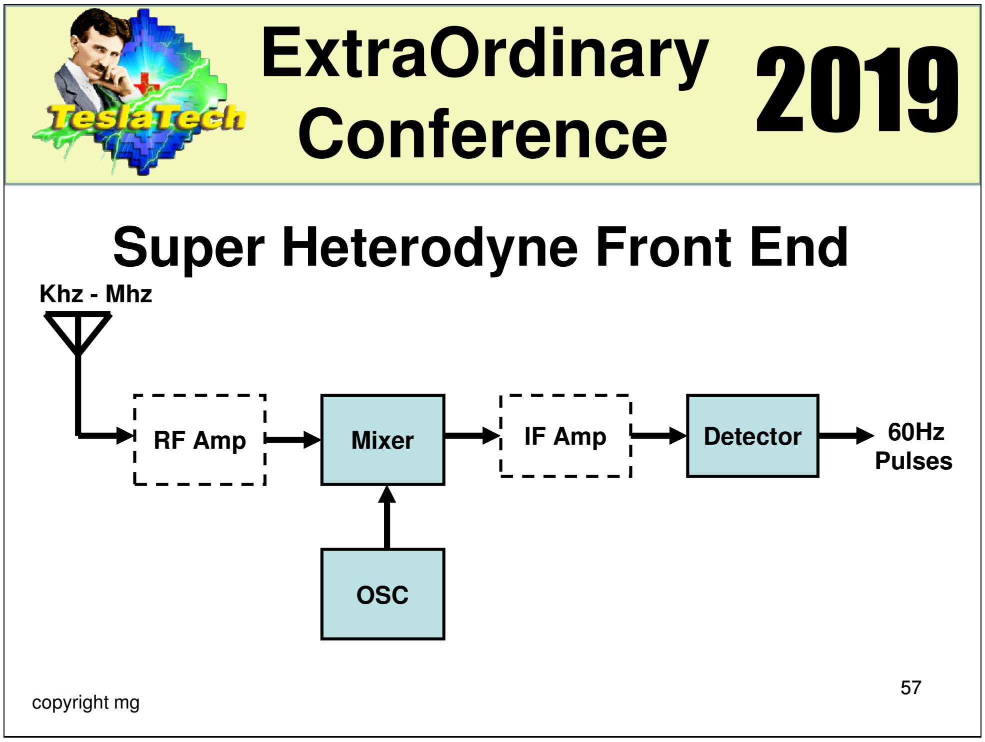
Actual O-scope plot of the “Dual Resonator” phase A/B resonator waves and the motor resonate wave showing all three (3) are tuned and running at 0deg phase (crossovers synchronized to the 60Hz chopper signal).



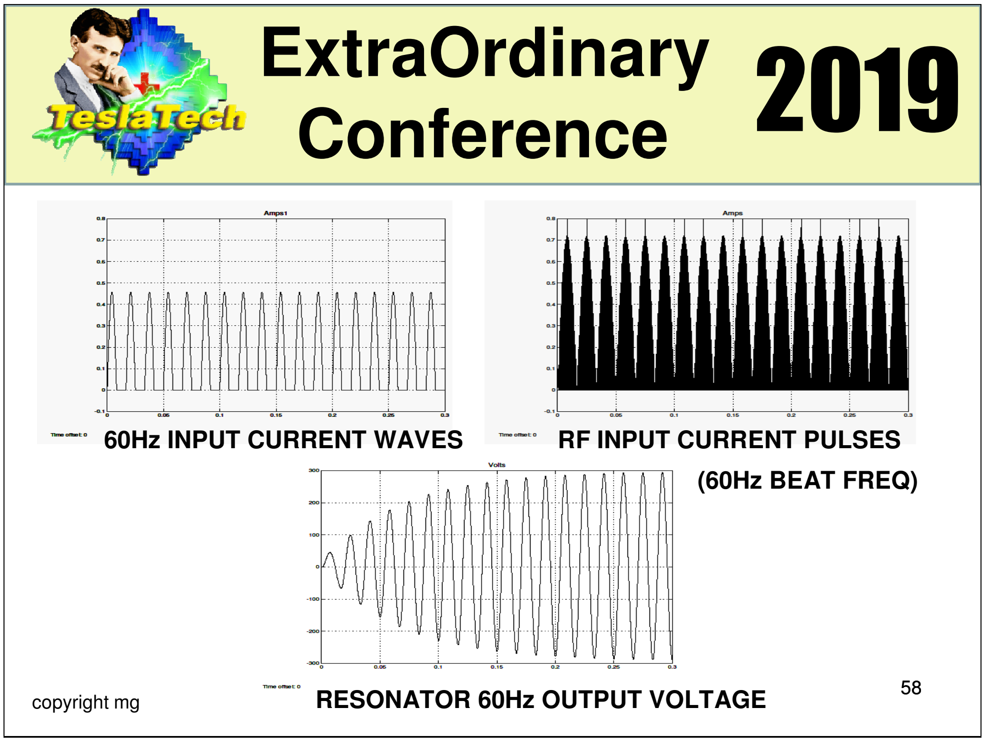
Actual O-scope plot of the “Off Resonance” phase A wave is lowered by 5uF and phase B wave is lowered by 15uF (crossovers NOT synchronized to the 60Hz chopper signal). Also, there is reduction in amplitude and distorted wave shape.



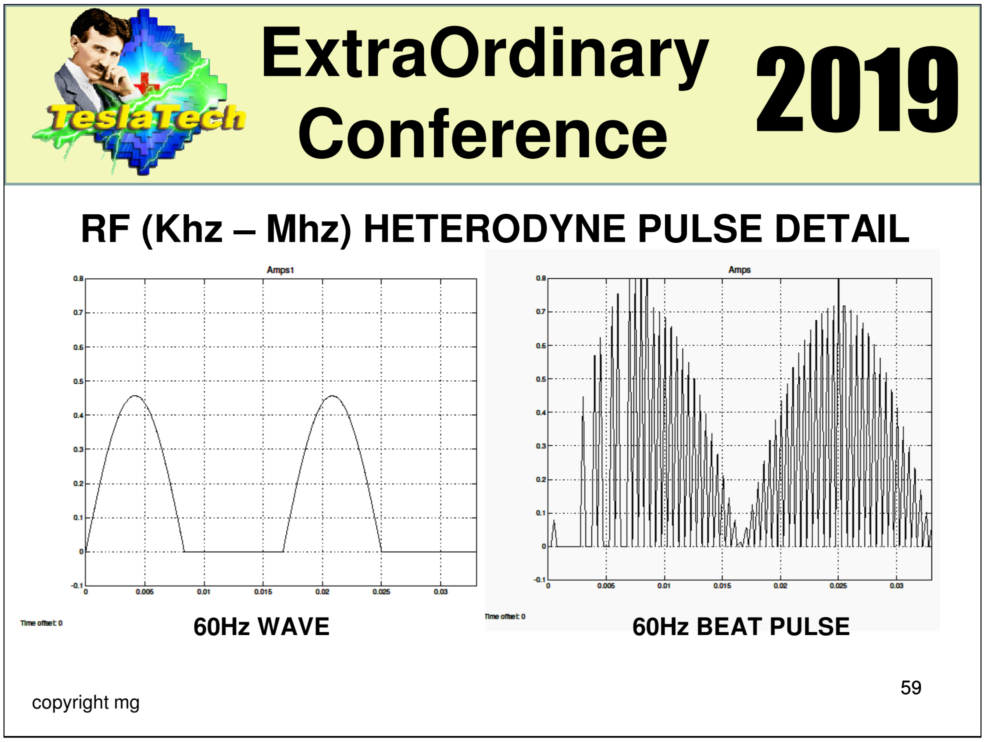
The fifth story stated Tesla used a Super Heterodyne input to his resonate power system. This would more closely match the antenna impedance. A 6ft whip antenna is better tuned to high Khz or low Mhz and would not need as much base loading as when operating at 60Hz.



The proposed “Super Heterodyne” input block diagram for the “Dual Resonate” system. I have spent the last three (3) years working on the power drive section, now I need to put some effort into the input section. The heterodyne circuit requires a mixer, local oscillator and detector; however, RF and/or IF amplifiers maybe needed.



MatLab simulations of the present “LC” resonator input current is two 60Hz half sine waves (left); one polarity to each resonator phase. The positive half wave generates the resonate (full cycle) sine wave output (bottom). The positive half sine wave (left) input can be replaced by RF pulses (right) which will generate the same amplititude output sine wave (bottom).



MatLab enlargement showing the details of how the 60Hz half sine wave input (left) is replaced by a 60Hz beat frequency (right) composed of many high frequency (RF) spikes (envelope). Also, note that the beat pulses require about a 1/3 more amplitude as the RF spikes have less power than the complete wave.

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Dual Resonate System Conclusions

1) Tweaked all three resonate circuits to run at 60Hz - difficult because of the mutual coupling

2) Fixed Inductors – Inductance varies as the current which also makes tweaking difficult (Gyrators)

3) So far the motor has not spooled up (self resonance) running with 91.9% resonators; needs a higher Q-factor (20?).

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2) Fixed Inductors – Inductance varies as the current which also makes tweaking difficult (Gyrators)

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Dual Resonate System Conclusions

4) The resonators have very good efficiency (91.9%)

Dual Resonator = 12.5 Q-Factor

Series Resonator = 10.1 Q-Factor

However, will need to boost the efficiency from 91.9% to 99.8% to achieve self resonance!

(In engineering achieving the last 10% usually requires 90% of the effort – so I have a ways to go)

5) The low current demo uses a lot of iron (4 inductors and 2 transformers) which may not be practical (too big) for larger high current systems. (Gyrators)

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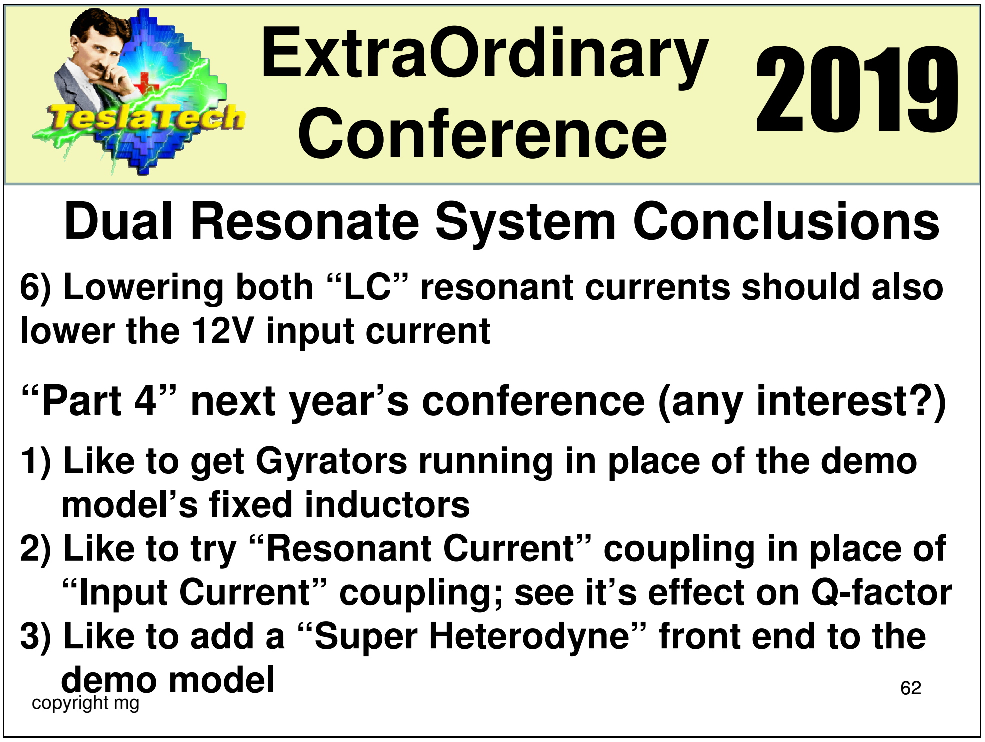

6) Lowering both LC resonant currents should also lower the 12V input current

“Purpose Part 4” for next year’s conference (any interest?)

1) Like to get Gyrators running in place of the demo model’s fixed inductors

2) Like to try “Resonant Current” coupling in place of “Input Current” coupling;
see it’s effect on the Q-factor

3) Like to add a “Super Heterodyne” front end to the demo model

Hope I have not bored you with all the numbers that engineers love! “Thank You” for watching this (part 3) reverse engineering of Tesla’s Resonate Electric Car Motor design. Any questions? Contact Information.