ScanTesla Instructions

V-7.40
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ScanTesla is a computer program designed to do computer modeling of Tesla coils. The program is capable testing millions of combinations of component values and finding the best configurations. The program uses real time linear analysis techniques in an engine from Antonio that actually "runs" virtual Tesla coil models inside the computer at very high speed. Unlike circuit simulators like MicroSim, ScanTesla can iterate through many component values and run hundreds of models per second in a giant search for the very "best" Tesla coil configuration.

ScanTesla is designed to model both conventional spark gap type Tesla coils and the new DRSSTC coils. It will not do tube type or CW coils at this time.

ScanTesla is free and the source code is in the Public Domain and included in the "zip" file. The "C" program is simple and easy to modify and compile as needed. The free "LCC" compiler was used to create it. The program will be improved over time as new data becomes available and the program is refined.

The Input File
ScanTesla reads all of it's data from a simple input file called "input.txt". This file tells the program all the coil's data and tells the program how to process it. The file has help text in it that start with a "*" which tells the program that the text on that line is not to be used buy the program itself. Lines that do not start with "*" are read into the program as live data. The order and number of live data lines cannot be changed and it is important not to mess this up ;-) The simple pure text file can be modified with any simple text program such as Windows NotePad.

A typical input file follows:

```
* * ScanTesla Parameter Input File
*
* This file should be in the same directory as the program.
*
* Lines starting with "*" are ignored.
*
* The program expects the parameters in order and as shown.
*
* Cprimary (farads) - start, stop, Inc
450.0e-9
450.0e-9
1.0e-9
* Rprimary (ohms) - Start, Stop, Inc
0.1
0.1
0.01
* Lprimary (heneries) - Start, Stop, Inc
10e-6
```

```
20.001e-6
0.1e-6
* Lsecondary (heneries) - Start, Stop, Inc
130.0e-3
130.0e-3
1.0e-3
* Coupling - Start, Stop, Inc
0.05
0.251
0.002
* Rsecondary (ohms) - Start, Stop, Inc
500.0
500.0
1.0
* Csecondary (farads) - Start, Stop, Inc
42.0e-12
42.0e-12
1.0e-13
* Cload (farads) - Start, Stop, Inc
6.0e-12
6.0e-12
1.0e-12
* Rload (ohms) - Start, Stop, Inc
220.0e3
220.0e3
1.0e3
* Time (sec) - Start, Stop, Inc - If Inc < 0 then automatic timing is used
0.0
500e-6
-100.0e-9
* Vrail - DRSSTC Buss Rail Voltage (volts) - 0.0 for a conventional coil.
320.0
* VCprimary Initial Value (volts) - Primary capacitor voltage for a conventional coil.
0.0 for a DRSSTC.
0.0
*Dwell Time (sec) - DRSSTC T1 time.  Ignored for conventional coil.
125.0e-6
* DRSSTC Current Limit (amps) - Set very high for conventional coil.
10000.0e0
* Bang Energy Limit (joules)
1000.0
* Goal Type - 0=find maximum VCsecondary  1=find maximum streamer energy  2=find all
2
*
```

Cprimary:
The primary capacitor value is defined first:

```
* Cprimary (farads) - start, stop, Inc
450.0e-9
450.0e-9
1.0e-9
```

The three live lines after the help line tell the program that the value of the primary capacitor should start with the value 450.0e-9 Farads, end with the value 450.0e-9 Farads and increment the value 1.0e-9 Farads. In this case, the starting and stopping values are the same, so the program will use 450e-9 Farads for the value of the primary capacitor and never change it. The “e” means the value following is the standard 10^ exponent value. Thus, 450.0e-9 is the same as 0.000000450. The program can accept any value in this scientific notation. Since the value of Cprimary is never changed, the increment value 1.0e-9 is ignored.

Note: The increment value must be greater than 0.0 or the program gets stuck. In some cases it is negative for an "automatic value.

Rprimary:
The “total” resistance of the primary circuit is represented by Rprimary. This resistance is the sum of primary capacitor resistance, spark gap resistance,

primary coil resistance, DRSSTC driver resistance, etc. This AC resistance is at the coil's running frequency. If you don't specifically know your coil's Rprimary resistance, use 3 ohms for a conventional spark gap coil or 0.1 ohms for a DRSSTC. The inputs for this value are formated just like Cprimary as are the rest.

Lprimary:
The coil's primary inductance can be found by “Wheeler's Formula” or with the many other Tesla coil programs available. It can also be directly measured if you have the tools. In this case, the value is “scanned”:

```
* Lprimary (heneries) - Start, Stop, Inc
10e-6
20.001e-6
0.1e-6
```

The primary inductance is set to start at 10e-6 Heneries and goes to 20.001e-6 Heneries. The value will be changed in 0.1e-6 Henery steps. It is good to add a tiny bit to the end value to be sure the program accepts the last value. Don't ask me “why” ;-) If the Increment value is less than 0.0, the program will automatically "tune" the primary inductance for you.

Lsecondary:
This is the inductance of your secondary coil. It can be found with the formulas, other programs, or by direct measurement.

Coupling:
This is the primary to secondary coil “Coupling Coefficient”. Programs like “MandK” can calculate the value very accurately as can some newer Tesla coiling programs. It can be measured with a little work. It is a fairly important number to know... In this case, it is set to scan over a range of values:

```
* Coupling - Start, Stop, Inc
0.05
0.251
0.002
```

It will start at 0.05, increment by 0.002, and stop when it gets too 0.251.

Rsecondary:
There are programs now that calculate this number. It can be found by fairly difficult measurement... I would say just set it to like 500 and be happy ;-)) Almost all coil's are in the 300 to 700 range and it is not very critical.

Csecondary:
This is your coil's total secondary capacitance. This would be the sum of the Medhurst and top terminal capacitance. Programs like E-Tesla will calculate it as will many other programs. You really should know this number.

Cload:
This is the streamer capacitance. It is 1e-12 for every foot of streamer you have or expect. If you streamers are 2 feet long, it is 2e-12. If your streamers are 11 feet long it is 11e-12... There is a lot behind that but the rule is just that simple... If the increment value is less than 0.0, the program will use the

streamer energy to automatically calculate the load.

Rload:
The value is 220.0e3. It does not change... Trust me ;-)

Time:
This is the time the models all run. It is fairly important! In this case:

```
* Time (sec) - Start, Stop, Inc - If Inc < 0 then automatic timing is used
0.0
500e-6
-100.0e-9
```

It starts at zero seconds and I cannot think of a case that it would not. It goes to 500uS. It is important to let the model run long enough that all the coil's "stuff" has time to be fully over before the model ends. In many cases, I would put that at 1e-3 seconds. 2e-3 to be safe. After things are tried, this number may be refined as needed. Just don't ever make it too short ;-)

The increment value has a trick. If you make it less than zero, the program will automatically "just fix it". In most cases, just make it -100e-9 and the program will take care of it. It assigns a time of 100 step per cycle when negative which is really good without waisting a lot of time. If it is a positive number, the program will use it faithfully.

Vrail:
This is the DRSSTC coil's driver rail voltage. If you have a regular spark gap coil, set this value to 0. For DRSSTCs this voltage is like 340.

VCprimary:
This is the coil's initial primary capacitor voltage. Set it to 0 for a DRSSTC. For a conventional coil, it will be 1.414 x your high voltage transformer voltage. For a 15kV NST, it is 21210.

Dwell Time:
This is only for the DRSSTC (T1 time). Set it to 1 for conventional coils.

DTSSTC Current Limit:
This is a primary current limit for DRSSTCs. DRRSTC people can set it to their coils. Conventional coils can be set to 10000.

Bang Energy Limit:
This the maximum bang energy that is accepted. The program can get kind of crazy at times and give giant sparks if given giant input power levels... If your coil is say 1500 watts at 120 BPS, then the bang energy is 1500/120 = 12.5 joules. You can set this really high if you want or use it to limit your coil's input power for the program.

Goal Type:
This is just the number 0, 1, or 2.

0 will tell the program to search for the configuration that give the maximum top terminal voltage. Very useful for tuning...

1 will tell the program to search for maximum streamer power. Useful for long arc configurations...

2 tells to program to dump every model's data into a big file called “data.csv” that other programs like Excel, OpenOffice, MathCad, etc. will use to make pretty graphs and do sophisticated analysis.

Screen Display:
The program has a DOS screen display when running. It will first give the input values for verification purposes.

```
ScanTesla  V-7.00  June 20, 2005  Terry Fritz
C1 4.500000e-007 4.500000e-007 1.000000e-009
R1 1.000000e-001 1.000000e-001 1.000000e-002
L1 1.000000e-005 2.000100e-005 1.000000e-007
L2 1.300000e-001 1.300000e-001 1.000000e-003
K12 5.000000e-002 2.510000e-001 2.000000e-003
R2 5.000000e+002 5.000000e+002 1.000000e+000
C2 4.200000e-011 4.200000e-011 1.000000e-013
C3 6.000000e-012 6.000000e-012 1.000000e-012
R3 2.200000e+005 2.200000e+005 1.000000e+003
T1 0.000000e+000 5.000000e-004 -1.000000e-007
Vrail 3.200000e+002
VCpri_init 0.000000e+000
DwellTime 1.250000e-004
Current_Limit 1.000000e+004
BangEnergy_Limit 1.000000e+003
Goal Type 2
Models Tested = 10201
```

It will then list a host of data for the preset best match found so far. This screen data is also recorded to the file “output.txt”.

```
ScanTesla  V-7.00  June 20, 2005  Terry Fritz
NEW HIGH!! Goal = -2.340349e+005
Goal Time = 1.312872e-004
Model Number = 24
Goal Number = 24

Cprimary = 4.500000e-007
Lprimary = 1.000000e-005
Rprimary = 1.000000e-001
Coupling = 9.600000e-002
Csecondary = 4.200000e-011
Lsecondary = 1.300000e-001
Rsecondary = 5.000000e+002
Cload = 6.000000e-012
Rload = 2.200000e+005

Ilprimay Maximum = 1666.804633
ICprimary RMS/sqrt(BPS) = 10.027314
VCprimary Maximum = 7862.084507
VCsecondary Maximum = -234034.920329
Bang Energy = 13.326250
Load Energy = 2.752966
Primary F0 = 75026.359680   Secondary F0 = 68112.027831
Load Energy Rise Time = 8.863551e-005
```

The “goal” is terminal voltage or load energy as defined by the input file. Goal time is the point in the model run that the goal was met. Model number and Goal number keep track of where the program is at. The program shows the present model coil values that are being processed... But the real stuff follows...

Ilprimay Maximum = The maximum primary current
ICprimary RMS/sqrt(BPS) = This number times SQRT(BPS) is the primary RMS current
VCprimary Maximum = Maximum primary voltage
VCsecondary Maximum = maximum secondary voltage
Bang Energy = Joules of energy per bang
Load Energy = Joules of energy to the streamer per bang
Primary F0 = 75026.359680 Secondary F0 = 68112.027831
Load Energy Rise Time = This is the 10% to 90% rise time of streamer load energy that seems to be very important!

The Output Files:

The program has three output files:

“output.txt” list the input variables and records the best configurations, in order, as the program runs.

“waveforms.csv” is a file that can be taken by Excel, OpenOffice, MathCad, etc. and has all the actual waveform data from the best run. This can be used to plot Vsecondary, Iprimary, ect. as a function of time. The first row in the file lists what the each column of data represents.

“data.csv” is used in mode 2 and lists all the input and output data points for every single model in the simulation. It can be used by Excel, OpenOffice, MathCad, etc. to make very pretty graphs and so sophisticated analysis of the coil. The first row lists what each column of data represents.

Do Something...:
Lets take the following input file:

```
* ScanTesla Parameter Input File
*
* This file should be in the same directory as the program.
*
* Lines starting with "*" are ignored.
*
* The program expects the parameters in order and as shown.
*
* Cprimary (farads) - start, stop, Inc
450.0e-9
450.0e-9
1.0e-9
* Rprimary (ohms) - Start, Stop, Inc
0.1
0.1
0.01
* Lprimary (heneries) - Start, Stop, Inc
10e-6
20.001e-6
0.1e-6
* Lsecondary (heneries) - Start, Stop, Inc
130.0e-3
130.0e-3
1.0e-3
* Coupling - Start, Stop, Inc
0.178
0.178
0.002
* Rsecondary (ohms) - Start, Stop, Inc
500.0
500.0
1.0
```

```
* Csecondary (farads) - Start, Stop, Inc
42.0e-12
42.0e-12
1.0e-13
* Cload (farads) - Start, Stop, Inc
6.0e-12
6.0e-12
1.0e-12
* Rload (ohms) - Start, Stop, Inc
220.0e3
220.0e3
1.0e3
* Time (sec) - Start, Stop, Inc - If Inc < 0 then automatic timing is used
0.0
500e-6
-100.0e-9
* Vrail - DRSSTC Buss Rail Voltage (volts) - 0.0 for a conventional coil.
320.0
* VCprimary Initial Value (volts) - Primary capacitor voltage for a conventional coil.
0.0 for a DRSSTC.
0.0
*Dwell Time (sec) - DRSSTC T1 time.  Ignored for conventional coil.
125.0e-6
* DRSSTC Current Limit (amps) - Set very high for conventional coil.
850.0e0
* Bang Energy Limit (joules)
25.0
* Goal Type - 0=find maximum VCsecondary  1=find maximum streamer energy  2=find all
0
*
```

It is s DRSSTC. All the values are fixed except Lprimary. The program will search for the best Vsecondary voltage and in effect tell us where to tune Lsecondary for the best output voltage. Once “input.txt” is edited and saved, we just run “ScanTesla700.exe”...

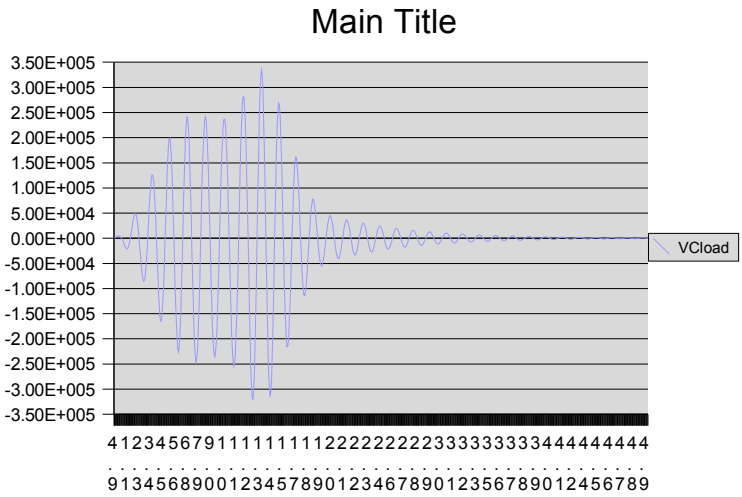
The screen will flash by a lot of stuff for a few moments and disappear. The end of the “output.txt” file has the data we want stored. The best last model is at the very bottom of the file.:

```
ScanTesla  V-7.00  June 20, 2005  Terry Fritz
NEW HIGH!! Goal = 3.347514e+005
Goal Time = 1.385602e-004
Model Number = 56
Goal Number = 14

Cprimary = 4.500000e-007
Lprimary = 1.550000e-005
Rprimary = 1.000000e-001
Coupling = 1.780000e-001
Csecondary = 4.200000e-011
Lsecondary = 1.300000e-001
Rsecondary = 5.000000e+002
Cload = 6.000000e-012
Rload = 2.200000e+005

Ilprimay Maximum = 782.414830
ICprimary RMS/sqrt(BPS) = 4.378210
VCprimary Maximum = -4708.481130
VCsecondary Maximum = 334751.364457
Bang Energy = 6.618698
Load Energy = 4.008335
Primary F0 = 60262.622272   Secondary F0 = 68112.027831
Load Energy Rise Time = 1.012236e-004
Models Tested = 101
```

It says that when Lprimary was 15.5uH, the output voltage was the highest at 334751volts peak. If we open the file “waveforms.csv” with OpenOffice and plot say VCload, we get:


Main Title
3.50E+005
3.00E+005
2.50E+005
2.00E+005
1.50E+005
1.00E+005
5.00E+004
0.00E+000
-5.00E+004
-1.00E+005
-1.50E+005
-2.00E+005
-2.50E+005
-3.00E+005
-3.50E+005
VCload
4123456791111111112222222223333333334444444449134568900123457890123467890123567890124567891