# ScanTesla Instructions

V-8.10
October 18, 2006
Terry Fritz


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, Solid State spark gap coils (SISG) 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 its 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  V-8.00
* New SISG 5400V 330nF coil
* This file should be in the same directory as the program.
*
* Lines starting with "*" are ignored.
*
* The program expects these input parameters in order and as shown.
*
* These parameters define the coil values to be scanned.
*
* Cprimary (Farads) - start, stop, Inc
165.0e-9
165.0e-9
50.0e-9
* Rprimary (Ohms) - Start, Stop, Inc
0.25
```

```
0.25
1.0
* Lprimary (Heneries) - Start, Stop, Inc
14.0e-6
16.0e-6
1.0e-8
* Lsecondary (Heneries) - Start, Stop, Inc
73.63e-3
73.63e-3
1.0e-3
* Coupling - Start, Stop, Inc
0.1936
0.1936
0.05
* Rsecondary (Ohms) - Start, Stop, Inc
205.0
205.0
1.0
* Csecondary (Farads) - Start, Stop, Inc
32.0e-12
32.0e-12
1.0e-12
* Cload (Farads) - Start, Stop, Inc - If Inc < 0 then automatic streamer load is used
5.7e-12
5.7e-12
-1.0e-12
* Terminal Diameter (Sphere or toroid cord section) inches
6.5
* Strike Distance (inches)
50.0
* Rload (Ohms) - Start, Stop, Inc
220.0e3
220.0e3
1.0e3
* Time (sec) - Start, Stop, Inc - If Inc < 0 then automatic timing is used
0.0e-6
500.0e-6
-1.0e-7
* Vrail - DRSSTC Buss Rail Voltage (volts) - 0.0 for a conventional coil.
0.0
* VCprimary Initial Value (volts) - Primary capacitor voltage for a conventional coil.
0.0 for a DRSSTC.
6900.0
* BPS - Coil Breaks Per Second
240.0
*Dwell Time (sec) start, stop, inc - DRSSTC T1 time.  Quench Time for conventional
coil.
225.0e-6
225.0e-6
1.0e-7
* DRSSTC Current Limit (Amps) - Set very high for conventional coil.
100000.0
* Coil Power Limit (Watts)
100000.0
* Goal Type - 0=find maximum VCsecondary  1=find maximum streamer energy  2=find all
* 3=find maximum leader length  If negative, no waveform file is made (faster!!).
3
*
```

**Cprimary:**
The primary capacitor value is defined first:

```
* Cprimary (Farads) - start, stop, Inc
165.0e-9
165.0e-9
50.0e-9
```

The three live lines after the help line tell the program that the value of the primary capacitor should "start" with the value 150.5e-9 Farads, "end" with the value 150.0e-9 Farads and "increment" the value 50.0e-9 Farads. In this case, the starting and stopping values are the same, so the program will use 150.5e-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, 150.5e-9 is the same as 0.0000001505. The program can accept any value in this scientific notation. Since the value of Cprimary is never changed, the

increment value 50.0e-9 is ignored.

Note: The increment value must be greater than 0.0 or the program gets stuck.

**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 and SISG. 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
14.0e-6
16.0e-6
1.0e-8
```

The primary inductance is set to start at 14.0e-6 Heneries and goes to 16.0e-6 Heneries. The value will be changed in 1.0e-8 Henery steps.

**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...

**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 ;-))

**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 1.5e-12 for every foot of streamer you have or expect. If you streamers are 2 feet long, it is 1.5e-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.

**Terminal Diameter:**
This is the diameter of the top terminal if it is a sphere. If it is a toroid, it is the diameter of the cord section.

**Strike Distance:**
In the dynamic streamer mode, the program will model strikes to ground. Strike distance is the distance from the terminal to the ground point.

**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
0.0e-6
500.0e-6
-1.0e-7
```

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. 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 the DRSSTC (T1 time). For conventional coils, it is the quench time.

**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 Amps.

**Coil Power Limit:**
This the maximum coil power that is accepted. The program can get kind of crazy at times and give giant sparks if given giant input power levels... 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 1, -1, 2, 3, -3.

**1** Tells the program to search for maximum streamer power. Useful for long arc configurations... If it is -1, the program will not write waveform.csv files making it go much faster.

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

**3** Tells the program to find the longest streamers. -3 will not write waveform files for much faster speed.

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

```
ScanTesla  V-8.10  October, 2006  Terry Fritz
C1 1.650000e-007 1.650000e-007 0.500000e-007
R1 2.500000e-001 2.500000e-001 1.000000e+000
L1 1.400000e-005 1.600000e-005 1.000000e-008
L2 7.363000e-002 7.363000e-002 1.000000e-003
K12 1.936000e-001 1.936000e-001 5.000000e-002
R2 2.050000e+002 2.050000e+002 1.000000e+000
C2 3.200000e-011 3.200000e-011 1.000000e-012
C3 5.700000e-012 5.700000e-012 -1.000000e-012
R3 2.200000e+005 2.200000e+005 1.000000e+003
T1 0.000000e+000 5.000000e-004 -1.000000e-007
Terminal Diameter 6.500000e+000
Strike Distance 5.000000e+001
Vrail 0.000000e+000
VCpri_init 6.900000e+003
BPS 2.400000e+002
DwellTime 2.250000e-004 2.250000e-004 1.000000e-007
Current_Limit 1.000000e+005
CoilPower_Limit 1.000000e+005
Goal Type 3

LeaderLengthVsecFactor 1.286000e+001
LeaderLengthPowerFactor 9.735000e-001
CapacitanceLengthFactor 1.000000e+000
StikeDistanceFactor 1.300000e+000
Elevation (Feet) 5.300000e+003
Temperature (F) 7.700000e+001
```

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-8.10  October, 2006  Terry Fritz
Goal =       36.761516762  Maximum Leader Length
Model Number =     108                   Goal Number =     103
Cprimary (nF) =  165.000
Lprimary (uH) =   15.070
Rprimary (Ohm) =  0.250
Coupling = 0.1936
Csecondary (pF) = 32.00
Lsecondary (mH) =   73.630
Rsecondary (Ohm) =  205.0
Primary Q =   38.2                       Secondary Q =  234.0
Cstreamer (pF) = 5.044
Rstreamer (kOhm) =  220.0
BPS =  240.000
Dwell (T1) Time (uSec) =  225.0
Ilprimay Maximum (A) = -708.95
ICprimary RMS (Arms) = 36.56             ILsecondary RMS (Arms) = 0.52654
VCprimary Maximum (kV) =   6.886
VCsecondary Maximum (kV) =  -386.420
Coil Power (W) =    942.68               Primary Bang Energy (J) =   3.928
Streamer Power (W) =    551.34           Streamer Bang Energy (J) =   2.297
```

```
Streamer Length (in) =  36.76 ( 47.79)    Air Streamer
Streamer Energy Length (in) =  25.99      Streamer Power Length (in) =  25.99
Primary F0 (Hz) = 100930.3                Secondary F0 (Hz) = 103685.4
Load Energy Rise Time (uSec) =   70.6

Models Tested = 201 / 201
```

**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. When the program is finished, the best model will be at the bottom of the file.

**"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. There are examples and column explanations in these files:

**"outputdata.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. There are examples and column explanations in these files:

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

```
* ScanTesla Parameter Input File  V-8.00
* New SISG 5400V 330nF coil
* This file should be in the same directory as the program.
*
* Lines starting with "*" are ignored.
*
* The program expects these input parameters in order and as shown.
*
* These parameters define the coil values to be scanned.
*
* Cprimary (Farads) - start, stop, Inc
165.0e-9
165.0e-9
50.0e-9
* Rprimary (Ohms) - Start, Stop, Inc
0.25
0.25
1.0
* Lprimary (Heneries) - Start, Stop, Inc
14.0e-6
16.0e-6
1.0e-8
* Lsecondary (Heneries) - Start, Stop, Inc
73.63e-3
73.63e-3
1.0e-3
* Coupling - Start, Stop, Inc
0.1936
0.1936
0.05
* Rsecondary (Ohms) - Start, Stop, Inc
205.0
205.0
1.0
```

```
* Csecondary (Farads) - Start, Stop, Inc
32.0e-12
32.0e-12
1.0e-12
* Cload (Farads) - Start, Stop, Inc - If Inc < 0 then automatic streamer load is used
5.7e-12
5.7e-12
-1.0e-12
* Terminal Diameter (Sphere or toroid cord section) inches
6.5
* Strike Distance (inches)
50.0
* Rload (Ohms) - Start, Stop, Inc
220.0e3
220.0e3
1.0e3
* Time (sec) - Start, Stop, Inc - If Inc < 0 then automatic timing is used
0.0e-6
500.0e-6
-1.0e-7
* Vrail - DRSSTC Buss Rail Voltage (volts) - 0.0 for a conventional coil.
0.0
* VCprimary Initial Value (volts) - Primary capacitor voltage for a conventional coil.
0.0 for a DRSSTC.
6900.0
* BPS - Coil Breaks Per Second
240.0
*Dwell Time (sec) start, stop, inc - DRSSTC T1 time.  Quench Time for conventional
coil.
225.0e-6
225.0e-6
1.0e-7
* DRSSTC Current Limit (Amps) - Set very high for conventional coil.
100000.0
* Coil Power Limit (Watts)
100000.0
* Goal Type - 0=find maximum VCsecondary  1=find maximum streamer energy  2=find all
* 3=find maximum leader length  If negative, no waveform file is made (faster!!).
3
*
```

It is a SISG coil. All the values are all fixed except Lprimary. The program will search for the best streamer load energy and in effect tell us where to tune Lsecondary for the best output voltage. Once “input.txt” is edited and saved, we just run “ScanTesla810.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.:

```
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Model Number =     108                    Goal Number =     103
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BPS =  240.000
Dwell (T1) Time (uSec) =  225.0
Ilprimay Maximum (A) = -708.95
ICprimary RMS (Arms) = 36.56              ILsecondary RMS (Arms) = 0.52654
VCprimary Maximum (kV) =   6.886
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Coil Power (W) =    942.68                Primary Bang Energy (J) =   3.928
Streamer Power (W) =    551.34            Streamer Bang Energy (J) =   2.297
Streamer Length (in) =  36.76 ( 47.79)    Air Streamer
Streamer Energy Length (in) =  25.99      Streamer Power Length (in) =  25.99
Primary F0 (Hz) = 100930.3                Secondary F0 (Hz) = 103685.4
Load Energy Rise Time (uSec) =   70.6
```
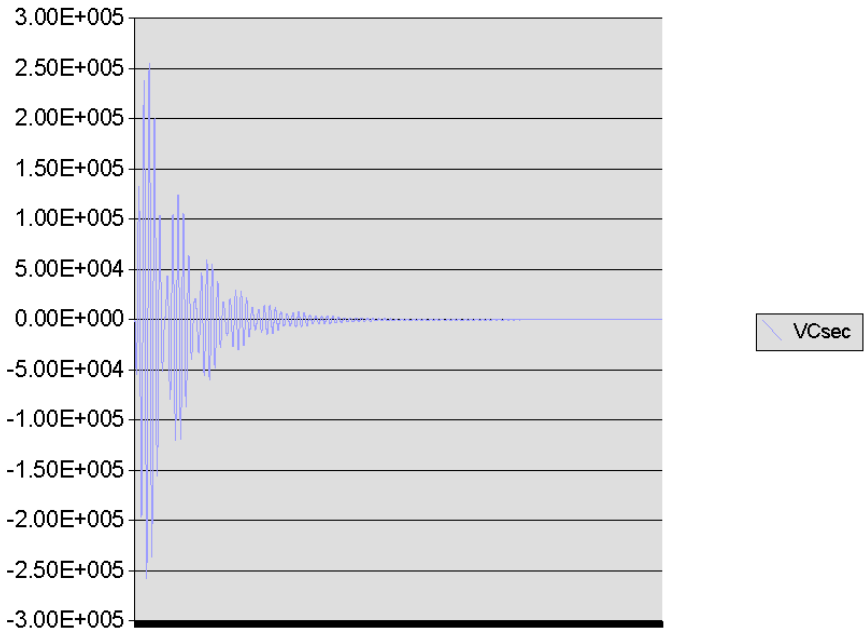

```
Models Tested = 201 / 201
Cprimary = 1.505000e-007
Lprimary = 1.710000e-005
Rprimary = 1.200000e-001
Coupling = 0.172600
Csecondary = 3.110000e-011
Lsecondary = 7.363000e-002
Rsecondary = 4.600000e+002
Cload = 4.534020e-012
Rload = 2.200000e+005
BPS = 120.000000
Dwell (T1) Time = 5.001000e-004
Ilprimay Maximum = -502.738877
ICprimary RMS (Arms) = 18.771659   ILsecondary RMS (Arms) = 0.263319
VCprimary Maximum = 5389.201693
VCsecondary Maximum = -257574.331051
Coil Power = 263.314800   Primary Bang Energy = 2.194290
Load Power = 189.398499   Load Bang Energy = 1.578321
Leader Length (in) = 36.056997  Streamer
Primary F0 = 99209.629209   Secondary F0 = 105175.003923
Load Energy Rise Time (uSec) = 75.800000

Models Tested = 51 / 51
```

It says that when Lprimary was 17.1uH, the streamer energy was the highest at 189.398499 watts. If we open the file “waveforms.csv” with OpenOffice and plot say VCsec, we get:




So that is basically what the program does.

Terry