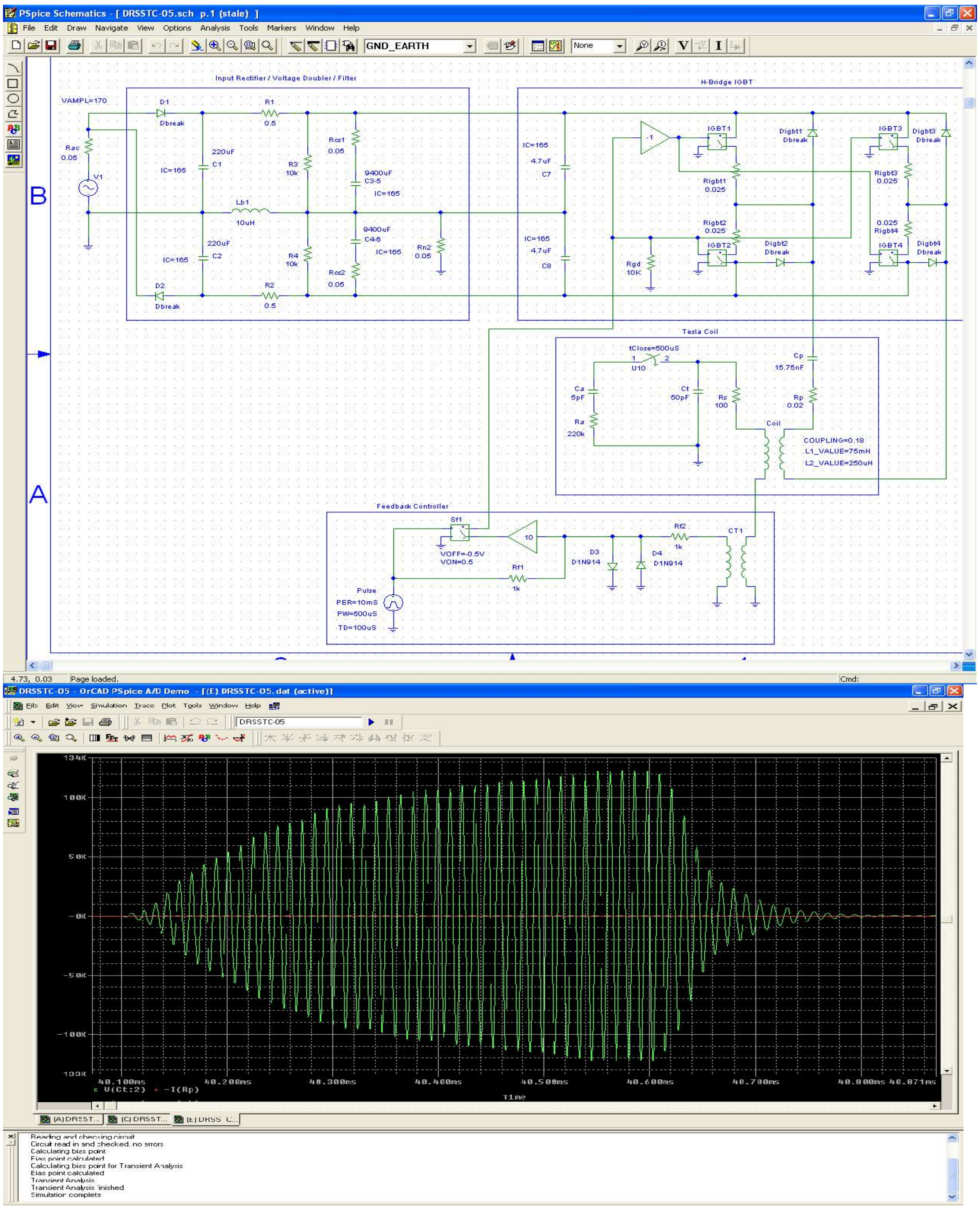
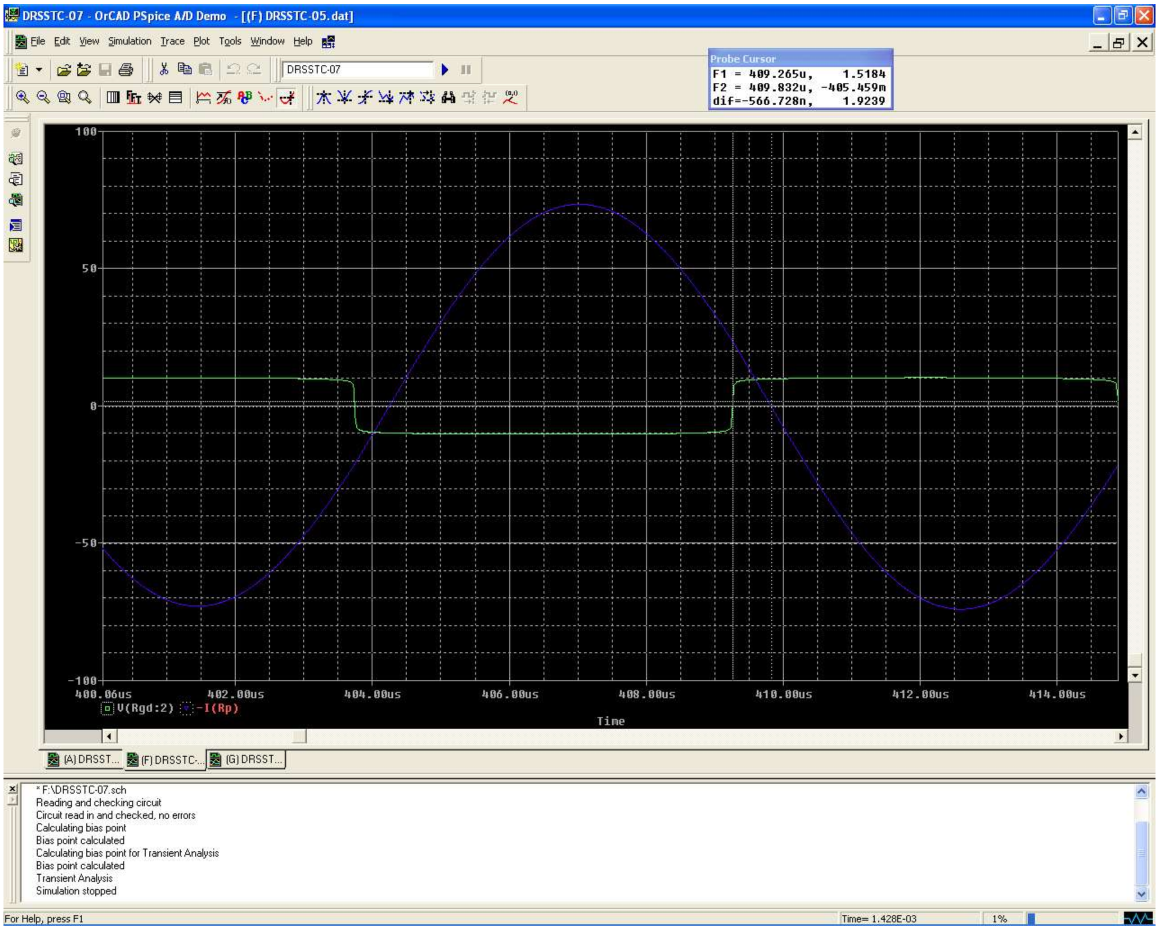
Possible Improvement to the DRSSTC Drive Circuit - Terry

At present, most DRSSTC drive circuits are “synchronized” using a feedback loop driven from the secondary base current. However, this type of feedback control may not align the IGBT switching times well with the zero current crossings in the primary loop. Shown below is a model of the conventional drive system.



The model predicts that the IGBT switching will differ from the primary current by about 570nS as shown.

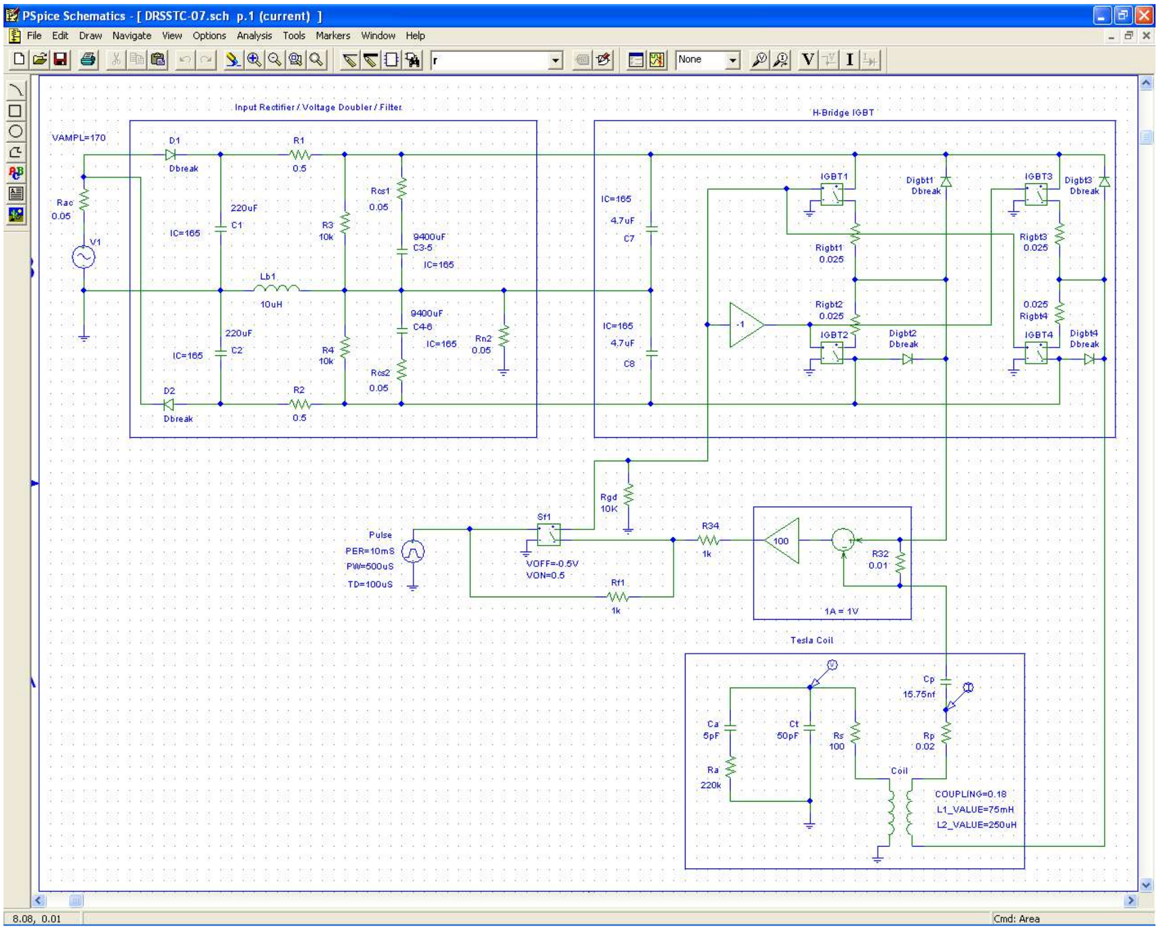


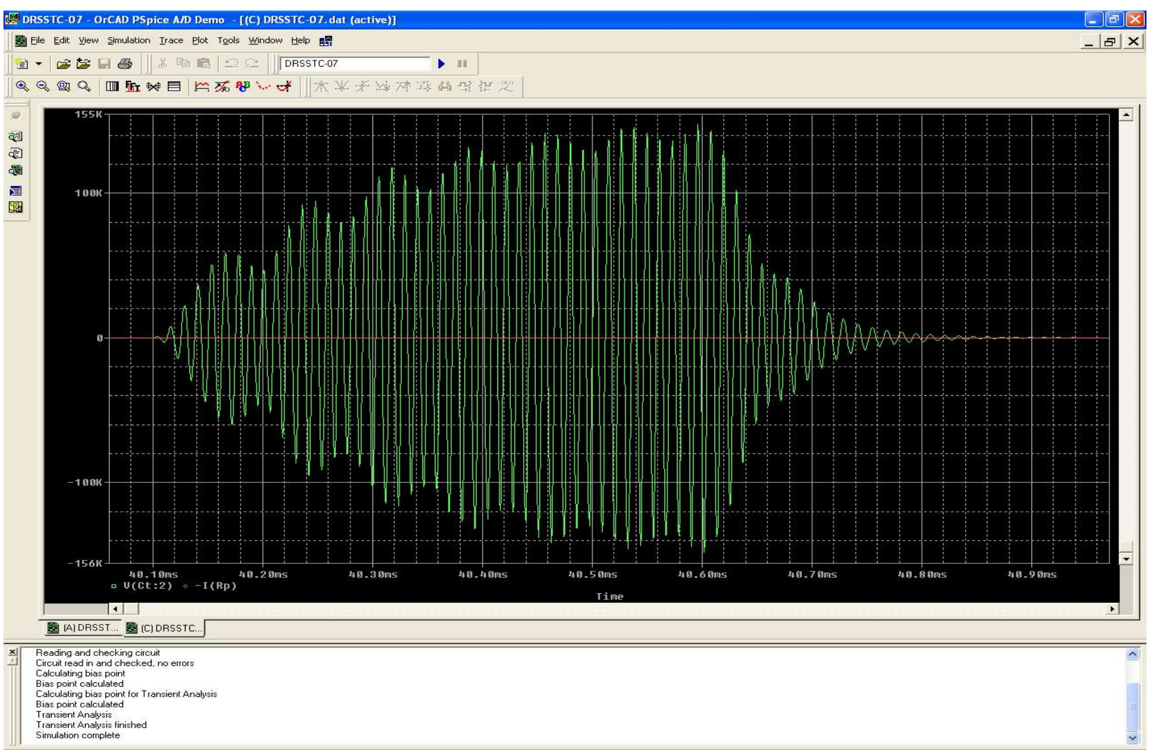
This means that there will be about 25 amps still flowing in the circuit during switching. The delay seems to be due to switching delays and natural instabilities in the Tesla coil system. Dan McCauley's DRSSTC-II book also shows this in his actual measurements.

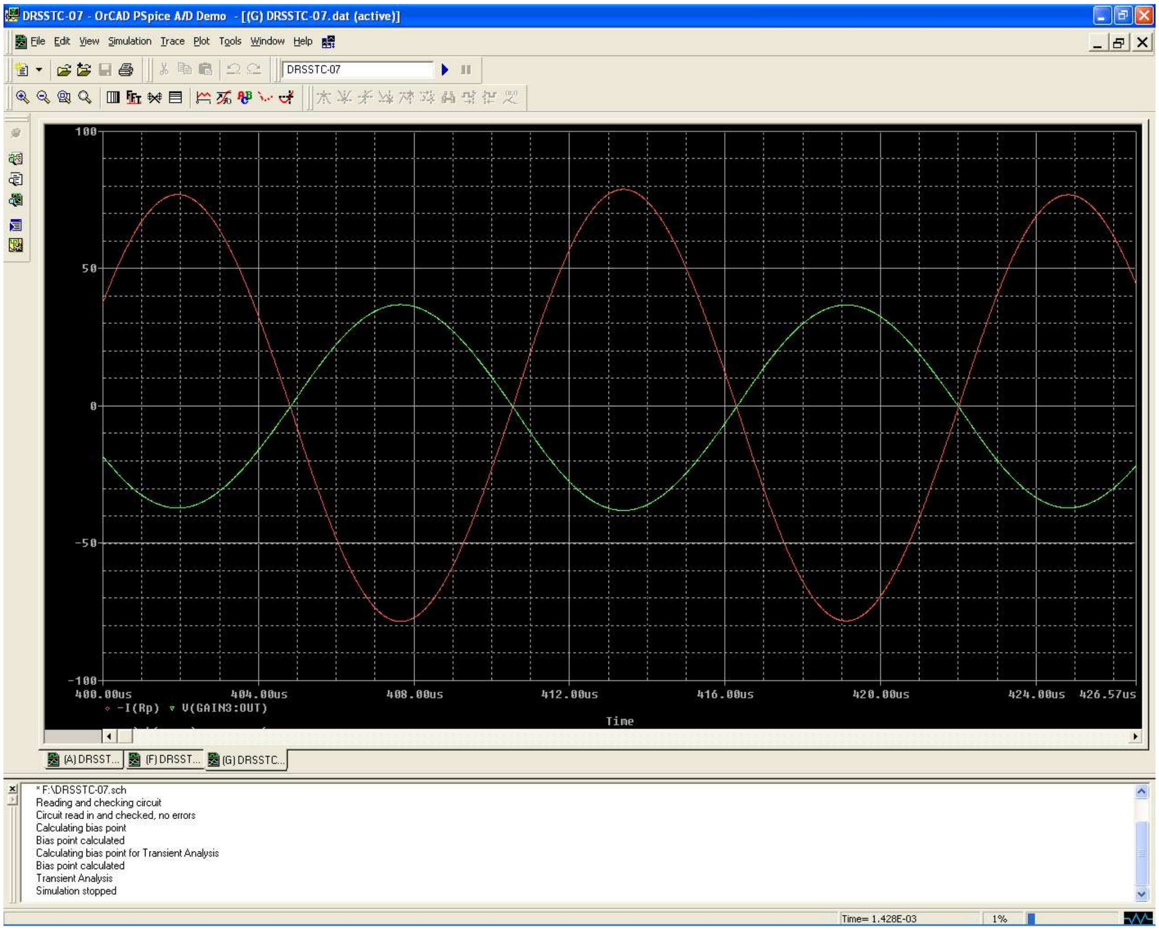
Having current still flowing at this critical time can cause glitches, waisted power, EMI, and other generally obnoxious things. In the real world case, Dan's data shows the delay to be rather random as the system “bounces” around during spark production.

I believe that there are just too many higher order elements in the loop between the primary LC system, coupling, secondary LC system, output arcs, current transformer, and IGBT drive system for the timing to be truly stable.

Therefore, I would propose the following improvement. I would suggest monitoring the primary current directly and controlling the IGBT switching based on the primary current zero crossings. Such a system is shown.


PSpice Schematics - [DRSSTC-07.sch p.1 (current)]
Input Rectifier / Voltage Doubler / Filter
H-Bridge IGBT
VAMPL=170
D1
Dbreak
R1
0.5
Rac
0.05
V1
220uF
C1
IC=165
R3
10k
Rcs1
0.05
9400uF
C3-5
Lb1
10uH
220uF
C2
R4
10k
9400uF
C4-6
Rn2
0.05
Rcs2
0.05
D2
Dbreak
R2
0.5
4.7uF
C7
C8
IGBT1
IGBT2
IGBT3
IGBT4
Digbt1
Digbt2
Digbt3
Digbt4
Rigbt1
Rigbt2
Rigbt3
Rigbt4
0.025
-1
Pulse
PER=10mS
PW=500uS
TD=100uS
Sf1
VOFF=-0.5V
VON=0.5
Rgd
10K
R34
1k
Rf1
1k
100
R32
0.01
1A = 1V
Tesla Coil
Cp
15.75nf
Ca
5pF
Ra
220k
Ct
50pF
Rs
100
Rp
0.02
Coil
COUPLING=0.18
L1_VALUE=75mH
L2_VALUE=250uH
8.08, 0.01
Cmd: Area


DRSSTC-07 - OrCAD PSpice A/D Demo - [(C) DRSSTC-07.dat (active)]
DRSSTC-07
155K
100K
0
-100K
-156K
40.10ms
40.20ms
40.30ms
40.40ms
40.50ms
40.60ms
40.70ms
40.80ms
40.90ms
V(Ct:2) -I(Rp)
Time
Reading and checking circuit
Circuit read in and checked, no errors
Calculating bias point
Bias point calculated
Calculating bias point for Transient Analysis
Bias point calculated
Transient Analysis
Transient Analysis finished
Simulation complete
For Help, press F1
Time= .1
100%



Now, the IGBTs switch “exactly” at the zero current crossing in the primary loop. Models are a little “too perfect” of course, but the timing is vastly better. Note the Ringing effect on the output now due the the resonance of the primary and secondary system “singing” to each other! This is a real behavior of the two coil system that was being hidden in the previous drive system. It appears however that everything “still works ok”, at least in the theoretical modeling case shown here.

The new drive system could drive the coil just through the two primary cables now without the feedback transformer (CT). Power dissipation on the IGBTs is vastly less which should allow far smaller and cheaper IGBTs to be used. Four 40N60 IGBT (bricks) seem “too large” for a ~1.5kW drive system ;-) I am tying to do the same system with four TO-247 style IGBTs costing about $6 each with small heat sinks. Thus, removing the high switching losses is critical!

The MicroSim V9.1 Student Version models are at:

http://www.hot-streamer.com/TeslaCoils/MyCoils/DRSSTC/DRSSTC-05.sch

http://www.hot-streamer.com/TeslaCoils/MyCoils/DRSSTC/DRSSTC-07.sch

Terry 2004-12-6