W Model for differential TL:

```
W1 N=2 TL_IN_POS TL_IN_NEG 0 TL_OUT_POS TL_OUT_NEG 0 RLGCMODEL=ECE733
l=0.1

.MODEL ECE733 W MODELTYPE=RLGC N=2
+Lo=
+300e-9
+60e-9 300e-9
+Co=
+120e-12
+ -24e-12 120e-12
+Ro=
+0.54
+0 0.54
+Rs=
+0.000462
+0 0.000462
+Gd=
+1.4e-11
+ -0.14e-11 1.4e-11
```

Explanation:

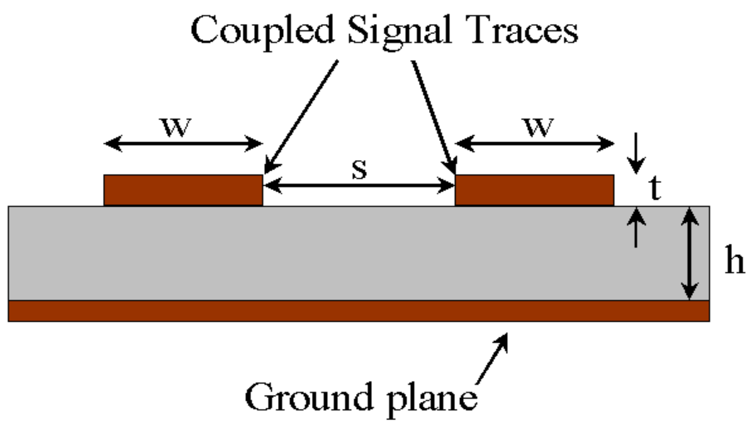

Fig.1 Actual Size

w=22mil, h=12mil, t=2~2.5mil, s=5*w, εr=4.6

1. Assume Coupled dielectric loss is 10% of the self dielectric loss, that is mutual Gd=1.4e-11*10%=0.14e-11. This mutual Gd is enough, given the space of the coupled traces is not place very near: w=5*s.

2. Mutual capacitance and mutual inductance of the coupled differential TL is derived from the actual geometrical, see detail derivation in the matlab file. The result is shown in Fig2 and Fig3. Fig2 shows Odd mode impedance and Even mode impedance Vs. S/W. We don't need to consider Even mode impedance too much since the common mode voltage on TL is zero for ACCI. Fig.3 shows the coupling coefficient: for lines in homogeneous medium, Km=Kc. For case of S=5*W, Km=Kc=0.2, Zodd=41ohm(that is Differential impedance is 80ohm).

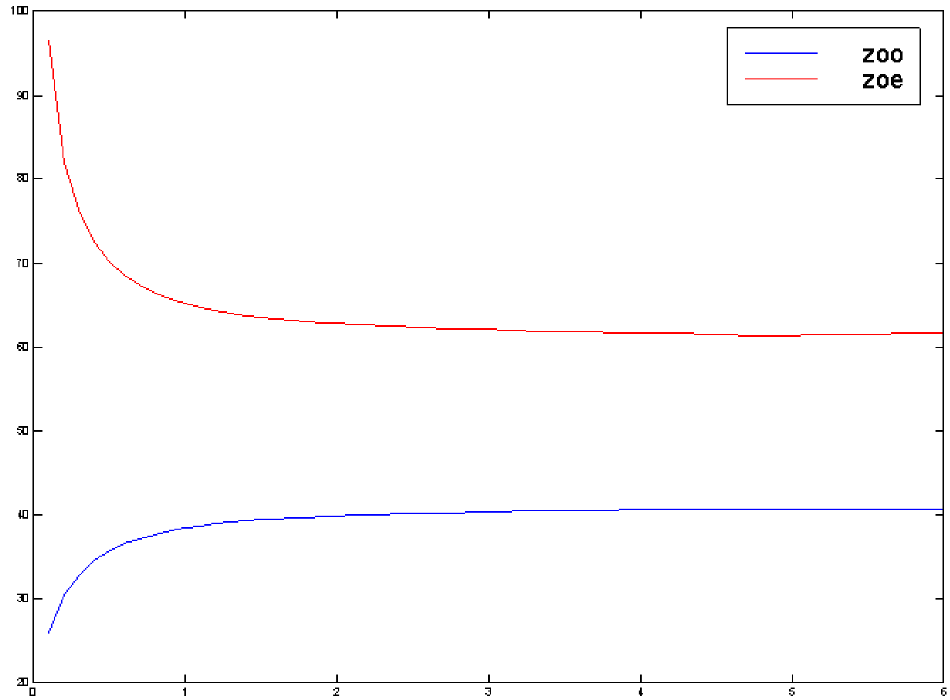

Fig2. Zodd and Zeven VS. S/W

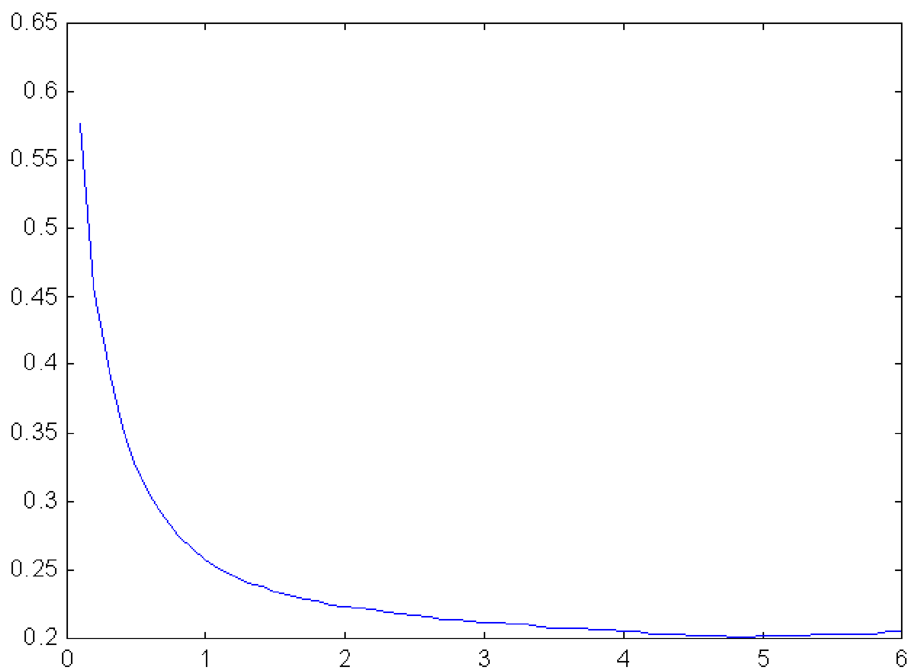

Fig.3 Kc and Km VS. S/W

Smaller S will lead to larger Kc,Km and smaller differential impedance.

3. This model is simulated in Hspice and when terminated by 41ohm, the reflection is the smallest, which proves the correctness. See attached spice file for details.

```
   ****Matlab file******
clear all;
close all;
w=22;

h=12;
e0=8.854e-12;
er=4.6;
eeff=(er+1)/2 + ((er-1)/2)/sqrt(1+12*h/w);
z0=50;
c0=120e-12;
c=3e8;

cp=e0*er*w/h;
cf=0.5*(sqrt(eeff)/(c*z0)-cp);

for i=1:300
   s(i)=0.1*i*w;
   k(i)=(s(i)/h)/(s(i)/h+2*w/h);
   k1(i)=sqrt(1-power(k(i),2));
   if power(k(i),2)<0.5
      kk(i)=(1/pi)*log(2*(1+sqrt(k1(i)))/(1-sqrt(k1(i))));
   else
      kk(i)=pi/log(2*(1+sqrt(k(i)))/(1-sqrt(k1(i))));
   end

   cga(i)=e0*kk(i);
   cgd(i)=(e0*er/pi)*log(coth((pi*s(i))/(4*h))) +
0.65*cf*(0.02*sqrt(er)*h/s(i)+1-power(er,-2));

cm(i)=cga(i)+cgd(i);

kc(i)=cm(i)/c0;
km(i)=kc(i);

zoo(i)=z0*sqrt((1-km(i))/(1+kc(i)));
zoe(i)=z0*sqrt((1+km(i))/(1-kc(i)));

end

figure(1);
grid on;
plot(s/w, zoo,'b');
hold on;
plot(s/w, zoe,'r');
xlabel('s/w');
ylabel('zo');
legend('zoo','zoe');

figure(2);
grid on;
```

```
plot(s/w, kc,'b');
xlabel('s/w');
ylabel('kc and km');

****Spice file*****

.param Rterm=35

R10 V_NEG IN_NEG  Rterm M=1.0
R0 V IN  Rterm M=1.0

V2 V_NEG 0  PULSE 1.0 0.0 0.0 50E-12 50E-12 50E-12 10E-9
V0 V 0  PULSE 0.0 1.0 0.0 50E-12 50E-12 50E-12 10E-9

R7 OUT_NEG 0  9E6 M=1.0
R5 OUT 0  9E6 M=1.0


W1 N=2 IN IN_NEG 0 OUT OUT_NEG 0 RLGCMODEL=ECE733 l=0.1

.MODEL ECE733 W MODELTYPE=RLGC N=2
+Lo=
+300e-9
+60e-9 300e-9
+Co=
+120e-12
+ -24e-12 120e-12
+Ro=
+0.54
+0 0.54
+Rs=
+0.000462
+0 0.000462
+Gd=
+1.4e-11
+ -0.14e-11 1.4e-11

* INCLUDE FILES

* END OF NETLIST
.TRAN  1.00000E-12 1.00000E-08 START=      0.
.TEMP    25.0000
.OP
.save
.OPTION  INGOLD=2 ARTIST=2 PSF=2 post
+        PROBE=0

.alter
.param Rterm=37
.alter
.param Rterm=39
.alter
.param Rterm=41
.alter
.param Rterm=43

.END
```

Note: the equations in Matlab file is originally used to calculate large coupling lines, so when S>6*W, the result is not quite correct. However, it gives the correct result for S<6*W.