



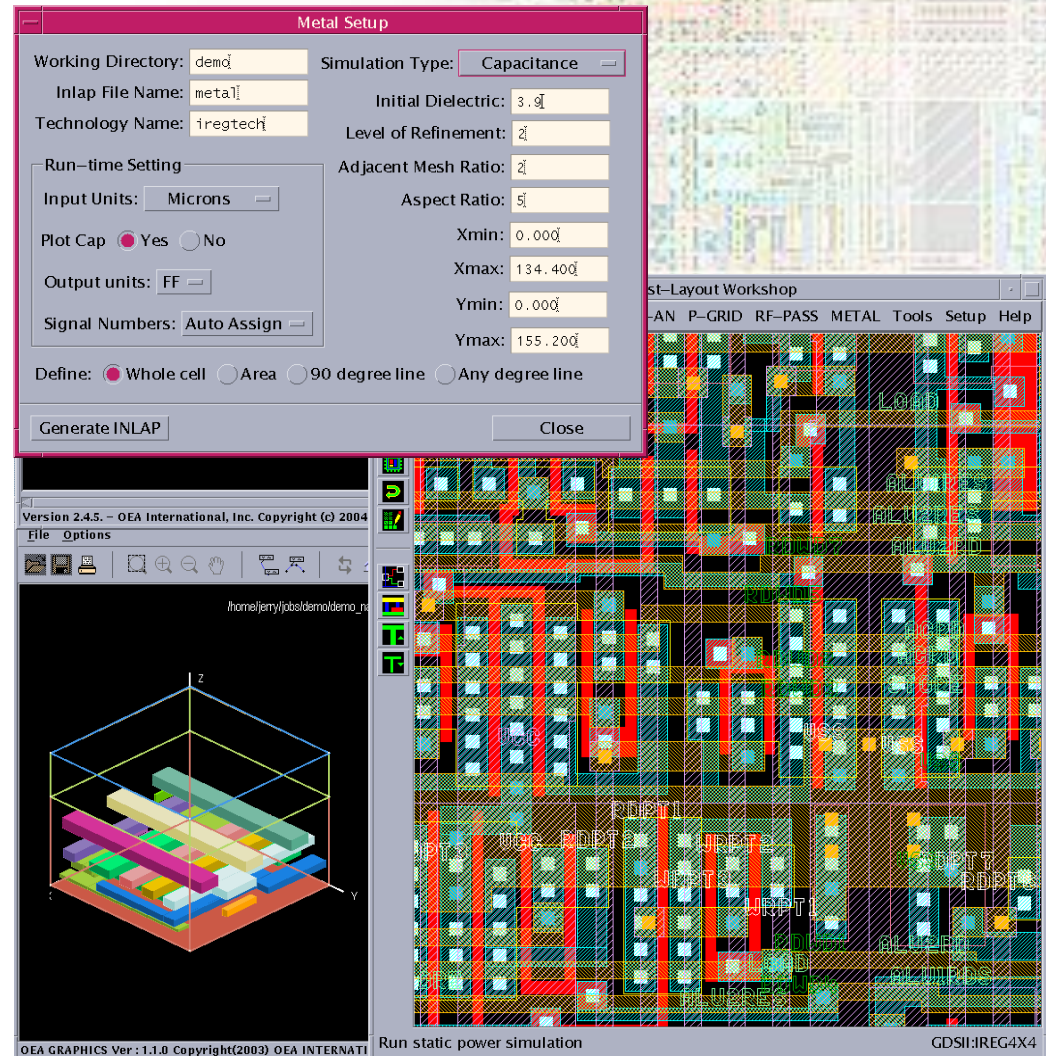
METAL™

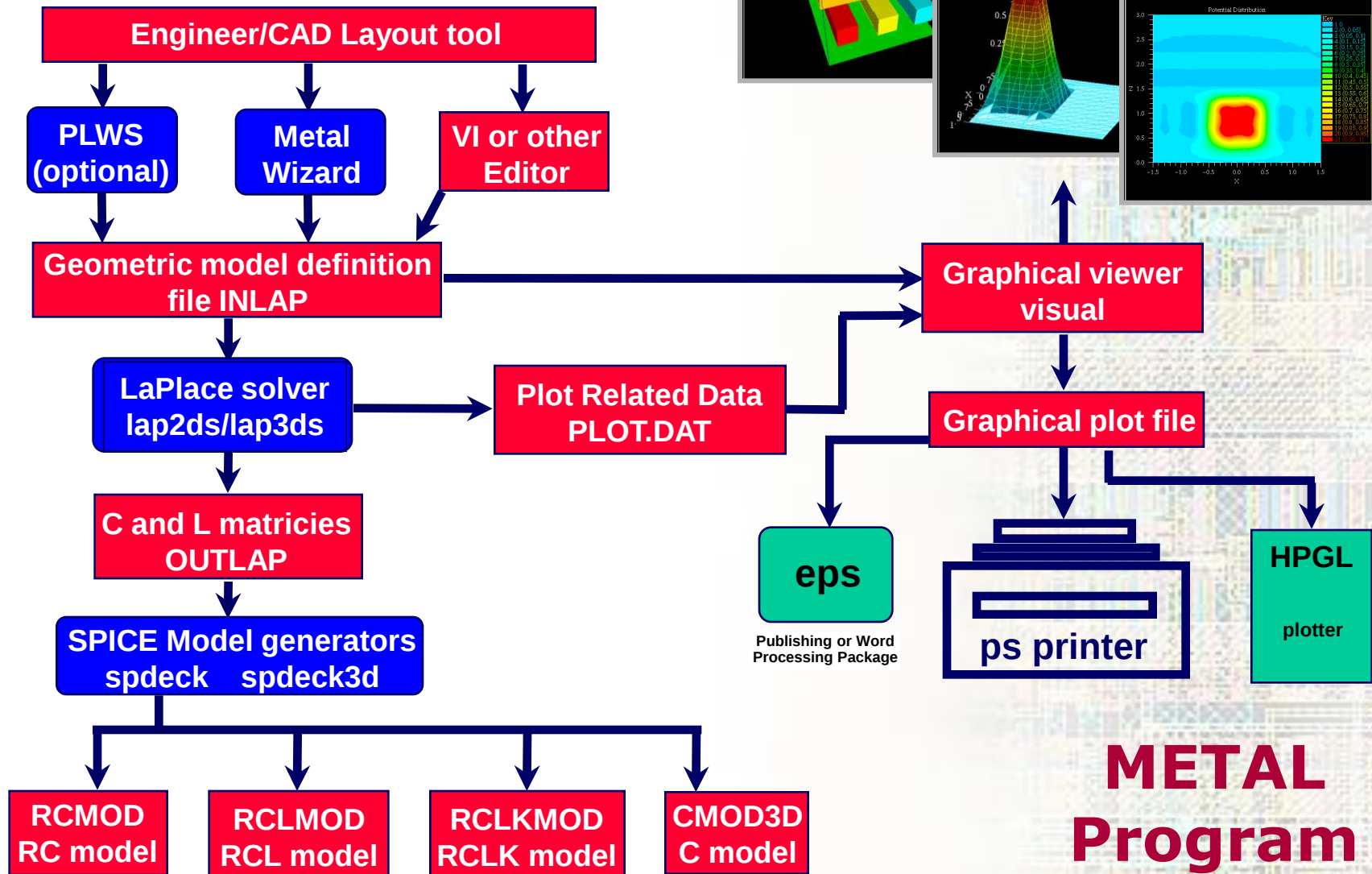
2D and 3D Interconnect Simulation Tool

OEA International, Inc.
155 East Main Ave, Suite 110
Morgan Hill, CA 95037
www.oea.com

METAL Features

- ◆ Extremely fast, efficient and accurate calculation
- ◆ Models 2D and full 3D Interconnect geometry
- ◆ 2D and 3D wizards easy geometry creation programs
- ◆ 3D graphic display with dynamic rotation and zoom
- ◆ Full R,C,L,M extracted
- ◆ Automatic mesh generation and refinement
- ◆ Runs on all popular workstation platforms



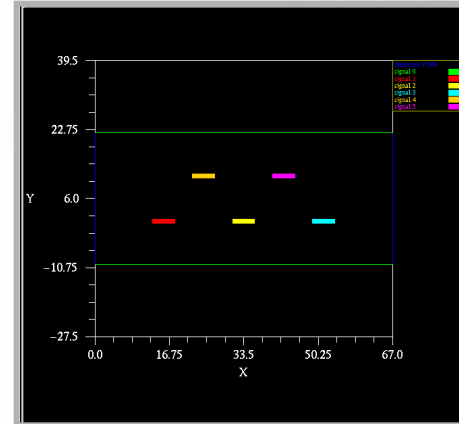


METAL
Program
Flow

METAL 2D - C,L,R

```

X MESH
0 67
Y MESH
-10 22
DIELECTRIC
*XMIN XMAX YMIN YMAX EPSILON
-100 100 -100 100 9.5
METAL
*XMIN XMAX YMIN YMAX SIGNAL LINE#
13 18 0 1 1
31 36 0 1 2
49 54 0 1 3
22 27 11 12 4
40 45 11 12 5
-100 100 -10 -10 0
-100 100 22 22 0
INPUT UNITS=MILS
OUTPUT UNITS=PF/MILS
PLOT CAPACITANCE
1 2 5
    
```



SPICE CAPACITANCE MATRIX

OUTPUT UNITS= PF/MILS

1	1	0.4313E-02	0.5884E-03	0.8974E-05	0.1231E-02	0.4751E-04
2	1	0.5884E-03	0.3361E-02	0.5884E-03	0.1077E-02	0.1077E-02
3	1	0.8974E-05	0.5884E-03	0.4313E-02	0.4751E-04	0.1231E-02
4	1	0.1231E-02	0.1077E-02	0.4751E-04	0.3685E-02	0.5767E-03
5	1	0.4751E-04	0.1077E-02	0.1231E-02	0.5767E-03	0.3685E-02

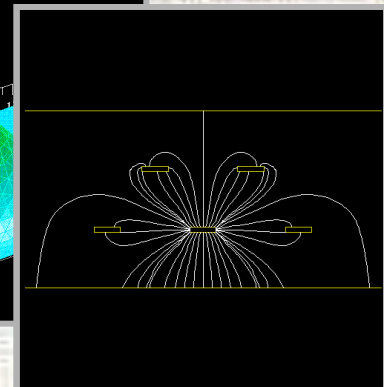
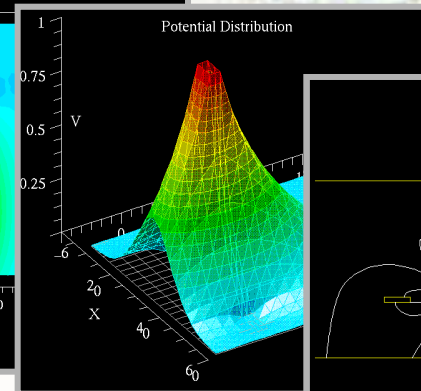
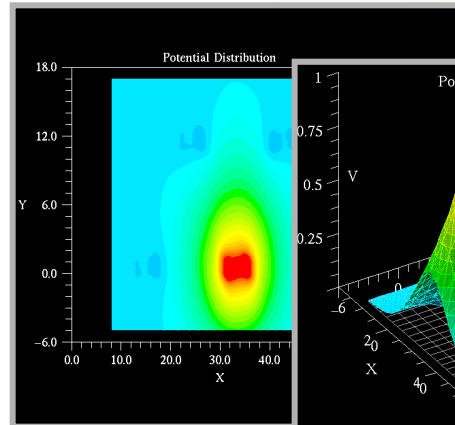
MAXWELL CAPACITANCE MATRIX

*	1	1	0.6189E-02	0.5884E-03	0.8974E-05	0.1231E-02	0.4751E-04
*	2	1	0.5884E-03	0.6693E-02	0.5884E-03	0.1077E-02	0.1077E-02
*	3	1	0.8974E-05	0.5884E-03	0.6189E-02	0.4751E-04	0.1231E-02
*	4	1	0.1231E-02	0.1077E-02	0.4751E-04	0.6618E-02	0.5767E-03
*	5	1	0.4751E-04	0.1077E-02	0.1231E-02	0.5767E-03	0.6618E-02

INDUCTANCE MATRIX

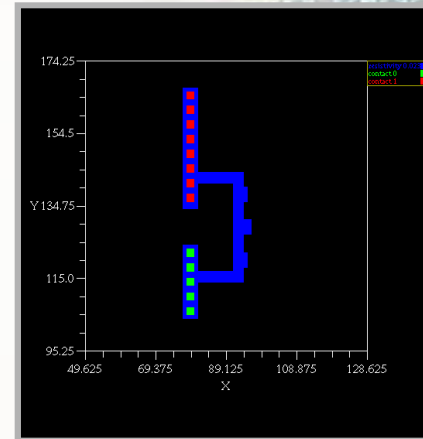
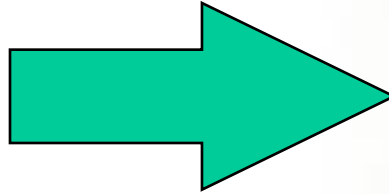
OUTPUT UNITS= PH/MILS

1	1	0.1166E+02	0.1549E+01	0.3041E+00	0.2477E+01	0.6082E+00
2	1	0.1549E+01	0.1121E+02	0.1549E+01	0.2327E+01	0.2327E+01
3	1	0.3041E+00	0.1549E+01	0.1166E+02	0.6082E+00	0.2477E+01
4	1	0.2477E+01	0.2327E+01	0.6082E+00	0.1128E+02	0.1493E+01
5	1	0.6082E+00	0.2327E+01	0.2477E+01	0.1493E+01	0.1128E+02

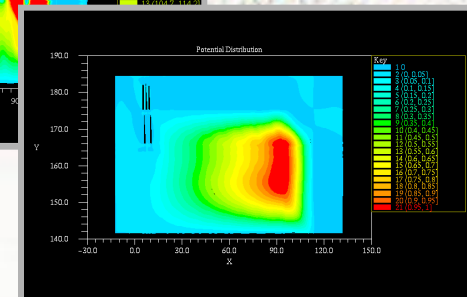
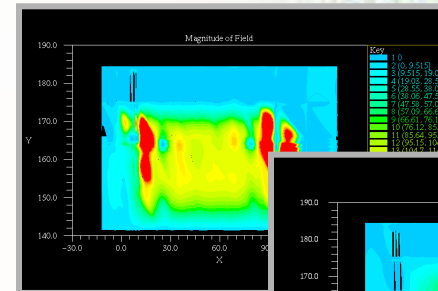
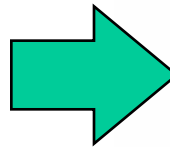


METAL 2D - R

INPUT UNITS = MICRONS
 OUTPUT UNITS = OHM
 ASPECT RATIO = 50
 ADJACENT MESH RATIO = 20
 LEVEL OF REFINEMENT = 2
 X MESH
 -12.250 131.750
 Y MESH
 141.500 184.500
 INVERTED
 PLOT
 RESISTIVITY
 0.000 100.000 161.000 172.000 0.023
 CONTACT
 93.000 95.000 162.000 164.000 1
 9.000 11.000 164.000 166.000 0
 5.000 7.000 164.000 166.000 0

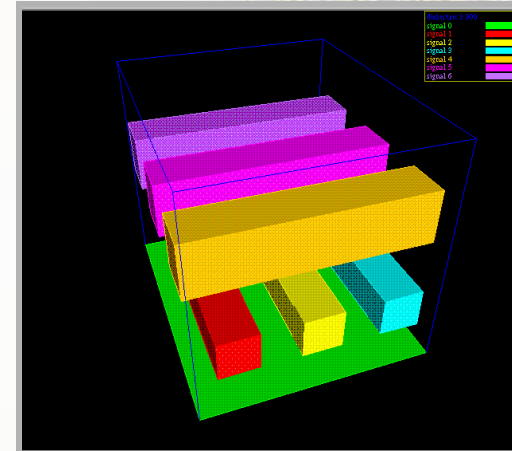
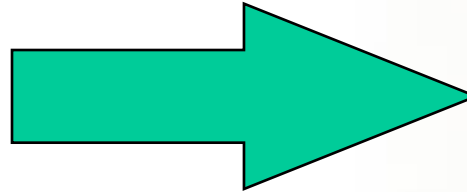


RESISTANCE= 0.1399E+00 OHM*CM
 MAXIMUM % ERROR IN FLUX CONSERVATION= 0.5658E-02
 FIELD CALCULATION RESULTS (V/CM)
 EXMAX= 0.1417E+03 EYMAX= 0.1271E+03 ETOTMAX= 0.1904E+03
 CURRENT DENSITY CALCULATION RESULTS (A/CM**2)
 DXMAX= 0.6163E+04 DYMAX= 0.5524E+04 DTOTMAX= 0.8276E+04
 CONTACT CURRENT DENSITY WAS = 0.7148E+01 A/CM



METAL 3D [C]

```
X MESH
-1.5 1.5
Y MESH
-1.8 1.8
Z MESH
0 3
DIELECTRIC
-1.5 1.5 -1.8 1.8 0 3 3.9
METAL DATA
* first LAYER
-1.25 -0.75 -1.8 1.8 0.6 1.1 1 // L_SIDE
-0.25 0.25 -1.8 1.8 0.6 1.1 2 // CENTER
0.75 1.25 -1.8 1.8 0.6 1.1 3 // R_SIDE
* second LAYER
-1.5 1.5 -1.5 -0.9 1.55 2.25 4 // L_SIDE
-1.5 1.5 -0.3 0.3 1.55 2.25 5 // CENTER
-1.5 1.5 0.9 1.5 1.55 2.25 6 // R_SIDE
-1.5 1.5 -1.8 1.8 0 0 0 // GROUND
PLOT CAPACITANCE
2 5
INPUT UNITS=MICRONS
OUTPUT UNITS=FF
ASPECT RATIO=6
ADJACENT MESH RATIO=4
LEVEL=2
```



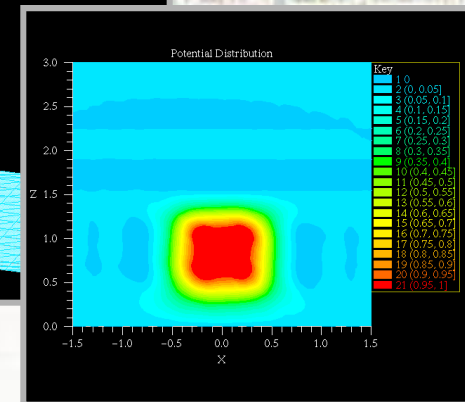
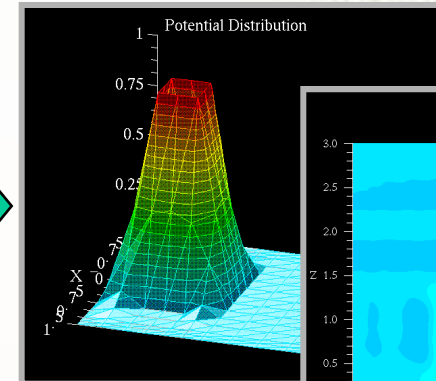
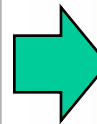
NUMBER OF SIGNAL LINES= 6 NUMBER OF GROUNDS= 1
SPICE CAPACITANCE MATRIX

OUTPUT UNITS= FF

```
1 1 0.1995E+00 0.1888E+00 0.3606E-03 0.8276E-01 0.8345E-01 0.8276E-01
2 1 0.1888E+00 0.2006E+00 0.1888E+00 0.8335E-01 0.8405E-01 0.8335E-01
3 1 0.3606E-03 0.1888E+00 0.1995E+00 0.8276E-01 0.8345E-01 0.8276E-01
4 1 0.8276E-01 0.8335E-01 0.8276E-01 0.5823E-03 0.2068E+00 0.5321E-02
5 1 0.8345E-01 0.8405E-01 0.8345E-01 0.2068E+00 0.5868E-03 0.2068E+00
6 1 0.8276E-01 0.8335E-01 0.8276E-01 0.5321E-02 0.2068E+00 0.5824E-03
```

MAXWELL CAPACITANCE MATRIX

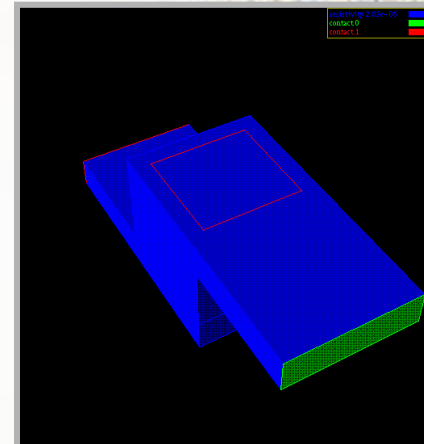
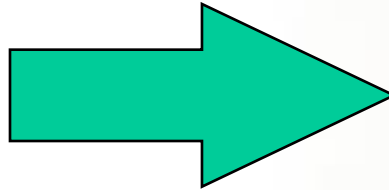
```
* 1 1 0.6377E+00 0.1888E+00 0.3606E-03 0.8276E-01 0.8345E-01 0.8276E-01
* 2 1 0.1888E+00 0.8289E+00 0.1888E+00 0.8335E-01 0.8405E-01 0.8335E-01
* 3 1 0.3606E-03 0.1888E+00 0.6377E+00 0.8276E-01 0.8345E-01 0.8276E-01
* 4 1 0.8276E-01 0.8335E-01 0.8276E-01 0.4615E+00 0.2068E+00 0.5321E-02
* 5 1 0.8345E-01 0.8405E-01 0.8345E-01 0.2068E+00 0.6651E+00 0.2068E+00
* 6 1 0.8276E-01 0.8335E-01 0.8276E-01 0.5321E-02 0.2068E+00 0.4615E+00
```



METAL 3D - R

```

X MESH
0 6
Y MESH
0 2
Z MESH
0 2
INVERTED
RESISTIVITY REGION DATA
* XMIN XMAX YMIN YMAX ZMIN ZMAX R(ohm*cm)
* FIRST LAYER METAL
-100 4 -10 10 0 0.5 2.824e-6
* SECOND LAYER METAL
2 100 -10 10 1.5 2 2.824e-6
* VIA WHICH TIES THE TWO TOGETHER
2 4 0 2 0.5 1.5 2.824e-6
INSULATOR REGION DEFINITION
* XMIN XMAX YMIN YMAX ZMIN ZMAX
* THE HOLE IN THE VIA
2.25 3.75 0.25 1.75 0.75 100
CONTACT DATA
* XMIN XMAX YMIN YMAX ZMIN ZMAX CONTACT#
0 0 -10.0 10.0 0 0.5 1
6 6 -10.0 10.0 1.5 2.0 0
PLOT
INPUT UNITS=MICRONS
LEVEL OF REFINEMENT=3
OUTPUT UNITS=OHMS
  
```



```

RESISTANCE= 0.1686E+00 OHM

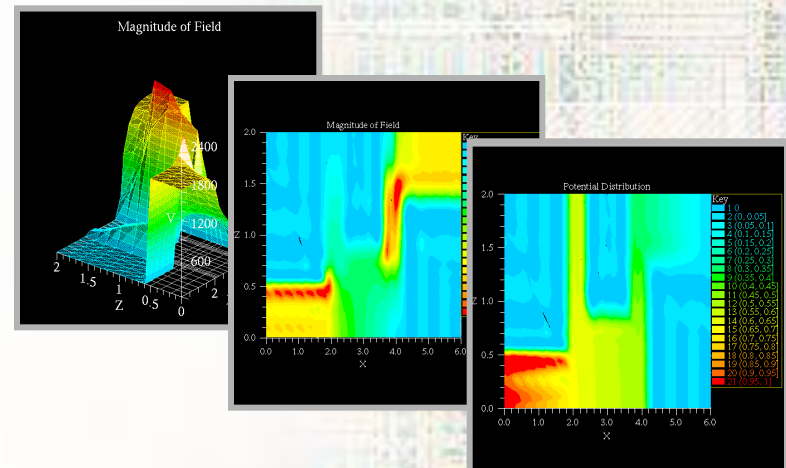
FIELD CALCULATION RESULTS (V/CM)

EXMAX= 0.2444E+04 EYMAX= 0.1220E+04 EZMAX= 0.2502E+04 ETOTMAX= 0.2713E+04

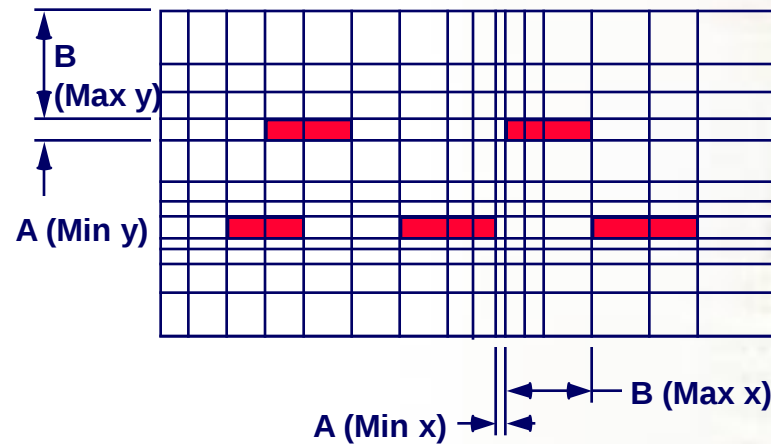
CURRENT DENSITY CALCULATION RESULTS (A/CM**2)

DXMAX= 0.8656E+09 DYMAX= 0.4321E+09 DZMAX= 0.8860E+09 DTOTMAX=
0.9608E+09

CONTACT CURRENT WAS = 0.5932E+01 A
  
```



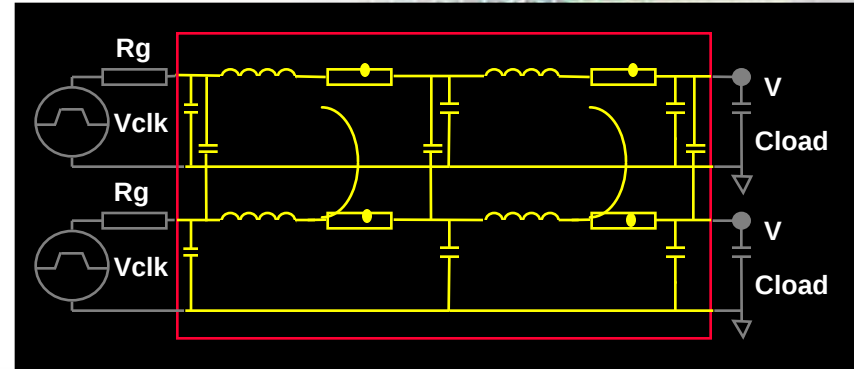
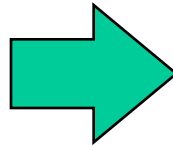
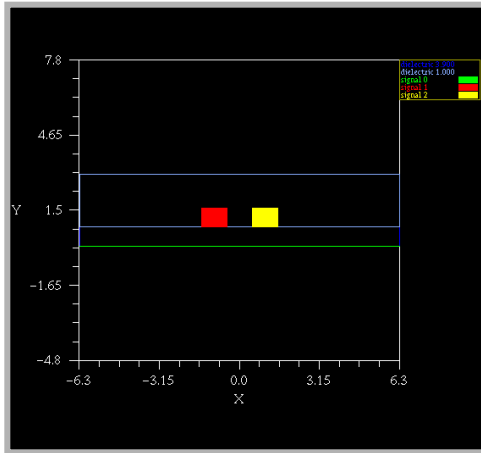
Meshing Process



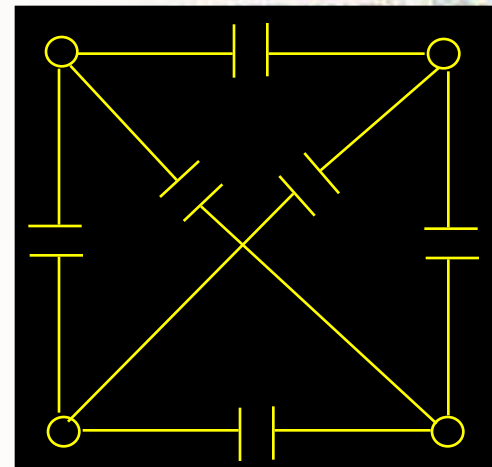
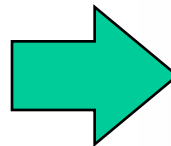
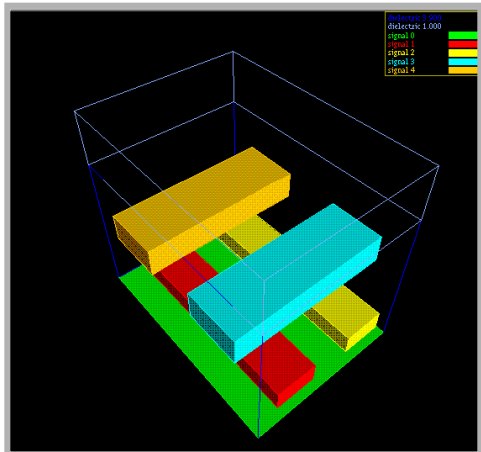
- Wherever ASPECT RATIO is $>$ 'value', add mesh lines
- Wherever ADJACENT MESH RATIO is $>$ 'value', add mesh lines.
- If iteration is $<$ 'value' of LEVEL OF REFINEMENT, go back to step #1, otherwise continue.
- Solve and look at 2nd and 3rd order derivative terms.
Refine mesh in areas with high relative derivative terms.

METAL Spice Conversions

Fully Coupled Sub-circuit of N-sections



Fully coupled element capacitance model



Summary of METAL Features

- Both 2D and 3D Poisson Field Solvers
- Solves both for Capacitance Matrix and Complex Resistance
- Builds Optimally Sectioned Bus RCLM SPICE Sub-Circuit Models from 2D Cross-sections
- Visual Plotting of Input Geometry, Calculated Fields and Voltage Potentials in Both 2D and 3D Views
- Optional GDSII Graphics Interface

