

# UWEE Foldy-Lax Via Tool v2.21 User Manual

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[http://www.ee.washington.edu/research/laceo/Via\\_Tool/](http://www.ee.washington.edu/research/laceo/Via_Tool/)

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# Introduction

The Foldy-Lax Via Tool is a fast full-wave 3D interconnector simulator for modeling massively-coupled multiple vias in multilayered electronic packaging.

The Foldy-Lax Via Tool is built based on the granted US Patent [7149666](#). This tool and its user interface are all protected by the existing or other pending intellectual property rights in the United States.

Updates and latest information will be posted on the official website of Laboratory of Applications and Computations in Electromagnetics and Optics ([LACEO](#)).

# Installation

The Foldy-Lax Via Tool v2.21 is coded on Matlab R2007b platform.

This tool is delivered in an encrypted self-unpacking format.

- UWEE\_Foldy\_Lax\_Via\_Tool\_pkg.exe
- UWEE\_Foldy\_Lax\_Via\_Tool\_DOS.exe
- UWEE\_Foldy\_Lax\_Via\_Tool\_DOS.ctf

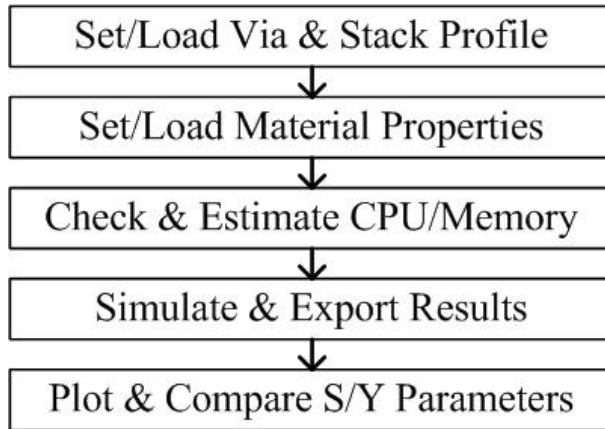
After installation, the following files will appear in the directory.

- UWEE\_Foldy\_Lax\_Via\_Tool.exe
- UWEE\_Foldy\_Lax\_Via\_Tool.ctf
- MCRInstaller.exe

Run MCRInstaller.exe, if no proper Matlab environment exists.

Run Tool.exe to use this tool. This .exe file will extract the compiled scripts from Tool.ctf to folder \...Tool\_mcr\ in its first run.

# Working Flow



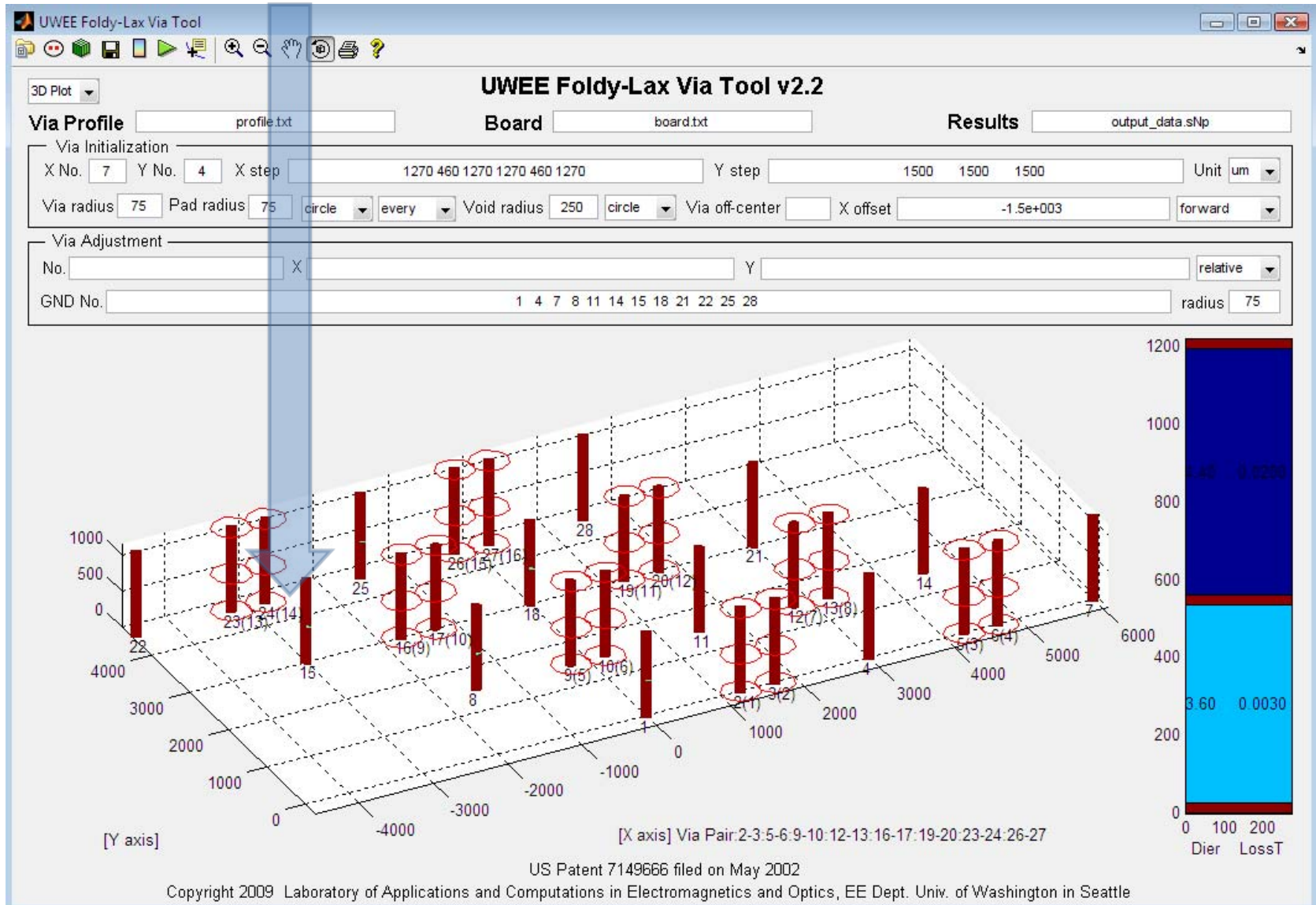
# Capabilities

- Layout signal and GND vias in different positions
- Vary the size of via, pad and void
- Model pad and void in circular or square shape
- Model the vias with off-center drilling
- Model the vias in the multilayered stack
- Model via pair in shared void for differential signaling
- Assign different materials with dielectric loss
- Provide mixed mode co-channel S-parameters

# A Quick Start

Global via No (signal via No.)

Use Global via No. in the panel input



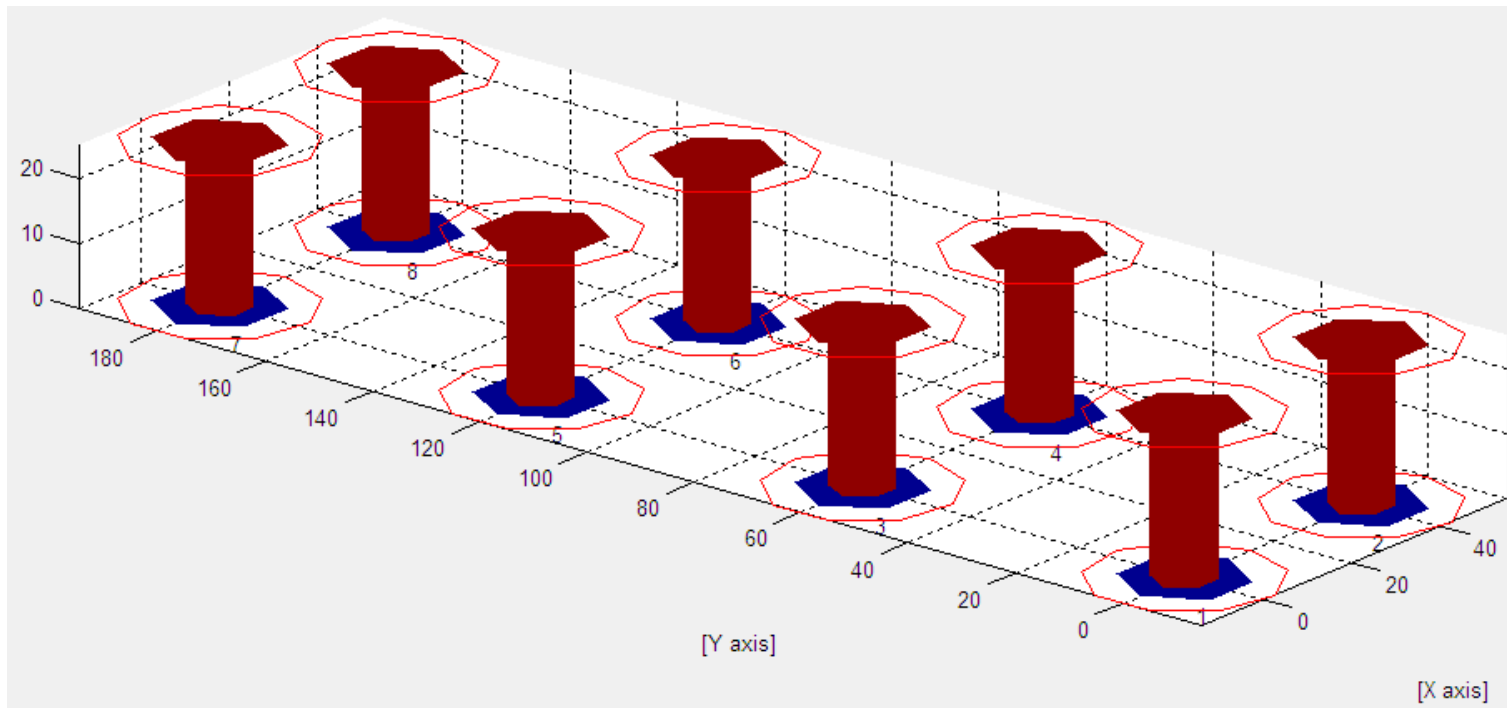
# How to position the vias (1)

For vias lying on the grid

e.g. 2-by-4 via array with X step-size of 40 mils and Y step-size of 60 mils

Via Initialization

X No.	<input type="text" value="2"/>	Y No.	<input type="text" value="4"/>	X step	<input type="text" value="40"/>	Y step	<input type="text" value="60"/>	Unit	<input type="text" value="mil"/>
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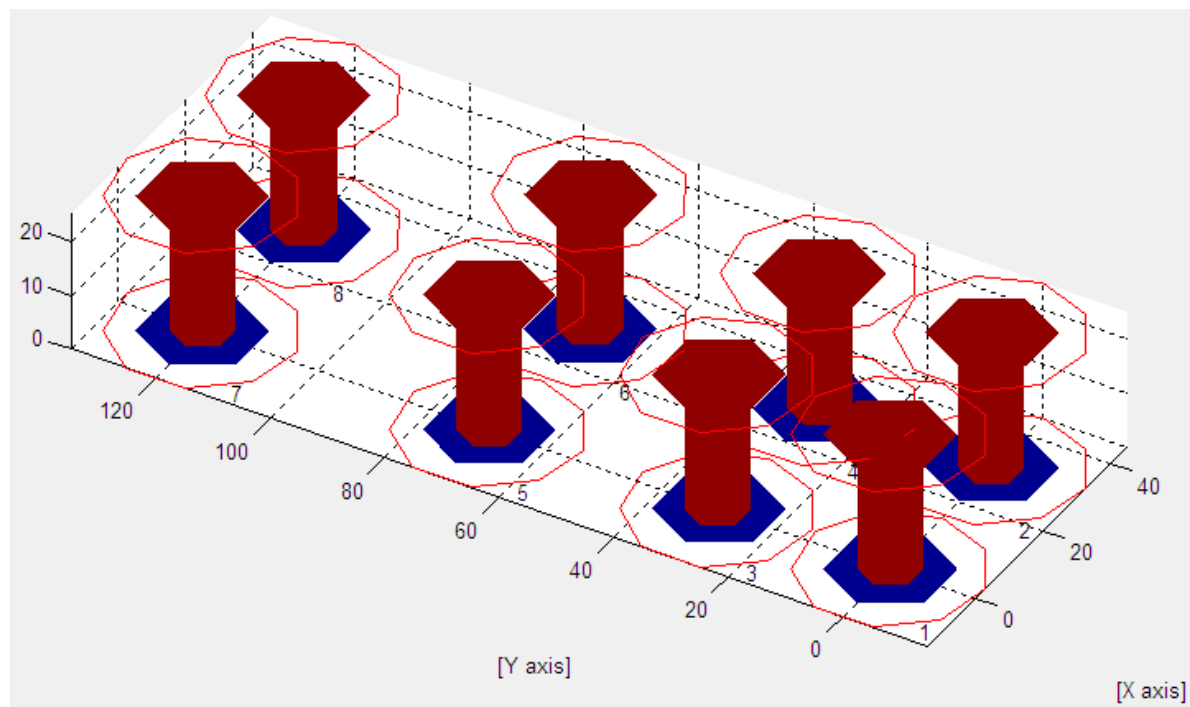
# How to position the vias (2)

For vias lying on the grid with different step-sizes

e.g. 2-by-4 via array with X step-size of 30 mils and Y step-sizes of 30, 40, 50 mils.

Via Initialization

X No.	<input type="text" value="2"/>	Y No.	<input type="text" value="4"/>	X step	<input type="text" value="30"/>	Y step	<input type="text" value="30 40 50"/>	Unit	<input type="text" value="mil"/>
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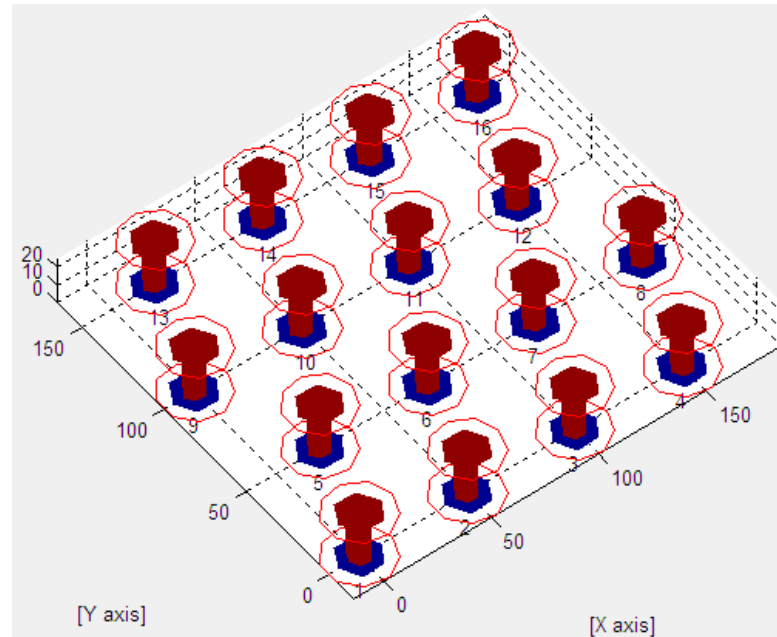
# How to position the vias (3)

For vias lying on the grid with column OFFSET

e.g. 4-by-4 via array with step-size of 50 mils and alternative column offset of 20 mils.

Via Initialization

X No.	4	Y No.	4	X step	50	Y step	50	Unit	mil					
Via radius	5	Pad radius	10	circle	every	Void radius	15	circle	Via off-center	<input type="checkbox"/>	X offset	20	back / forth	back / forth



# How to position the vias (4)

For vias lying slightly OFF the grid

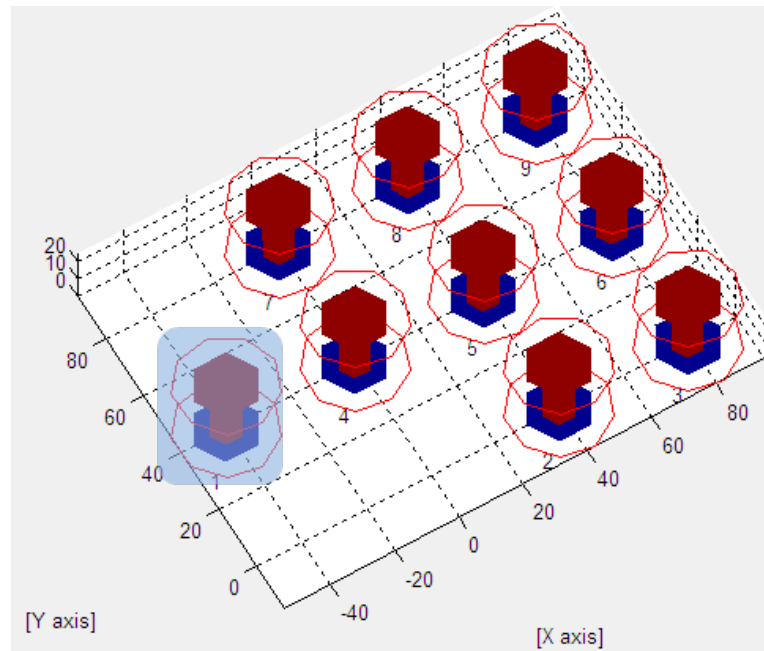
e.g. 3-by-3 via array with step-size of 40 mils, then shift Via No.1 from (0,0) to (-40,40)

Via Initialization

X No.  Y No.  X step  Y step  Unit

Via Adjustment

No.  X  Y



# How to position the vias (5)

For vias NOT lying on the grid

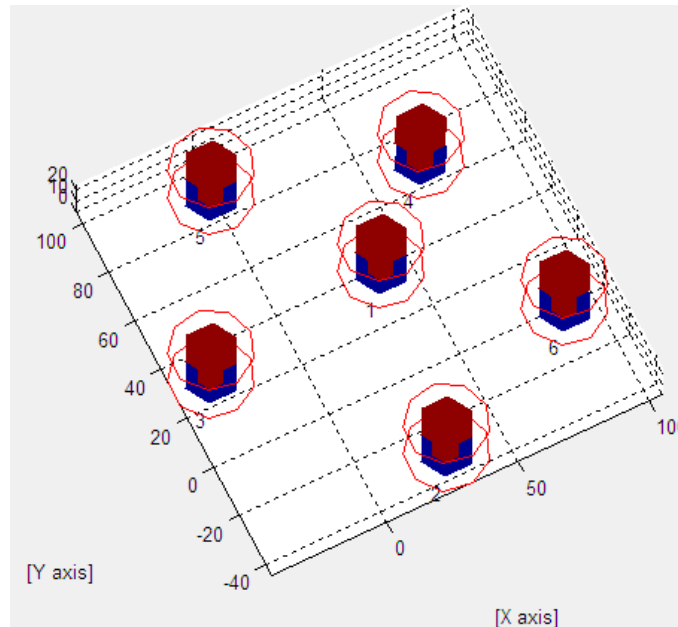
e.g. 6 vias at (40,40) (30,-30) (-30, 30) (70, 70) (0, 90) (90, 0)

Via Initialization

X No.  Y No.  X step  Y step  Unit

Via Adjustment

No.  X  Y



# How to vary the via geometry structures

- Radius of via (barrel) drilling



Via radius <input type="text" value="75"/>	Pad radius <input type="text" value="75"/>	<input type="text" value="circle"/> ▼	<input type="text" value="every"/> ▼	Void radius <input type="text" value="250"/>	<input type="text" value="circle"/> ▼	Via off-center <input type="text"/>
--------------------------------------------	--------------------------------------------	---------------------------------------	--------------------------------------	----------------------------------------------	---------------------------------------	-------------------------------------

- Radius of via-void (antipad)
- Void shape could be circle (default) or square



- Radius of via-pad (larger or equal to via radius)
- Via-pad could be in the shape of circle (default) or square
- Via-pad could lie on every layer (default) or only at via ends



- Via drilling off-center  
*all vias shift in X direction  
pads and voids remain*



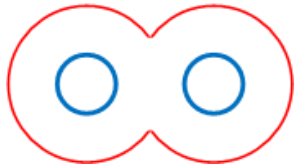
After your setup, please double-check there is no short-circuit.

# How to label via pair in shared void for differential signaling

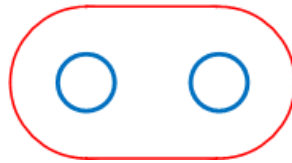
- Assign first via No. of the pair in the first line
- Then second via No. of the pair in the second line
- Void shape of via pair will not be plotted in GUI.

Global via No. here

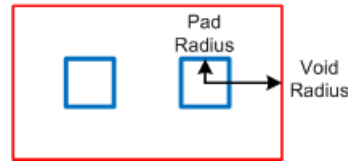
1. Lemniscate



2. Oval



3. Rectangle



Via No. (first)  
2 5 9 12 16 19 23 26

Via No. (second)  
3 6 10 13 17 20 24 27

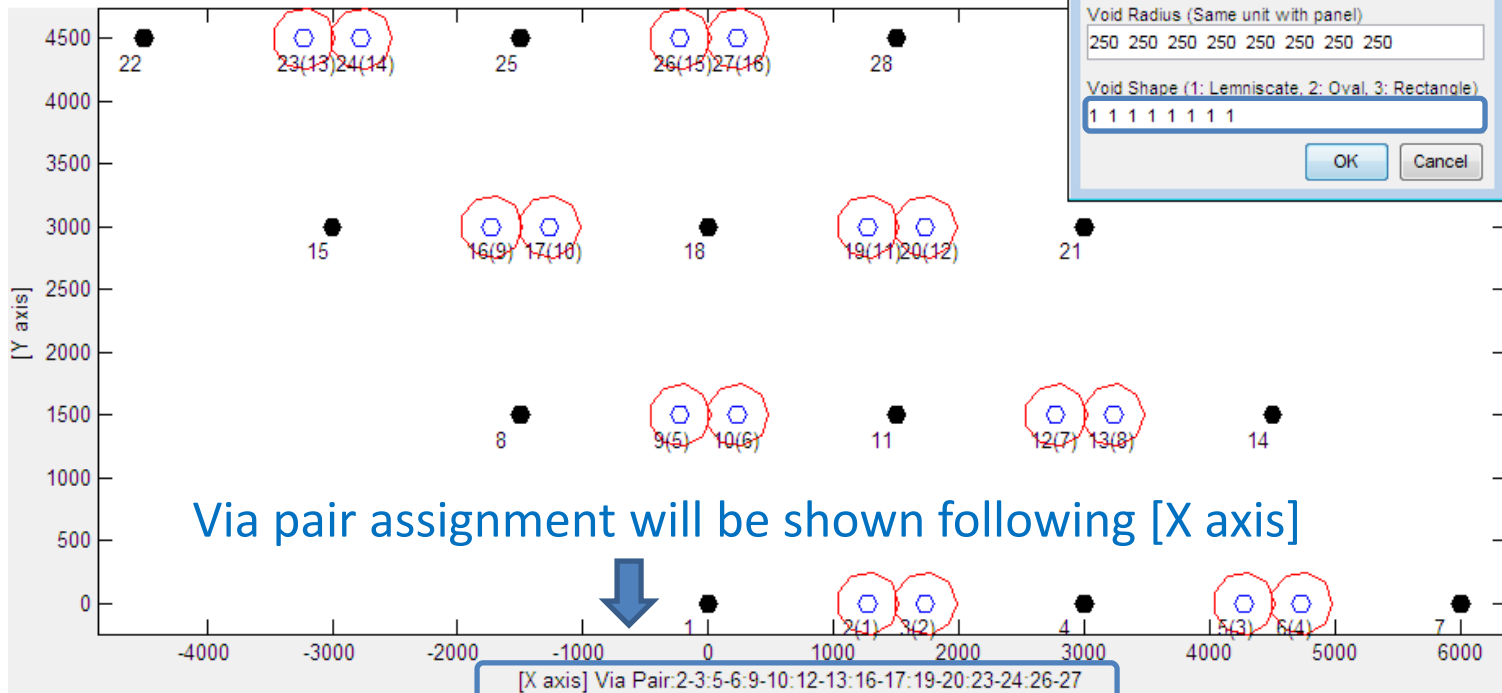
Pad Radius (Same unit with panel)  
75 75 75 75 75 75 75 75

Pad Shape (1: Circle, 2: Square)  
1 1 1 1 1 1 1 1

Void Radius (Same unit with panel)  
250 250 250 250 250 250 250 250

Void Shape (1: Lemniscate, 2: Oval, 3: Rectangle)  
1 1 1 1 1 1 1 1

OK Cancel



# How to assign materials for multilayered stackup

- Assign the materials from BOTTOM to TOP
- Materials properties can be frequency dependent.
- Layered dielectrics can be assigned between '0's, which indicates conducting plates.
- Unit used for stack info can be different with that in the via profile.

Please *SAVE board.txt* to ensure the loading of your stack info.

M\_assign

Stack Information

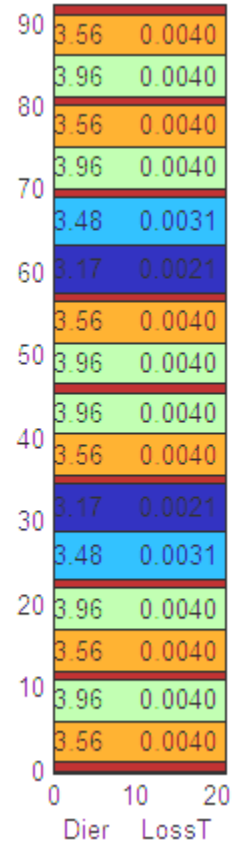
Name: board1.txt      Unit: mil      (Note: Use No. 0 to represent conducting plate)

Thickness: 1 5 5 1 5 5 1 5.8 5.8 1 5 5 1 5 5 1 5.8 5.8 1 5 5 1 5 5 1

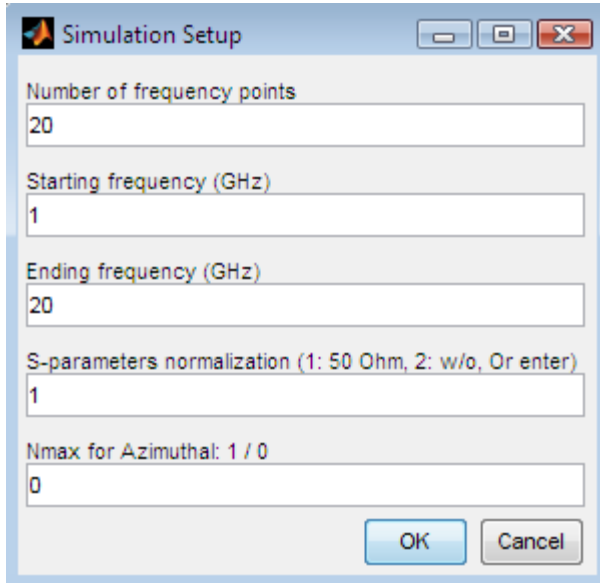
Material No.: 0 1 2 0 1 2 0 3 4 0 1 2 0 2 1 0 4 3 0 2 1 0 2 1 0

Material Properties

No.	Name	Frequency (GHz)	Dielectric Constant	Loss Tangent
1	M_356	1	3.56	0.004
2	M_396	1	3.96	0.004
3	M_348	1	3.48	0.0031
4	M_317	1	3.17	0.0021
5	FR4	1	4.4	0.015



# How to setup the simulation



Simulation Setup

Number of frequency points  
20

Starting frequency (GHz)  
1

Ending frequency (GHz)  
20

S-parameters normalization (1: 50 Ohm, 2: w/o, Or enter)  
1

Nmax for Azimuthal: 1 / 0  
0

OK Cancel

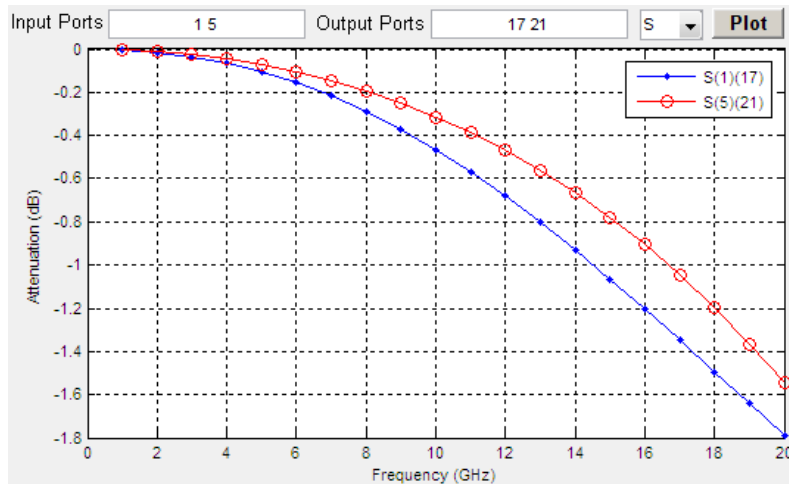
## Normalization for S-parameters calculation

- The default reference impedance is 50 Ohm.
- Take Opt.2 to use calculated impedance of coaxial port
- Or enter  $Z_0$  for any known impedance
- Only one reference impedance for all ports

## $N_{\max}$ for Azimuthal

- The default value 0 is good for most situations.
- Use 1, if vias are particularly placed close to each other.
- Use 0, if pads are only on via ends or large GND vias exist.
- Use 0 for fast calculation, if more than a hundred of vias.

# How to plot the results



- Numbers aside via stand for bottom ports.
- Add  $N_{\text{total}}$  for upper ports
- If GND exist, use via No. inside parentheses.
- The upper two figures give complete  $S_{\text{DD}}$ .
- The lower two figures only plot  $S_{\text{DD}12}$ .
- If via pair assigned, only modal  $\mathbf{S}$  is provided.
- load touchstone (\*.sNp) or matlab (\*.mat) for plot

# How to run the command-line (DOS) version

Set simulation parameters in *simulation\_setup.txt*

The format of *simulation\_setup.txt* can be found in the appendix.

Make sure the board file (*\*.txt*) is also properly set.

Command line > UWEE\_Foldy\_Lax\_Via\_Tool\_DOS *profile\_name*

Or

Double-click *UWEE\_Foldy\_Lax\_Via\_Tool\_DOS.exe*

The default profile name is *profile.txt*

If *profile.txt* does not exist, the tool will ask for re-entering the profile name in the command line.

# Frequently Asked Questions (1)

- *Why I cannot run Tool.exe to use the tool?*

Please install MCRInstaller.exe. If still not work, please contact us.

- *Why profile.txt is modified though I did not press the SAVE bottom?*

The profile.txt will be modified when pressing the “RUN” bottom or “SAVE” bottom. The new profile will be generated from the current information on the GUI.

- *Why profile.txt can not be properly loaded after text editing?*

The profile.txt should strictly follow the certain data format. Please check the Appendix for details.

- *Why the tool shut down without any notice?*

Please make sure your input is valid without any short-circuit.

If still not work, please contact us and provide profile.txt or screen-print.

# Frequently Asked Questions (2)

➤ *Why the results in touchstone file are all NaNs?*

Please make sure your input dimensions are reasonable. Too large or too small size will cause matrix ill-conditioned and unable to solve.

➤ *What kind of port setup does current tool use?*

Currently the tool only uses coaxial cable as the port. It is same with the waveport setup in the HFSS. Practically this is similar to the press-fit connector.

➤ *Can this tool model the via-trace bend as the port setup?*

So far not. But we are now investigating this part and will add this function very soon.

➤ *What is the frequency limitation of the current tool?*

The current tool provides good accuracy from 1GHz ~ 40 GHz. You can find quasi-static physical models for results below 1GHz. We are now focusing on the research of the high frequency range.

# Frequently Asked Questions (3)

➤ *How to incorporate metal loss in this tool?*

As we investigated the metal loss contribute few to the total insertion loss (only -0.003 at 10GHz). Therefore, to simply the algorithm, we ignore the metal loss in the current tool.

➤ *Why I cannot set the size of board and GND planes?*

The current tool uses the algorithm which assumes the GND planes and board are relatively very large. We are still researching on the case of finite GND planes and plane splits/gaps.

➤ *How to model the vias with different radius?*

Currently, we can set different radius for GND vias only. We are testing the case of different radius on each signal via and will add this function very soon.

➤ *Does the current tool provide parallel computing using 32 bits?*

If your computer uses 32 bits, the current tool can make full use of your memory capacity. We are still working on the parallel computing code for simulating over ten-thousand vias problem.

# Frequently Asked Questions (4)

➤ *How to model via stub and back-drilled via?*

The current tool provides both S and Y network parameters. For via stub case,  $Y_{uu}$  (self port) can be used instead of  $Y_{ub}$  (through port). For back-drilled via case, please assign the stack info starting from your drilling-stop position.

➤ *How to model the buried via?*

The current tool assumes all the vias have the same vertical length. If targeting specifically on the buried via, please re-assign the stack info only containing the buried via section, and later cascade the network parameters of rest stacks.

➤ *Other question?*

Technical Support: Boping Wu [bennywu@ieee.org](mailto:bennywu@ieee.org)

# Appendix

- profile.txt
- board.txt
- simulation\_setup.txt

Please keep the files in the same folder as *Tool.exe*

# profile.txt

```
board.txt
output_data.sNp
2.540000e-005
12
8.000000e+001 -4.000000e+001
4.000000e+001 0.000000e+000
8.000000e+001 0.000000e+000
1.200000e+002 0.000000e+000
0.000000e+000 4.000000e+001
4.000000e+001 4.000000e+001
8.000000e+001 4.000000e+001
1.200000e+002 4.000000e+001
0.000000e+000 8.000000e+001
4.000000e+001 8.000000e+001
8.000000e+001 8.000000e+001
4.000000e+001 1.200000e+002
4
40 40 40
3
40 40
0
0
6.000000e+000
8.000000e+000
1.750000e+001
0
0
0
0.000000e+000
1 2 5 8 11 12
9.000000e+000
1
2
1 8.000000e+001 -4.000000e+001
12 4.000000e+001 1.200000e+002
1
3 4 8.000000e+000 0 1.750000e+001 1
4 7 8.000000e+000 0 1.750000e+001 1
```

Board file name  
Output file name  
Unit used (1 mil = 2.54e-5 meters)  
Total number of vias (Nv)  
X\_1 Y\_1  
:  
X\_Nv Y\_Nv  
Number of columns (X No.)  
Column separations (X steps)  
Number of rows (Y No.)  
Row separations (Y steps)  
Option for via array column offset (0 is Back / Forth, 1 is Forward)  
Column offset (X offset)  
Radius of via, pad, void  
Pad shape (0 is circle, 1 is square)  
Pad Layer (0 is on every layer, 1 is only on via terminals)  
Void shape (0 is circle, 1 is square)  
Via off-center drilling  
GND Via No.  
GND Via radius  
Option for via position adjustment (0 is Relative, 1 is Absolute)  
Number of vias needed for position adjustment (Na)  
Via\_1 No. Via\_1 X Via\_1 Y  
:  
Via\_Na No. Via\_Na X Via\_Na Y  
Number of via pairs assigned for sharing the void (Nd)  
Via\_1\_1 No. Via\_1\_2 No. Pad radius/shape Void radius/shape  
Via\_Nd\_1 No. Via\_Nd\_2 No. :

# board.txt

2.540000e-005	...	Unit used for stack info
1 30 1	...	Height (from BOTTOM to TOP)
0 11 0	...	No. of Materials (Use 0 to representing conducting plates )
Teflon	...	Material No.1
1 9	...	Frequency Points (in GHz)
2.1 3.1	...	Dielectric Constants
0.001 0.001	...	Loss Tangent
Duroid	...	Material No.2
1 9	...	Frequency Points (in GHz)
2.2 3.1	...	Dielectric Constants
0.0009 0.001	...	Loss Tangent
Neltec NX9250	...	Material No.3
1 9	...	Frequency Points (in GHz)
2.5 3.1	...	Dielectric Constants
0.0016 0.001	...	Loss Tangent

# simulation setup.txt

- 20 ... Number of frequency points
- 1 ... Starting frequency (in GHz)
- 20 ... Ending frequency (in GHz)
- 1 ... S-parameters normalization (1: 50 Ohm, 2: w/o, Or enter)
- 0 ... Nmax for Azimuthal: 1 / 0