

Advanced RF Board Skills in ADS

Sharon CHEN

2020.04.09

Application Engineer



Outline

- Quick review of Momentum
- Lab1: Port Type Overview
- Lab2: Net Type Setup for Physical Model Simplified
- Lab3: Understand Mesh, Solver and Preprocessor
- Summary

Hot Keys – Schematic

Edit Commands

Following table lists the hot keys for the Edit menu options.

Menu Name	Default
Edit > Copy	Ctrl+C
Edit > Copy/Paste > Copy Using Reference	C
Edit > Cut	Ctrl+X
Edit > Delete	Del
Edit > End Command	Esc
Edit > Mirror About X	Shift+X
Edit > Mirror About Y	Shift+Y
Edit > Move > Move Component Text	F5
Edit > Move > Move Edge	
Edit > Move > Move Using Reference	M
Edit > Move > Move Wire Endpoint	Ctrl+Shift+M
Edit > Paste	Ctrl+V
Edit > Redo	Ctrl+Y
Edit > Rotate	Ctrl+R
Edit > Undo	Ctrl+Z

View Commands

Following table lists the hot keys for the View menu options.

Menu Name	Default
View > Clear Highlighting	F8
View > Command Quick Help	Shift+F1
View > Grid Display	Ctrl+G
View > Origin Crosshair	Shift+O
View > Pan View	Tab
View > Pop Out Of Hierarchy	B
View > Push Into Hierarchy	Shift+E
View > Restore Last View	Ctrl+L
View > View All	F
View > Zoom > Zoom Area	
View > Zoom > Zoom By Factor > Zoom In x2	+
View > Zoom > Zoom By Factor > Zoom Out x2	-
View > Zoom > Zoom To Selected	Z

Insert Commands

Following table lists the hot keys for the Insert menu options.

Menu Name	Default
Insert > Change Entry Layer To	Ctrl+Shift+C
Insert > Component > Component Library...	I
Insert > Measure...	Ctrl+M
Insert > Shape > Polygon	Shift+P
Insert > Shape > Rectangle	R
Insert > Shape > Undo Vertex	Backspace
Insert > Text	Ctrl+T
Insert > Wire	Ctrl+W

Window and Miscellaneous Cor

Following table lists the hot keys for the Window and Miscellaneous

Menu Name	Default
Window > Close	Ctrl+F4
Window > Layout	Ctrl+Shift+L
Window > Open Another Schematic Window	Ctrl+Shift+S
Help > Topics and Index	F1
Options > Snap Enabled	Ctrl+E
Select > Select All	Ctrl+A
Simulate > Simulate	F7

- Help > F1

Hot Keys – Data Display

File Command

Following table lists the File menu commands

Menu Name	Default
File > New	Ctrl+N
File > Open...	Ctrl+O
File > Print...	Ctrl+P
File > Save	Ctrl+S

Edit Commands

Following table lists the Edit menu commands

Menu Name	Default
Edit > Copy	Ctrl+C
Edit > Cut	Ctrl+X
Edit > Delete	Del
Edit > End Command	Esc
Edit > Paste	Ctrl+V
Edit > Redo	Ctrl+Y
Edit > Select All	Ctrl+A
Edit > Undo	Ctrl+Z

View Commands

Following table lists the View menu commands

Menu Name	Default
View > Grid Display	Ctrl+G
View > Restore Last View	Ctrl+L
View > View All	F
View > Zoom > Zoom Area	
View > Zoom > Zoom In x2	+
View > Zoom > Zoom Out x2	-

Miscellaneous Commands

Following table lists the various other menu commands

Menu Name	Default
Help > Topics and Index	F1
Marker > New...	Ctrl+M
Options > Hide ADS Logo on all plots	Alt+L
Options > Snap Enabled	Ctrl+E
Window > Close	Ctrl+F4
Window > New	Ctrl+Shift+D

- Help > F1

ADS Tips Forum (ADS小秘訣) www.keysight.com/find/ADS_tips

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- 达人谈仿真
- Quick Links for All Applications
- EDU (自学教材)**
- 5G (5G 通信系统仿真)
- Automotive Radar (汽车雷达)
- Power Electronics (电力电子)
- ADS - 入门
- ADS - 电路设计与仿真
- ADS - SI PI EMI RFI
- ADS - 布局布线与电磁仿真
- Device Modeling (半导体器件建模)
- EESof 实作研讨会教材 (Workshop)
- EMPro (三维电磁场仿真)
- RFIC and MMIC Design
- SystemVue (通信系统仿真)

清除选取的

動作

- 提問
- 啟動一個討論區
- 上傳檔案
- 撰寫文件
- 建立視訊

所有內容 (15) 文件 (0) 討論區 (0) 問題 (15) 視訊 (0)

依動作篩選: [無] 依分享的内容篩選

輸入以按文字篩選 依標記篩選 依最近的活動排序: 最新在前

標題	作者	最近的活動	檢視	0	0	2	0
2019 大学学术论文 (shared in Keysight EESof Design Forum)	Jiarui Wu	2019年11月12日 下午 07:36:58	529	0	0	2	0
Keysight EDA 软件免费学习资源汇总-2019.11	Jiarui Wu	2019年11月7日 下午 06:13:28	5368	2	2	0	0
新入职工程师必看视频 - ADS Basic (YOUKU)	XUYue	2019年10月14日 上午 12:44:51	1706	0	0	0	0
新入职工程师必看视频 - SystemVue Basic - Communication (YouTube)	Jiarui Wu	2019年10月1日 下午 05:32:54	238	0	0	0	0
新入职工程师必读课程 - 微波单片集成电路设计 (MMIC)	xindong	2019年9月17日 下午 11:38:28	1671	0	0	0	0
新入职工程师必读课程 - 射频匹配 (RF Matching)	XUYue	2019年9月17日 下午 10:00:23	5922	0	0	4	0
新入职工程师必看视频 - ADS Basic (YouTube)	SharonChen	2019年9月15日 下午 11:37:13	319	0	0	0	0
新入职工程师必读课程 - 三维电磁仿真 (EMPro)	zeyu.yi@keysight.com	2019年9月9日 下午 08:28:01	2830	0	1	2	0
新入职工程师必读课程 - 通信系统 (SystemVue)	Jiarui Wu	2019年7月23日 上午 05:14:33	5244	2	1	1	0
新入职工程师必读课程 - IBIS AMI 建模 (SystemVue+ADS)	Jiarui Wu	2019年6月11日 上午 02:41:00	1918	0	0	0	0
新入职工程师必读课程 - 半导体器件建模 (Device Modeling)	ShaoliLv	2019年6月10日 下午 05:56:42	1282	0	0	0	0
新入职工程师必读课程 - 信号完整性 (Signal Integrity)	Chih Yuan Tu	2019年6月9日 下午 11:18:44	4904	0	2	0	0
SystemVue 通信实验教程 (适用于高校)	Jiarui Wu	2019年2月1日 下午 05:55:09	3584	0	1	0	0
2018 Train The Teacher 培训材料 (通信/SystemVue部分)	Jiarui Wu	2019年2月1日 下午 05:55:05	1097	0	1	0	0

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標題	作者	最近的活動	檢視	0	0	2	0
Power Integrity Workshop	Chih Yuan Tu	2019年12月16日 上午 07:20:05	1017	2	0	2	0
2019 大学学术论文 (shared in Keysight EESof Design Forum)	Jiarui Wu	2019年11月12日 下午 07:36:58	529	0	0	2	0
EESof Design Forum 2019 (Hsinchu and Shanghai)	Chih Yuan Tu	2019年10月30日 下午 05:37:05	275	0	0	0	0
[HSD] 2019OCT_FlexDCA&COM Workshop	Chih Yuan Tu	2019年10月14日 下午 05:51:03	175	0	0	0	0
[Workshop] 2019Q4 RF Basic - Efficient Impedance Matching with ADS	SharonChen	2019年9月23日 上午 12:08:34	929	0	0	0	0
FY17Q2 Workshop_ EMI辐射干扰 (RE) 仿真	zeyu.yi@keysight.com	2019年8月27日 下午 04:21:20	663	0	0	0	0
FY19Q2 Workshop: Optical Module SI/EMI Simulation	zeyu.yi@keysight.com	2019年8月25日 上午 12:03:24	579	0	0	4	0
[Workshop] 2019Q4 Understanding PCB Effects in DC-DC Converters	JasonChen	2019年8月23日 下午 05:30:33	252	0	0	0	0
ADS2019 SI/PI Seminar (西安、苏州、南京、深圳和北京)	Xiuguo	2019年8月9日 下午 07:05:50	915	0	0	1	0
2017Q1_SSO Simulation with Power Aware IBIS Model within ADS	Chih Yuan Tu	2019年7月29日 下午 05:54:58	214	1	0	0	0
2016Q1_Advanced SI Simulation Skills	Lin_Ming_Chih	2019年7月22日 下午 11:07:55	2081	0	0	0	0
2019.6.11/13 深圳上海ADS电源完整性仿真与测量训练营资料	zhangtao	2019年6月15日 上午 12:15:19	1040	0	0	3	0
全新射频匹配流程_ADS2019Update1.0	XUYue	2019年5月5日 上午 06:22:38	958	0	0	0	0

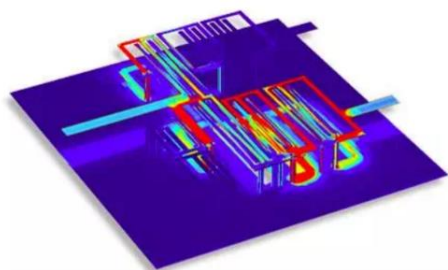
微信公眾號

< 訂閱帳號 是德科技EESof软件 

星期四 下午5:23

单片微波集成电路 (MMIC) 设计系列——MMIC基础

8月3日



EDA_Forum由是德科技EESof EDA大中华地区运营，介绍EDA设计的基础知识，实用经验分享。戳

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ID: EDA Forum



信号完整性

1、分享信号完整性 (SI)、电源完整性 (PI)、电磁兼容性和微波射频方面的知识/行业信息及动态； 2、不定期举办线下/上公益活动； 3、帮助大家更好的学习和了解硬件、高速电路、微波射频电路、EMC和高速PCB的设计。 SIPIEMC

70篇原创文章，16位朋友关注

进入公众号

取消关注

ID: SI_PI_EMC

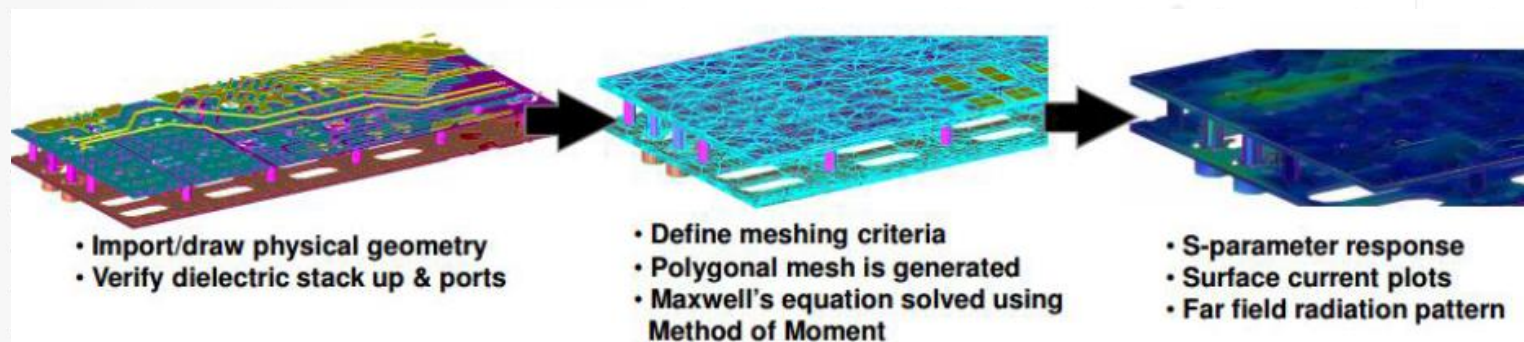


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- Quick review of Momentum
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Momentum Overview

- Method of Moment (MoM) technology
- Accurate and efficient simulation of complex multilayer geometries



Advantages and Applications:

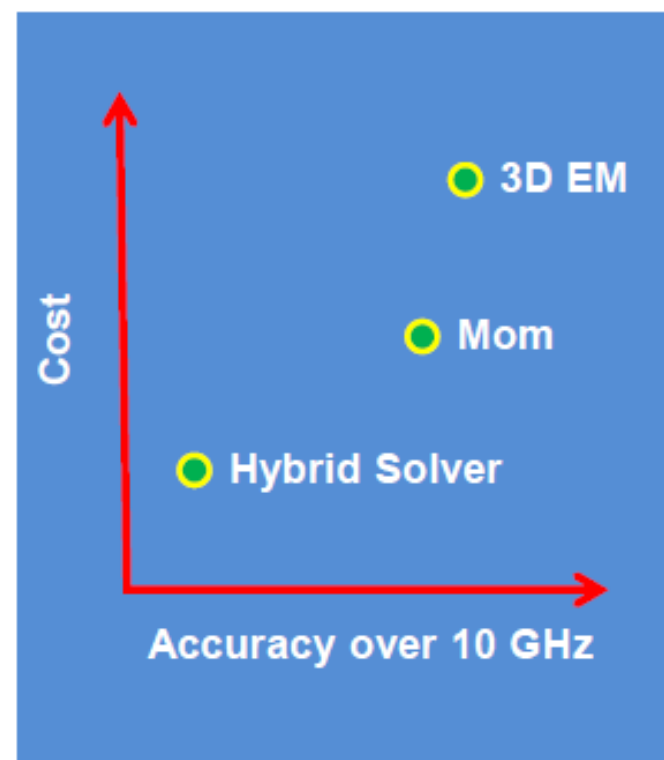
- Tightly integrated within ADS environment
- Design flow integration with ADS tools
- Solves complex 3D multilayer planar geometry
- Fast and efficient simulation
- Accurate from DC up to 100's of GHz
- Simulate large number of ports
- PCB, Packages



First version of Momentum simulator :
Released in 1994

Benefit and Cost of MoM Technology

	Hybrid Solver	Mom	3D EM
Accuracy >10 GHz	Low	High	High
Learning	Easy	Normal	Hard
Usability	Easy	Normal	Normal
Flexibility	Low	Medium	High
Speed	Fast	Medium	Slow
Memory Required	Low	Medium	High
Price	Medium	Medium	High



EM Setup Are Different for Each Solver Technology

- FDTD (Finite Difference Time Domain)
- FEM (Finite Element Method)
- MoM (Method of Moment)

- Arbitrary 3D structures
- Time Domain
- Full Wave EM Simulations
- Handles much larger and complex problems
- Each port requires separate simulation
- GPU based hardware acceleration
- EMPro UI

- Arbitrary 3D structures
- Frequency Domain
- Full Wave EM Simulations
Direct, Iterative Solvers
- Multiport Simulations at no Additional Cost
- High Q
- ADS or EMPro UI

Today's Focus

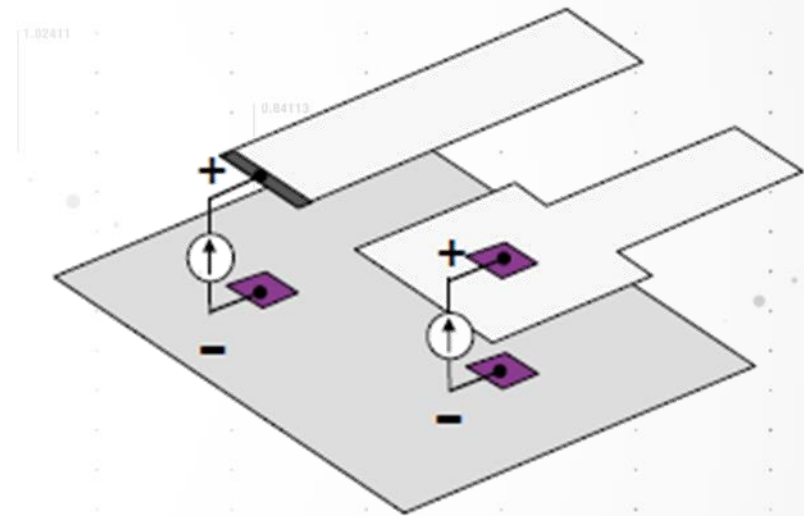
- Restricted 3D Structures
- Frequency Domain
- Full-Wave and Quasi-Static Simulations
- Dense & Compressed Matrix Solvers
- Multiport Simulations at no Additional Cost
- High Q
- ADS UI

Outline

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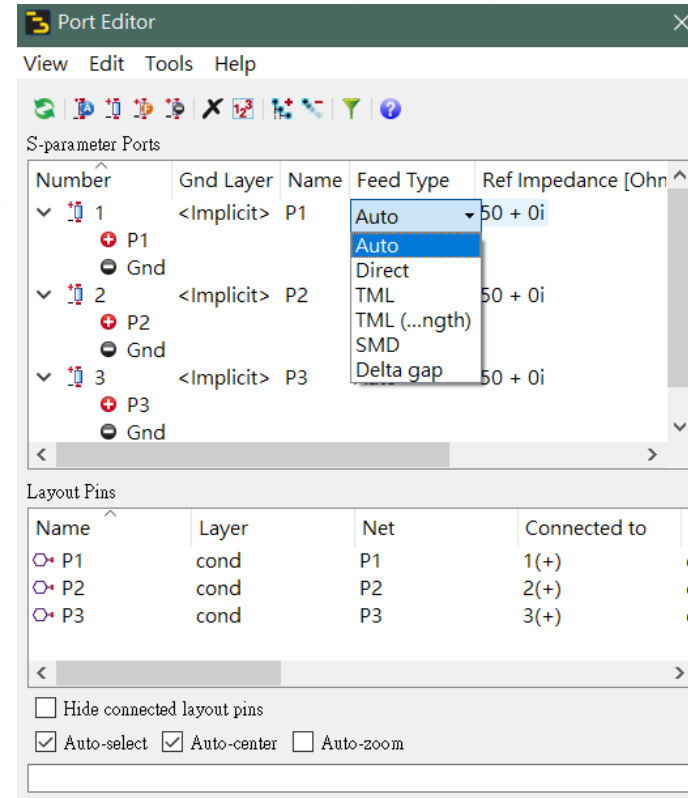
EM Ports in MoM Technology

- Consist of + and – terminals
- Placed where EM models connect to circuit components
- Compute voltages and currents from E&H field, and also S-parameters
- A lumped source is attached with a source impedance
 - No phase delay between + and –terminal
 - Must be electrically small (size $< \lambda/10$)
 - Otherwise it may result unphysical behaviors



EM Port Calibration in MoM Technology

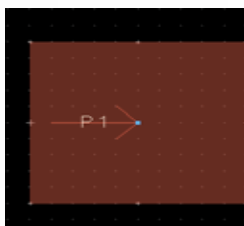
- Direct
- TML (Transmission Line)
- TML (zero length)
- SMD (Surface Mount Devices)
- Delta gap



General Pin Types

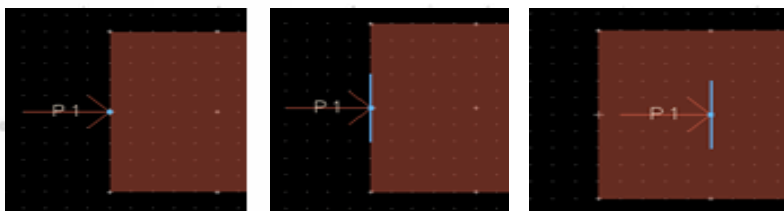
- Correct Pins Allow for Correct Ports

Point Pin



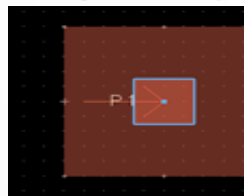
Pin placed anywhere within a geometry, but not on an edge.

Edge Pin

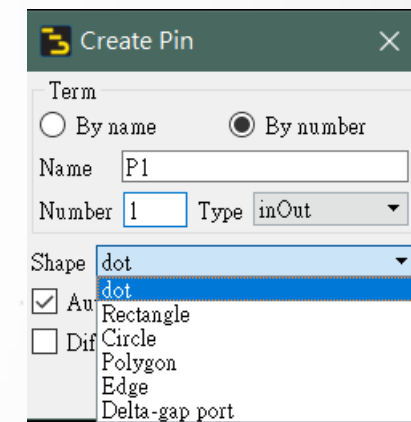


Pin placed on any geometry edge or any explicitly defined Edge Pin.

Area Pin



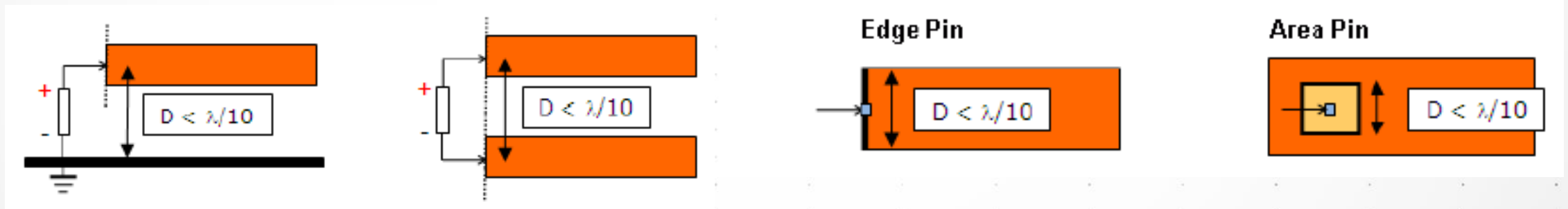
Explicitly defined Area Pin.



Excitation voltages can be limited in extent by using Edge/Area Pins

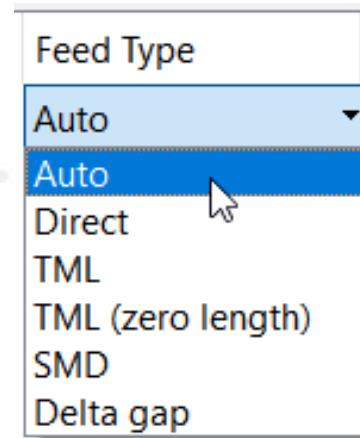
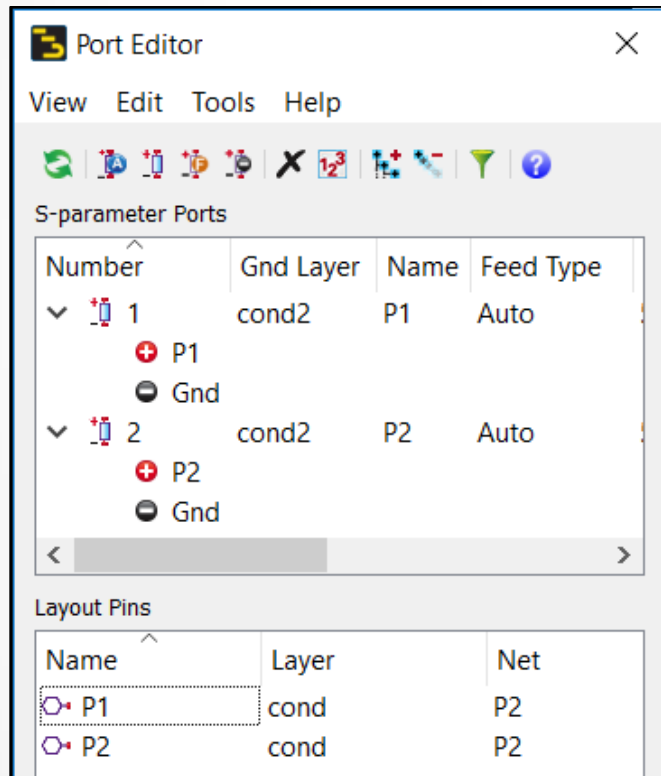
ADS Momentum Port Calibration/Feed Types

- MoM Ports placed on a metal EDGE will excite the entire edge with constant potential. Unless Edge Port is used to confine excitation. If the edge is $>1/10$ wavelength results can become non-physical.
- MoM Ports placed inside metal are point sources that will excite a mesh element around the port. Unless Area Port is used, area becomes constant potential.
- MoM Ports inject current with 0 deg phase shift (Lumped Source). If the physical difference between the + and - pins is $> 1/10$ wavelength results can become non-physical.
- MoM ports, being lumped sources will NOT couple to surrounding structures.
- Port Size restrictions:

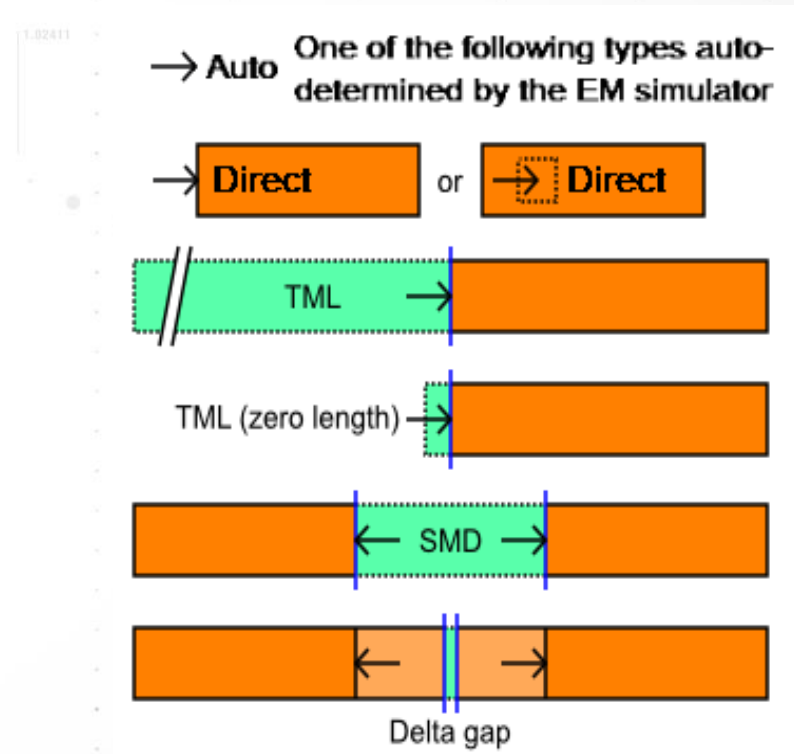


EM Ports Editor

- A Glimpse into Calibration/Feed Types



Hover over Feed Type for pop-up help graphic



Summary of EM Ports in ADS 2016

- “Old” Nomenclature for Calibration/Feed Type

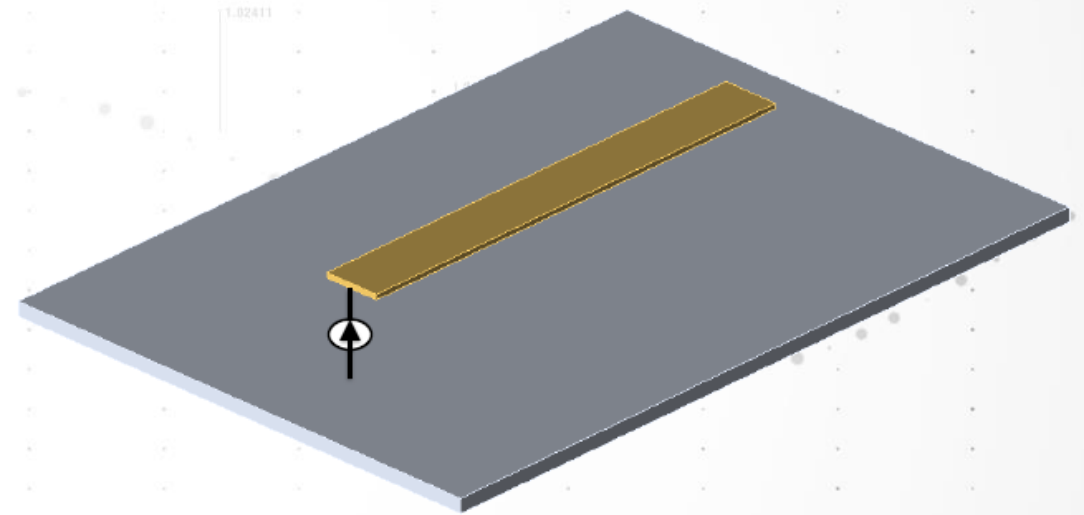
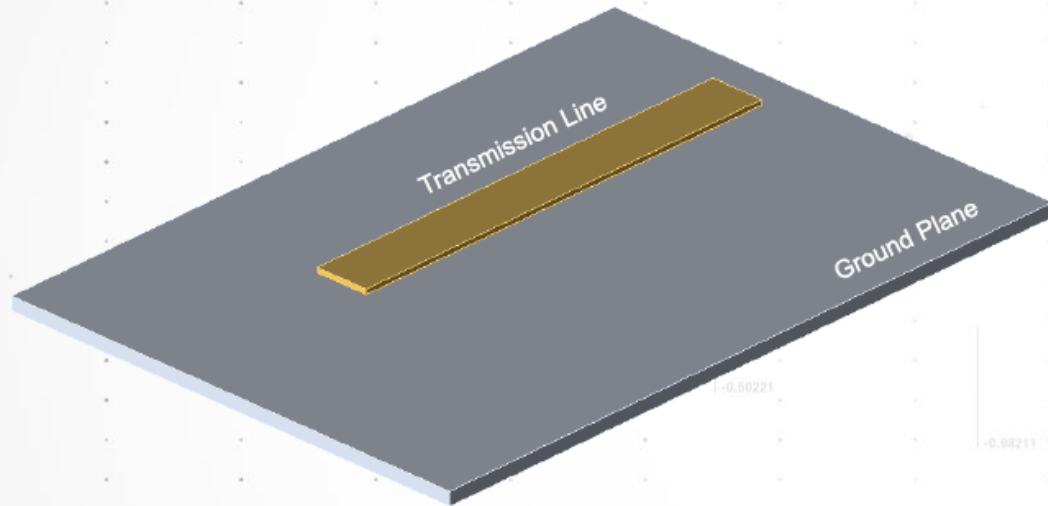
Calibration Type	Momentum
None	If none of the available calibration types is valid for the connecting component, specify “None”.
TML <i>(this is the default, changed @ sim time if not on outer edge)</i>	This calibration type assumes the structure is fed through a transmission line. It removes the open end effect and adds the mutual coupling induced by the feeding transmission line.
TML (zero length)	This calibration type removes the open end effect.
SMD	This calibration type removes the open end effect at port and adds the mutual coupling between the current flowing from the + to – pins and the rest of the circuit assuming the area between both pins would be filled with metal.
Delta Gap	This calibration type adds the effect of metal filled in the area between the + and – pins. A gap in the middle allows connecting the source.

Summary of EM Ports in ADS 2017 & Newer

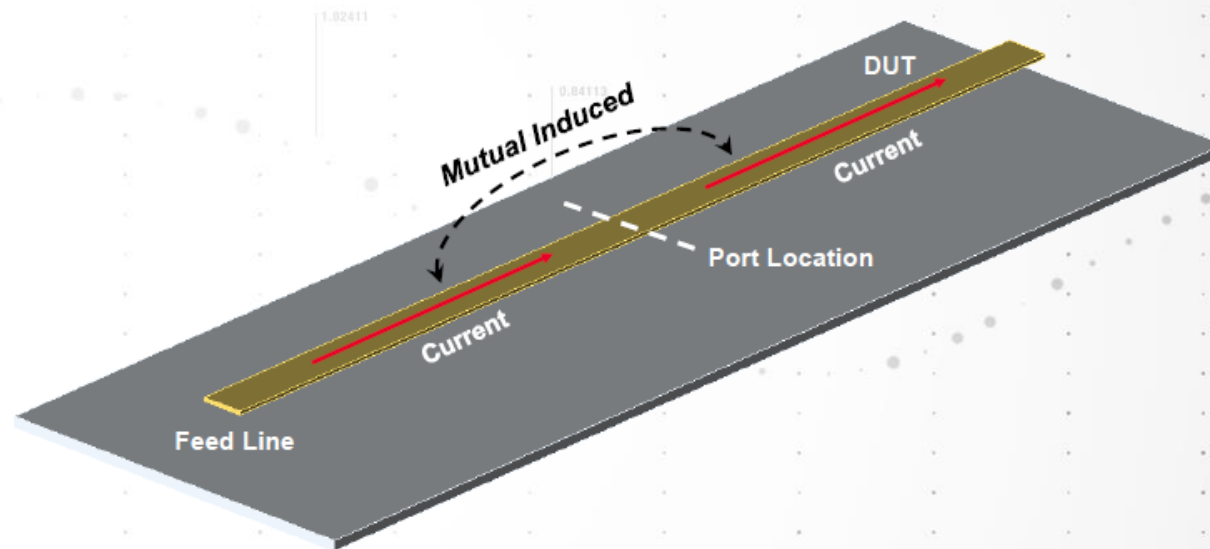
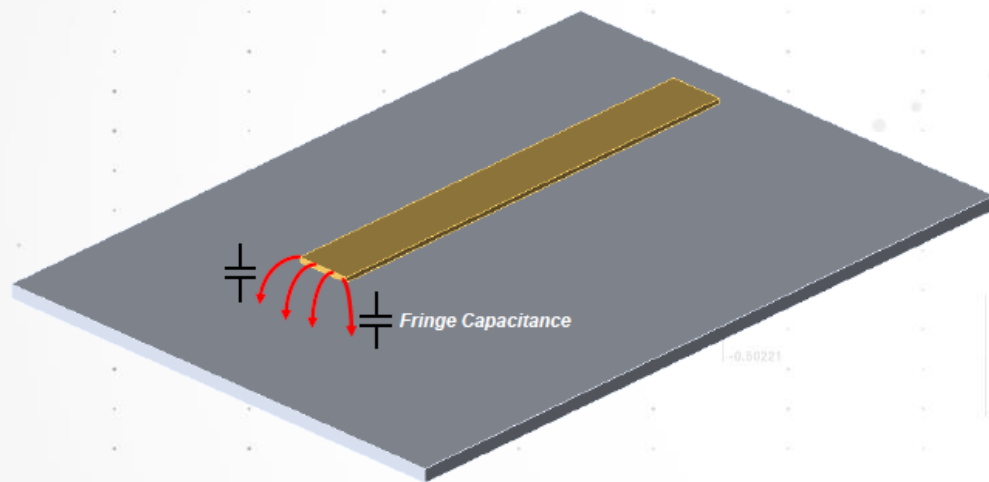
- New Nomenclature for Calibration/Feed Type

Feed Type	Momentum
Auto	This becomes Direct feed 99% of the time. Only TML if placed on outer edge of a slot plane geometry.
Direct	If none of the available calibration Feed types is valid for the connecting component, specify "Direct".
TML	This calibration Feed type assumes the structure is fed through a transmission line. It removes the open end effect and adds the mutual coupling induced by the feeding transmission line.
TML (zero length)	This calibration Feed type removes the open end effect.
SMD	This calibration Feed type removes the open end effect at port and adds the mutual coupling between the current flowing from the + to – pins and the rest of the circuit assuming the area between both pins would be filled with metal.
Delta Gap	This calibration Feed type adds the effect of metal filled in the area between the + and – pins. A gap in the middle allows connecting the source.

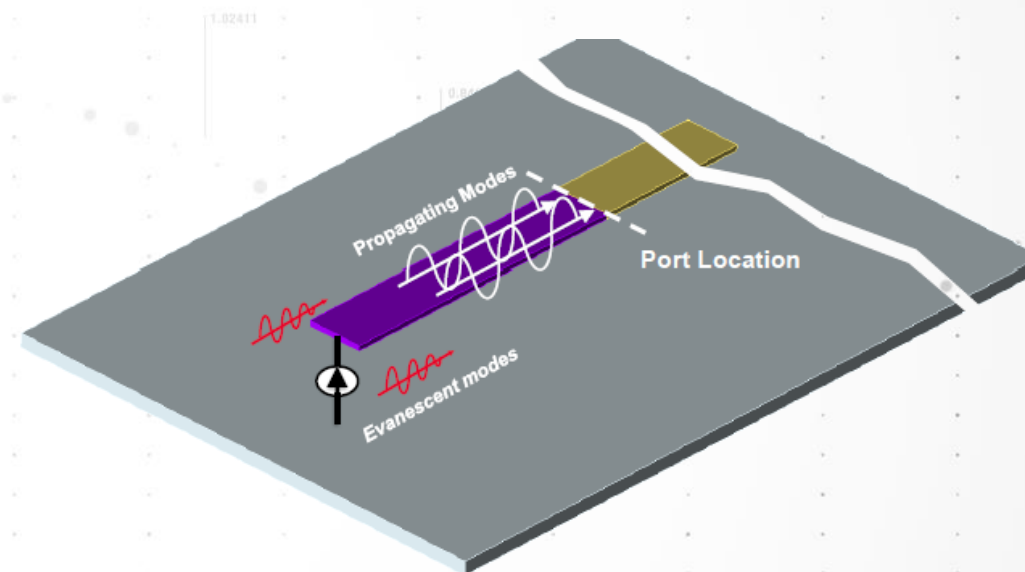
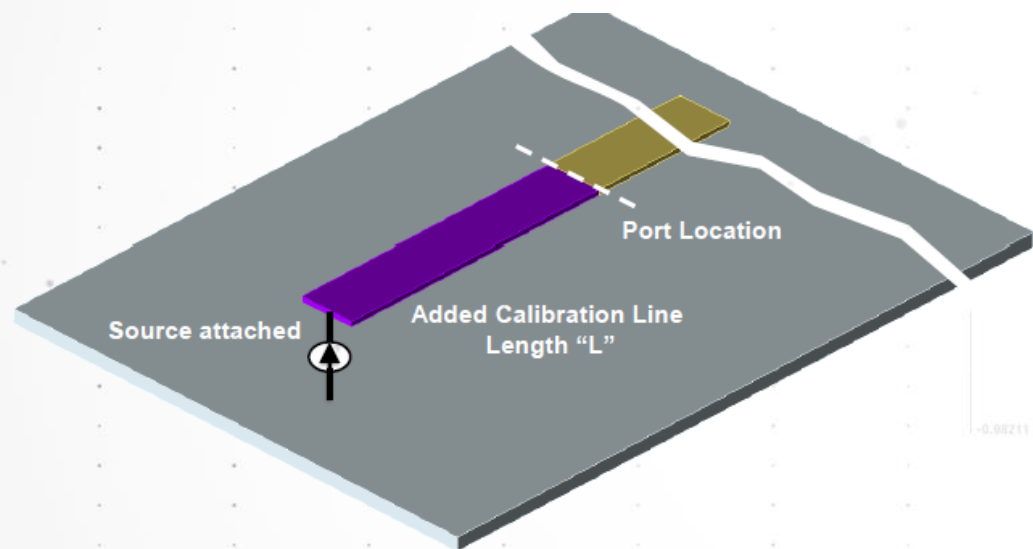
TML Feed Type (1/5)



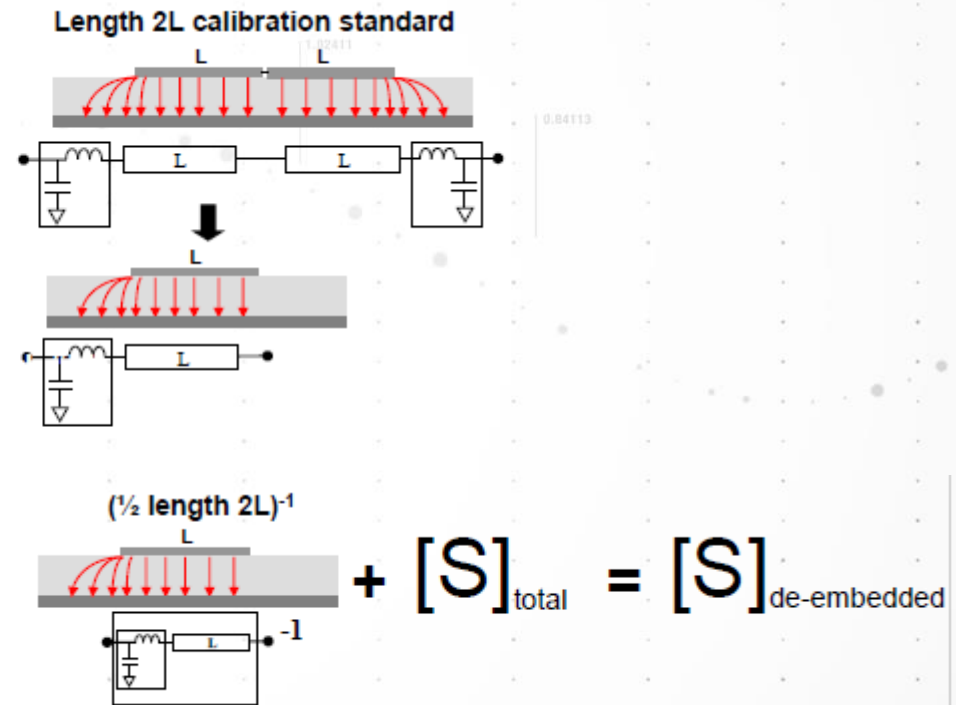
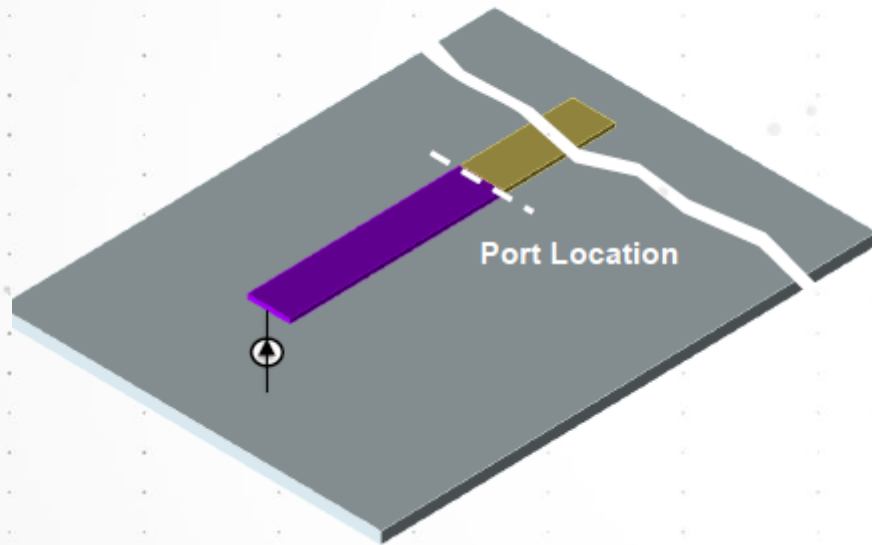
TML Feed Type (2/5)



TML Feed Type (3/5)

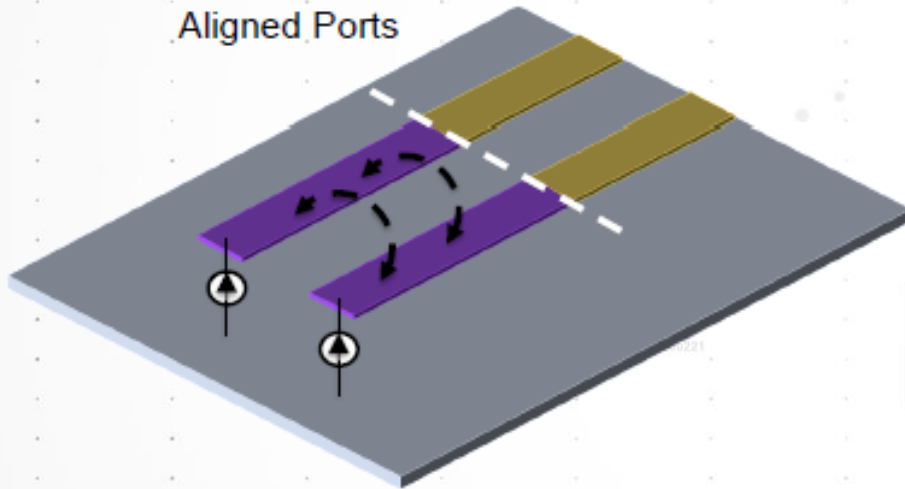


TML Feed Type (4/5)



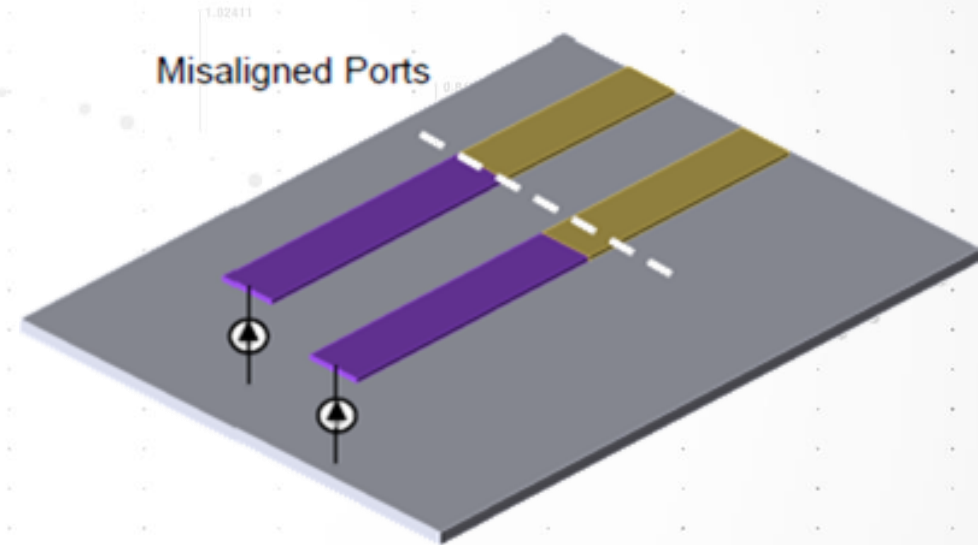
TML Feed Type (5/5)

Aligned Ports



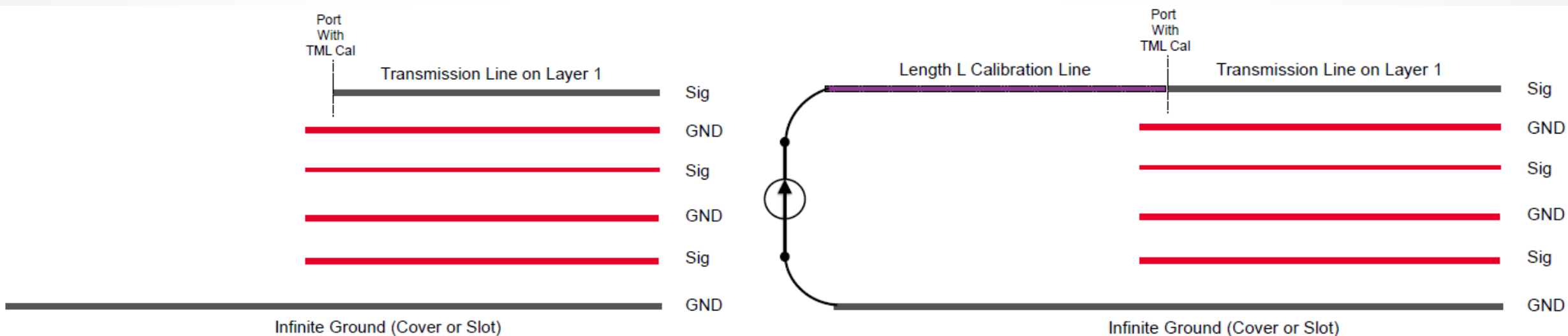
Mutual coupling between the feed lines **will be removed** after TML calibration

Misaligned Ports

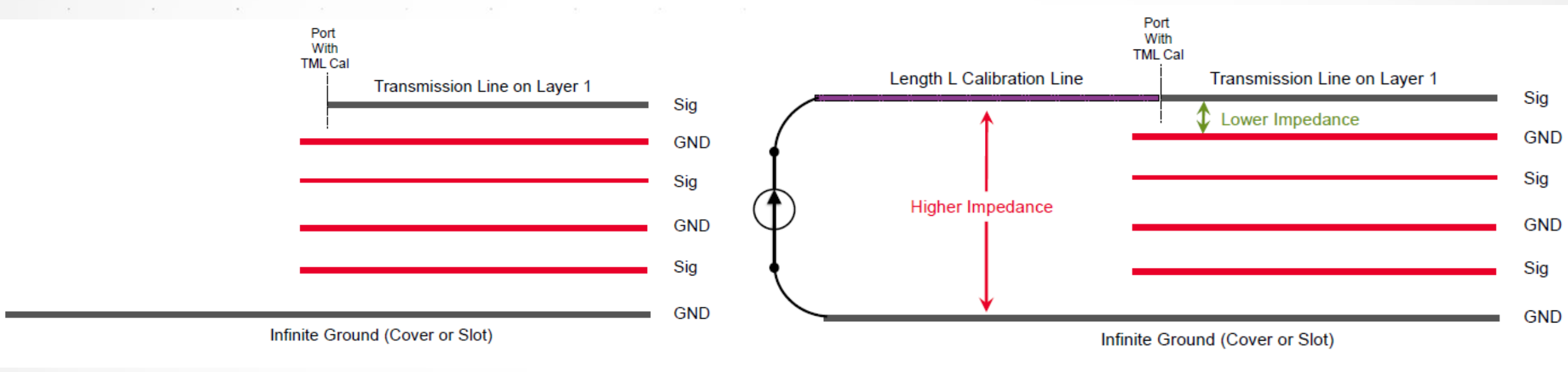


Mutual coupling between the feed lines **will be turned off** during TML calibration

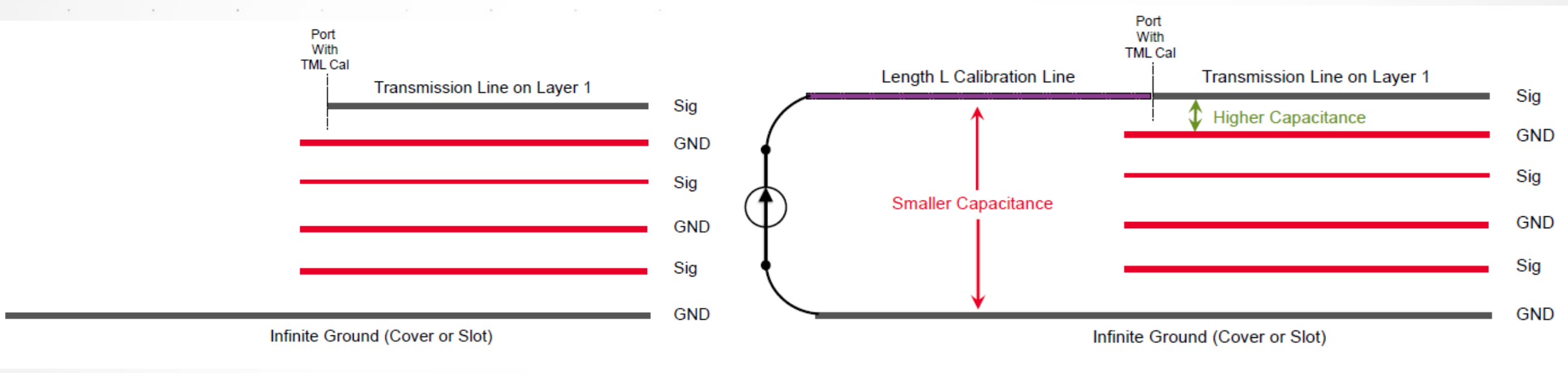
Incorrect Use of TML Feed Type



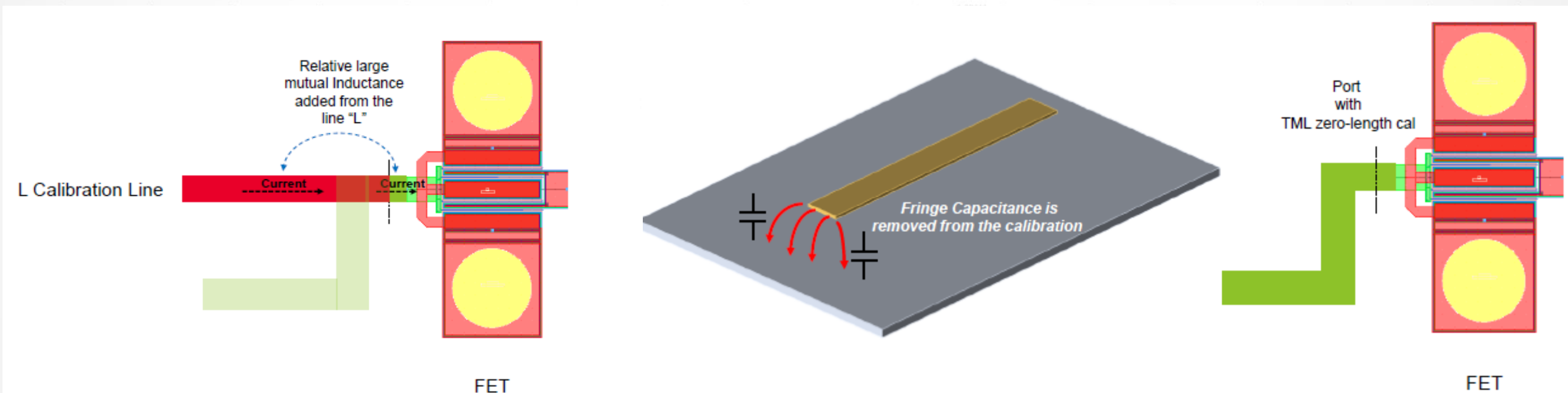
Incorrect Use of TML Feed Type



Incorrect Use of TML Feed Type

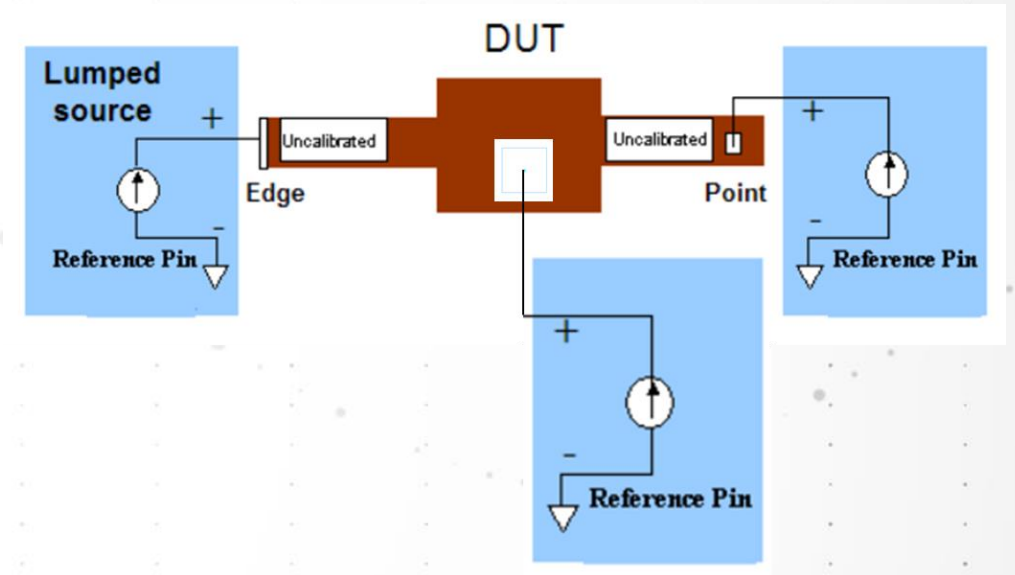


TML Zero-Length Feed Type

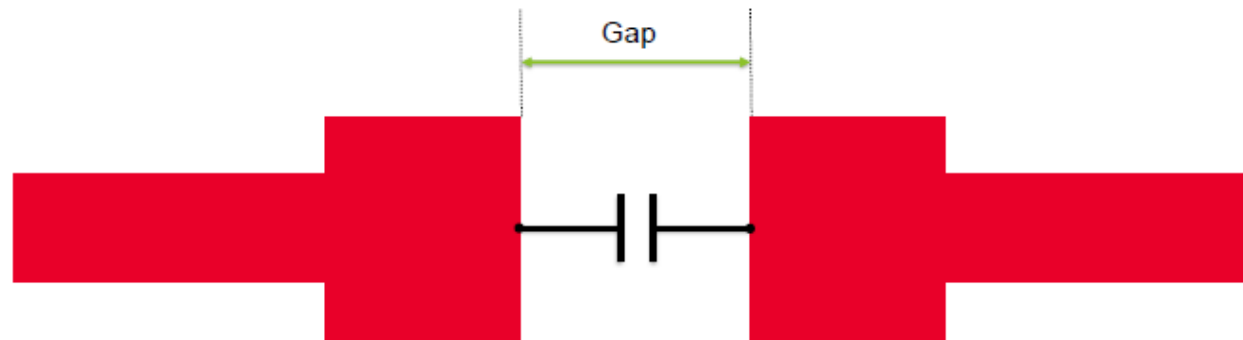
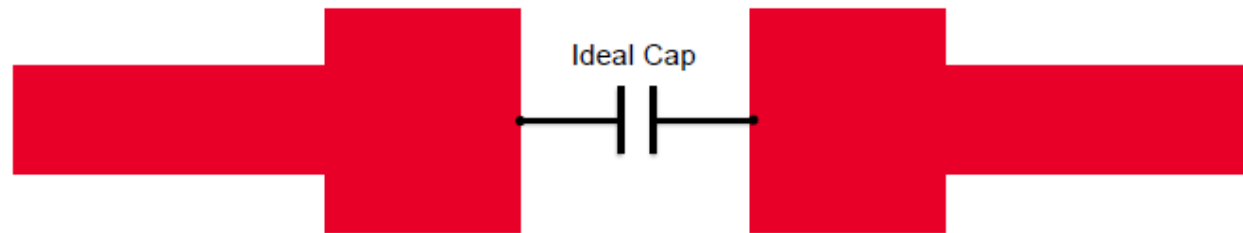


None Calibration - Direct Feed Type

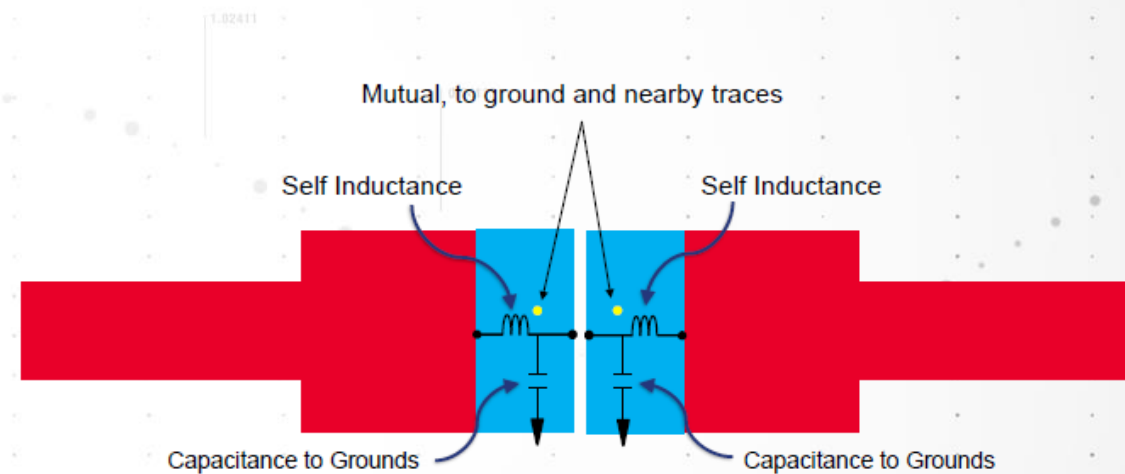
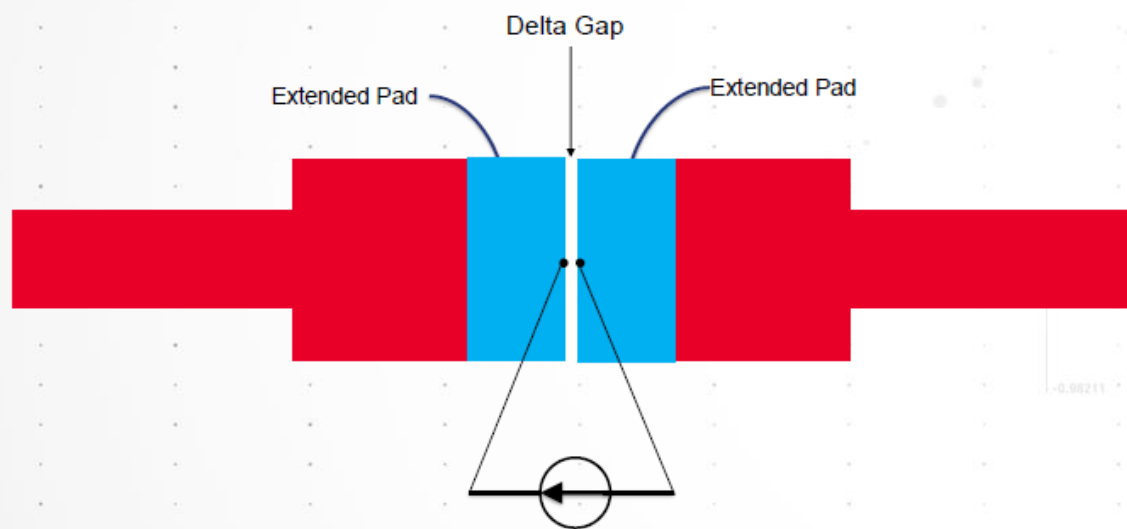
- No port calibration but could be very versatile
- Ground reference can be anywhere
- Applies to point pins, edge pins and area pins
- Some guidelines
 - Port size must be electrically small (length $< \lambda/10$)
 - Ground reference should be on the true ground return path
 - A local open end effect is included in the DUT model. This is a result of the direct feed being applied to the edge port.



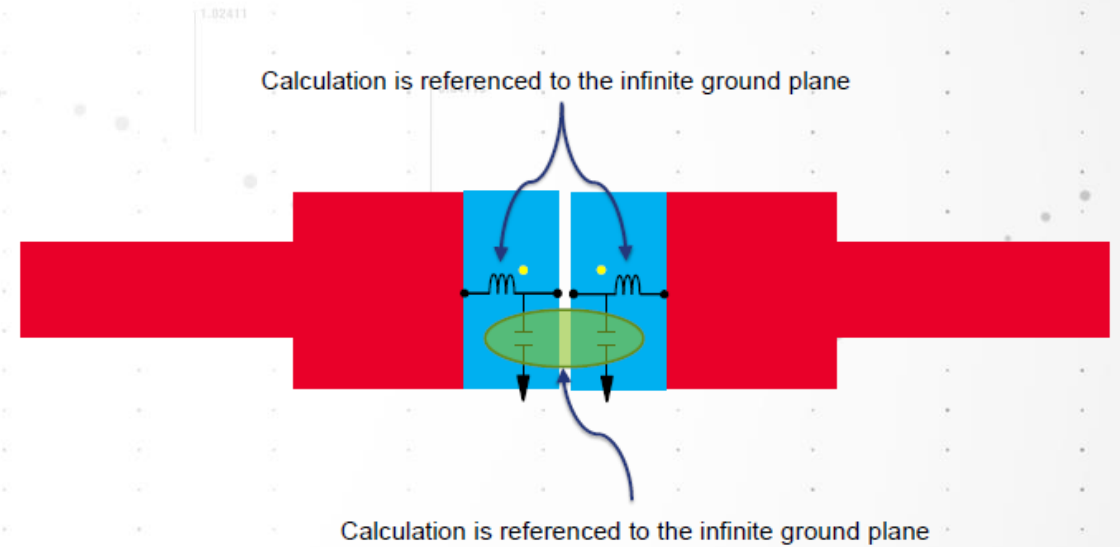
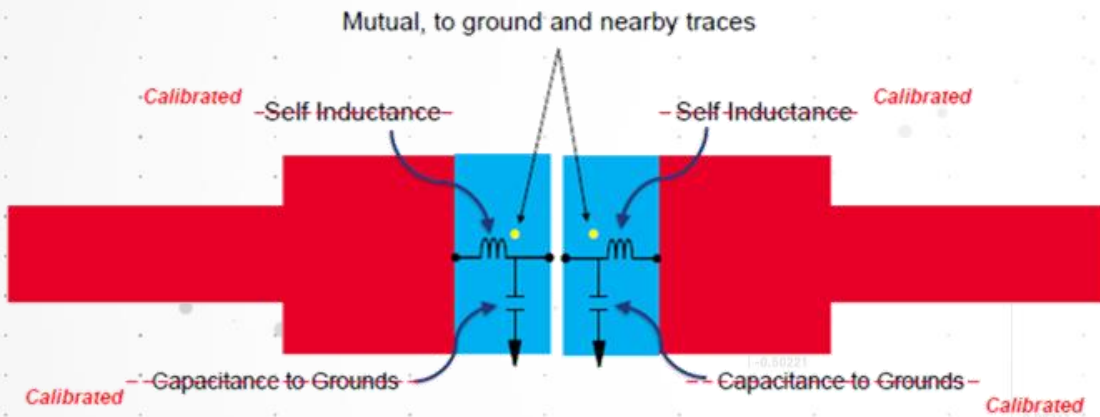
Delta-Gap Feed Type



Delta-Gap Feed Type

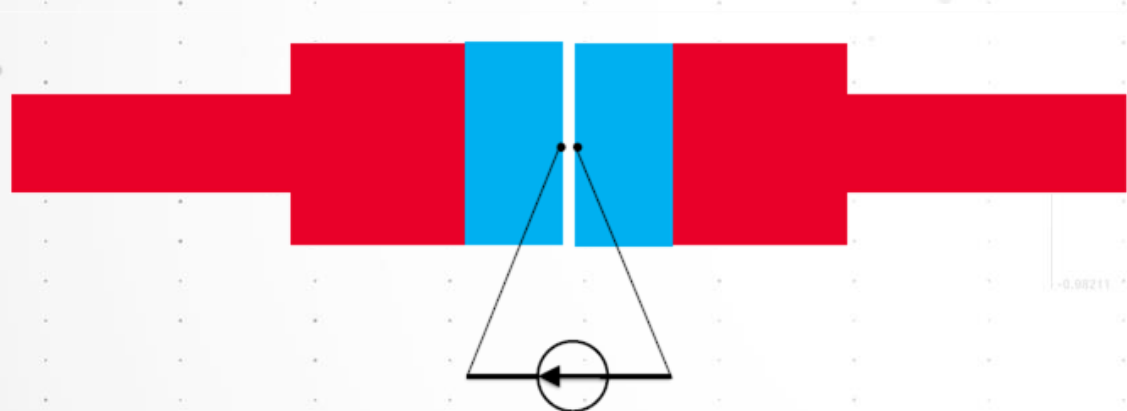


SMD Feed Type

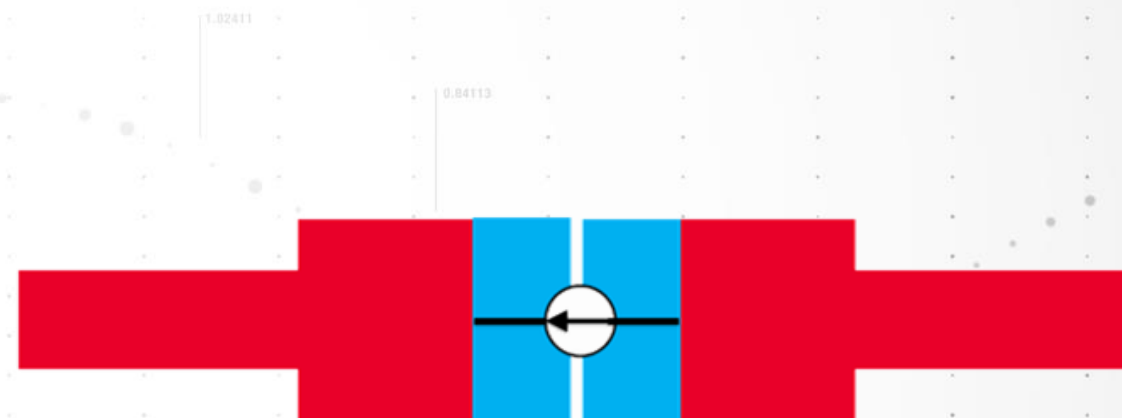


Both of Delta-gap and SMD Feed Type

- Only differential mode supported



- Current flows straight through the added pads



Lab1 – Port Calibration/Feed Types

- Long line with gap for SMD component
- Gap port calibration = DeltaGap|SMD|None(Direct)
- Gap shorted

Through Line



Port Feed Type = Direct



Port Feed Type = SMD

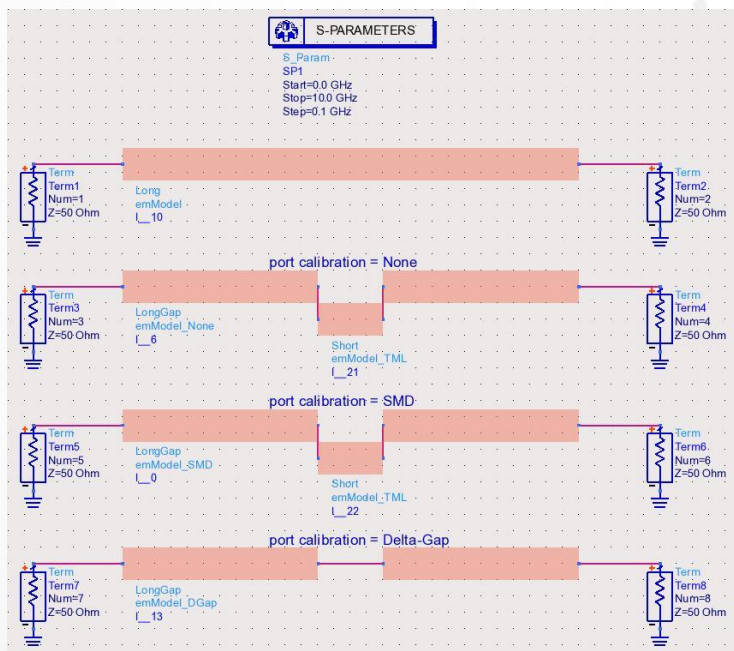


Port Feed Type = Delta-Gap



Lab1 – Port Calibration/Feed Types

- Long line with gap for SMD component
- Gap port calibration = DeltaGap|SMD|None(Direct)
- Gap shorted with short line (TML calibration)

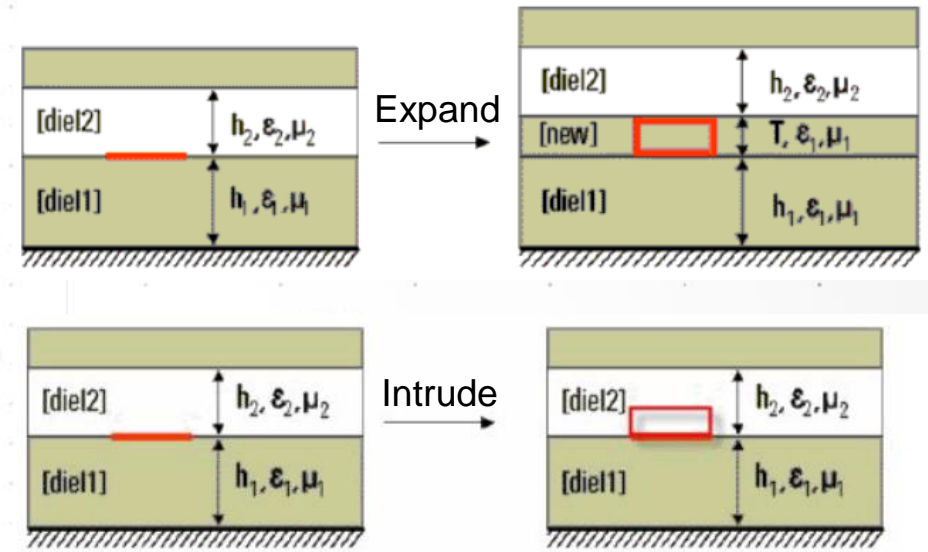
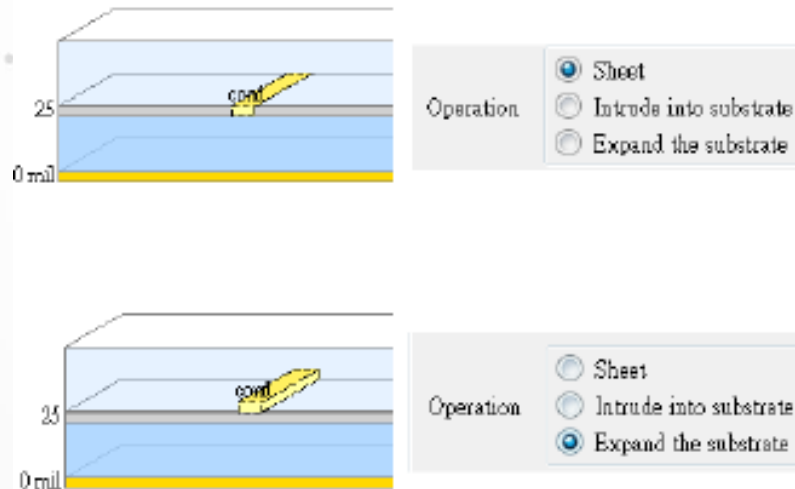


Outline

- Quick review of Momentum
- Lab1: Port Type Overview
- **Lab2: Net Type Setup for Physical Model Simplified**
- Lab3: Understand Mesh, Solver and Preprocessor
- Summary

Metal Model Types

- Sheet-Sheet
- Intrude/Expand-Sheet
- Intrude/Expand-2D distributed
- Intrude/Expand-3D distributed (Recommended)



Model type for currents

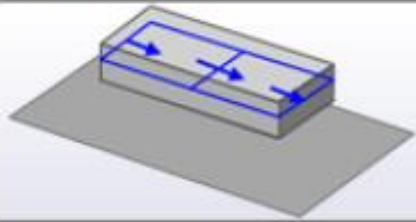
Thick conductor

- 3D-distributed
- Sheet
- 2D-distributed
- 3D-distributed

Via

Thick Metal Model Types

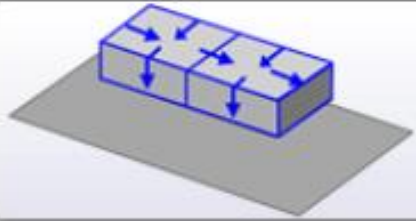
Sheet



- Top and bottom currents collapsed
- No sidewall currents

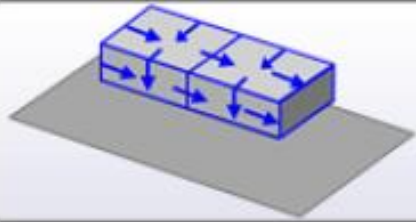
184113

2D distributed



- Top and bottom currents separate
- Vertical sidewall currents only

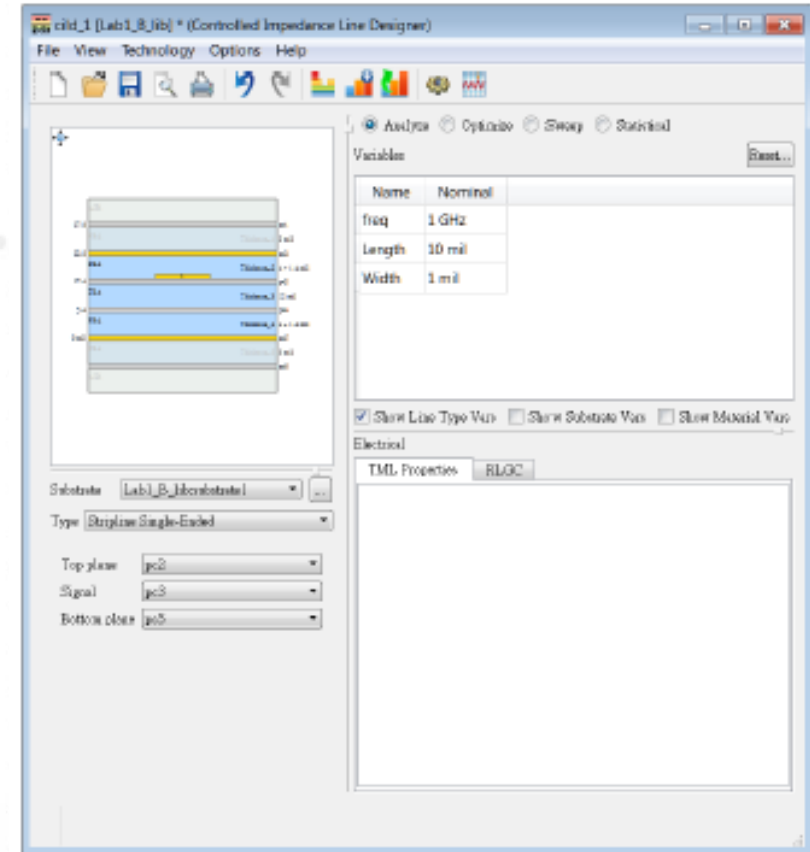
3D distributed(Recommended)



- Top, bottom and sidewall currents separate
- Any surface current

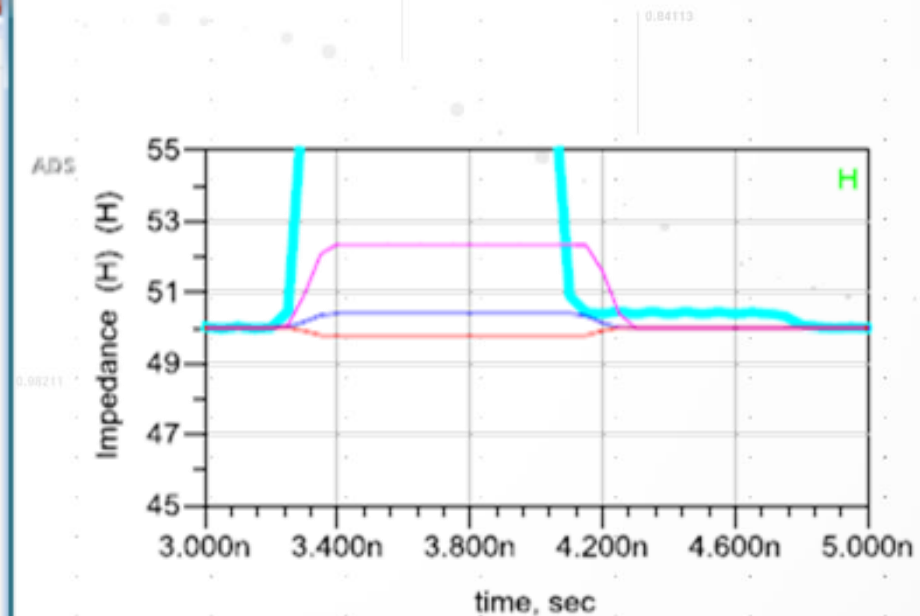
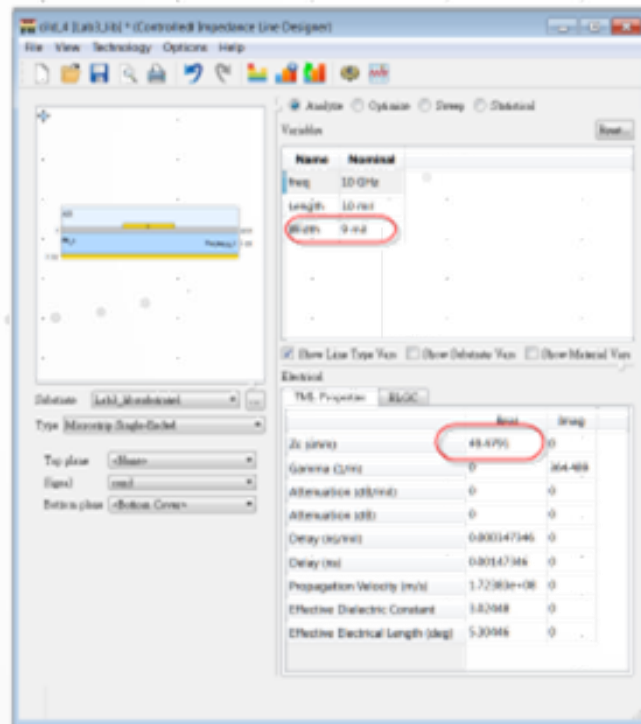
Controlled Impedance Line Designer (CILD)

- Impedance Calculation
- Width Calculation for specific impedance
- Support Strip, Microstrip, CPW, Single-Ended, Differential Pair Types
- Statistical Calculation
- Model Generation



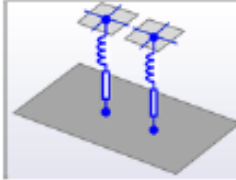
Check TDR of Metal Type

Accuracy: 3D+Edge > 3D > 2D >> Sheet



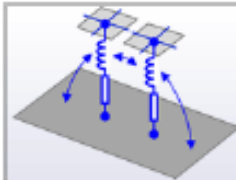
Via Modeling

Lumped
(Recommended for
Power/Ground vias)



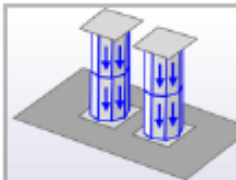
- DC resistance and skin effect
- Wire self inductance
- Meshless equivalent circuit

Wire



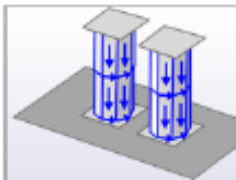
- DC resistance and skin effect
- Wire self inductance
- Mutual wire-wire and wire-infinite ground inductances
- Meshless equivalent circuit

2D-Distributed
(Recommended for
TLine vias)



- DC resistance and skin effect
- All self and mutual inductances and capacitances
- Vertical sidewall currents only

3D-Distributed



- DC resistance and skin effect
- All self and mutual inductances and capacitances
- Any surface current

RFPro Vision: EM for every RF circuit designer

Allows users to focus on design rather than setting up EM

- Integration

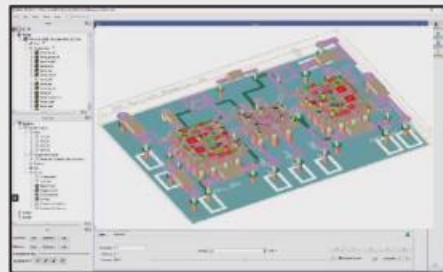
- ✓ 3D view
- ✓ Solution for RF PCB, RFIC, MMIC and RF Modules
- ✓ Enhanced ADS MOM and FEM simulator performance

- Solver

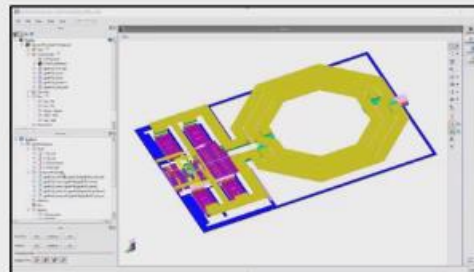
- ✓ Automatic EM expert settings guarantee confidence in EM results for novice and expert users
- ✓ Fast & correct analysis setup for **EM-circuit co-simulation**

- Layout

- ✓ No Cookie cutting
- ✓ **No exporting**
- ✓ No removing active devices and placing pins & ports
- ✓ **No reconnecting schematics to s-parameter files**



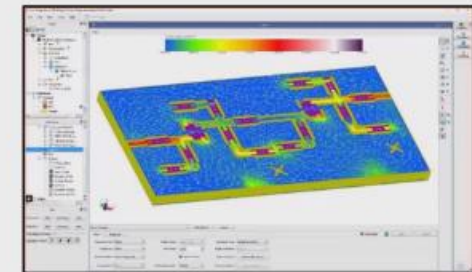
RF Module



RFIC



MMIC



RF Board

RFPPro Momentum: Automatic Mode for Vias/Thick Metals

- Thanks to RFPPro platform, Momentum can now automatically apply different via/thick conductor models depending on the nets type : signals, grounds and power planes

Physical model
Thick conductor model
Via conductor model

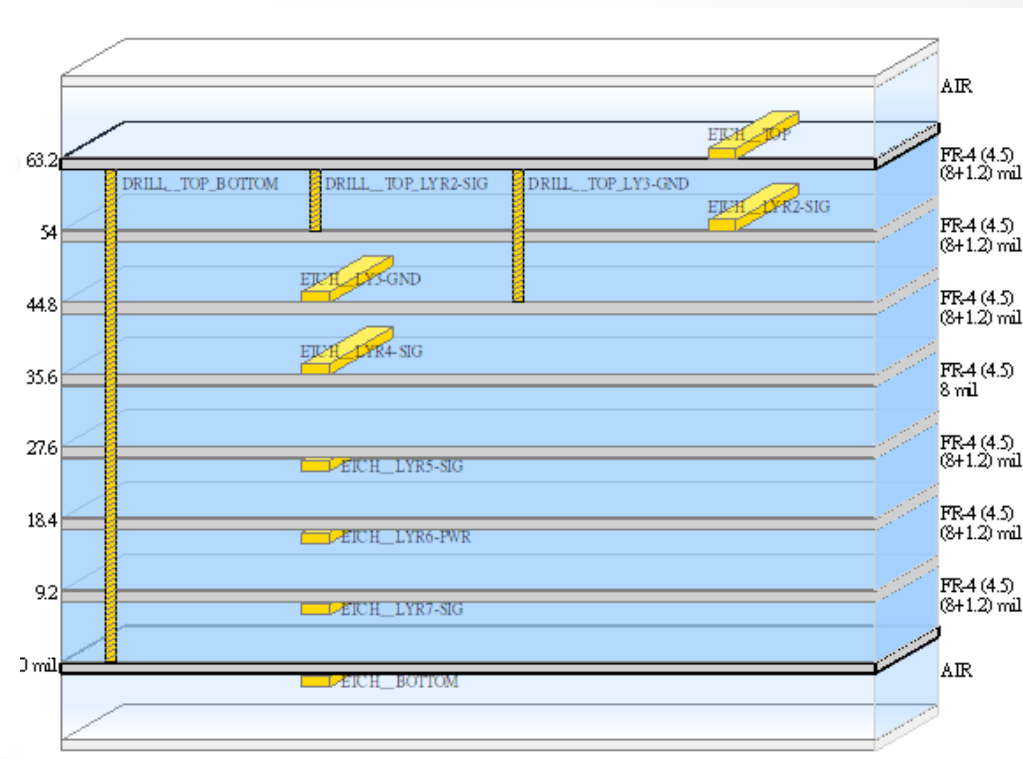
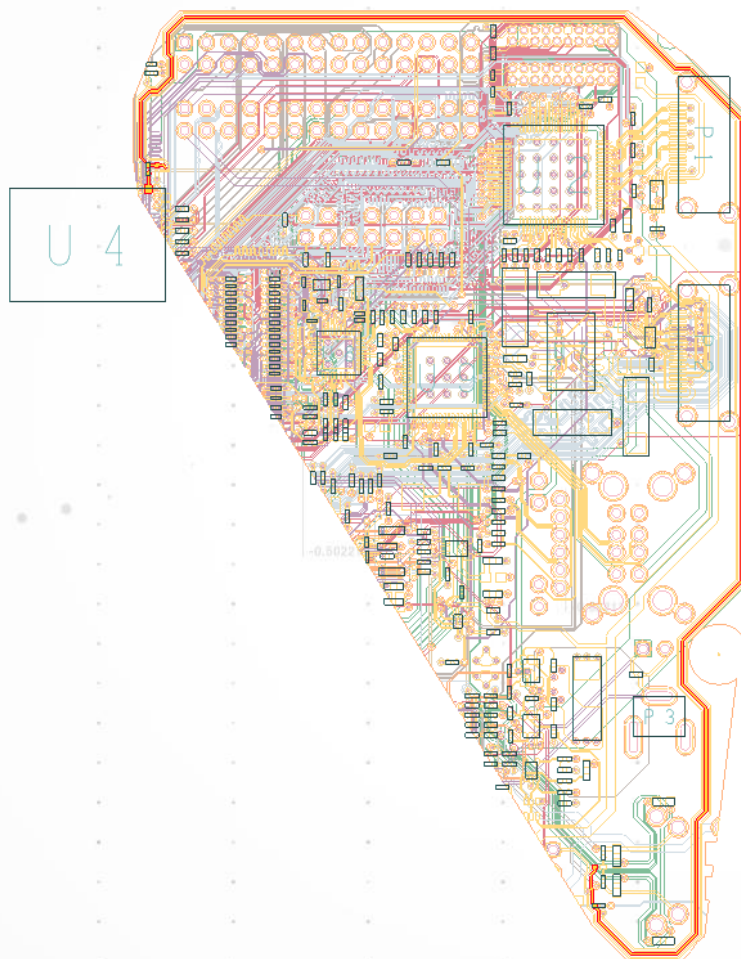
Automatic
Automatic

Example on a 60 GHz Wilkinson divider

	RFPPro 2020	RFPPro 2020U1
Matrix size	127500	4750
Runtime (MomRF)	> 10h	27mn

Lab2 - Net Type Setup for Physical Model Simplified

- Panda Board
- FM_ANT_RX
- FM_ANT_IN
- Frequency Range
 - 0~500 MHz



Simulation Result with Automatic Physical Model

- Thick Conductor Model
 - Automatic
- Via Conductor Model
 - Automatic

```
Summary Log X Auto-scroll Update
Starting Momentum simulation.
Starting C:\Program Files\Keysight\ADS2020_update2\Momentum\2020.20\win32_64\bin\MomEngine.exe
Waiting for license...
License checkout took 4 min, 0.326 sec
License checkout took 0.033 sec
Momentum MomEngine_64 2020.20.064 (*) built: Feb 13 2020
Copyright 1992 - 2020 Keysight Technologies
Simulation started on: Mon Apr 6 09:37:37 2020
Simulation Mode: RF
Substrate valid
Layout simplification started
Layout simplification finished
Generating mesh at 500 MHz...
S-parameter simulation
S-parameter simulation started
...initializing
...extracting layout
...expanding thick conductors
Layout is electrically small below 1.15 GHz (space wave radiation)
Substrate is electrically small below 9.98 GHz (surface wave radiation)
...reducing mesh
Automatic selection: direct compressed matrix solver
Using multi-threading (8 threads)
Matrix size: 21433 (reduced: 7054)
Simulation temperature: 298.15 K
Adaptive frequency sweep started
Simulation frequency [1] = 0 Hz
```


Simulation Result with Manuel Physical Model

- Thick Conductor Model
 - 3D
- Via Conductor Model
 - 2D

```
Summary Log [X] Auto-scroll [Update]
Starting Momentum simulation.
Starting C:\Program Files\Keysight\ADS2020_update2\Momentum\2020.20\win32_64\bin\MomEngine.exe
License checkout took 0.098 sec
License checkout took 0.032 sec
Momentum MomEngine_64 2020.20.064 (*) built: Feb 13 2020
Copyright 1992 - 2020 Keysight Technologies
Simulation started on: Mon Apr 6 09:44:35 2020
Simulation Mode: RF
Substrate valid
Layout simplification started
Layout simplification finished
Generating mesh at 500 MHz...
S-parameter simulation
S-parameter simulation started
...initializing
...extracting layout
...expanding thick conductors
Layout is electrically small below 1.15 GHz (space wave radiation)
Substrate is electrically small below 9.98 GHz (surface wave radiation)
...reducing mesh
Automatic selection: direct compressed matrix solver
Using multi-threading (8 threads)
Matrix size: 14670 (reduced: 3501)
Simulation temperature: 298.15 K
Adaptive frequency sweep started
Simulation frequency [1] = 0 Hz
...loading Green functions
```

Simulation Result with Different Net Type

1. Set D_GND net type as GND
2. Set D_GND net type as PWR
3. Set D_GND net type as SIG

```
Summary Log [X] Auto-scroll
Starting Momentum simulation.
Starting C:\Program Files\Keysight\ADS2020_update2\Momentum\2020
Waiting for license...
License checkout took 4 min, 0.326 sec
License checkout took 0.033 sec
Momentum MomEngine_64 2020.20.064 (*) built: Feb 13 2020
Copyright 1992 - 2020 Keysight Technologies
Simulation started on: Mon Apr 6 09:37:37 2020
Simulation Mode: RF
Substrate valid
Layout simplification started
Layout simplification finished
Generating mesh at 500 MHz...
S-parameter simulation
S-parameter simulation started
...initializing
...extracting layout
...expanding thick conductors
Layout is electrically small below 1.15 GHz (space wave radiation)
Substrate is electrically small below 9.98 GHz (surface wave radiation)
...reducing mesh
Automatic selection: direct compressed matrix solver
Using multi-threading (8 threads)
Matrix size: 21433 (reduced: 7054) 1
Simulation temperature: 298.15 K
Adaptive frequency sweep started
Simulation frequency [1] = 0 Hz

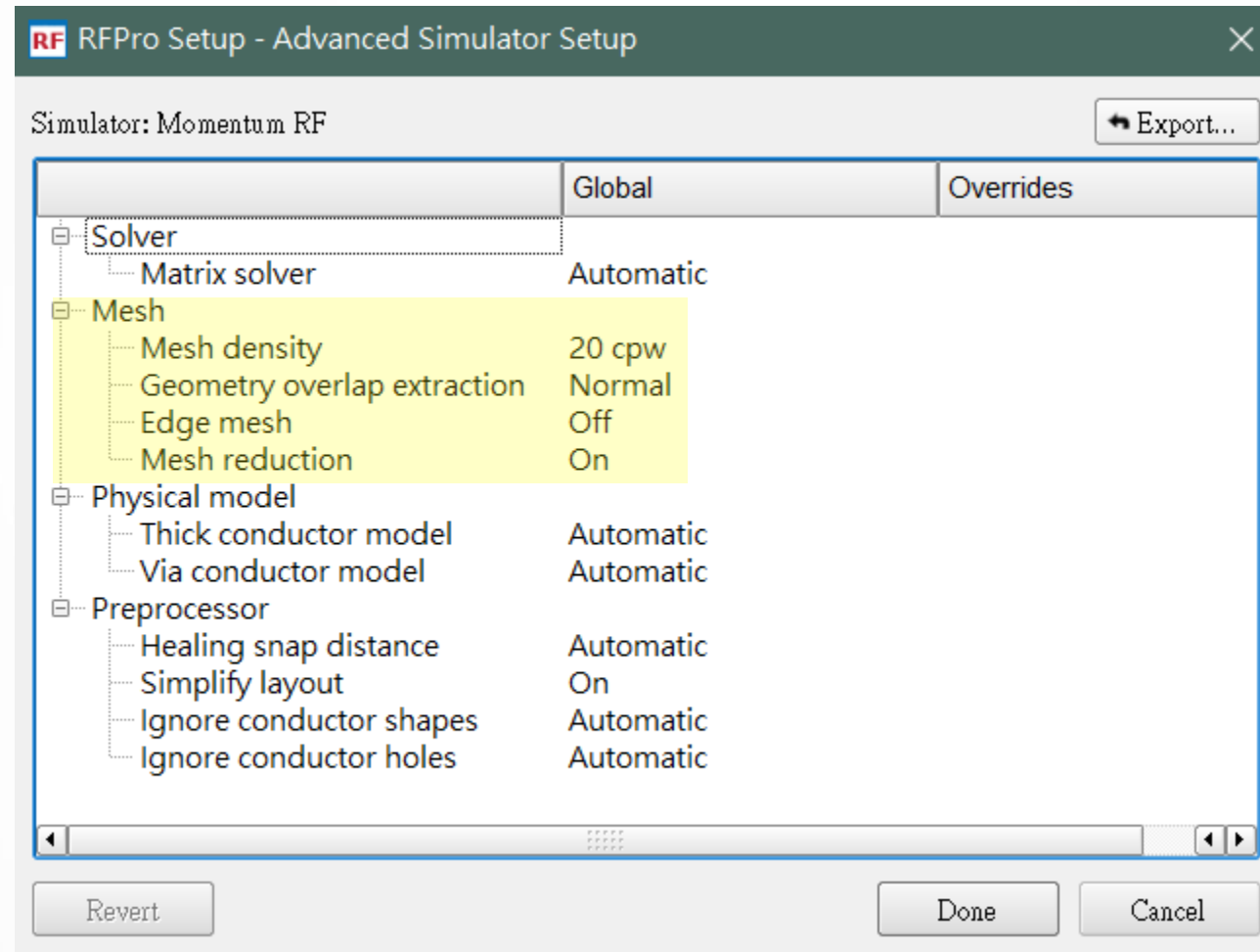
Using multi-threading (8 threads) 2
Matrix size: 21433 (reduced: 7054)
Simulation temperature: 298.15 K
Adaptive frequency sweep started
Simulation frequency [1] = 0 Hz

Using multi-threading (8 threads) 3
Matrix size: 192893 (reduced: 71568)
Simulation temperature: 298.15 K
Adaptive frequency sweep started
Simulation frequency [1] = 0 Hz
```

Outline

- Quick review of Momentum
- Lab1: Port Type Overview
- Lab2: Net Type Setup for Physical Model Simplified
- Lab3: Understand Mesh, Solver and Preprocessor
- Summary

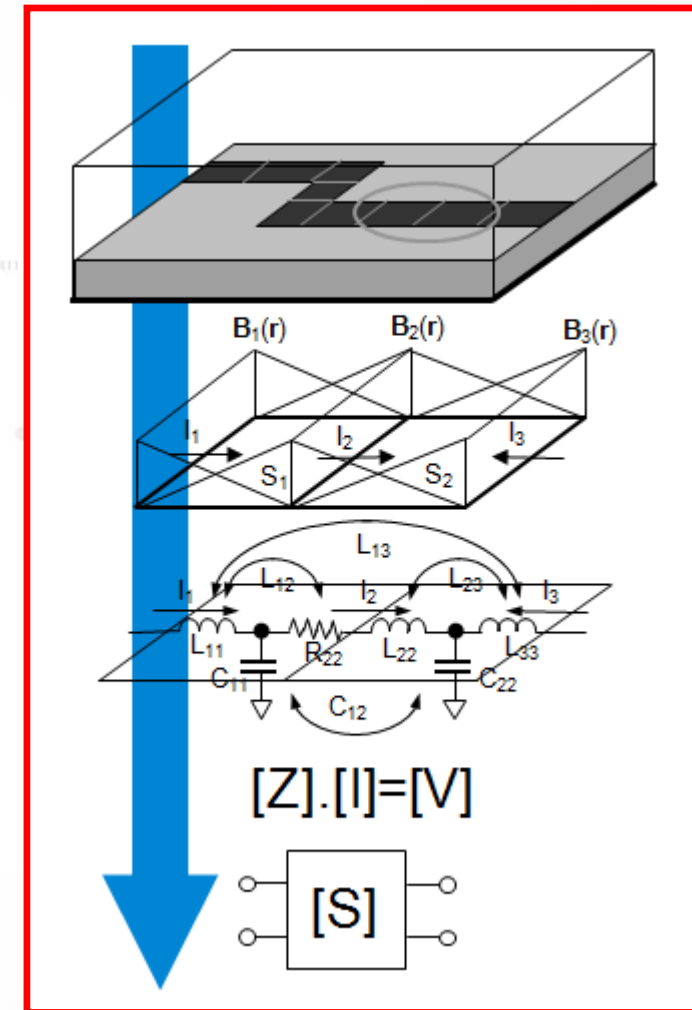
Mesh in RFPPro



Momentum Mesh Generator

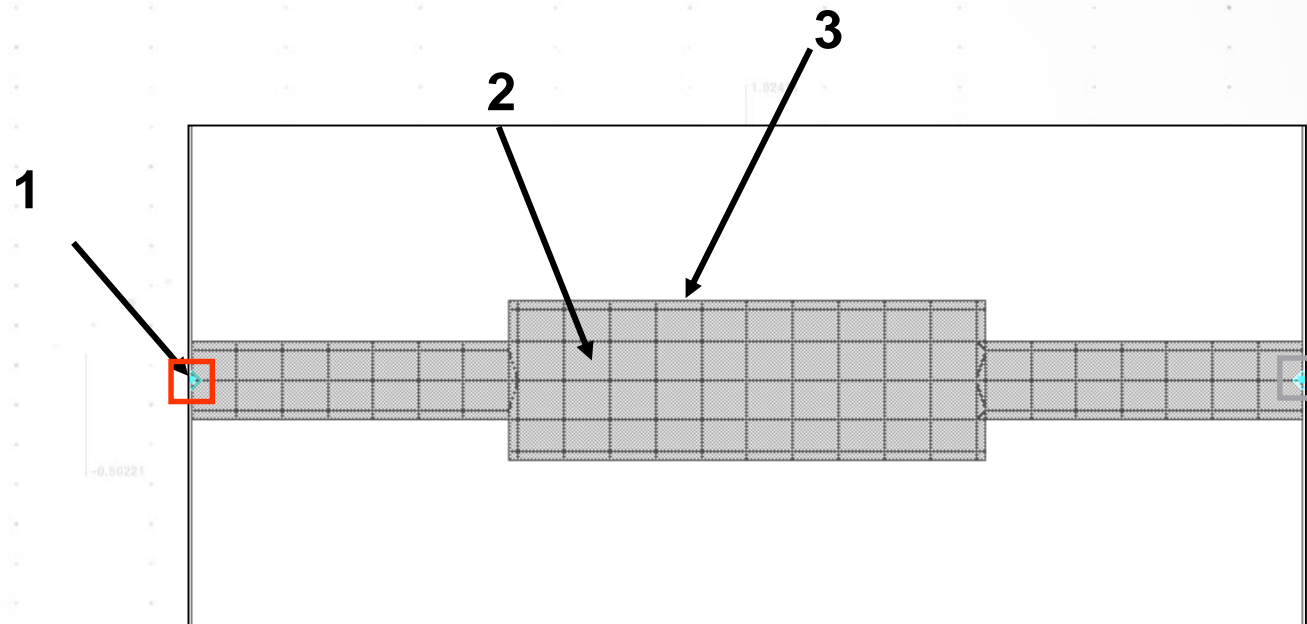
- Layout conforming meshes with quadrilateral, rectangular and triangular cells used to compute currents

- MoM problem can be mathematically thought of as a 3D equivalent circuit network with frequency-dependent R's, L's, and C's
- An impedance matrix is created and then solved that allows us to obtain the current amplitudes based on the excitations at the ports
- Create matrix = Matrix Load (quadruple integrals over surfaces of all cell pairs)



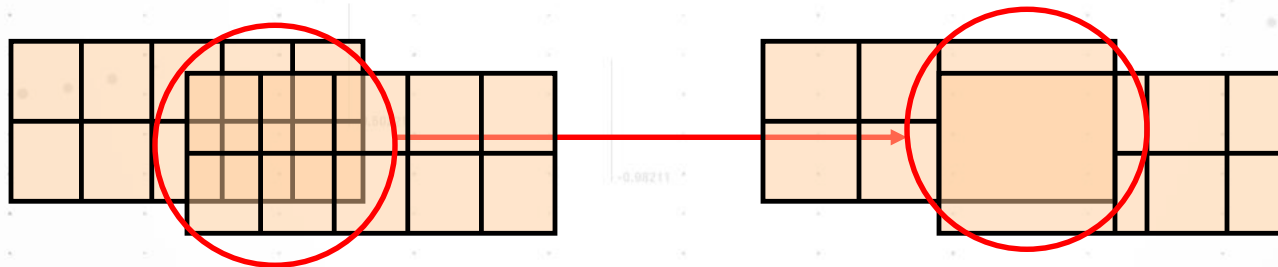
Edge Mesh

- 1 - Port
- 2 - Mesh
- 3 - Edge Mesh



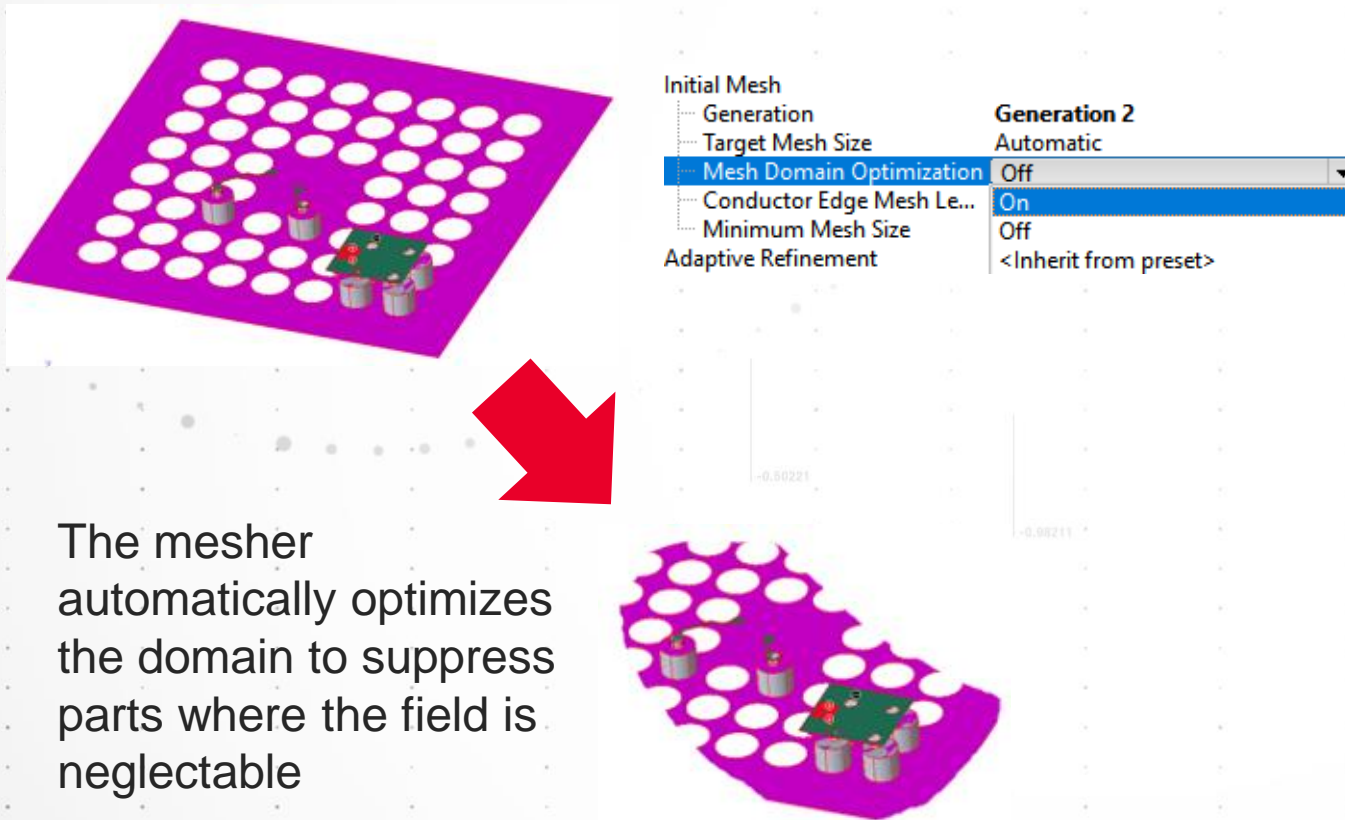
Geometry Overlap Extraction

- Thin Layer Overlap
- If two drawing layers are separated by a thin substrate layer and the mesh cells and object boundaries are not aligned correctly, the simulation data may be less accurate



FEM Generation 2 : Mesh-domain optimization

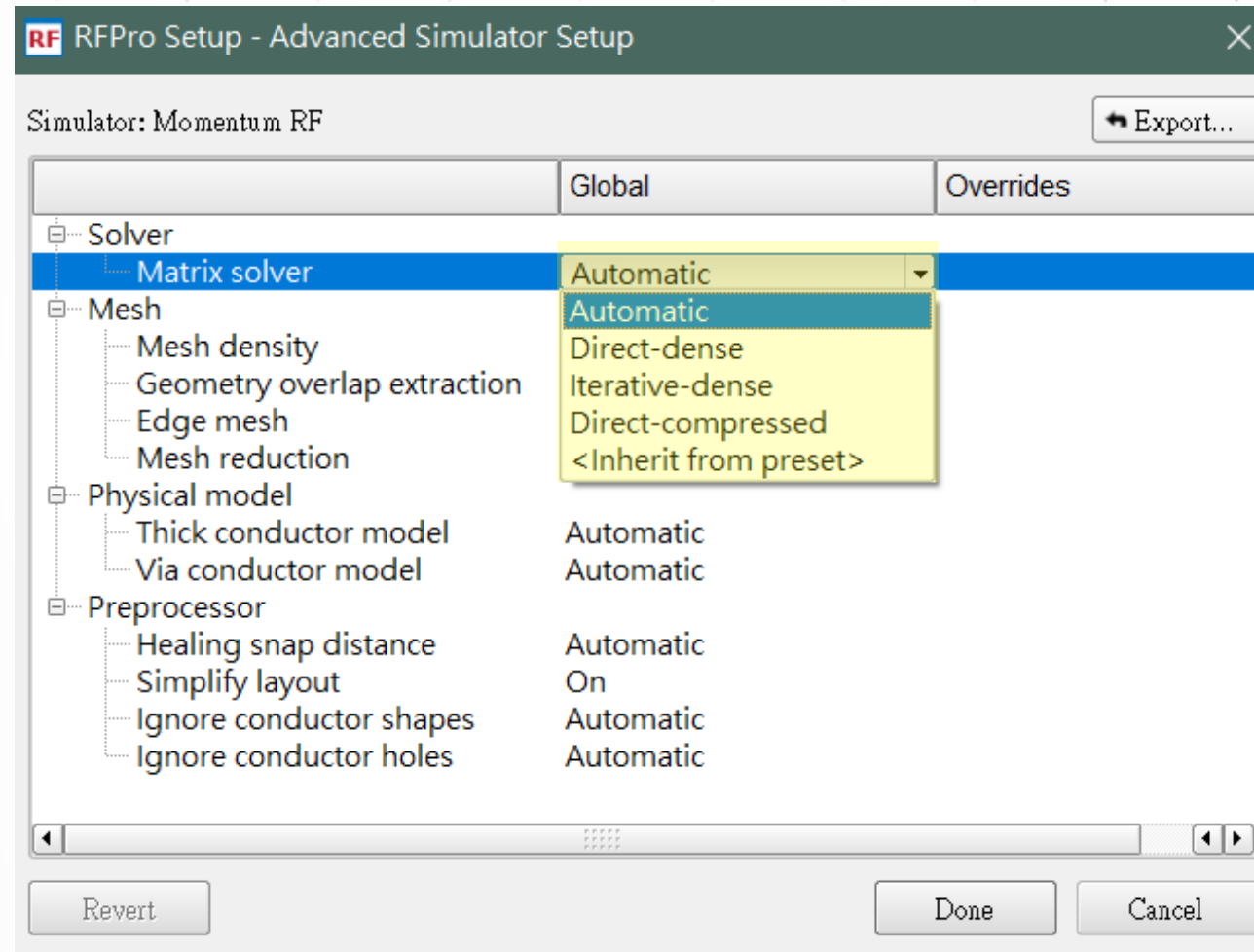
Mesh-domain optimization in Momentum is coming soon.



The mesher automatically optimizes the domain to suppress parts where the field is neglectable

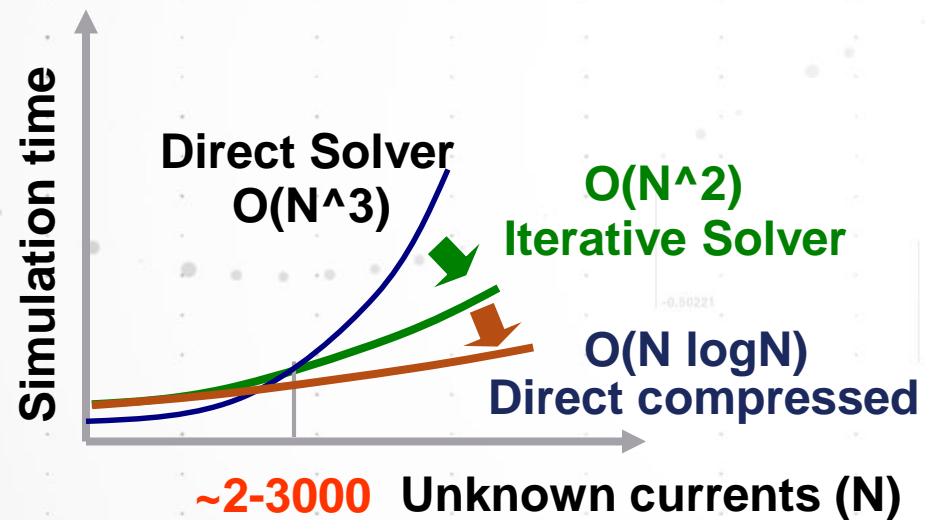
- In case of large ground or power planes, the simulation space might still be too large to be efficient
- ADS 2020 Update 1.0 Mesh Domain Optimization to reduce the simulation space with 2 constraints
 - Much more stable than a cookie cut
- Automatically adapts for several critical nets to be simulated in series
 - No need to multiply layout views for each cookie cut

Solver in RFPro



Solver in RFPro

- MoM technology chooses automatically the best solver for your application



$$\text{CPU time} = A + B N + C N^2 + D N^3$$

where:

N = number of unknowns

The constant term **A** accounts for the simulation set up time.

The meshing of the structure is responsible for the linear term, **BN**.

The loading of the interaction matrix is responsible for the quadratic term and the solving of the matrix equation accounts for:

- Part of the quadratic term (when using the iterative solver)
- The cubic term (when using the direct solver)

Preprocessor in RFPro

RF RFP Pro Setup - Advanced Simulator Setup

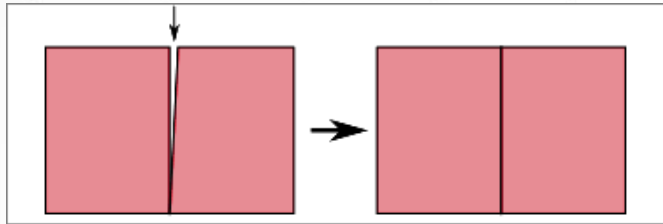
Simulator: Momentum RF Export...

	Global	Overrides
<input type="checkbox"/> Solver		
Matrix solver	Automatic	
<input type="checkbox"/> Mesh		
Mesh density	20 cpw	
Geometry overlap extraction	Normal	
Edge mesh	Off	
Mesh reduction	On	
<input type="checkbox"/> Physical model		
Thick conductor model	Automatic	
Via conductor model	Automatic	
<input type="checkbox"/> Preprocessor		
Healing snap distance	Automatic	
Simplify layout	On	
Ignore conductor shapes	Automatic	Ignore (remove) conductor shapes up to a width or height of 5 microns.
Ignore conductor holes	Automatic	Ignore (fill) conductor holes up to a width or height of 5 microns.

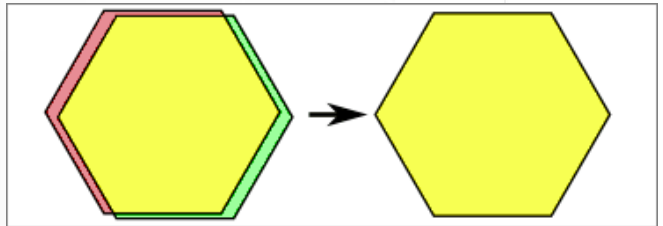
Revert Done Cancel

Layout Healing

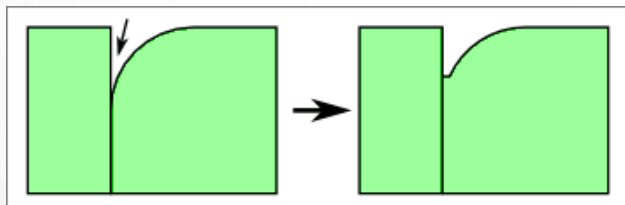
- Closes unintentional gaps between adjacent shapes



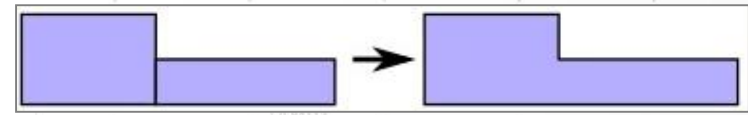
- Ensures that stacked vias have only one joint boundary



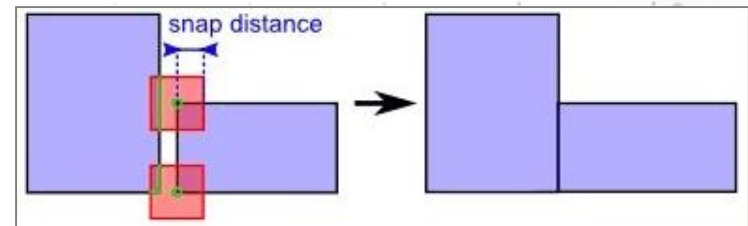
- Eliminates acute angles



- Merge

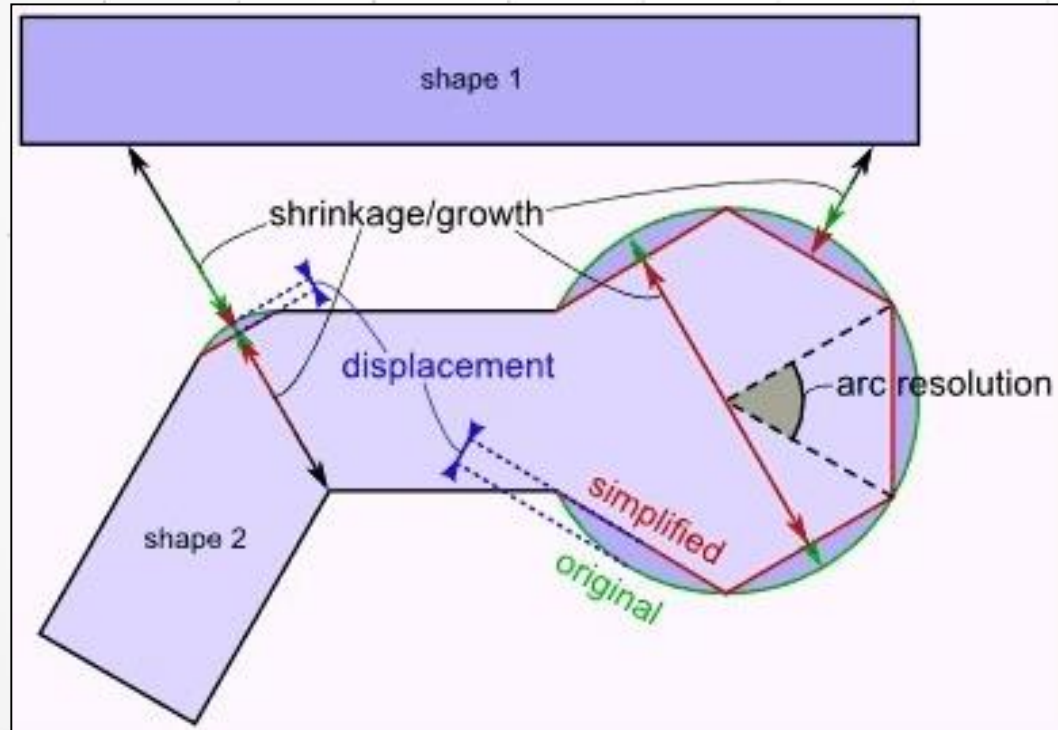


- Snap



Layout Simplification

- Layout simplification is required to reduce number of meshes without loss of accuracy



Simulation Options

Preset: Default Rename... Remove

Description **Physical Model** Preprocessor Mesh Solver Expert

Global: All Shapes **Global: Patterns** Layer Specific

Show Visual Aid

Heal the layout
nearby edges and vertices will be snapped together
 Auto-determine a safe snap distance (conservative)
 User specified snap distance: 0 mil

Merge shapes touching each other where possible
shared edges in the mesh will not be preserved

Simplify the layout
vertex count will be reduced, without changing the topology
Constraints (upper limits)
Displacement 1 % of the wavelength
Shrinkage/growth 7.6 % or arc resolution 45 degrees

Use different constraints for vias
Displacement 1 % of the wavelength
Shrinkage/growth 7.6 % or arc resolution 45 degrees

Never change lines whose length exceeds 0 mil

Ignore shapes on the following purposes:
dummy dummy2

Guidance RFP Pro Setup for IC Design

Reasonable defaults for IC Designs:

- **Mode**: MomRF (switch to MomMW if status window indicates electrically large design)
- **Ports**: 'Auto'/'Direct' for most ports, TML only if intend design to be included in context with same transmission line widths at those port locations.
- **Frequency plan**: include DC in frequency plan
- **Output Plan**: only save currents if necessary for post-processing visualization (also uncheck 'Reduce to decrease size' in Model options if you do wish to visualize currents)
- **Physical Model**: 3D-distributed thick conductor model, 2D-distributed/Wire via model for most (3D Distributed for via in RF path)
- **Preprocessor**: displacement=0.1 um or auto, arc resolution = 5 degrees for arcs, 45 degrees for vias, use via merge options and/or metal fill options (when needed)
- **Mesh**: mesh density 200-1000 cells @ highest frequency, edge mesh (on for sheet conductors, off for thick conductors), thin layer overlap extraction (Normal for MIM caps, off otherwise), consider Layer Specific meshing if need finer/coarser mesh on specific layer(s)
- **Solver**: if using 'Auto-select' or 'Direct Compressed' ('Direct Dense' guarantees highest accuracy, at potential cost of more RAM and sim time)

Guidance RFP Pro Setup for Laminate/PCB

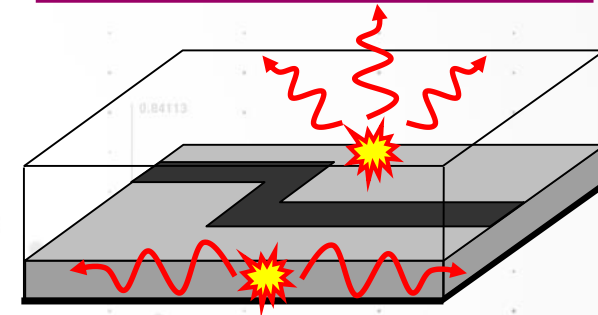
Reasonable defaults for Laminate/PCB Designs:

- **Mode**: MomRF (switch to MomMW if status window indicates electrically large design)
- **Ports**: 'Auto'/'Direct' for most ports, TML only if intend design to be included in context with same transmission line widths at those port locations.
- **Frequency plan**: include DC in frequency plan
- **Output Plan**: only save currents if necessary for post-processing visualization (also uncheck 'Reduce to decrease size' in Model options if you do wish to visualize currents)
- **Physical Model**: 3D-distributed thick conductor model, 2D-distributed/Wire via model for most (3D Distributed for via in RF path)
- **Preprocessor**: displacement=1 um or auto, arc resolution = 5 degrees for arcs, 45 degrees for vias
- **Mesh**: mesh density 20-60 cells @ highest frequency, edge mesh (on for sheet conductors, off for thick conductors), thin layer overlap extraction off, consider Layer Specific meshing if need finer/coarser mesh on specific layer(s)
- **Solver**: if using 'Auto-select' or 'Direct Compressed' ('Direct Dense' guarantees highest accuracy, at potential cost of more RAM and sim time)

Momentum RF vs. Momentum Microwave

- Physical structures radiate into free space (spherical waves) and into substrates (cylindrical waves)
- Radiation for electrically small structures is very small
- MomRF mathematically eliminates radiation
- Computes quasi-static Green's functions at a low frequency
- High accuracy possible even at very high frequencies (100 GHz or more) – just depends on electrical size of structure
- Approximate frequency limits are reported in the log file

Space & Substrate Radiation

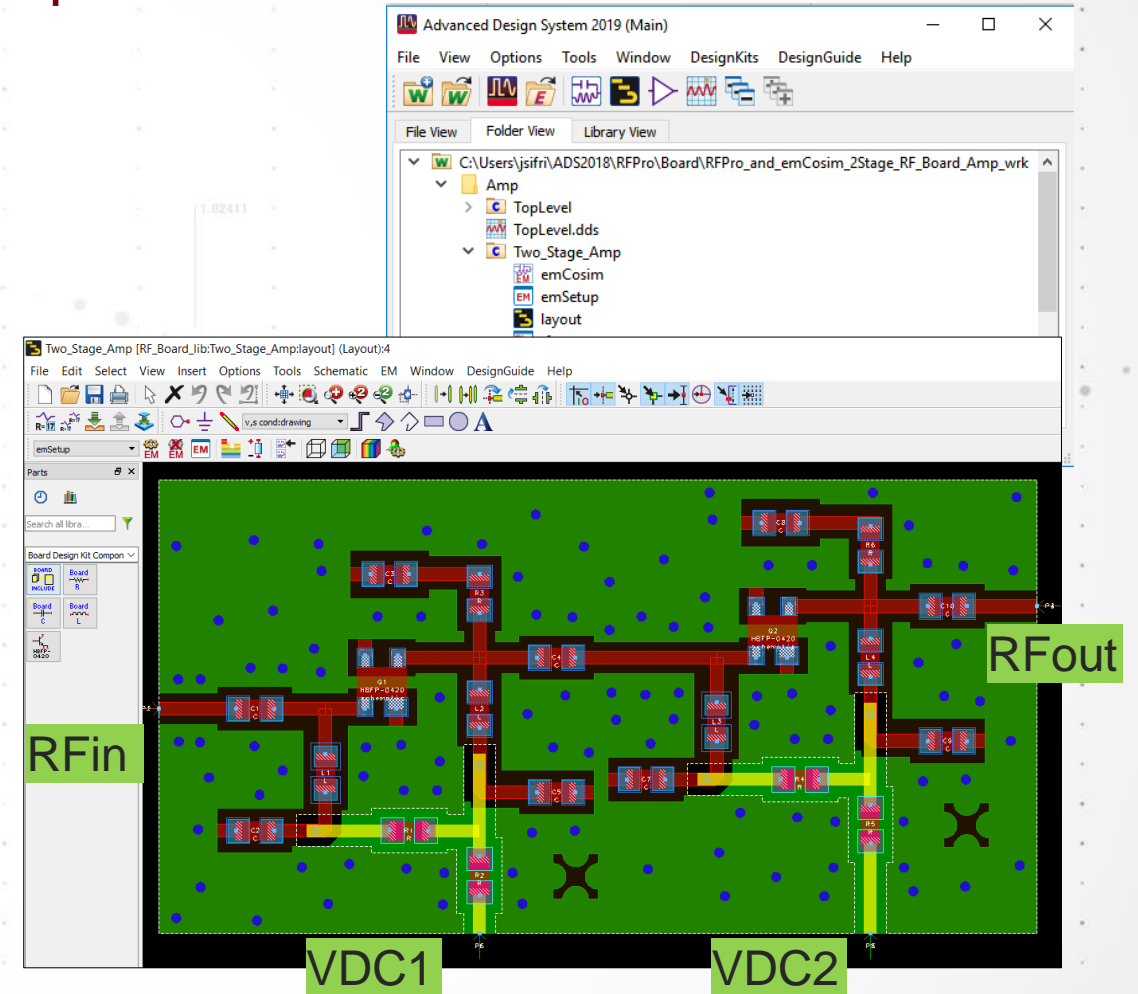


```
S-parameter simulation
S-parameter simulation started
...initializing
Layout is electrically small below 18.4 GHz (space wave radiation)
Substrate is electrically small below 8.05 GHz (surface wave radiation)
...extracting layout
Automatic selection: direct dense matrix solver
Using multi-threading (2 threads)
Adaptive frequency sweep started
Simulation frequency [1] = 0 Hz
```

Lab3 - RFPro EM-cosimulation

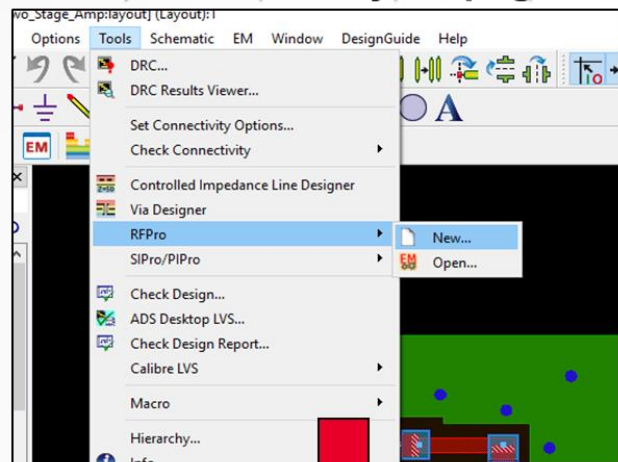
Two-Stage RF Board Amplifier with SMT Components

- A 2-stage LNA built on a 2-layer board.
- SMT components (transistors, capacitors, inductors, resistors) are from a board design kit, all have component models.
- Interconnect lines are Layout based and will be simulated with EM.
- There are 4 ports (8 pins)
 - 2 pins RFin (Signal, Gnd)
 - 2 pins RFout (Signal, Gnd)
 - 2 pins VDC1 (Power, Gnd)
 - 2 pins VDC2 (Power, Gnd)

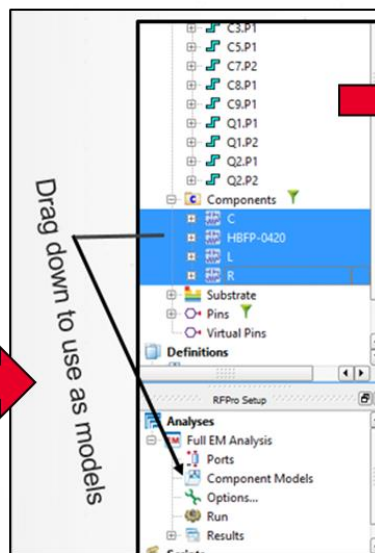
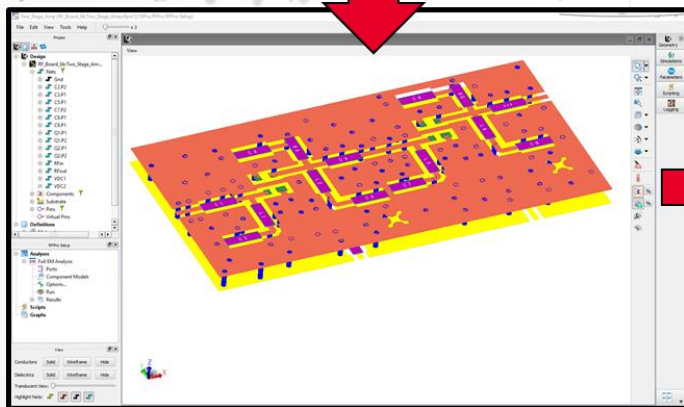


Three Main Steps to RFPro

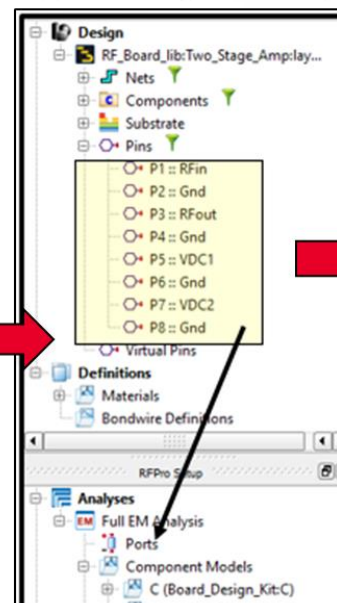
Start RFPro from Layout page



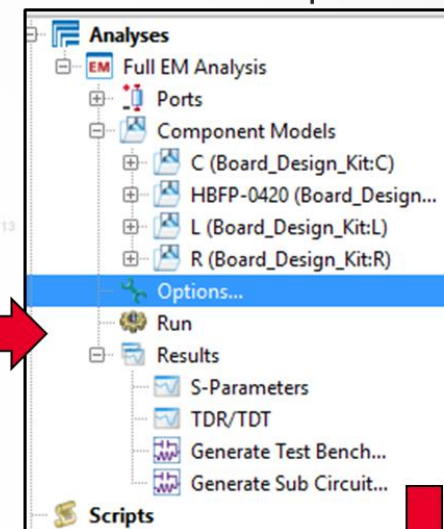
1- Drag down circuit model components into analysis section



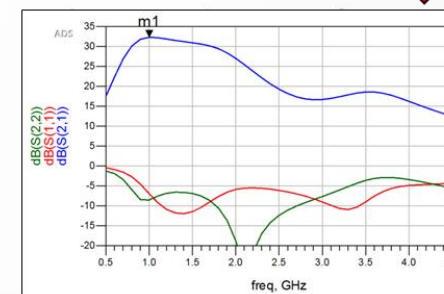
2- Drag down Pins into analysis section to form Ports



3- Setup the simulation frequency and EM Simulator in "Options"



Run simulation

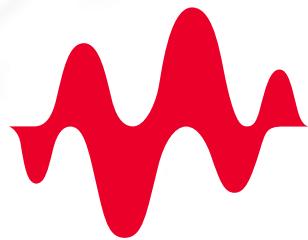


Outline

- Quick review of Momentum
- Lab1: Port Type Overview
- Lab2: Net Type Setup for Physical Model Simplified
- Lab3: Understand Mesh, Solver and Preprocessor
- **Summary**

Summary

- This Webinar help users to understand the port type (calibration type), physical model, mesh, solver and preprocessor setting of MoM technology (Momentum) in RFPPro.
- There are different factors having to be taken into account when modeling. User have to understand the difference between condition to get accurate results. It is important to seek balance between cost and accuracy.
- ADS RFPPro not only can do EM & Circuit co-simulation easily, but also check TDR/TDT impedance, near-field, far-field directly. It's a useful tool for users to analyze simulation quality.



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