



Simbeor Application Note #2013_04, February 2013
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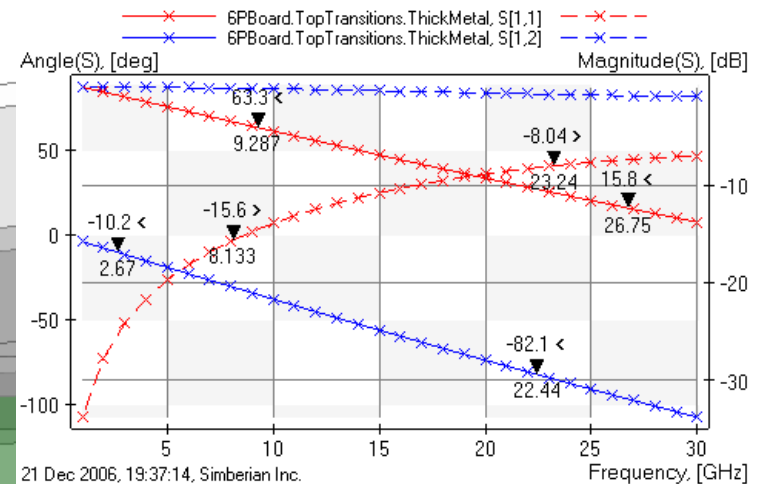
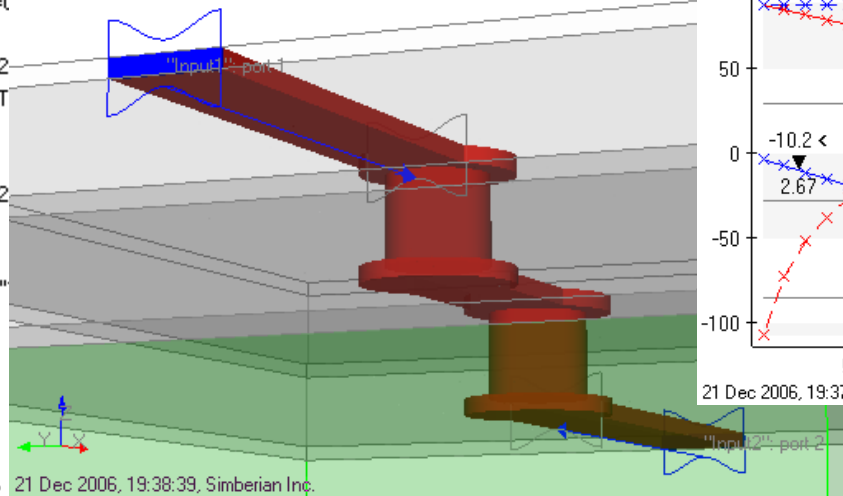


Analysis of differential line transition from tight to loose coupling

Solution: "MicroVias"

- 6PBoard
 - Materials
 - "copper", RRes=1, Rough=0.01
 - "IdealMetal"
 - "prepreg", DK=4.7, LT=(
 - "vacuum"
 - "FR4", DK=4.2, LT=0.02
 - StackUp: LU=[mil], NL=15, T
 - TopTransitions
 - CircuitData: LU=[mil]
 - Multiport: 2 inputs, 2
 - LatticeBox
 - Geometry
 - GeoComposite: "
 - TLines
 - Inputs
 - ThickMetal
 - CollapsedMetal
 - BottomTransition

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Introduction

- ❑ Routing traces on densely populated boards may require transitions between tight and loosely coupled differential pairs
- ❑ Such transition must be optimized to minimize differential reflection and transformation to common mode
- ❑ This example demonstrates how to use electromagnetic simulator for quantitative analysis of the transition effect and geometry optimization
- ❑ Simbeor 2013 full-wave 3D solver for multilayered circuits is used to generate the results

Transmission lines

- Tightly coupled microstrip pair: 5.54 mil traces and 5 mil separation (voltage coupling coefficient 0.16)

Solution: "Tight2Loose"

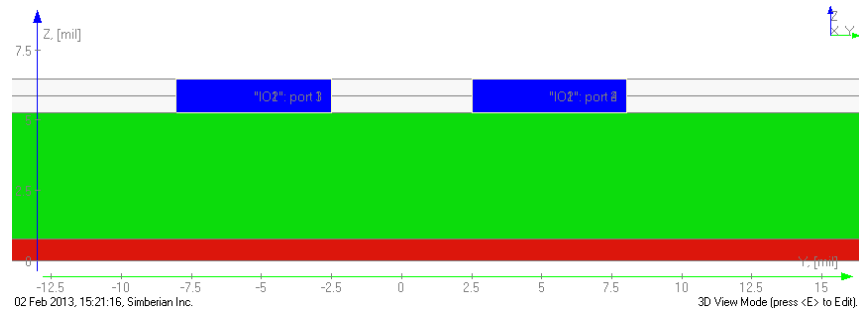
Project(1)

Materials: T=20[°C],...

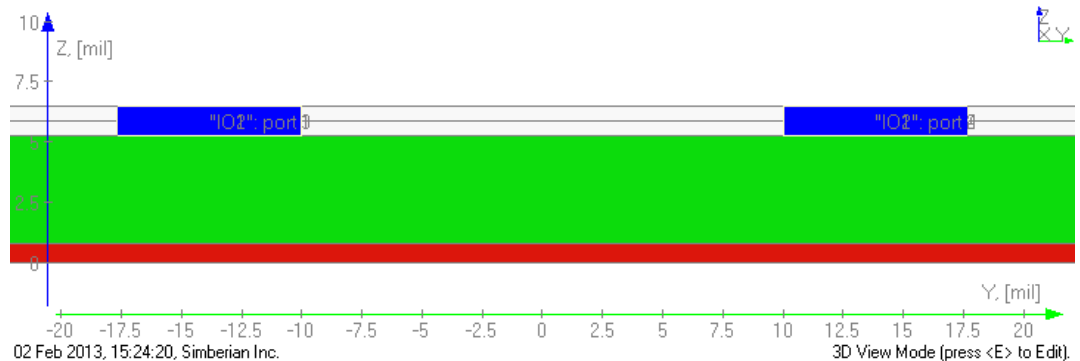
- "Copper", RR=1
- "FR4", Dk=4.2, LT=0.02, PLM=WD, Dk(0)=5.06, Dk(inf)=3.83
- "Air"

StackUp: LU=[mil], NL=2, T=6.47[mil]

- 1| Signal: "Signal1", T=1.2, Ins="Air", Cond="Copper"
- 2| Medium: T=4.5, Ins="FR4"
- 3| Plane: "Plane1", Cond="Copper", T=0.77, Ins="FR4"

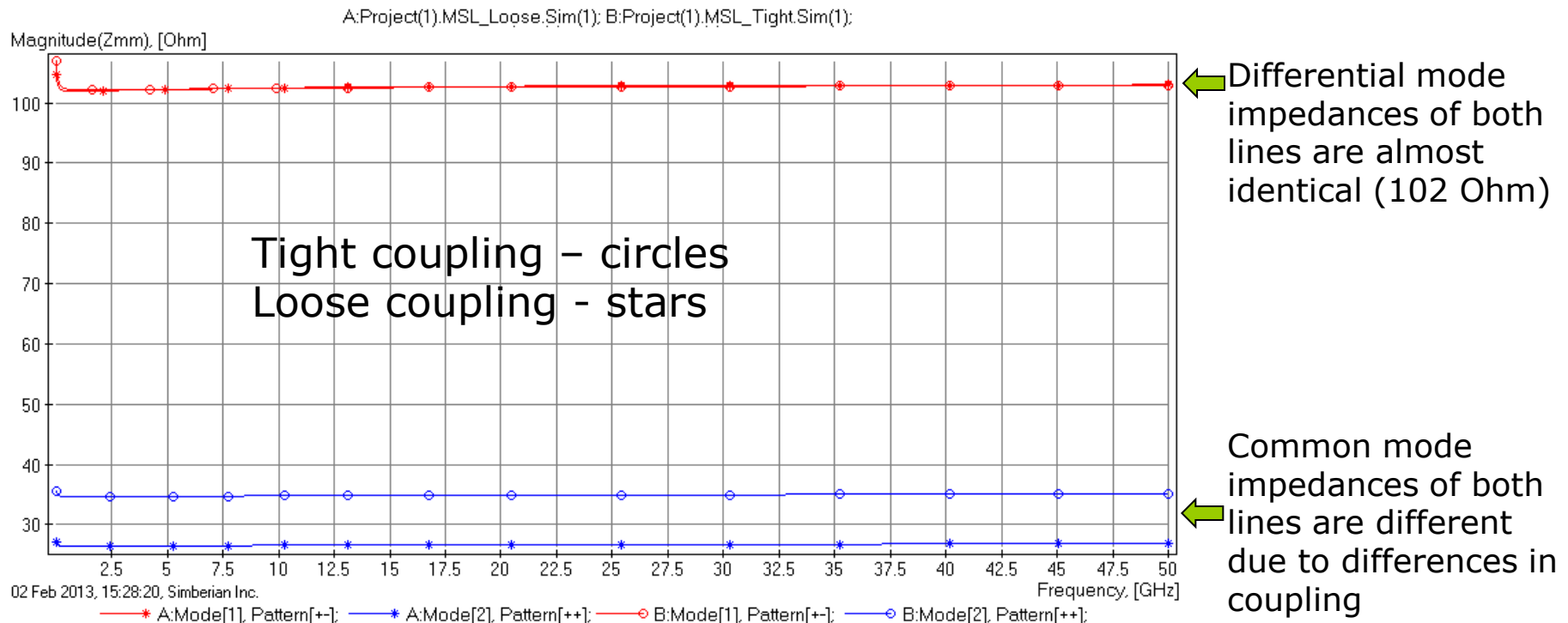


- Loosely coupled microstrip pair: 7.66 mil trances with 20 mil separation ($K_v=0.025$)



Transmission line impedances

- Computed with Simbeor 3DML electromagnetic solver (accounts for dielectric, conductor and high-frequency dispersion and losses)

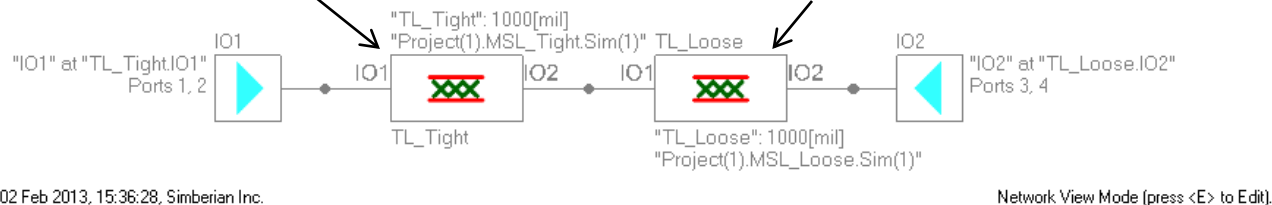


What if we just connect two line segments?

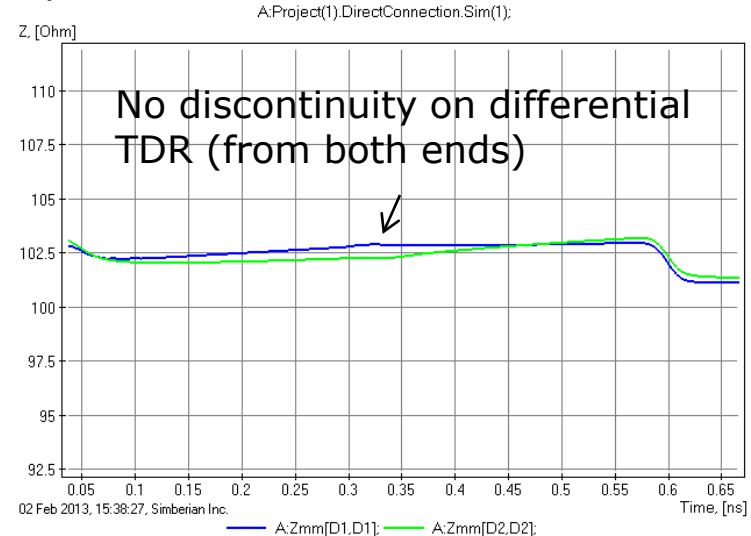
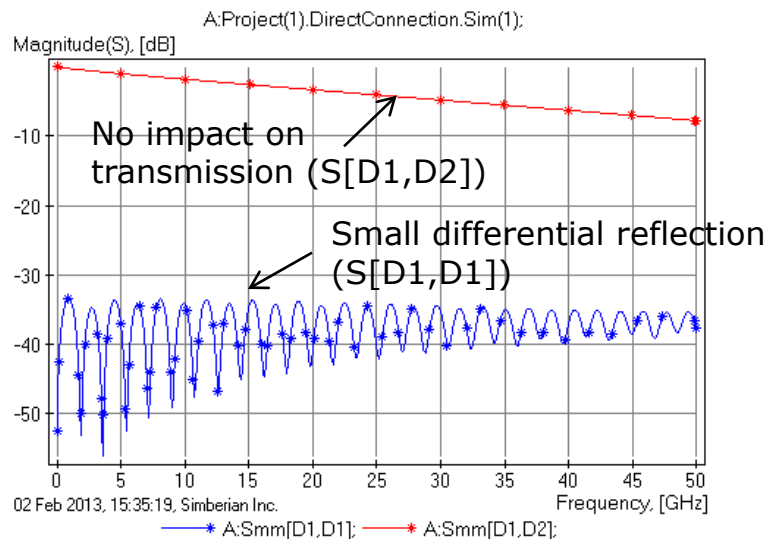
- Ideal connection – no discontinuity between lines

1 inch of tightly coupled differential line

1 inch of loosely coupled differential line



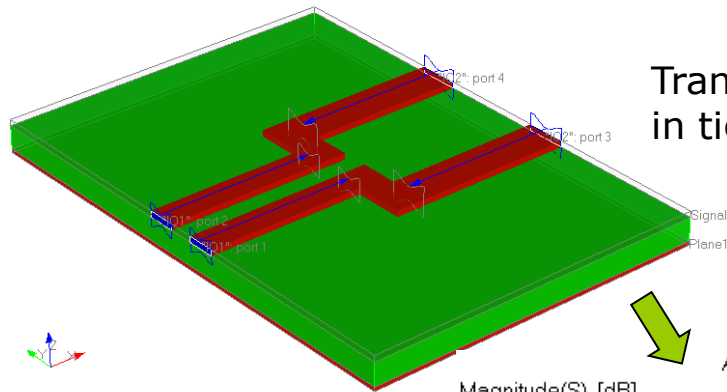
Differential mode parameters:



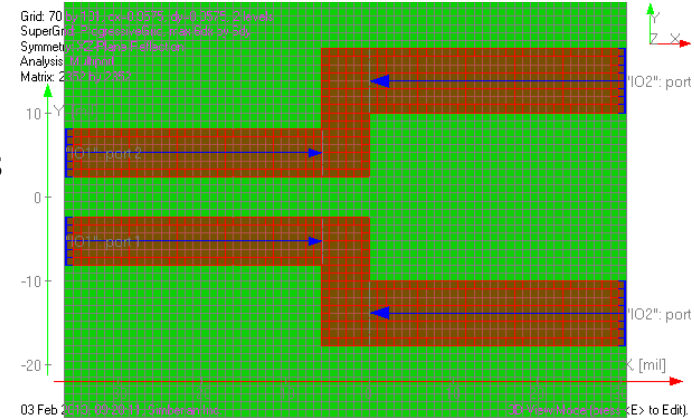
Problem solved? – Not really, we need layout...

How to transition between the cross-sections?

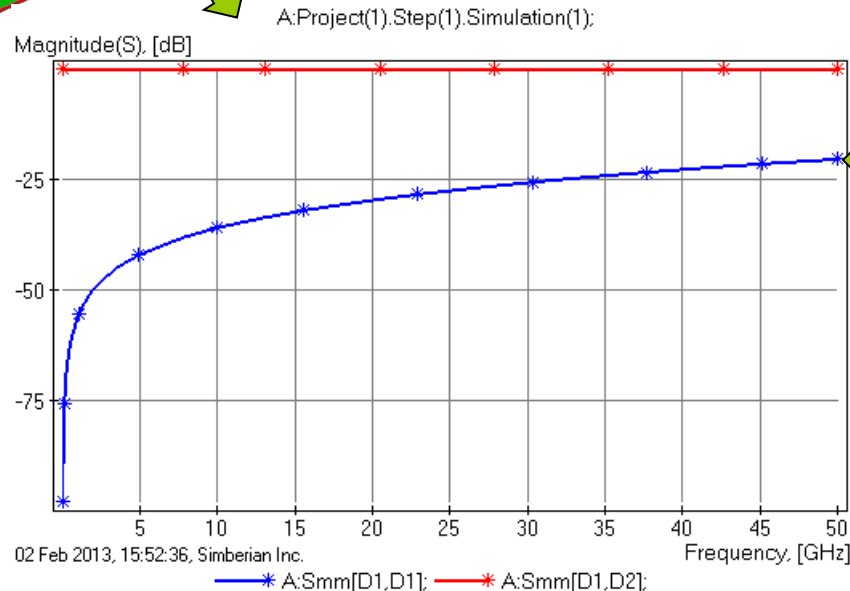
- Use simplest step transition? Let's try...



02 Feb 2013, 15:50:26, Simberian Inc.



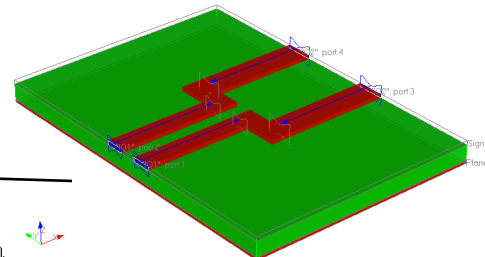
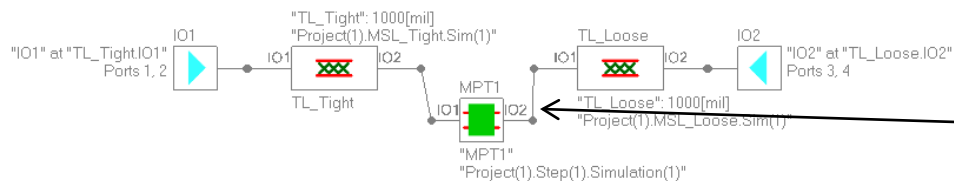
3D Full-wave analysis with metal thickness: about 1.5 min CPU time



Differential mode reflection parameter (S[D1,D1]) is below -20 dB (may be acceptable?)

Initial step transition between two 1-inch segments

Decompositional analysis in FD and TD: less than 2 sec

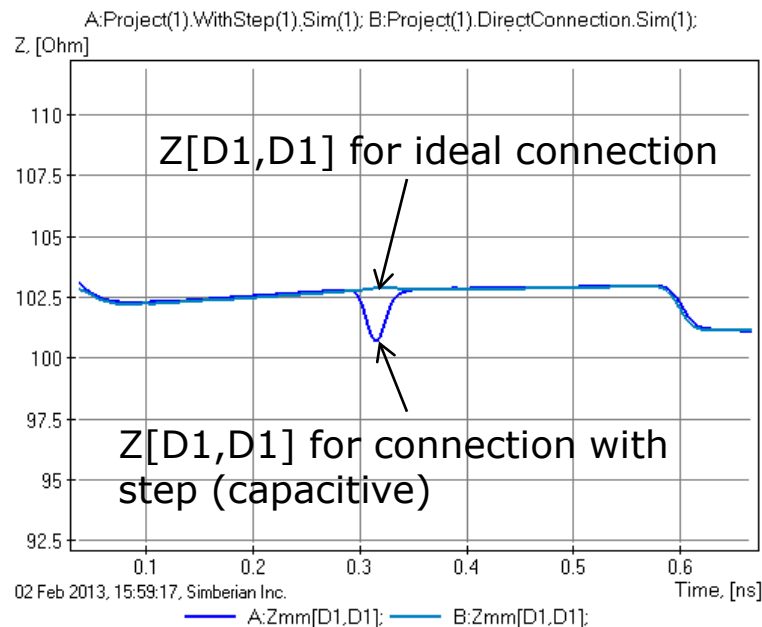
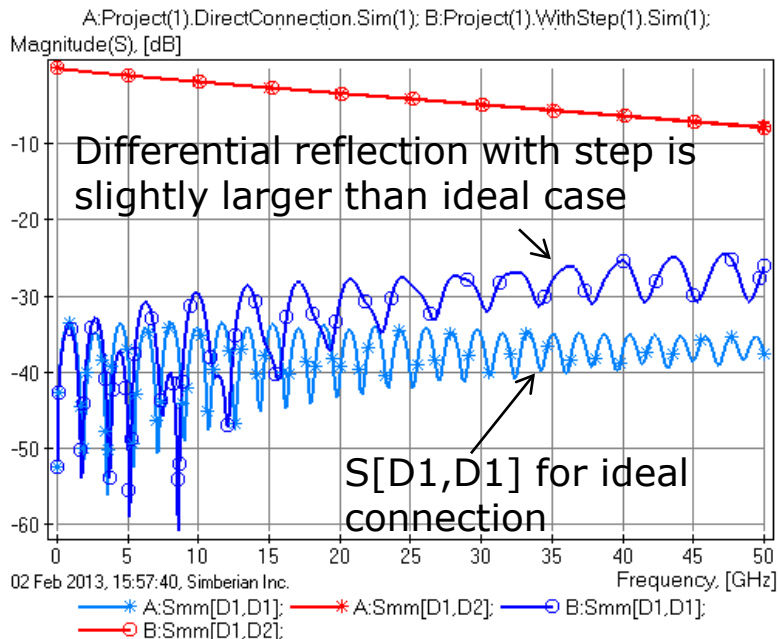


02 Feb 2013, 15:56:02, Simberian Inc.

Network View Mode (press <E> to Edit)

02 Feb 2013, 15:50:35, Simberian Inc.

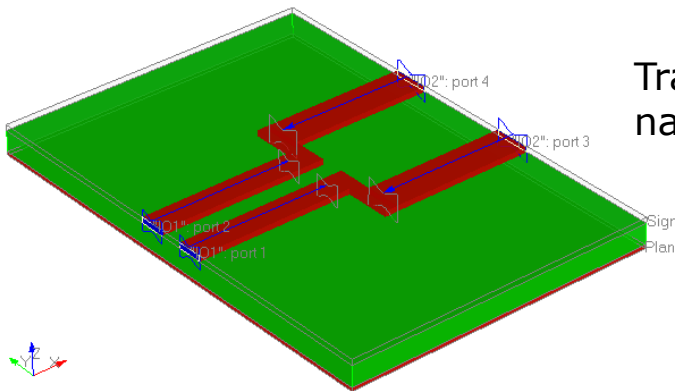
3D View Mode (press <E> to Edit)



Can we further optimize it? Sure, why not...

Optimal step transition (final result)

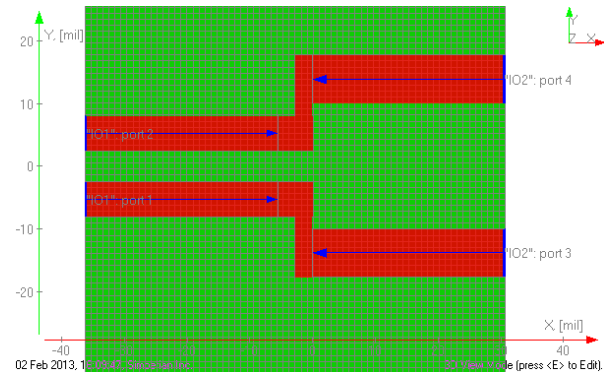
- Transition is done with narrower strips to eliminate the excessive capacitance



Transition with narrow strips

02 Feb 2013, 16:09:28, Simberian Inc.

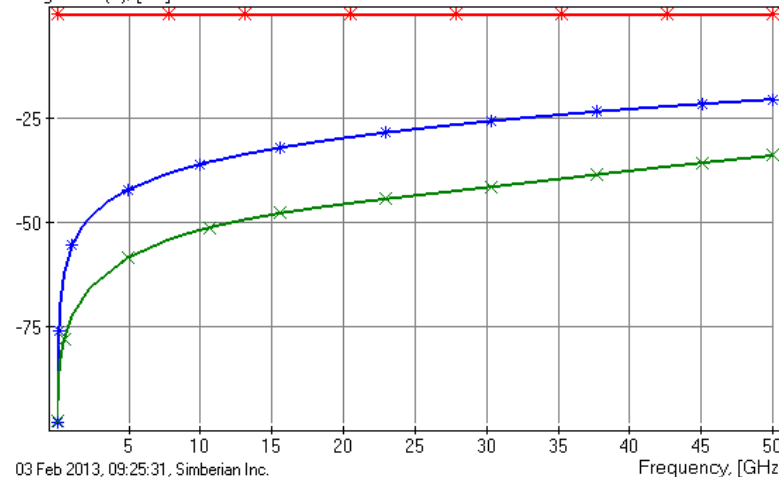
3D View Mode (press <E> to Edit)



02 Feb 2013, 16:09:28, Simberian Inc. 3D View Mode (press <E> to Edit)

Capacitance can be reduced in multiple ways – this is just an example of what can be done and how to estimate the effect

A:Project(1).Step(1).Simulation(1); B:Project(1).Step(3).Simulation(1); Magnitude(S), [dB]



S[D1,D1] with wider strips

S[D1,D1] for optimal structure with narrow strips (below -30 dB)

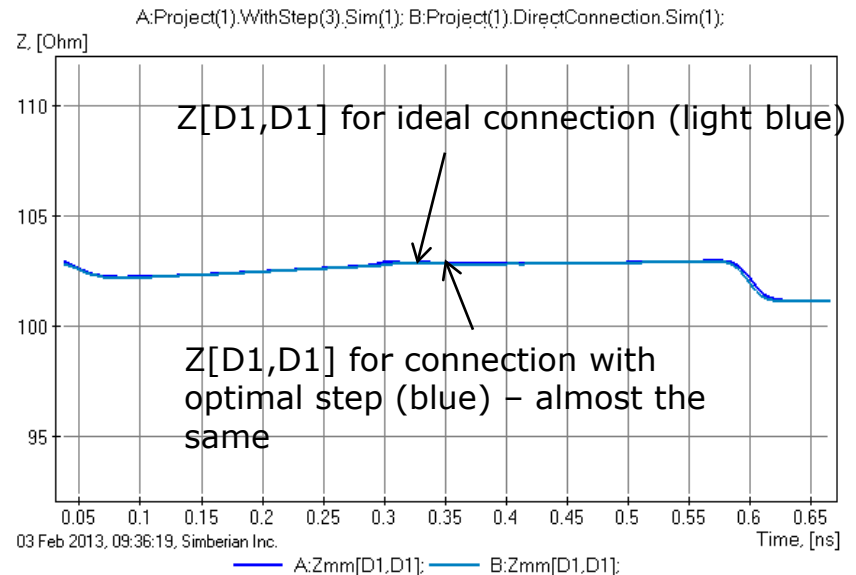
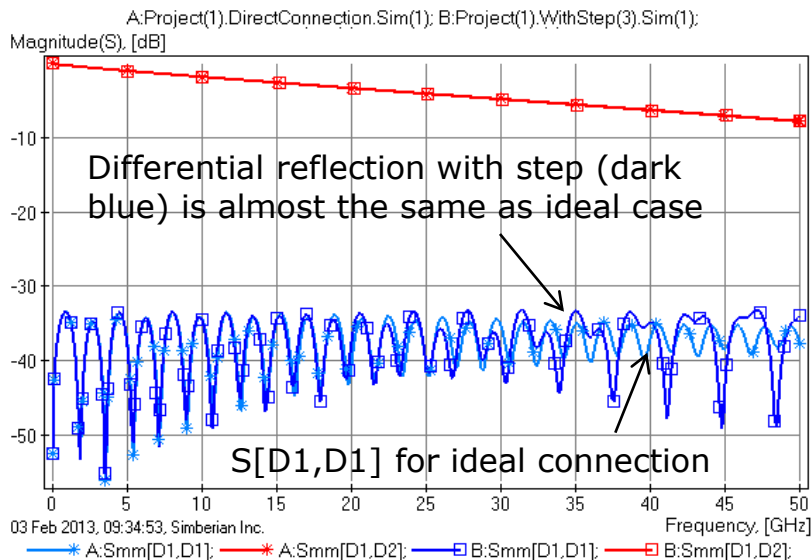
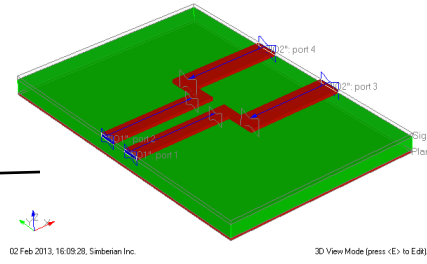
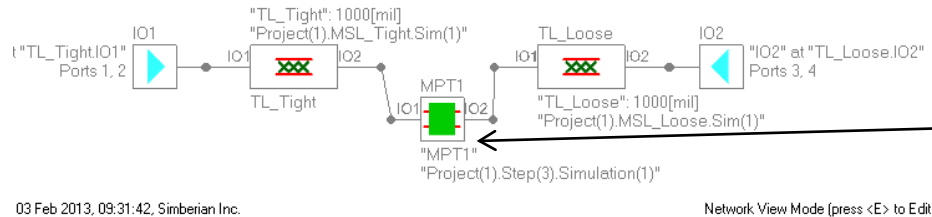
03 Feb 2013, 09:25:31, Simberian Inc.

Frequency, [GHz]

—*— A:Smm[D1,D1]; —*— A:Smm[D1,D2]; —x— B:Smm[D1,D1]; —x— B:Smm[D1,D2];

Optimal step transition between two 1-inch segments

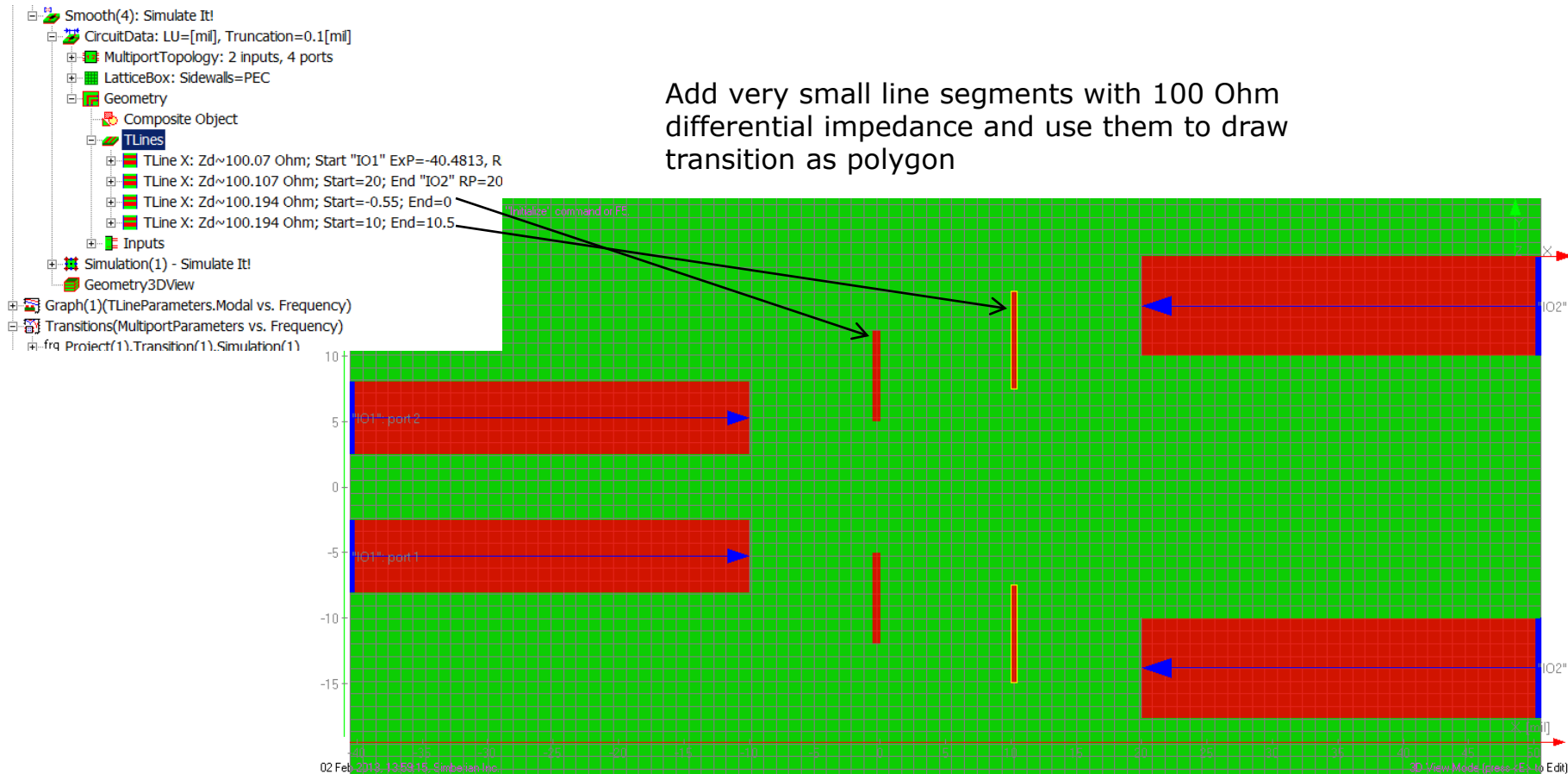
Decompositional analysis in FD and TD: less than 2 sec



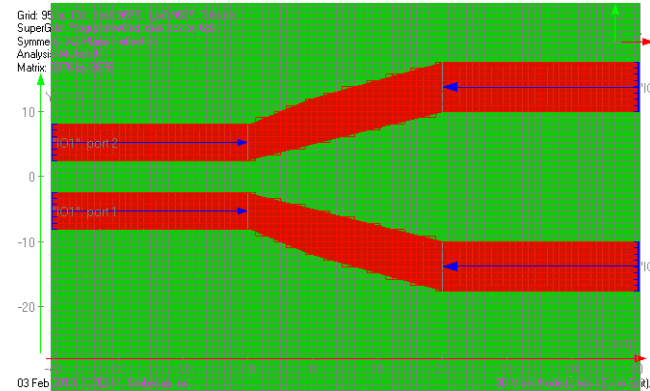
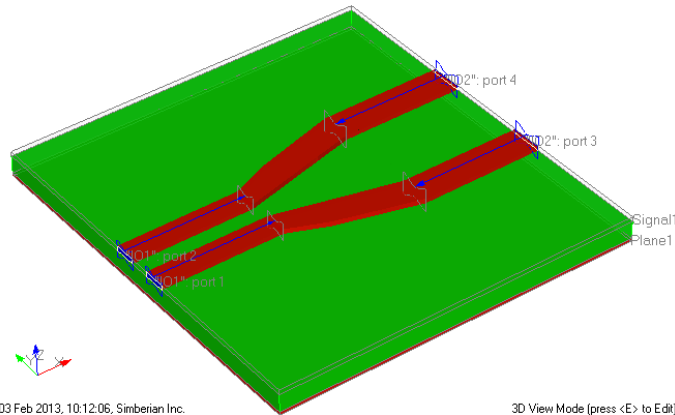
Perfect, but looks unusual. What about a smooth transition? Let's try...

Smooth transition model building

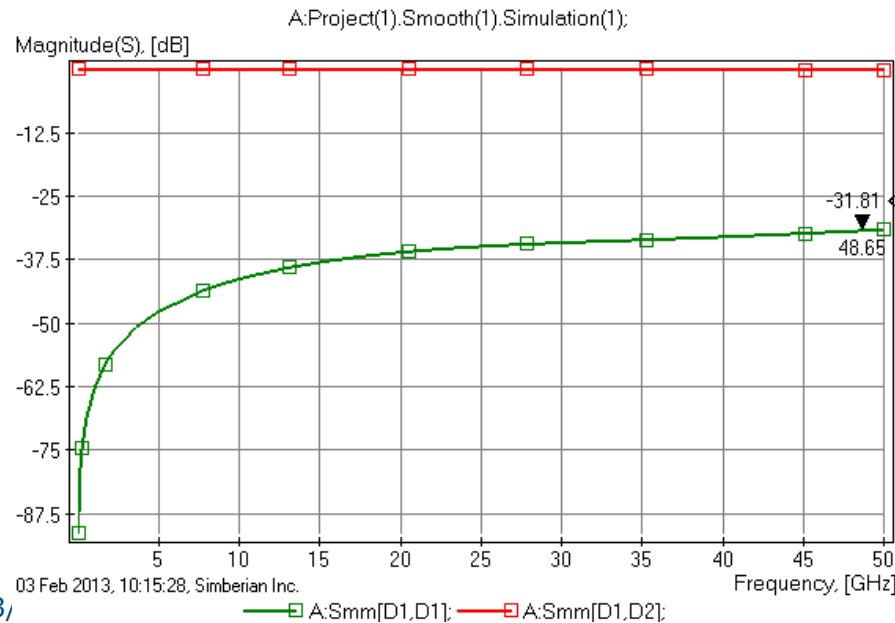
- Goal – have about 100 Ohm differential in each cross-section between tightly and loosely coupled lines on a 30 mil segment



Smooth transition – final geometry



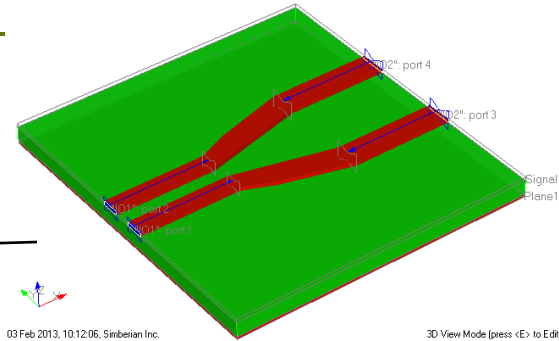
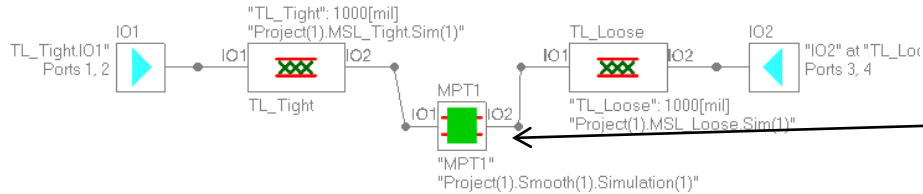
3D Full-wave analysis
with metal thickness:
about 2 min CPU time



Differential mode reflection parameter (S[D1,D1]) is below -30 dB (good)

Smooth transition between two 1-inch segments

Decompositional analysis in FD and TD: less than 2 sec

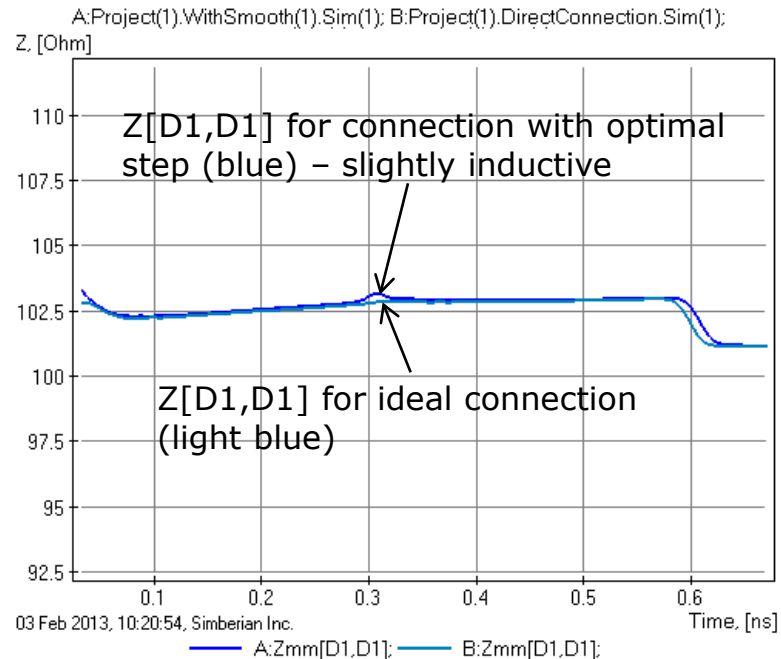
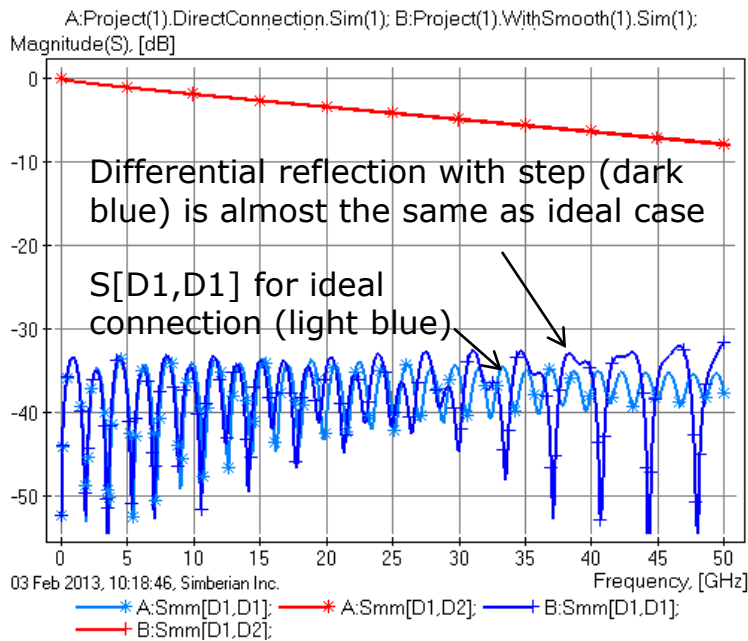


03 Feb 2013, 10:22:13, Simberian Inc.

Network View Mode (press <E> to Edit).

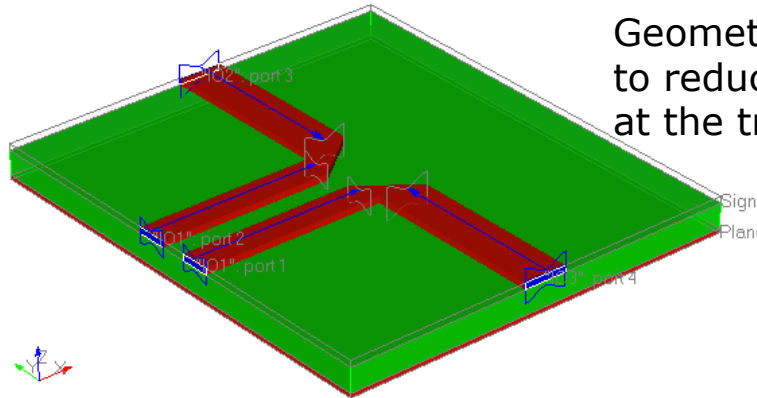
03 Feb 2013, 10:12:06, Simberian Inc.

3D View Mode (press <E> to Edit)

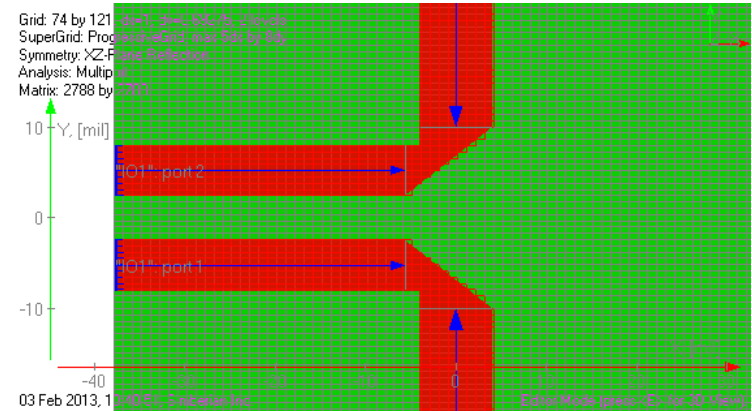


Good. What if I need to split into two single-ended? No problem...

Tightly coupled to single-ended transition



Geometry is optimized to reduce capacitance at the transition



03 Feb 2013, 10:41:17, Simberian Inc.

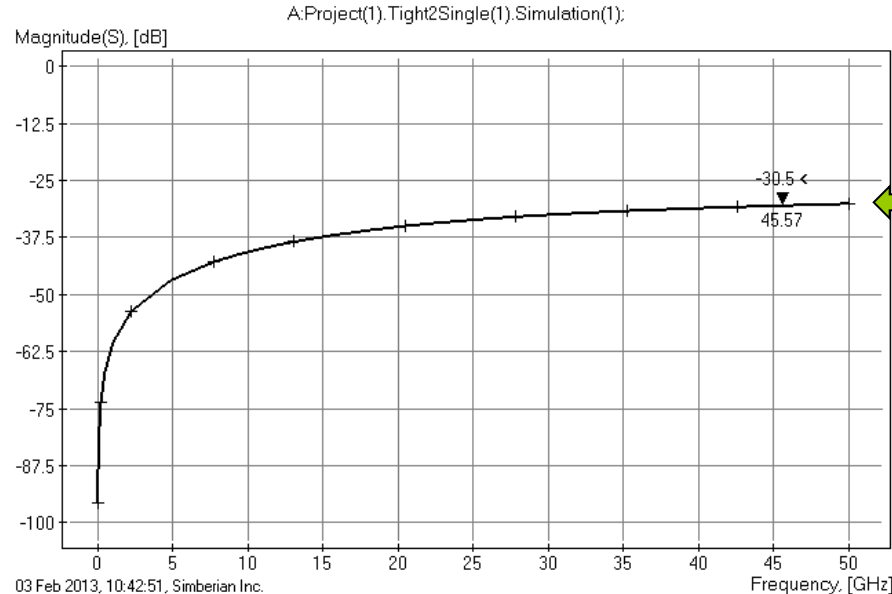
3D View Mode (press <E> to Edit).

03 Feb 2013, 10:40:51, Simberian Inc.

Editor Mode (press <E> for 3D View)

3D Full-wave analysis with metal thickness: about 2 min CPU time

Note: The simplest and the best way to split is to do it immediately – less space, no complicated geometries, same weave effect...



Differential mode reflection parameter (S[D1,D1]) is below -30 dB (good)

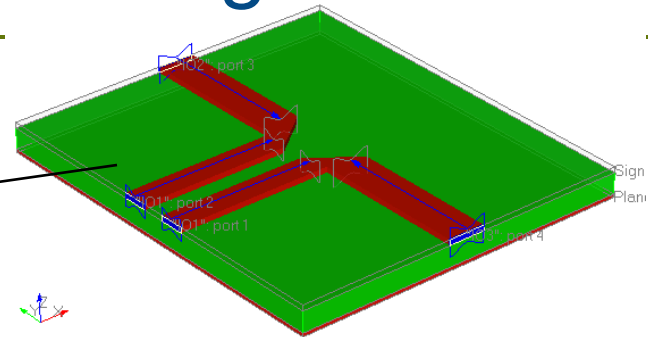
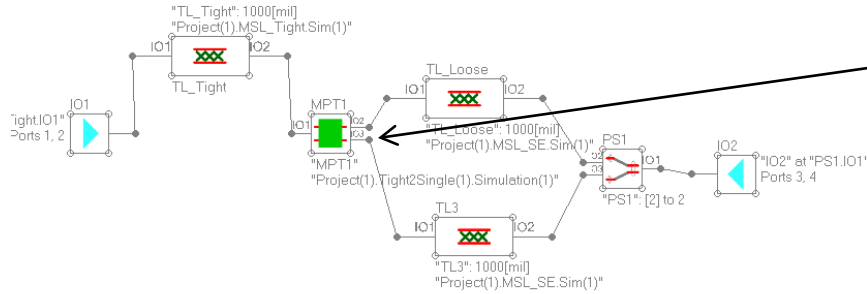
03 Feb 2013, 10:42:51, Simberian Inc.

—+ A:Smm[D1,D1];

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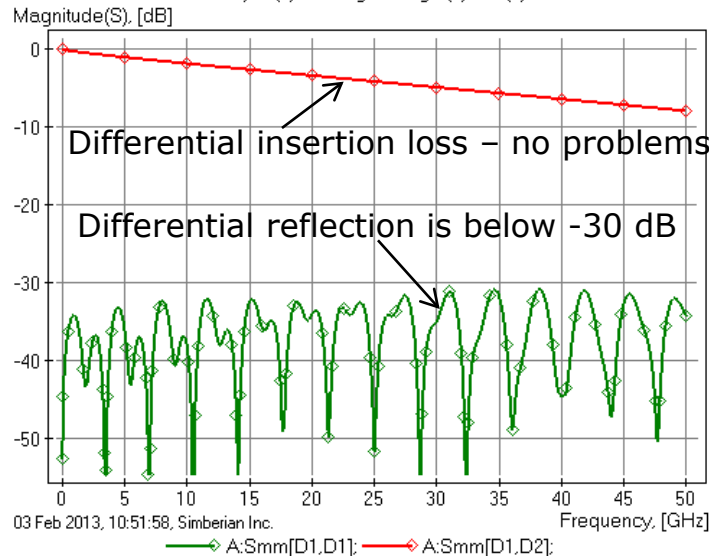
Smooth transition between tight 1-inch segment and two 1-inch SE segments

Decompositional analysis in FD and TD: less than 2 sec



03 Feb 2013, 10:48:17, Simberian Inc.

A:Project(1).WithTight2Single(1).Sim(1):

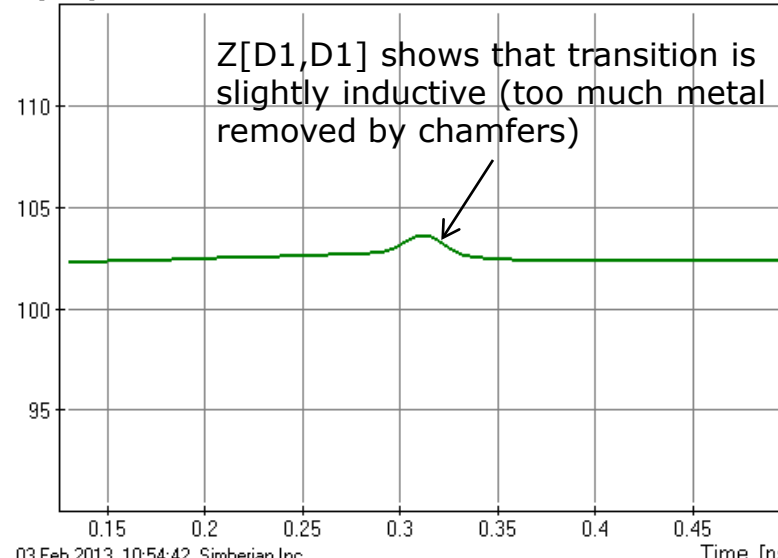


03 Feb 2013, 10:51:58, Simberian Inc.

—◇ A:Smm[D1,D1]; —◇ A:Smm[D1,D2];

Editor Mode (press <E> for Network View)

Z, [Unm]



03 Feb 2013, 10:54:42, Simberian Inc.

— A:Zmm[D1,D1];

Good. Any other geometries?...

Conclusion

- ❑ A few scenarios for routing with tightly and loosely coupled lines are investigated with em analysis up to 50 GHz
 - Optimal geometry can be achieved in multiple ways
 - Routing rules can be generated with the optimization results
 - All transitions had symmetry to avoid differential to common transformations
- ❑ Problem setup and **analysis on a laptop** – less than an hour (Simbeor is the most productive and accurate tool for such analysis)
- ❑ Simbeor solution file with all examples is available at <http://kb.simberian.com/SimbeorExample.php?id=141>

Simberian Inc.

□ Mission

- Build easy-to-use, efficient and cost-effective electromagnetic software for high-speed electronic design automation

□ Incorporated in USA on February 28, 2006

- Founder and President Yuriy Shlepnev
 - PhD in computational electromagnetics
 - 25-years experience in building electromagnetic software

□ Development in Las Vegas, USA, St. Petersburg and Voronezh Russia

□ Location and contacts

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