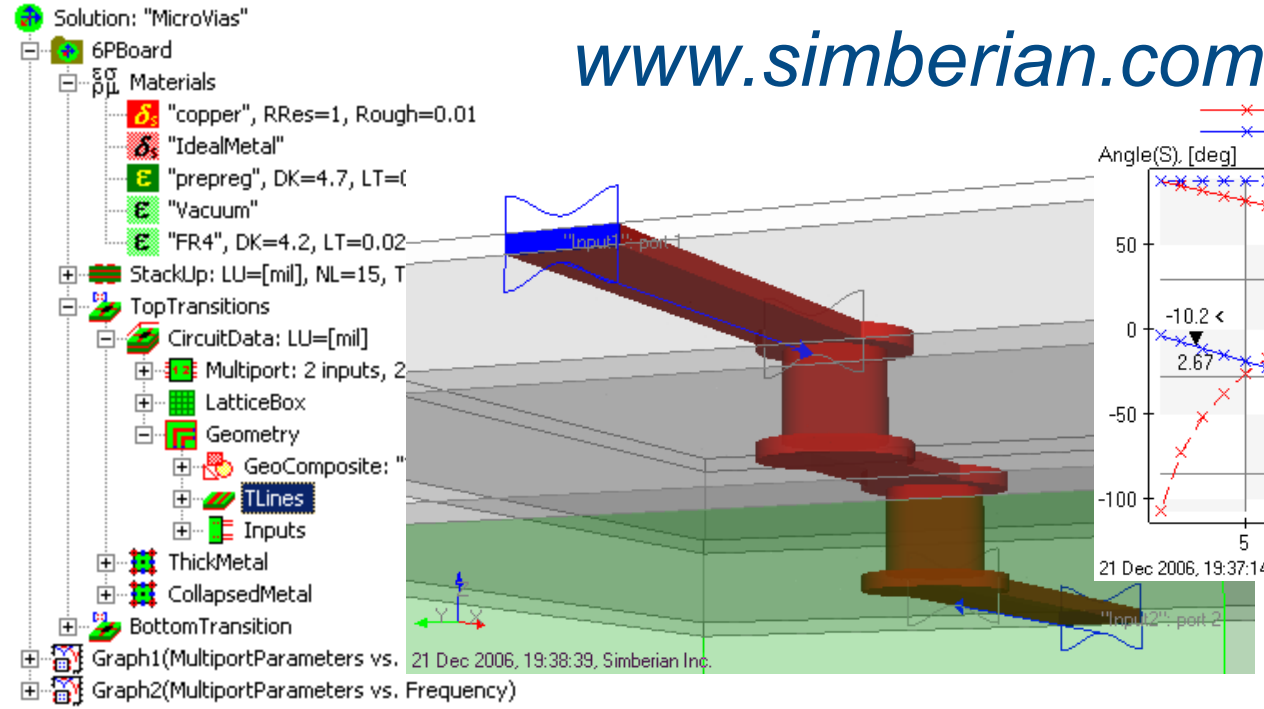
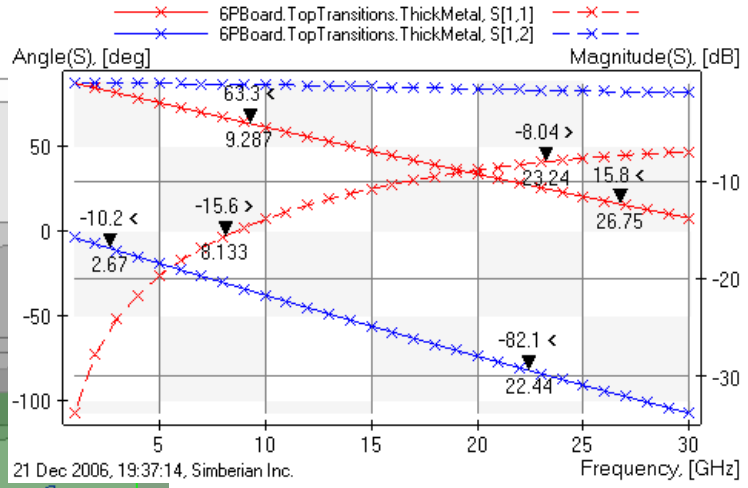
Simbeor Application Note #2013_04, February 2013

Analysis of differential line transition from tight to loose coupling

www.simberian.com





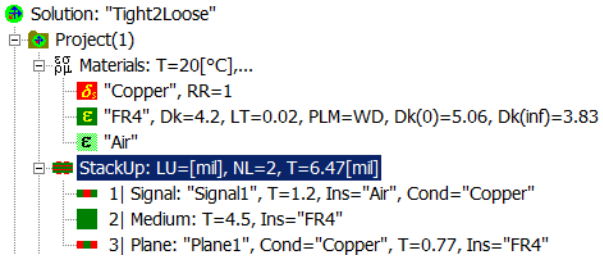
Simbeor®: Accurate, Fast, Easy, Affordable Electromagnetic Signal Integrity Software…

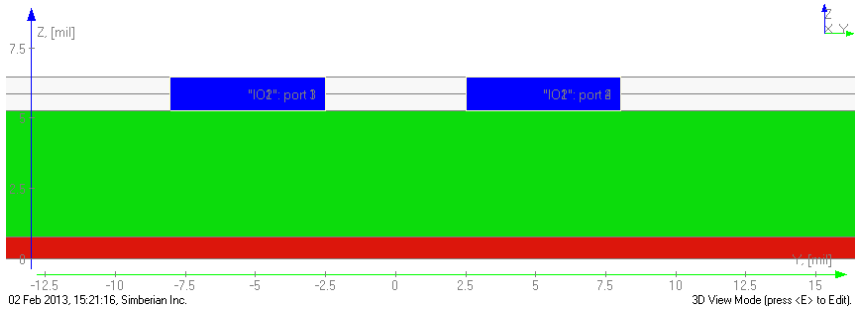
Introduction

- 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

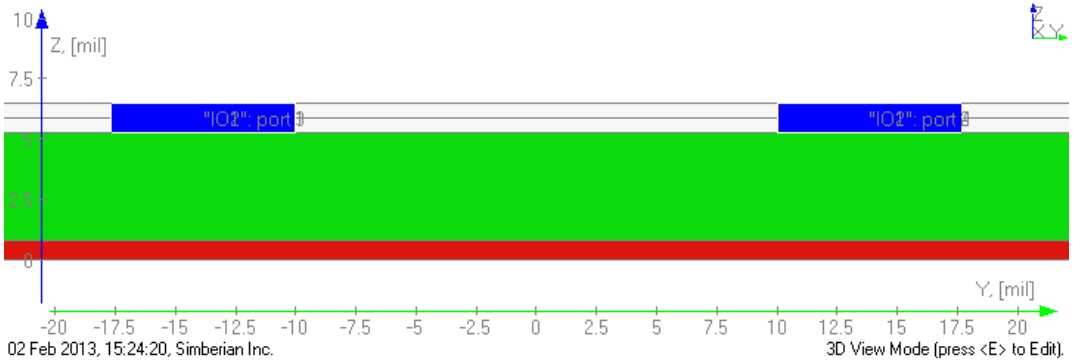
Transmission lines

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



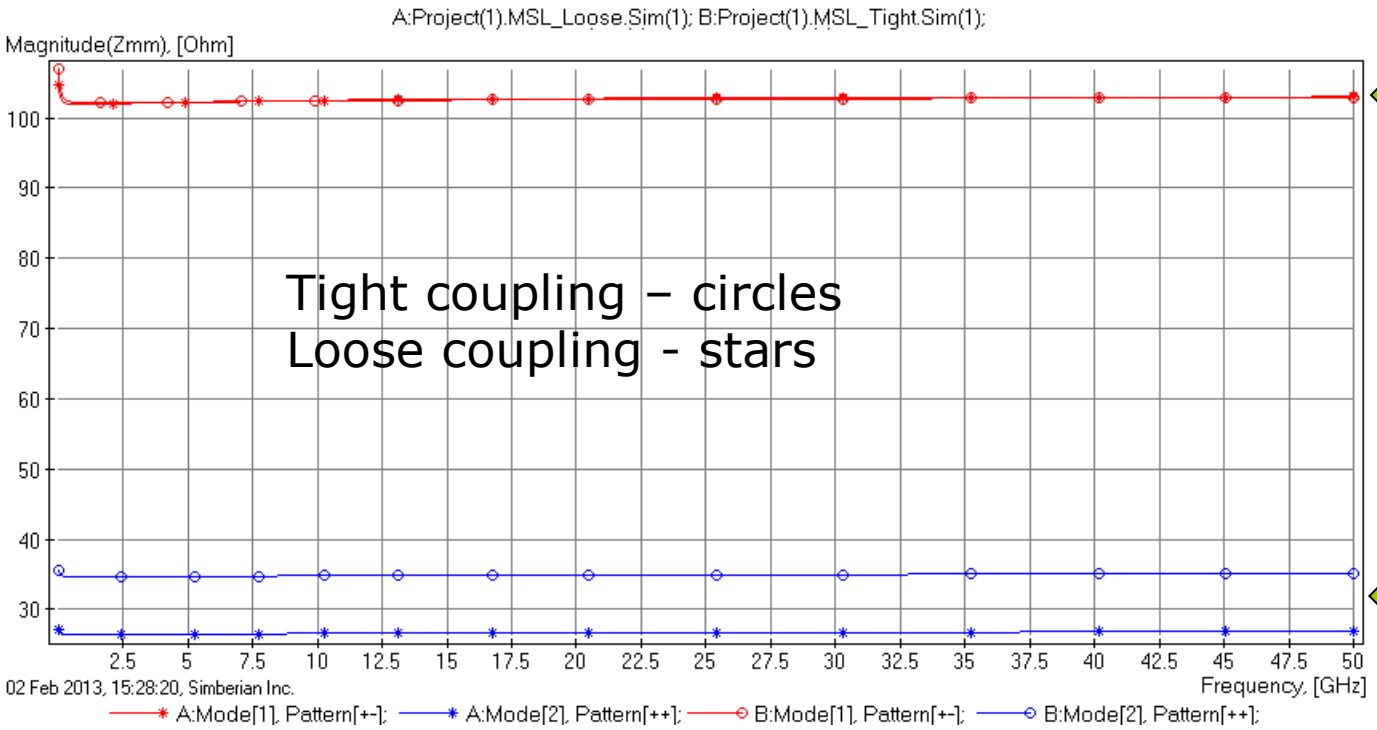


- Loosely coupled microstrip pair: 7.66 mil trances with 20 mil separation (Kv=0.025)



Transmission line impedances

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

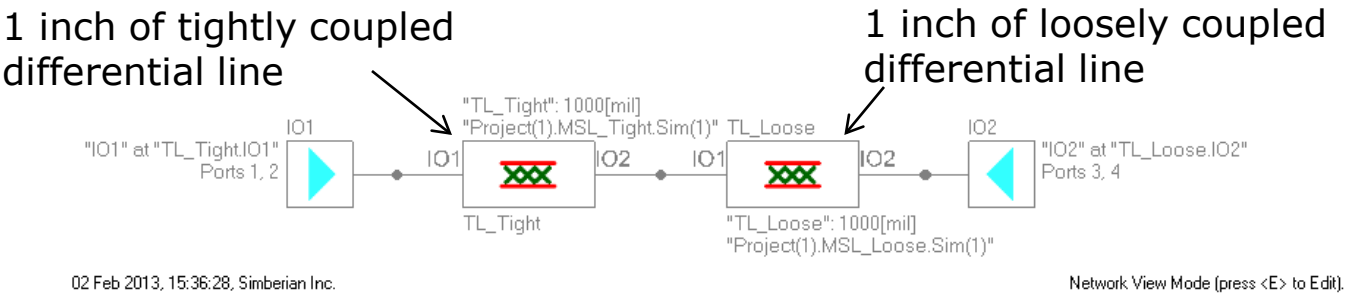


Differential mode impedances of both lines are almost identical (102 Ohm)

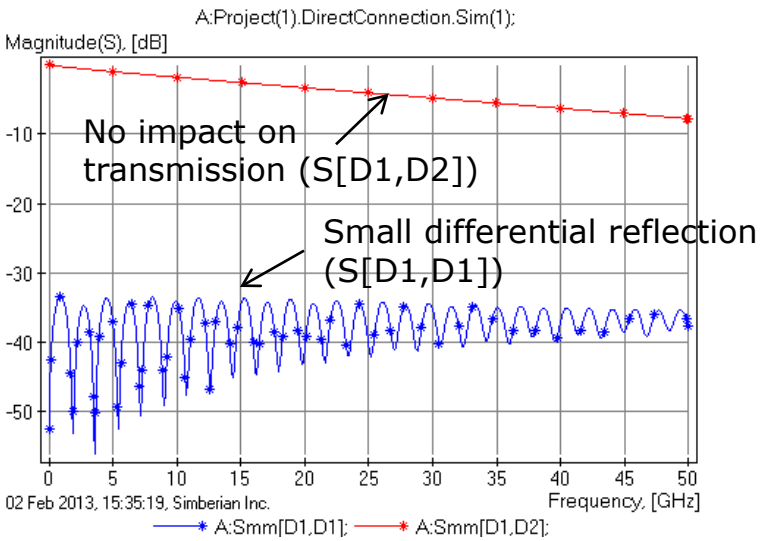
Common mode impedances of both lines are different due to differences in coupling

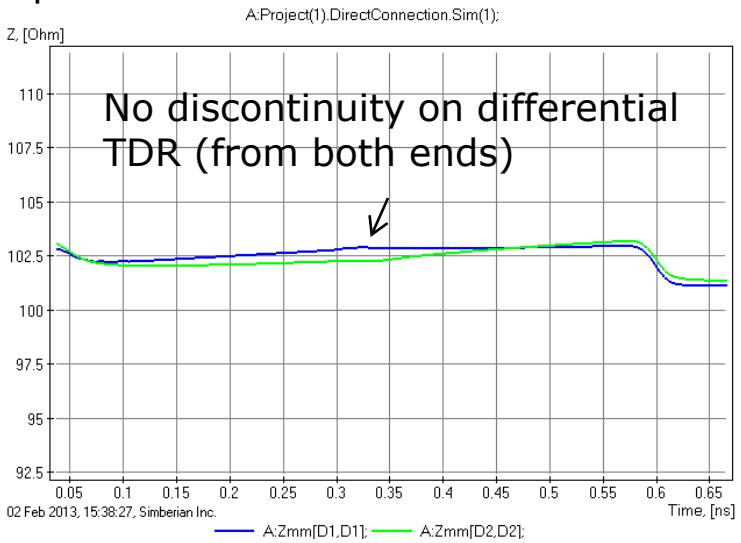
What if we just connect two line segments?

- Ideal connection – no discontinuity between lines



Differential mode parameters:

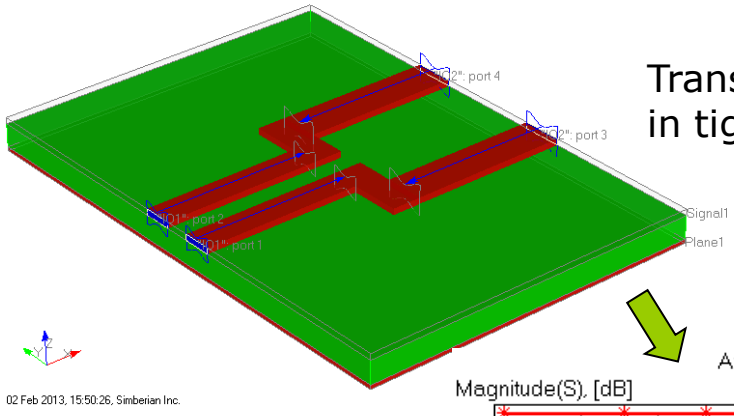




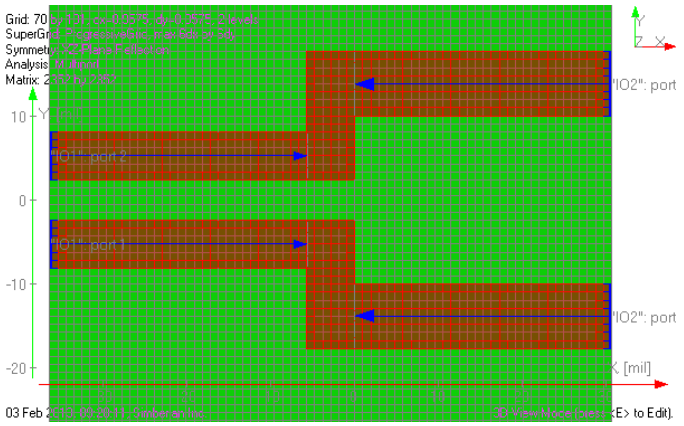
Problem solved? – Not really, we need layout…

How to transition between the cross-sections?

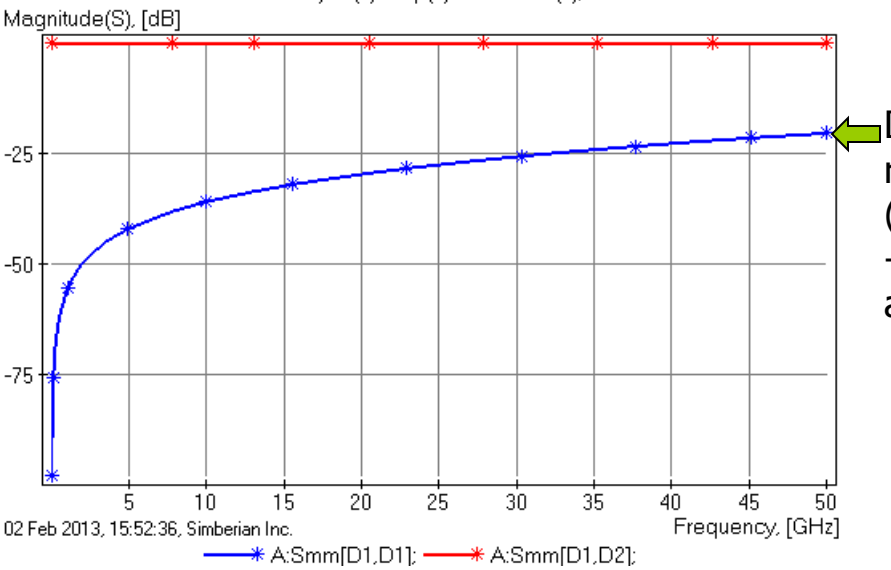
- Use simplest step transition? Let's try…



Transition with strips as in tightly coupled pair



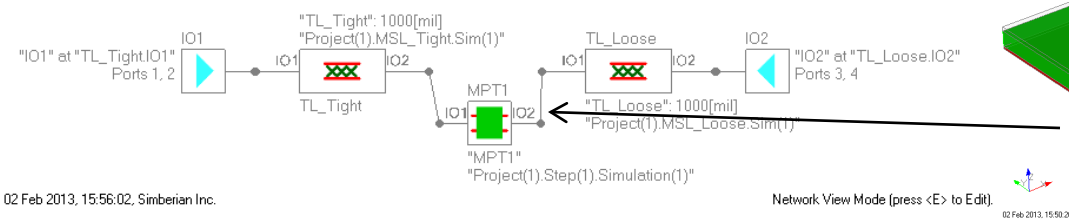
3D Full-wave analysis with metal thickness: about 1.5 min CPU time

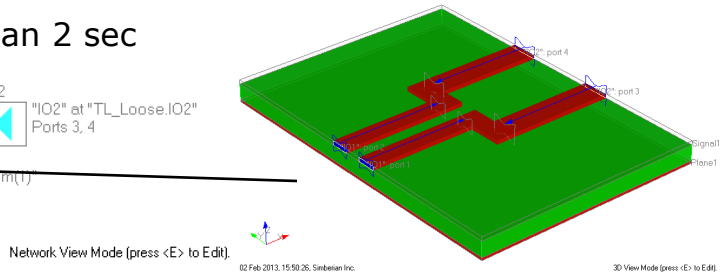


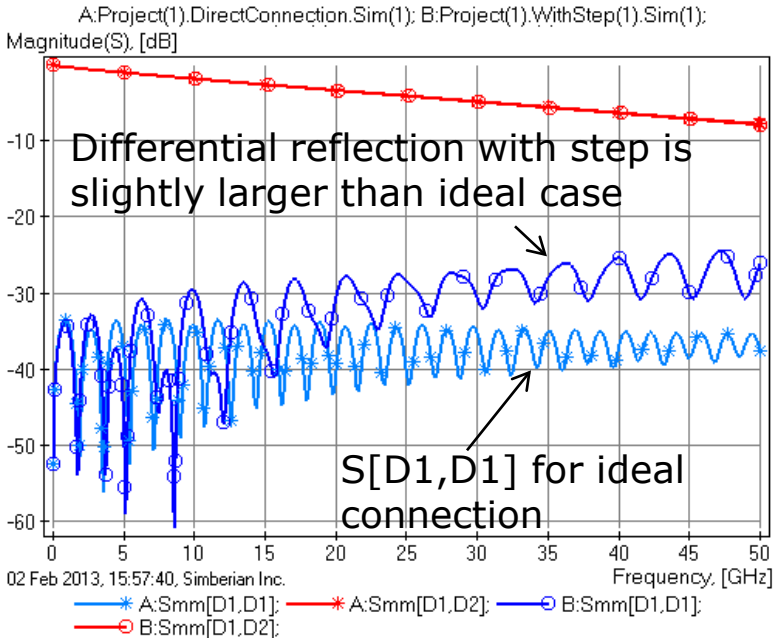
Differential mode reflection parameter (S[D1,D1]) is below -20 dB (may be acceptable?)

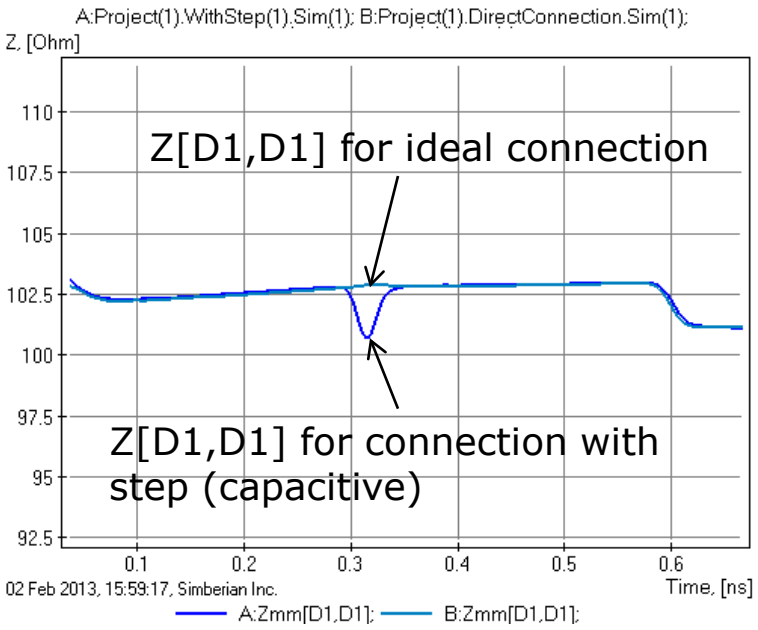
Initial step transition between two 1-inch segments

Decompositional analysis in FD and TD: less than 2 sec





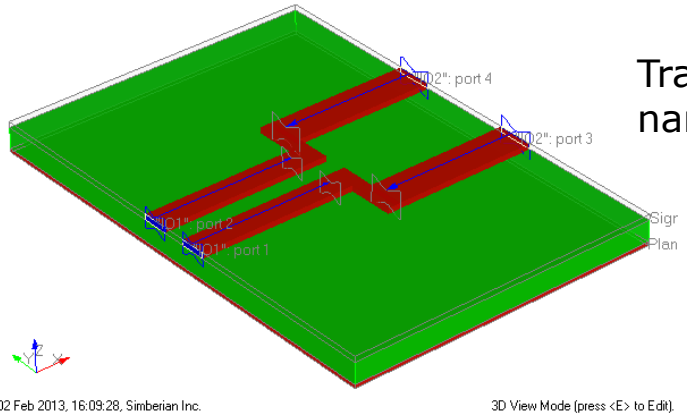




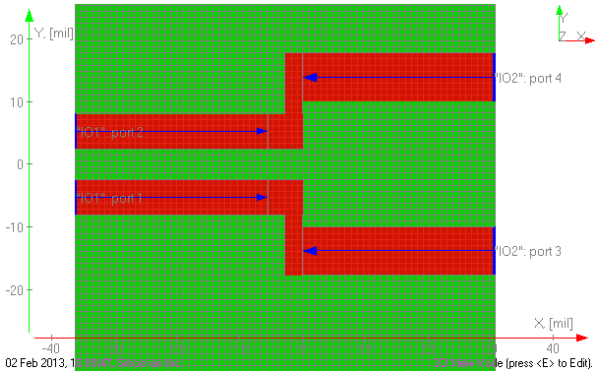
Can we further optimize it? Sure, why not…

Optimal step transition (final result)

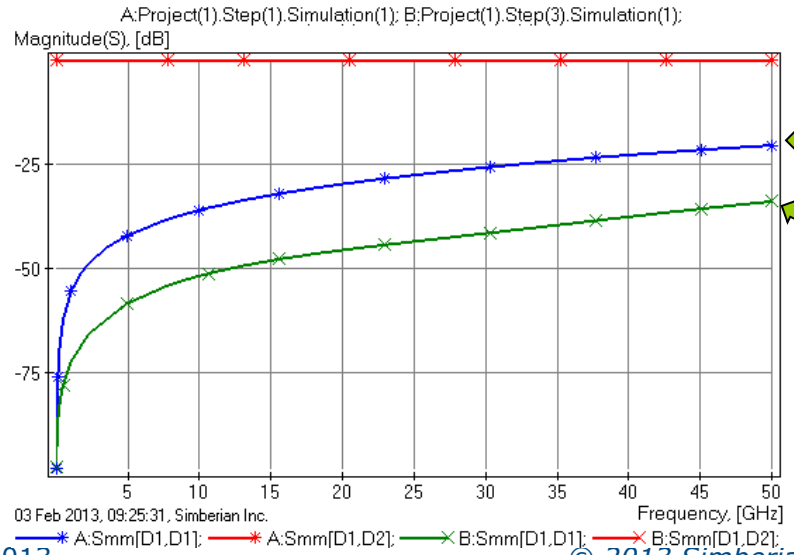
- Transition is done with narrower strips to eliminate the excessive capacitance



Transition with narrow strips



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

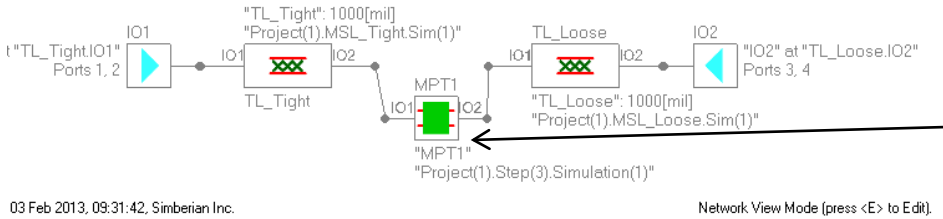


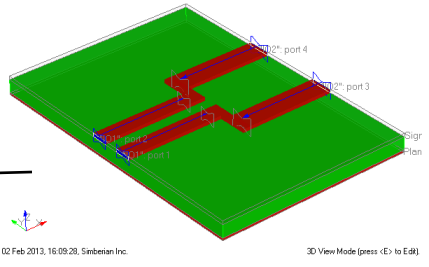
S[D1,D1] with wider strips

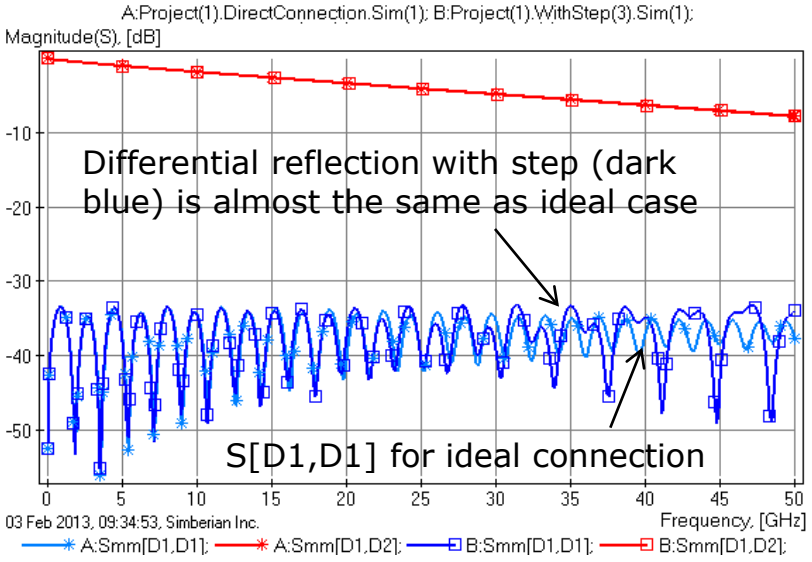
S[D1,D1] for optimal structure with narrow strips (below -30 dB)

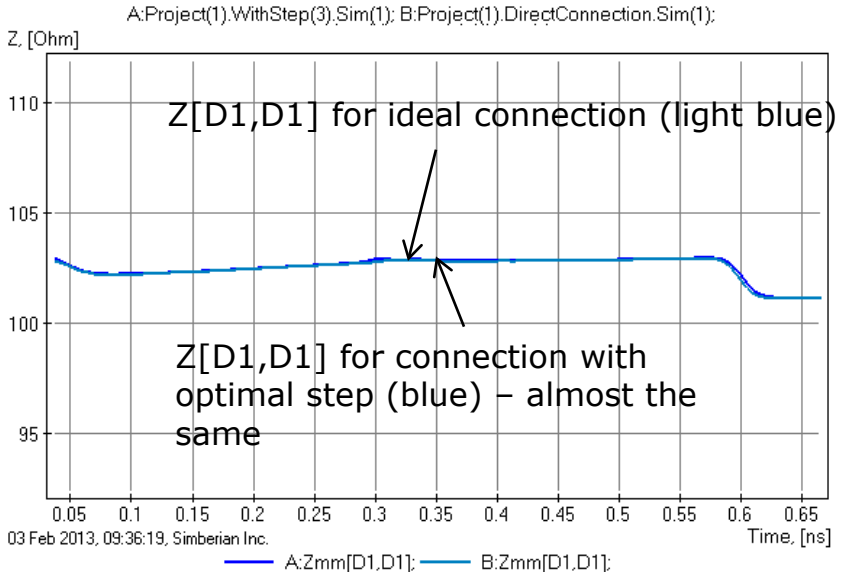
Optimal step transition between two 1-inch segments

Decompositional analysis in FD and TD: less than 2 sec





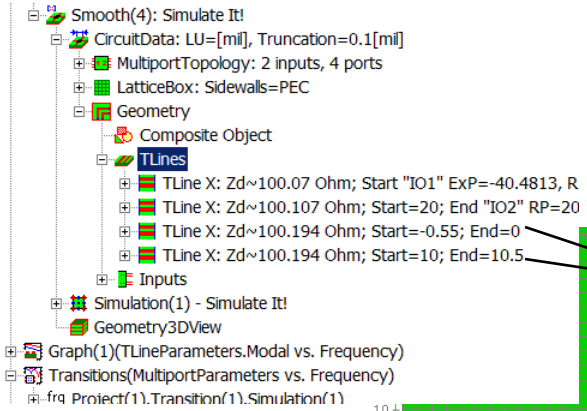




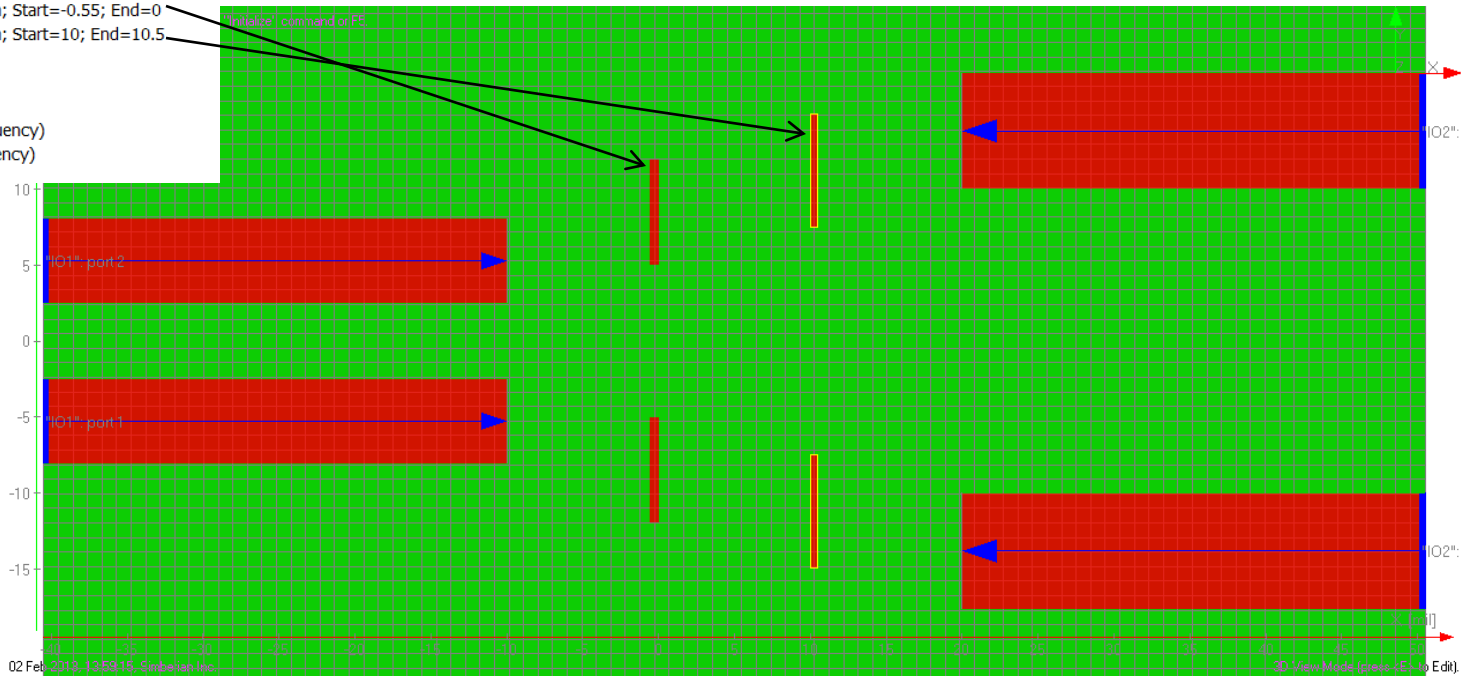
Perfect, but looks unusual. What about a smooth transition? Let's try…

Smooth transition model building

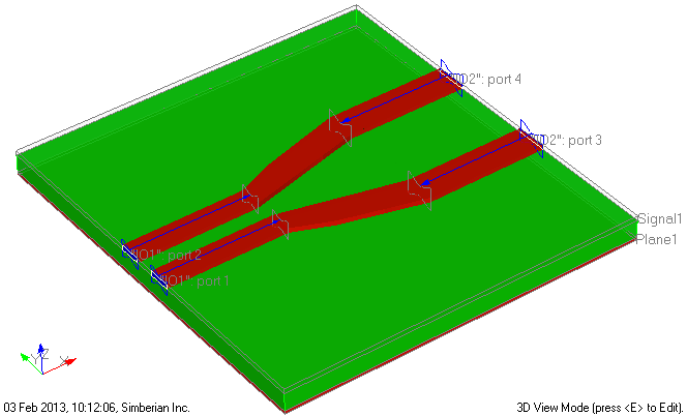
- Goal – have about 100 Ohm differential in each cross-section between tightly and loosely coupled lines on a 30 mil segment

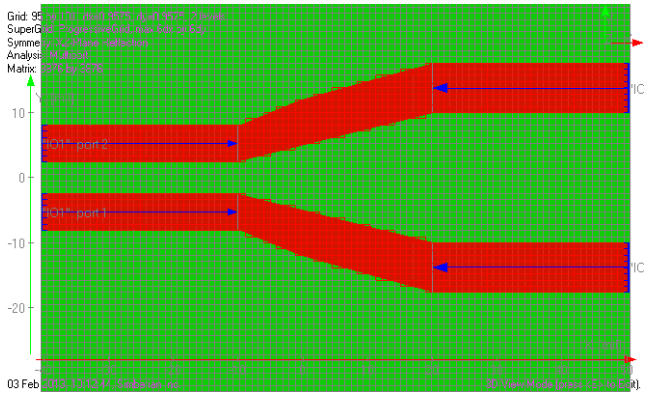


Add very small line segments with 100 Ohm differential impedance and use them to draw transition as polygon

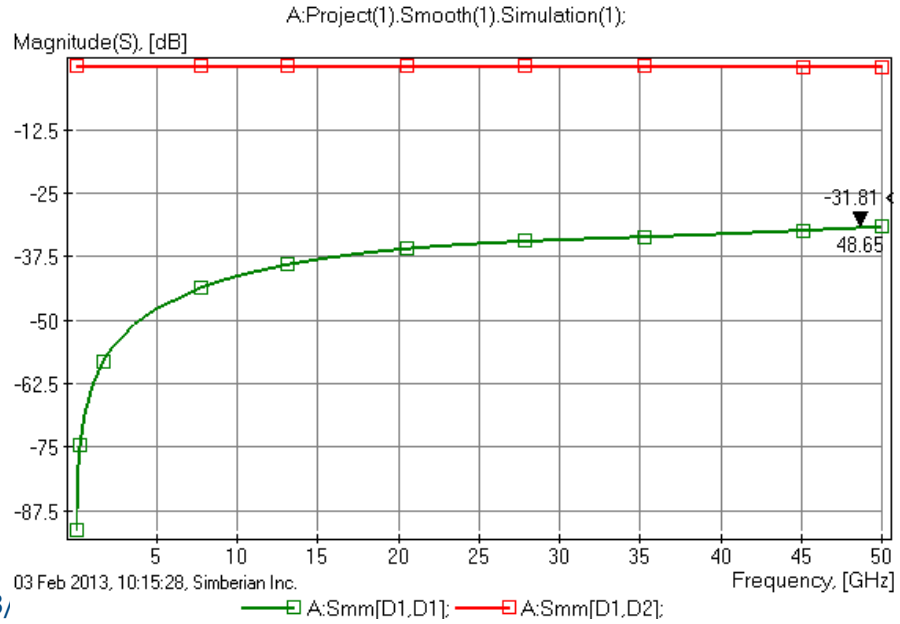


Smooth transition – final geometry





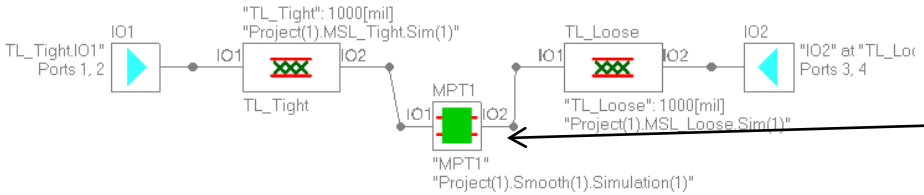
3D Full-wave analysis with metal thickness: about 2 min CPU time

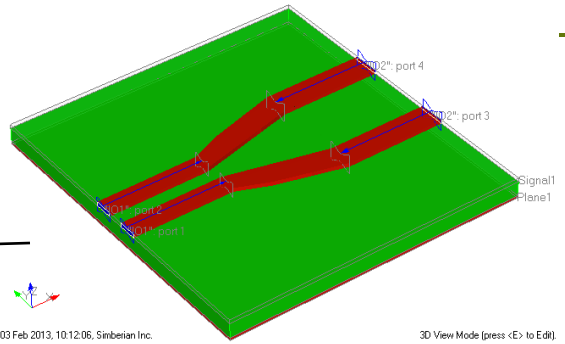


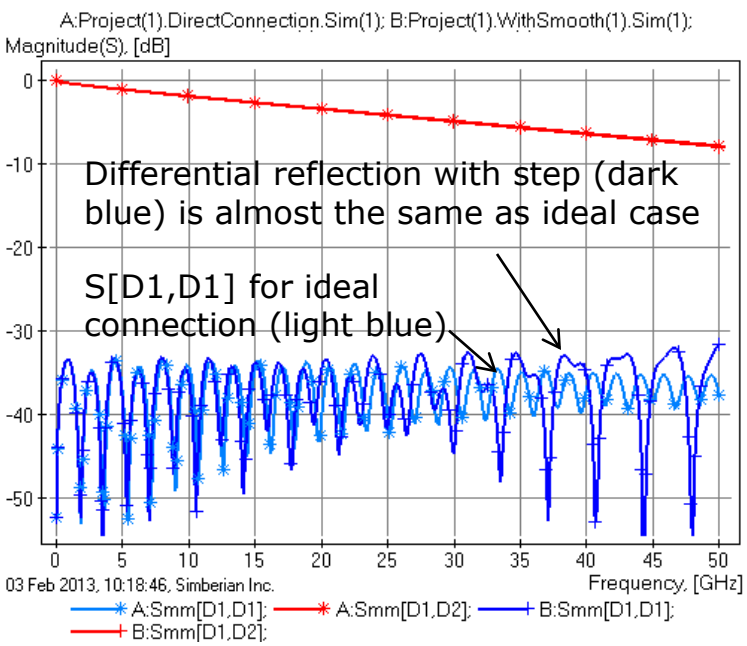
Differential mode reflection parameter (S[D1,D1]) is below -30 dB (good)

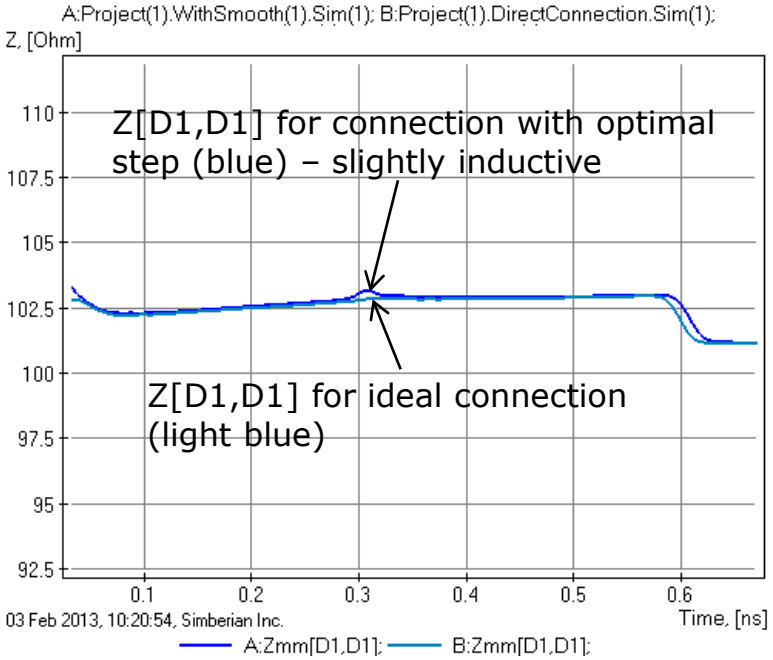
Smooth transition between two 1-inch segments

Decompositional analysis in FD and TD: less than 2 sec



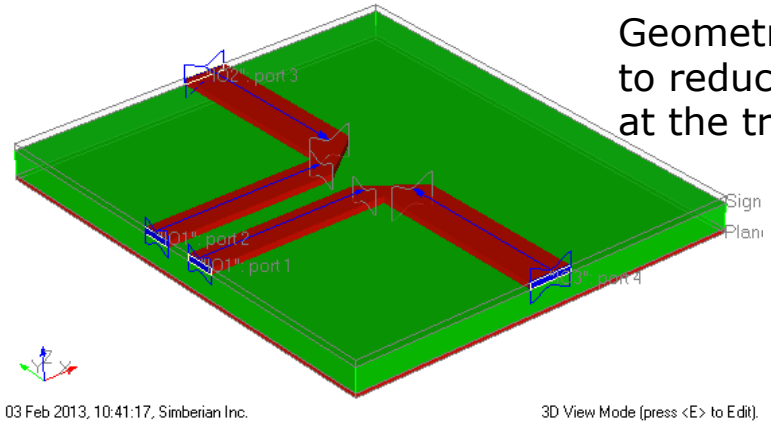




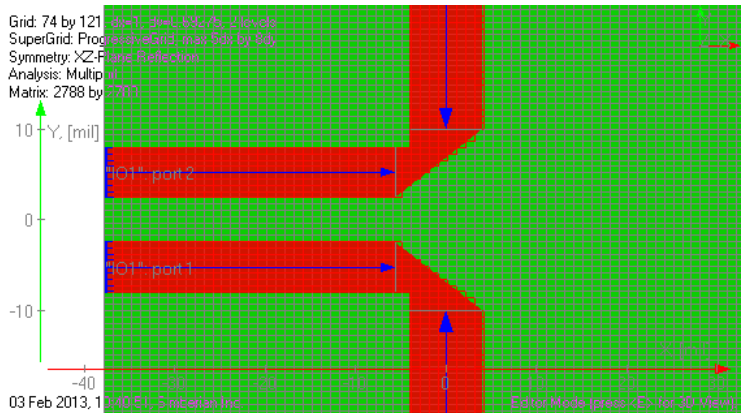


Good. What if I need to split into two single-ended? No problem…

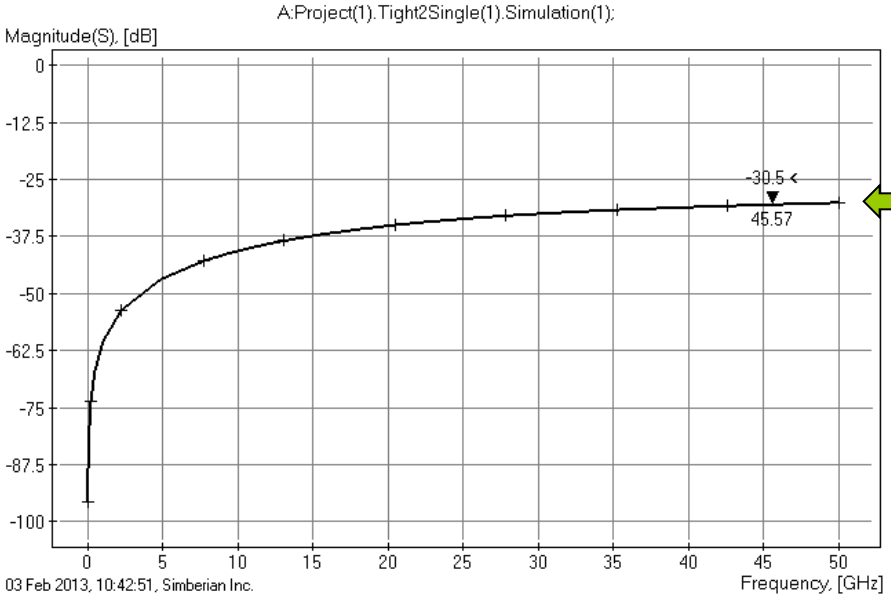
Tightly coupled to single-ended transition



Geometry is optimized to reduce capacitance at the transition



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

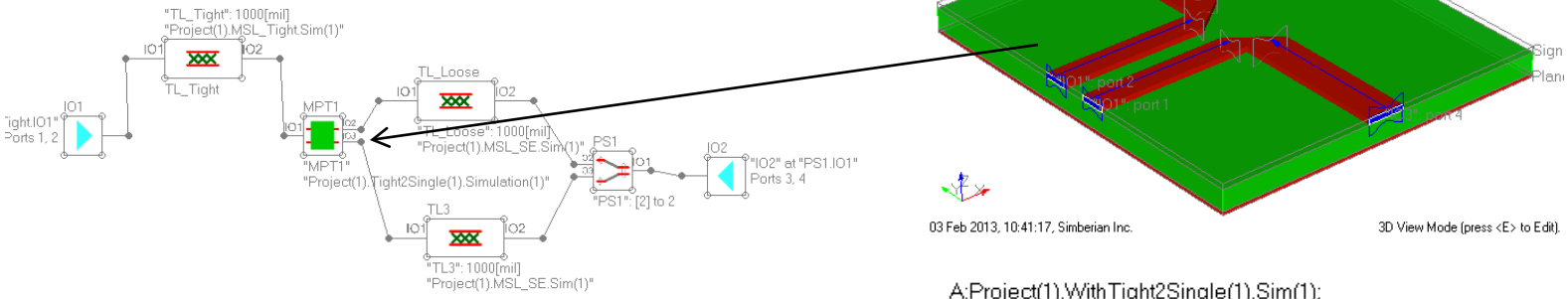


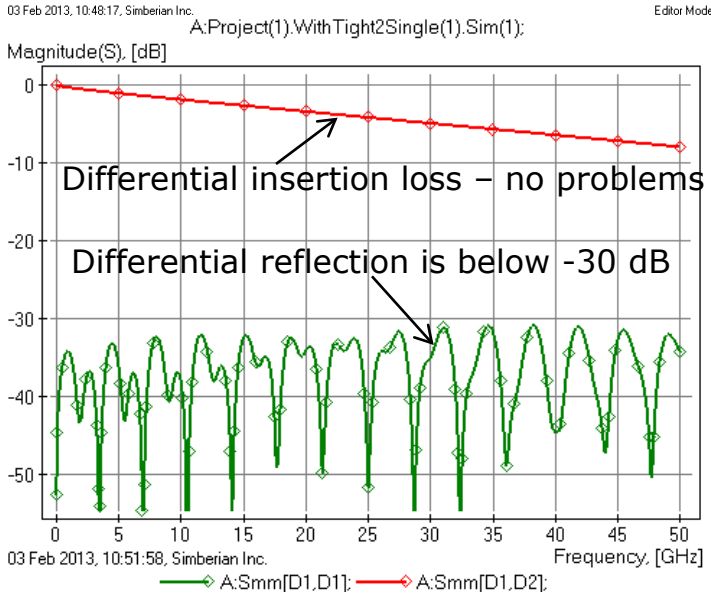
Differential mode reflection parameter (S[D1,D1]) is below -30 dB (good)

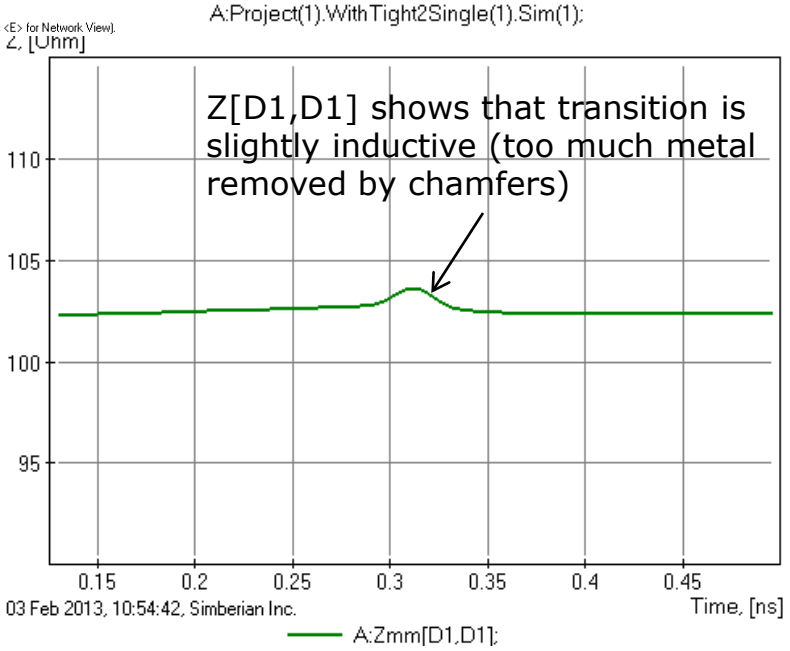
Note: The simplest and the best way to split is to do it immediately – less space, no complicated geometries, same weave effect…

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

Decompositional analysis in FD and TD: less than 2 sec







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 then 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 in computational electromagnetics
    - 25-years experience in building electromagnetic software
- Development in Las Vegas, USA, St. Petersburg and Voronezh Russia
- Location and contacts
  - Corporate office: 3030 S Torrey Pines Dr., Las Vegas, NV 89146, USA Tel/Fax +1-702-876-2882, skype *simberian*
  - Distributor in Asia Pacific region – Polar Instruments Asia Pacific www.polarinstruments.asia
  - Web: www.simberian.com
  - Support knowledge base www.kb.simberian.com