

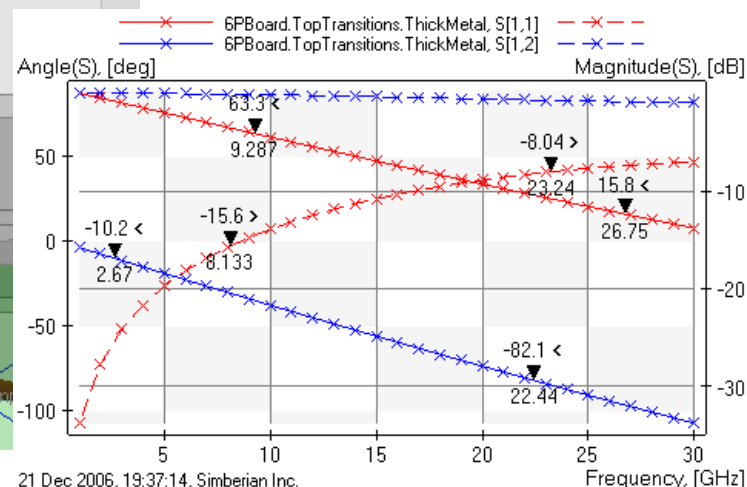
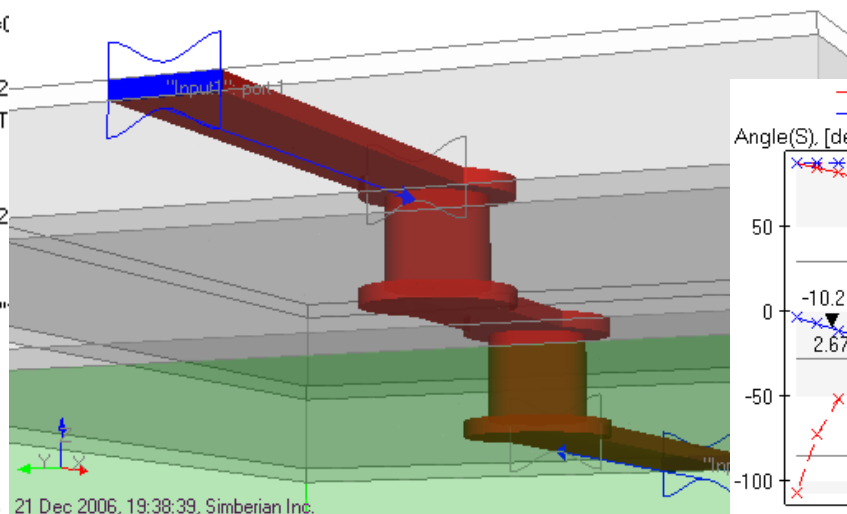
Design of optimal differential via-holes for 6-plane board

Solution: "MicroVias"

- 6PBoard
 - Materials
 - "copper", RRes=1, Rough=0.01
 - "IdealMetal"
 - "prepreg", DK=4.7, LT=0.02
 - "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: "
 - ILines
 - Inputs
 - ThickMetal
 - CollapsedMetal
 - BottomTransition

Simberian, Inc.

www.simberian.com

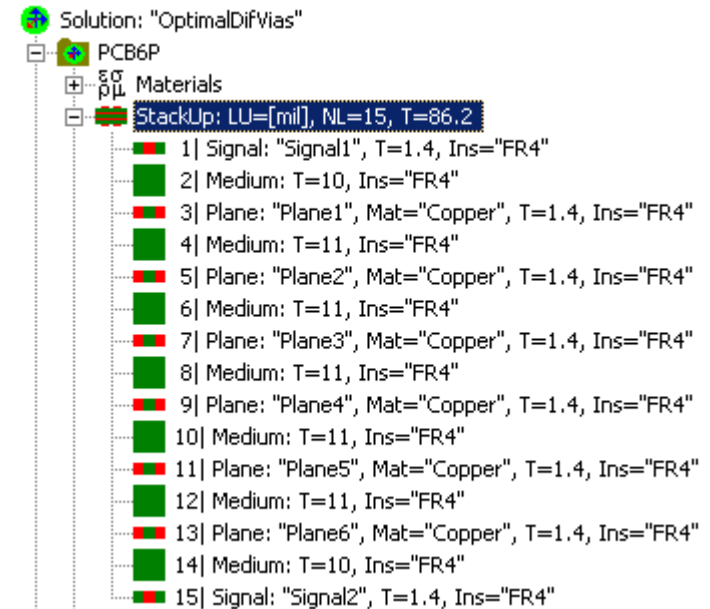


Introduction

- ❑ Via-hole transitions are the major contributors to signal degradation in multi-gigabit data channels
- ❑ Geometry of the via-holes have to be optimized to minimize the reflection and to maximize the transition of the differential signal
- ❑ This example shows
 - How to use Simbeor 2007 to create optimal via-holes for 10 Gbps channel and
 - How to generate 3D full-wave S-parameter models and use it in the system-level analysis

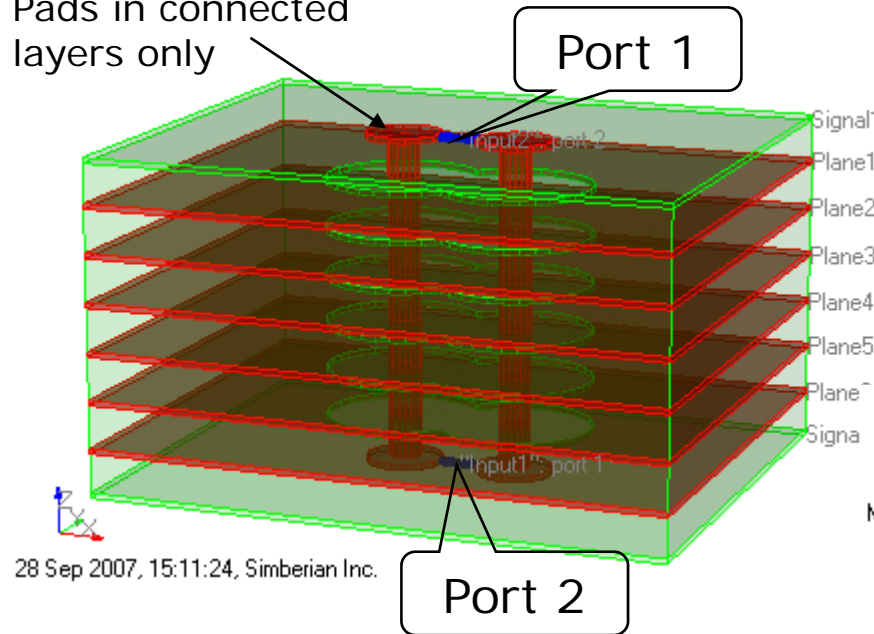
Differential via-holes design example

- ❑ Stackup with 6 plane layers
- ❑ Drill diameter is 8 mil, differential traces are 6 mil wide 10 mil apart
- ❑ Goal is to design differential through-vias from Signal1 to Signal2
- ❑ Steps:
 1. Create and optimize via-holes geometry for differential mode only (using lumped ports) by minimizing $|S_{11}|$ for 100-Ohm normalized S-parameters
 2. Add transition to differential transmission line and generate final model for the system-level analysis

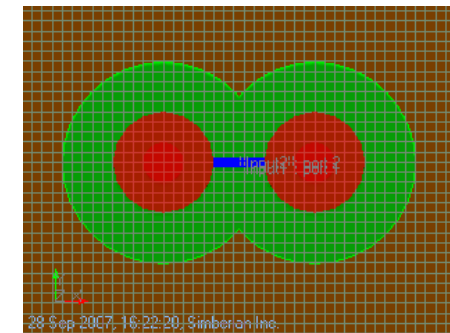


Geometry synthesis and electromagnetic analysis with Simbeor 2007

Pads in connected layers only



28 Sep 2007, 15:11:24, Simberian Inc.



28 Sep 2007, 16:22:20, Simberian Inc.

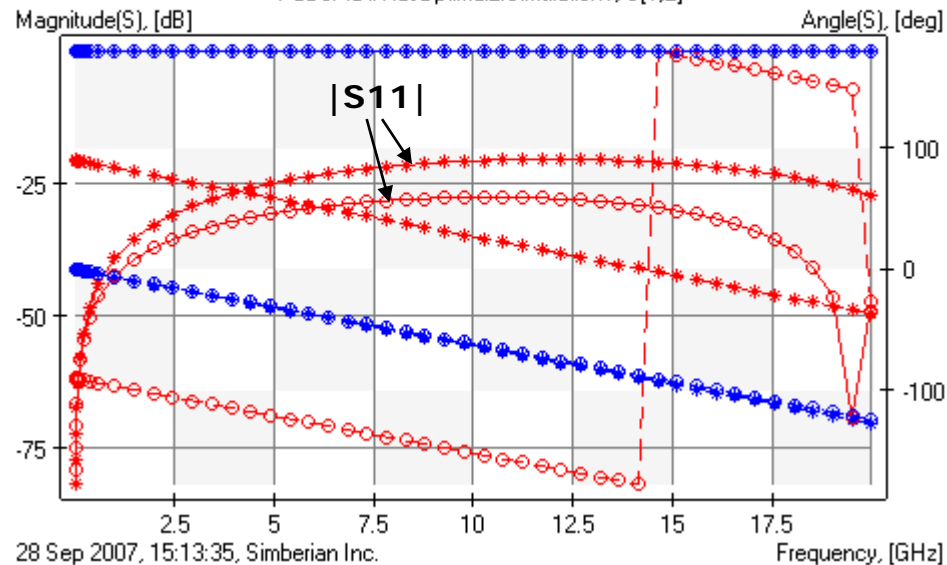
S-parameters normalized to 100 Ohm

Two configurations with lumped differential ports has been created with the via-holes creation wizard:

DifViasOptimal – vias are 30 mil apart with 40 mil anti-pads and 20 mil pads - $|S_{11}|$ below -20 dB

DifViasOptimal2 – vias are 24 mil apart with 32 mil anti-pads and 20 mil pads - $|S_{11}|$ below -25 dB

- *— PCB6P.DifViasOptimal.Simulation1, S[1,1]
- *— PCB6P.DifViasOptimal.Simulation1, S[1,2]
- PCB6P.DifViasOptimal2.Simulation1, S[1,1]
- PCB6P.DifViasOptimal2.Simulation1, S[1,2]



28 Sep 2007, 15:13:35, Simberian Inc.

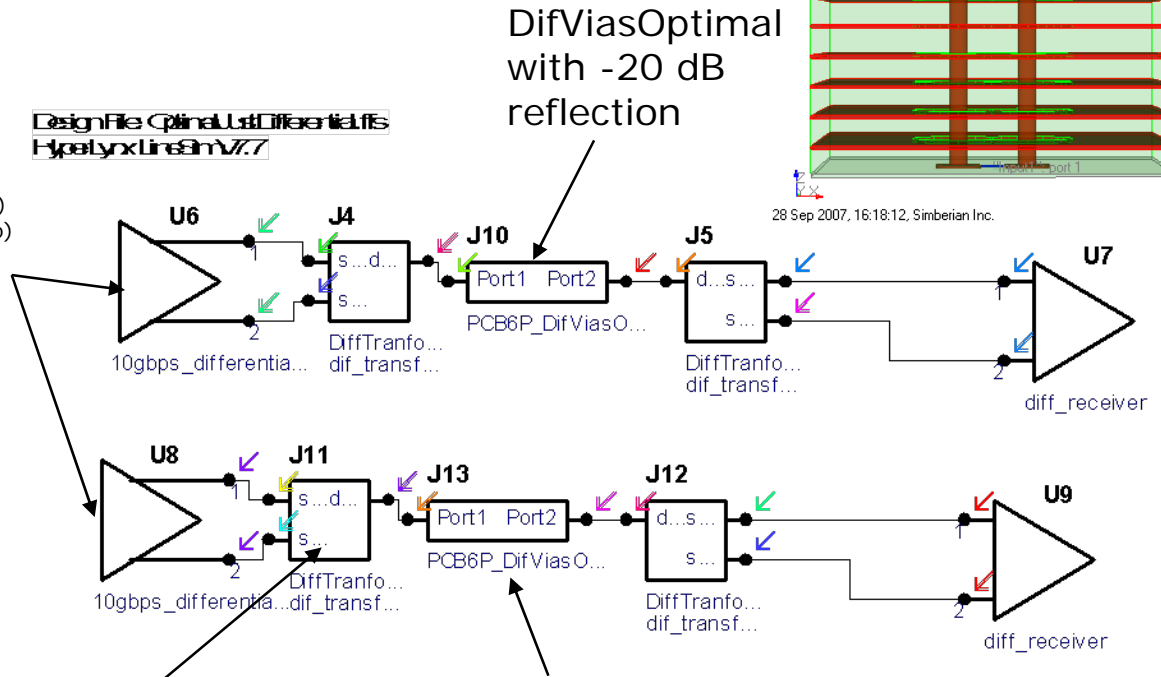
© 2007 Simberian Inc.

Simulation in time domain with system-level simulator HyperLynx 7.7 with Eldo

Simple SPICE 100 Ohm differential drivers to generate 10 Gbps pulse train

```
.subckt 10gbps_differential_driver outp outm
voutp outp n1 pulse(-1.0 1.0 0 25p 25p 62.5p 200p)
voutm outm n2 pulse(1.0 -1.0 0 25p 25p 62.5p 200p)
routp n1 0 50
routm n2 0 50
.ends differential_driver
```

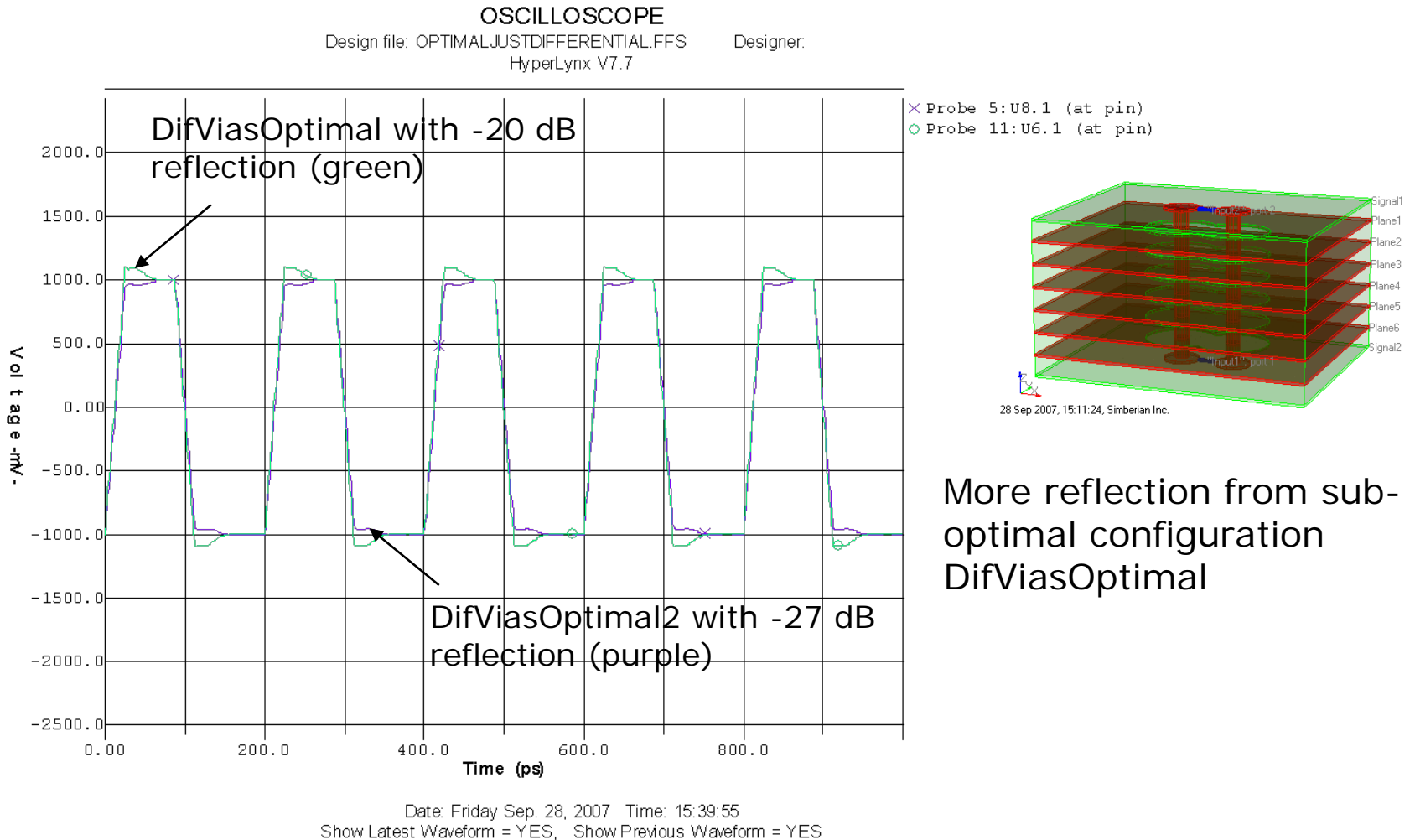
Design File: C:\Program Files\HyperLynx\7.7



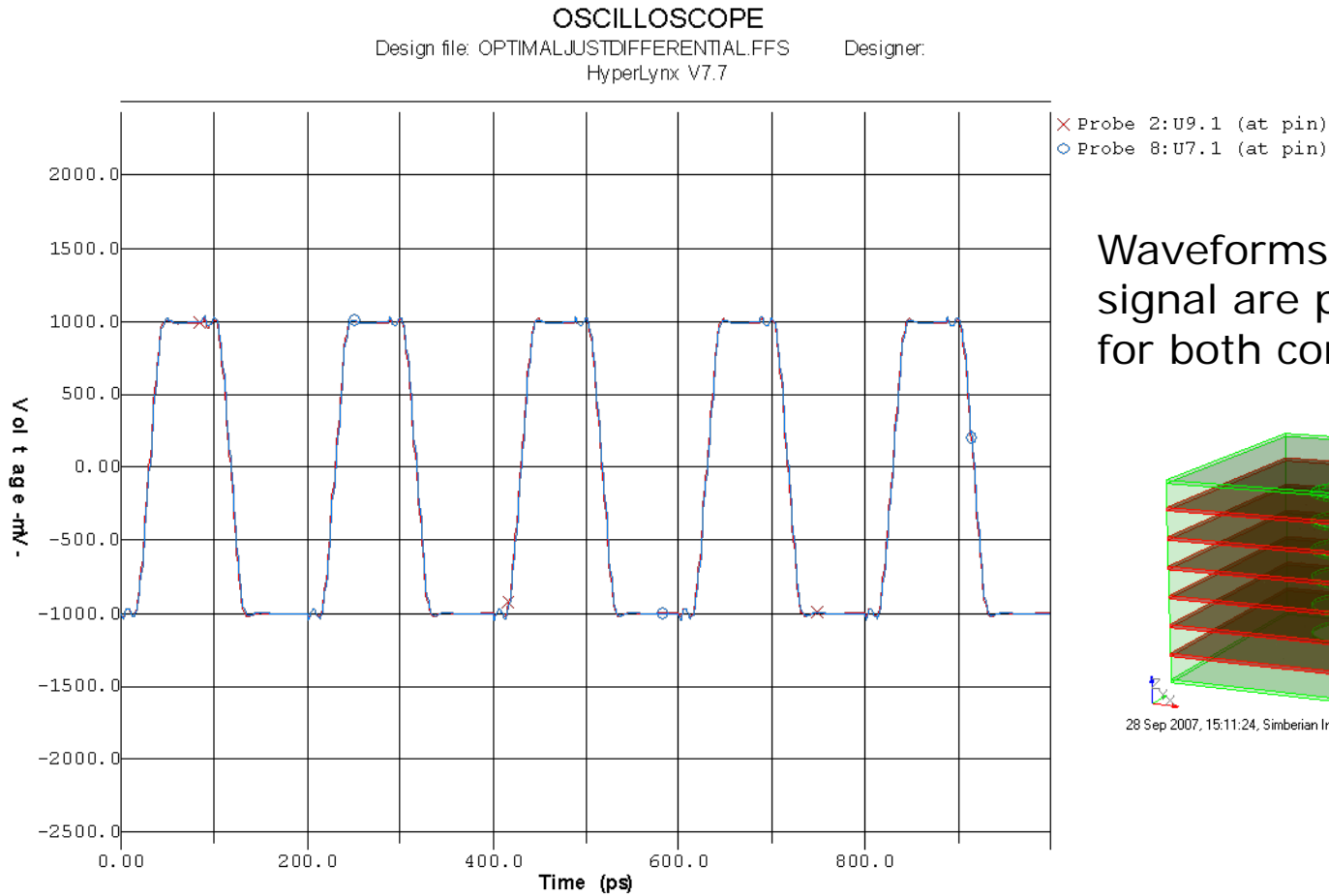
HyperLynx and Eldo are system-level analysis tools from Mentor Graphics Corporation

Transformers from terminal space to differential mode and back

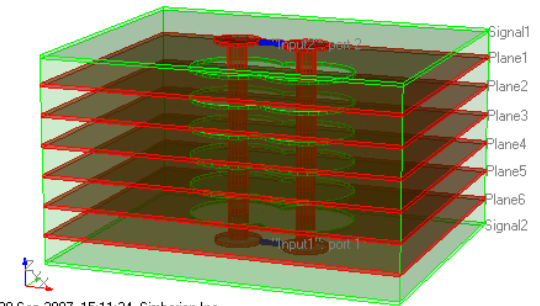
Comparison of reflection in time-domain



Comparison of transmission in time-domain



Waveforms of the transmitted signal are practically identical for both configurations

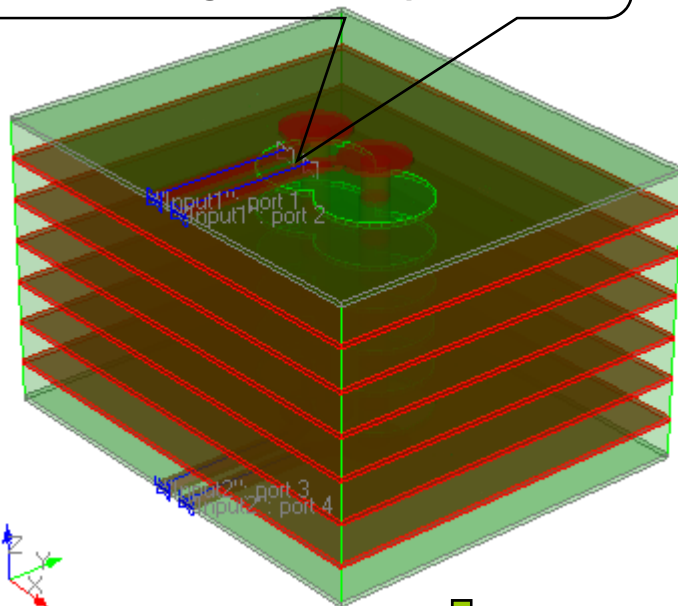


28 Sep 2007, 15:11:24, Simberian Inc.

Date: Friday Sep. 28, 2007 Time: 15:30:54
Show Latest Waveform = YES, Show Previous Waveform = YES

Final via-holes design and 4-port model

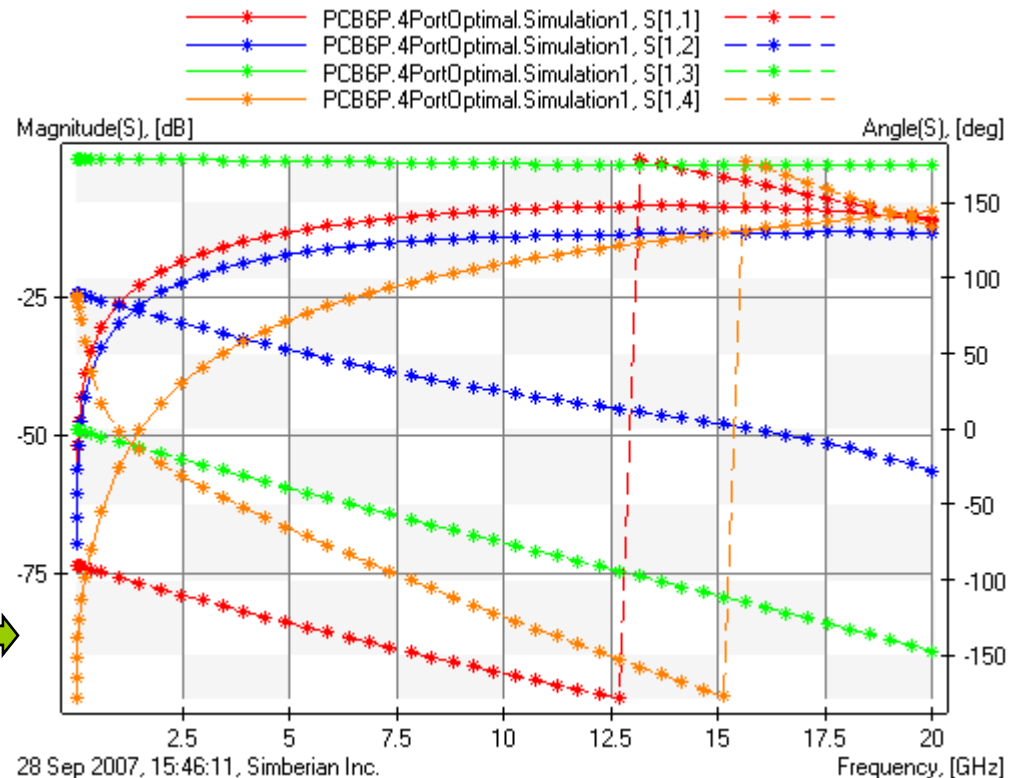
De-embedded wave-ports are used with the phase reference shift to the edges of anti-pads



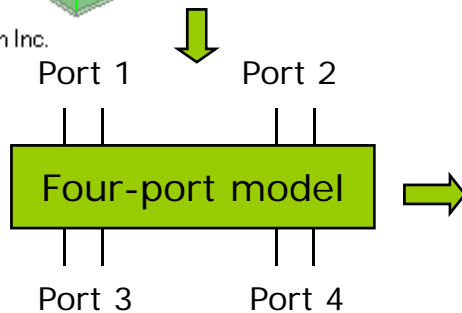
Configuration created by via-hole creation wizard and t-line inputs specified as the ports (wave-ports)

Vias are 24 mil apart with 32 mil anti-pads and 20 mil pads, traces are 6 mil wide 10 mil apart

The model can not be used to predict common mode propagation – no stitching vias



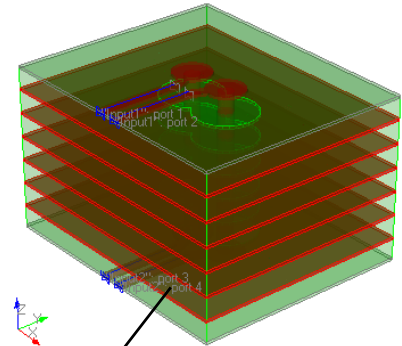
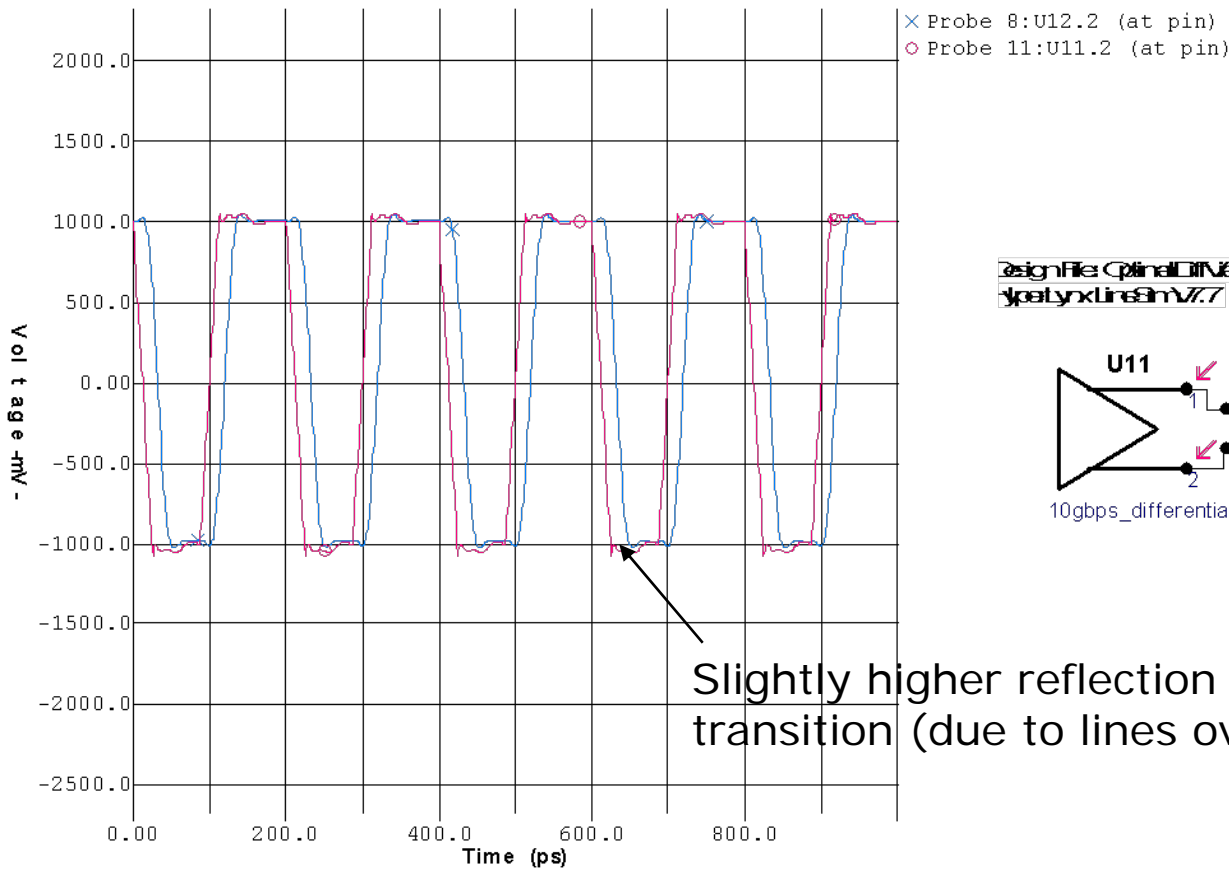
28 Sep 2007, 15:45:33, Simberian Inc.



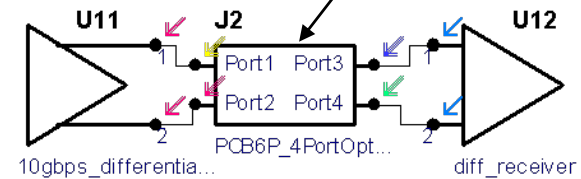
Reflection and transmission of differential mode in time domain

OSCILLOSCOPE

Design file: OPTIMALDIFFVIAS.FFS Designer:
HyperLynx V7.7

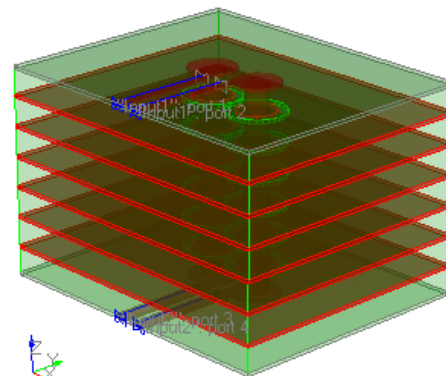


Design File: OptimalDiffVias.FFS
HyperLynx V7.7
28 Sep 2007, 15:45:33 Simberian Inc.



Date: Friday Sep. 28, 2007 Time: 16:00:32
Show Latest Waveform = YES, Show Previous Waveform = YES

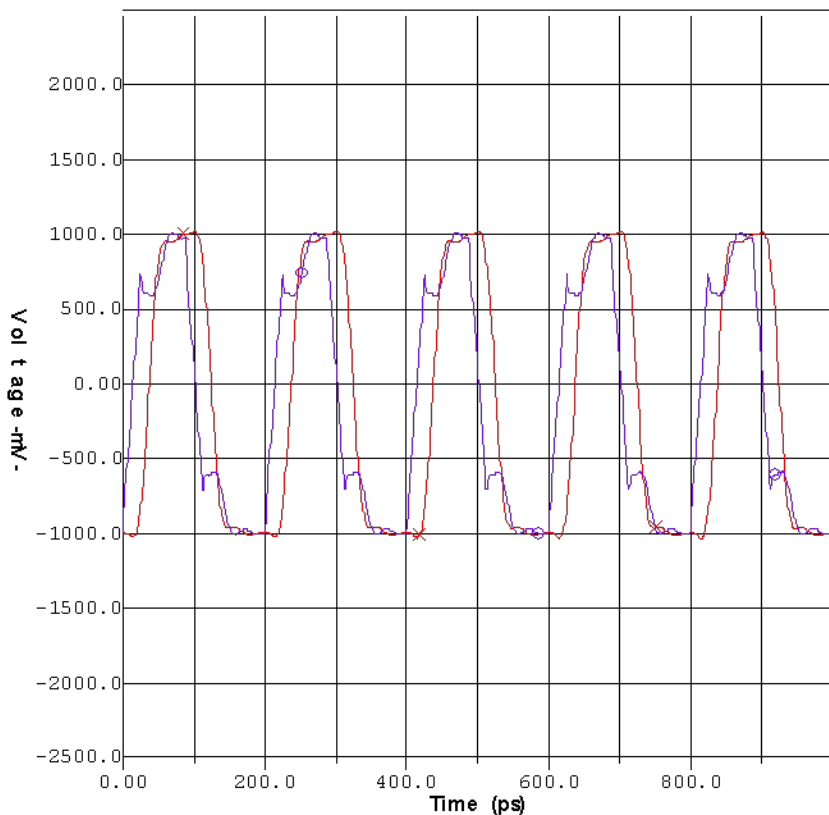
Not optimal via-holes can significantly degrade the signal



OSCILLOSCOPE

Design file: OPTIMALANDNOTOPTIMALDIFFVIAS.FFS
HyperLynx V7.7

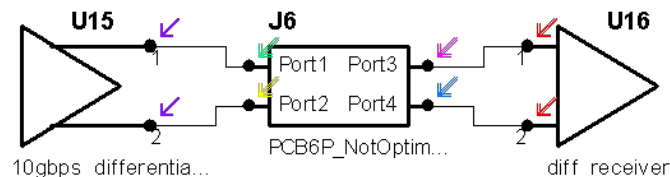
Designer:



× Probe 26: U16.1 (at pin)
○ Probe 29: U15.1 (at pin)

Design file: OptimalAndNotOptimal...
HyperLynx V7.7

28 Sep 2007, 16:29:06, Simberian Inc.



10-mil vias are 24 mil apart with 24 mil anti-pads and 16 mil pads in all layers, traces are 6 mil wide 10 mil apart

Pads in plane layers increase the capacitance and decrease the effective impedance of vias to 60 Ohm

Date: Friday Sep. 28, 2007 Time: 16:26:12

Show Latest Waveform = YES, Show Previous Waveform = YES

Conclusion

- ❑ Geometry of differential via-holes have to be optimized to have reflection for differential mode at least below -25 dB
 - Simbeor 2007 via-holes creation wizard allows to synthesize “impedance-controlled” vias without long electromagnetic optimization
- ❑ Even optimal vias require 3D full-wave S-parameters models for the system-level analysis of a complete channel (small reflections can cause system-level resonances)
- ❑ Non-optimal via-holes can cause significant degradation of 10 Gbps signal and even malfunction of the complete channel
- ❑ Generated with a 3D full-wave solver localized models without stitching vias are valid only in case of small or no common mode at the via-hole transition
 - Vias stitching the top and bottom reference planes have to be added to create accurate localized model that includes the common mode
 - Common mode analysis without stitching vias requires a hybrid system-level model with all planes and decoupling structures)

Solutions and contact

- Solution files and HyperLynx schematic files are available for download from the simberian web site

http://www.simberian.com/AppNotes/Solutions/OptimalDifViaholesDesign6pPCB_2007_08.zip

- Send questions and comments to

- General: info@simberian.com

- Sales: sales@simberian.com

- Support: support@simberian.com

- Web site www.simberian.com