

Inductive compensation for package impedance discontinuity

Intel Corporation, 2005

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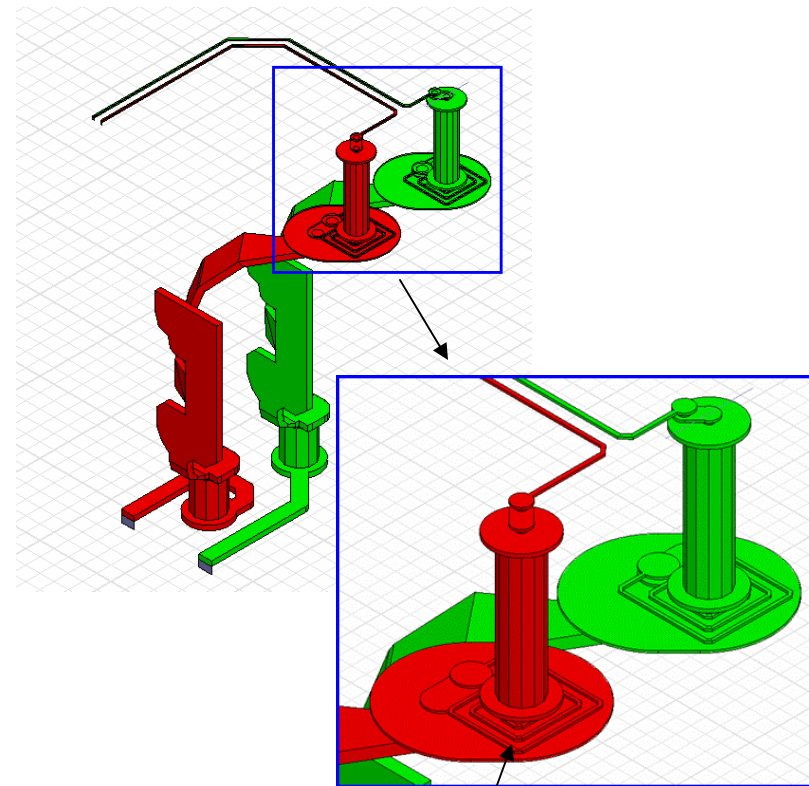
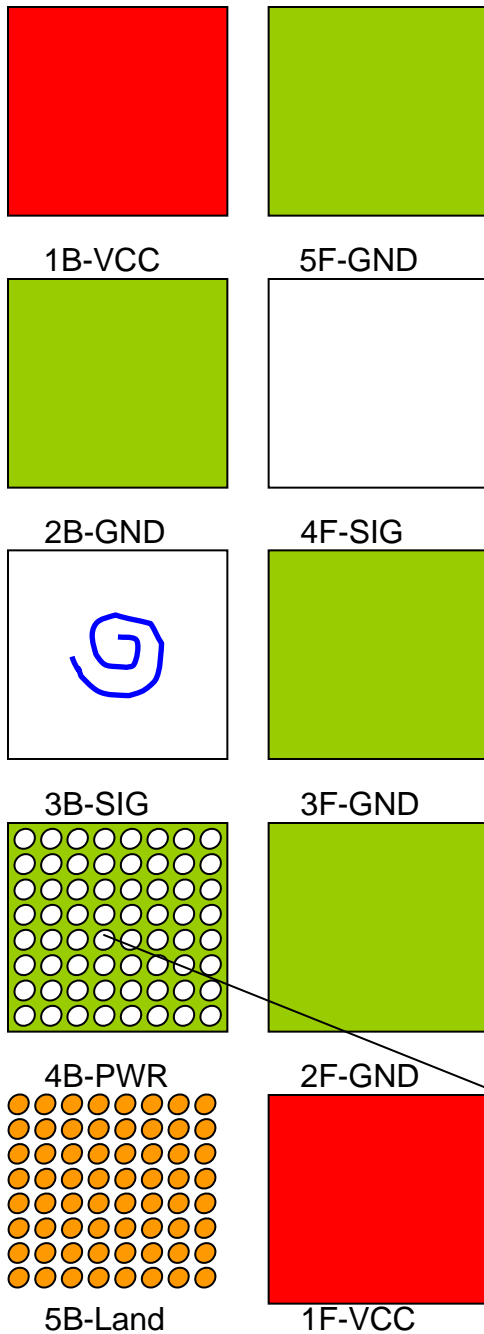
Abstract

- The LGA package has shown impedance discontinuity due to higher layer counts and larger land pad. A technique using spiral compensation is proposed to counteract the capacitive parasitics along the vertical signal path. The structure has been modeled and measured to show the effectiveness of inductive compensation.

Introduction

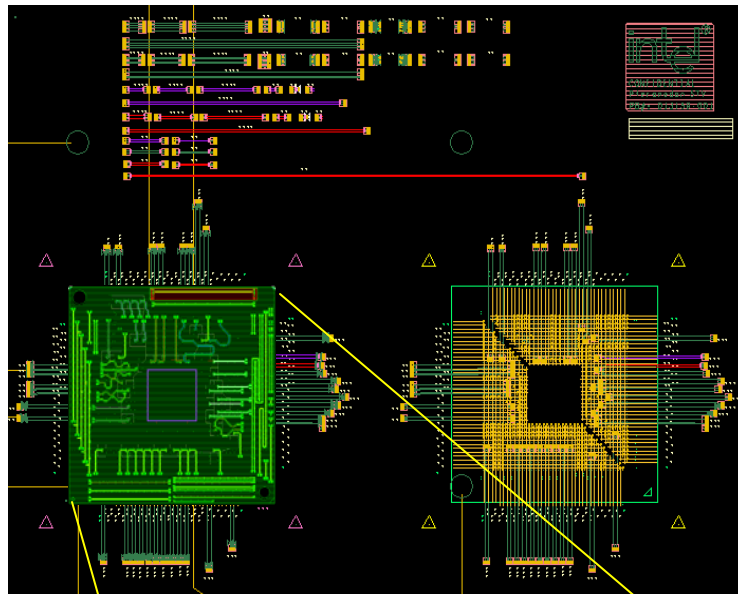
- Package impedance discontinuity
- inductive compensation using spiral structure
- Modeling and measurement correlation from the Spiral Test vehicle
- Full channel time domain simulation results
- Learning and recommendations

SpiralTV package stackup

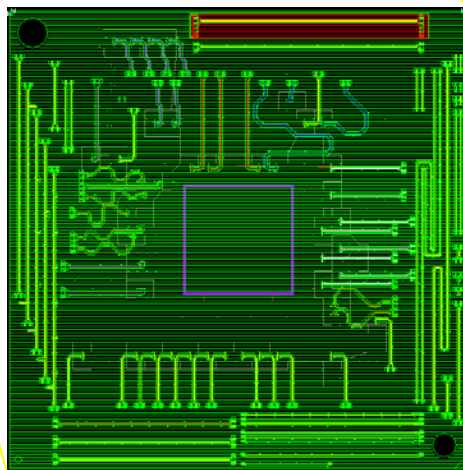


$$Z = \sqrt{\frac{L}{C}}$$
 ← Spiral routing

Test Board & Test Package Layout

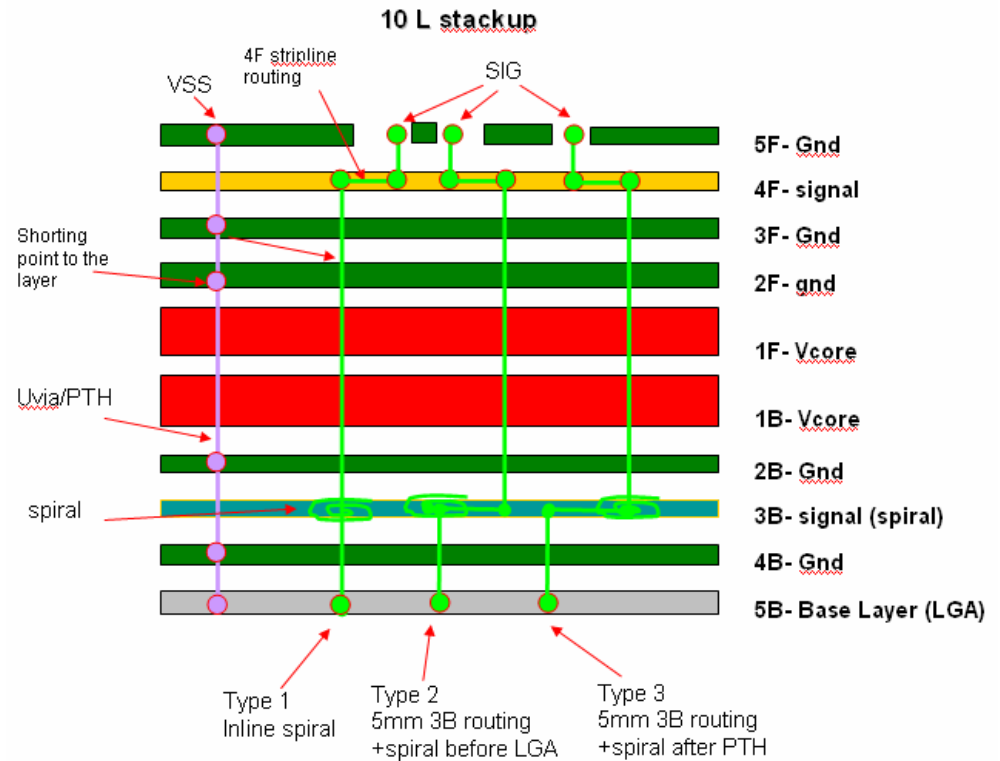


Test board

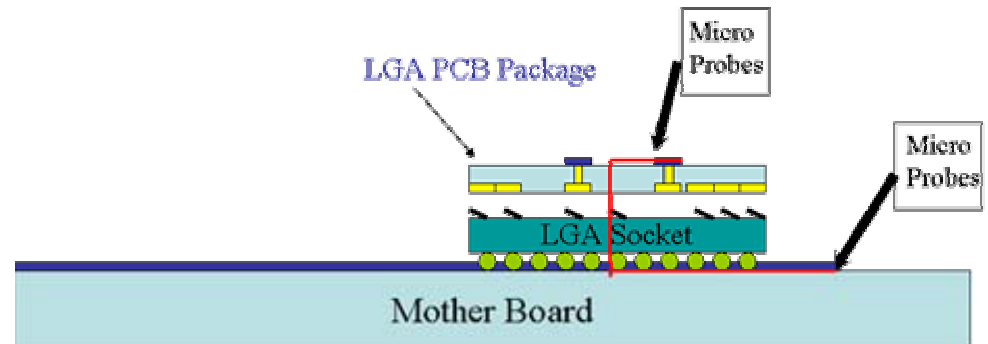


Test package

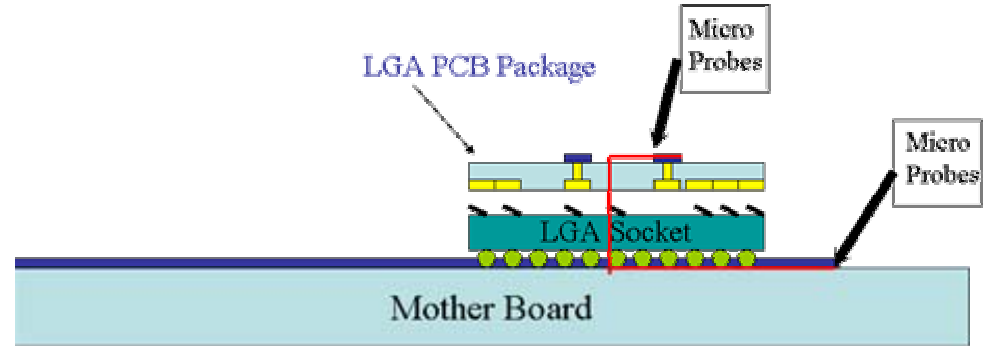
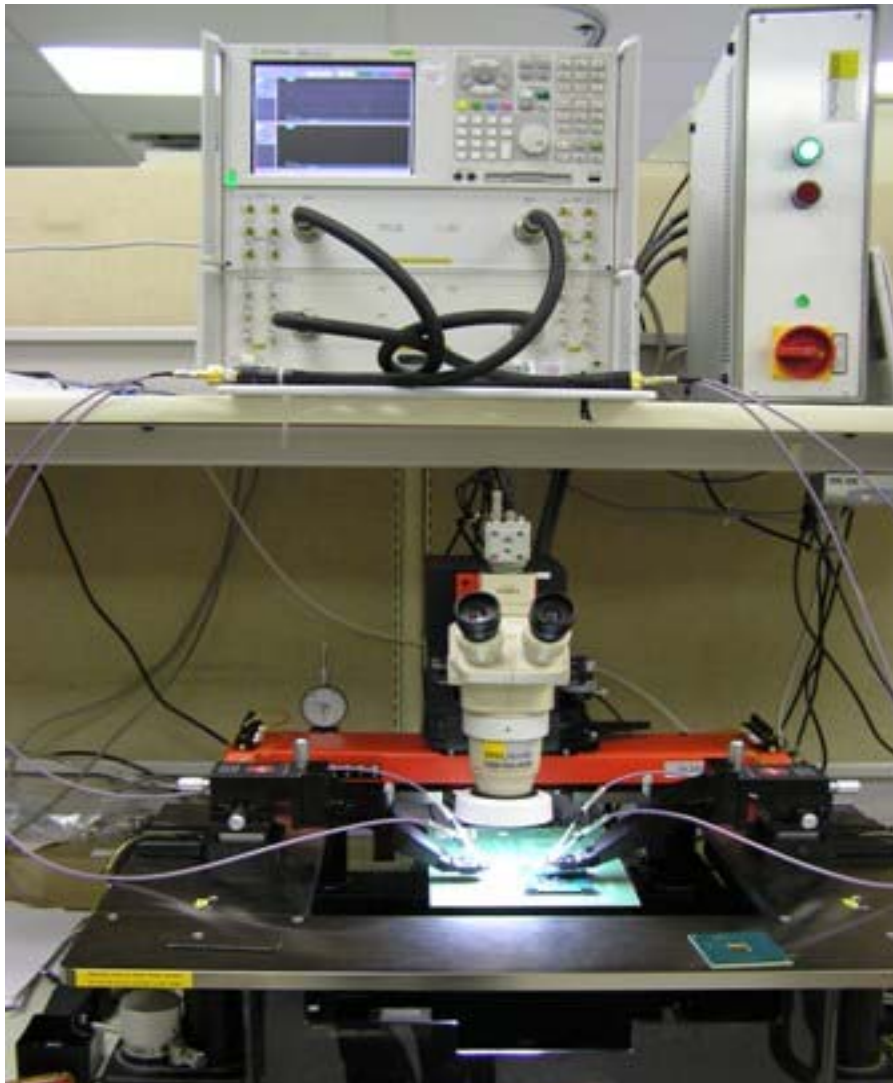
SpiralTV Package Stackup



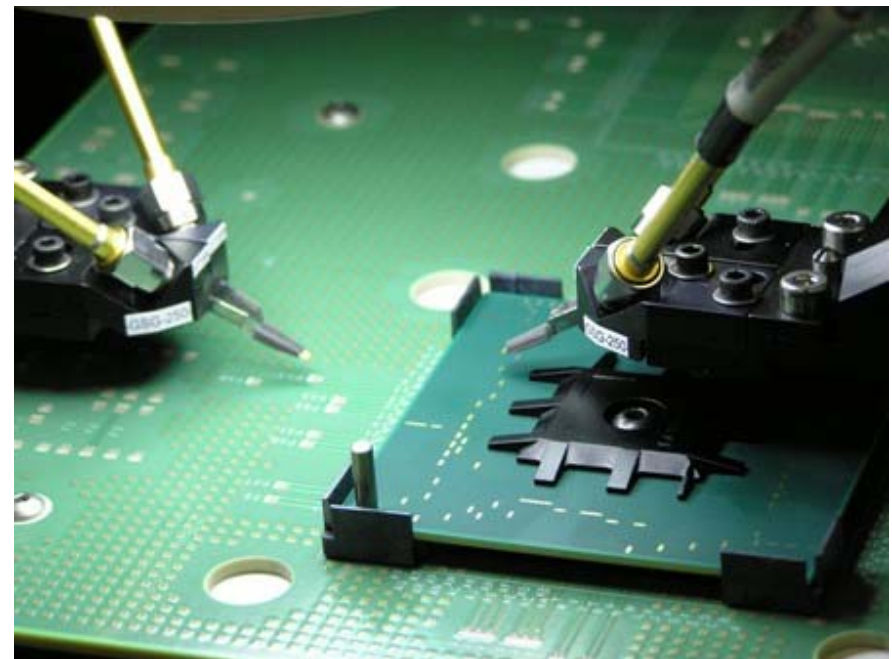
Test/Probing configuration



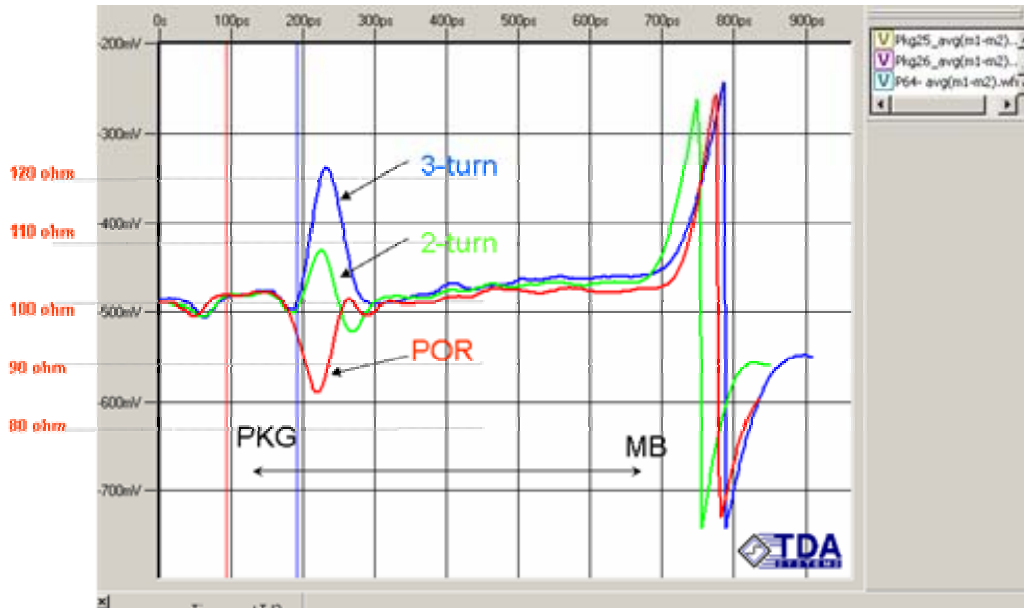
Probing station setup



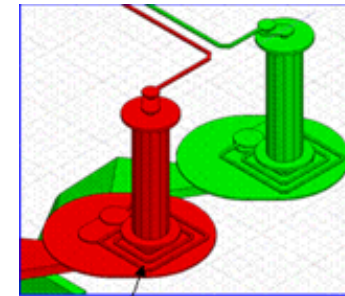
test setup close-up



TDR measurement

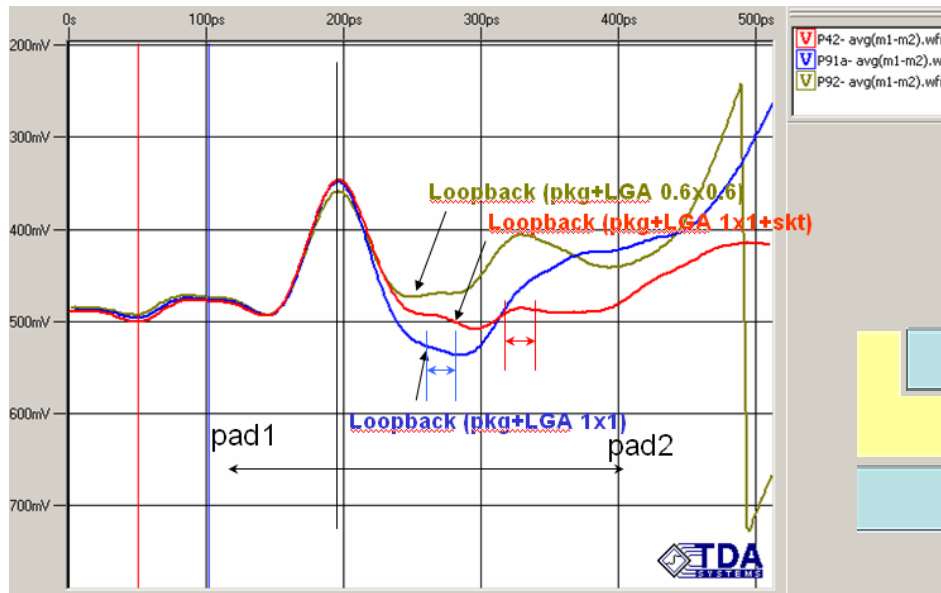


- 2-turn is the best for 10L LGA package- type 1 routing (via straight down)
- 3-turn provides 2 times of the 2-turn inductance

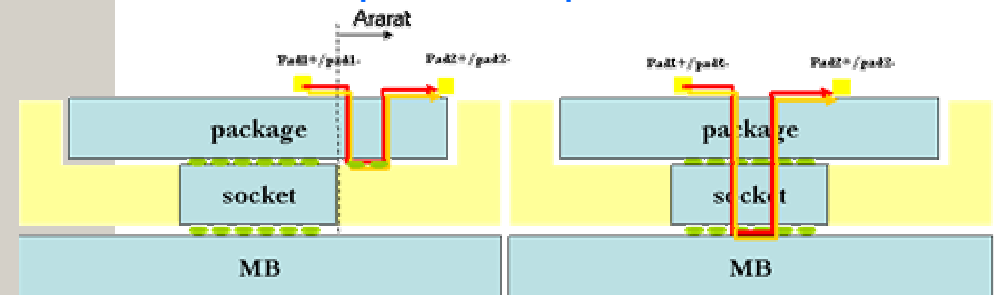


Spiral routing

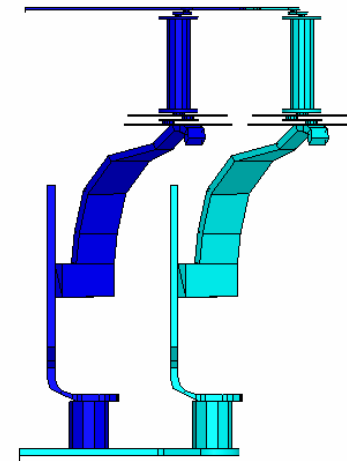
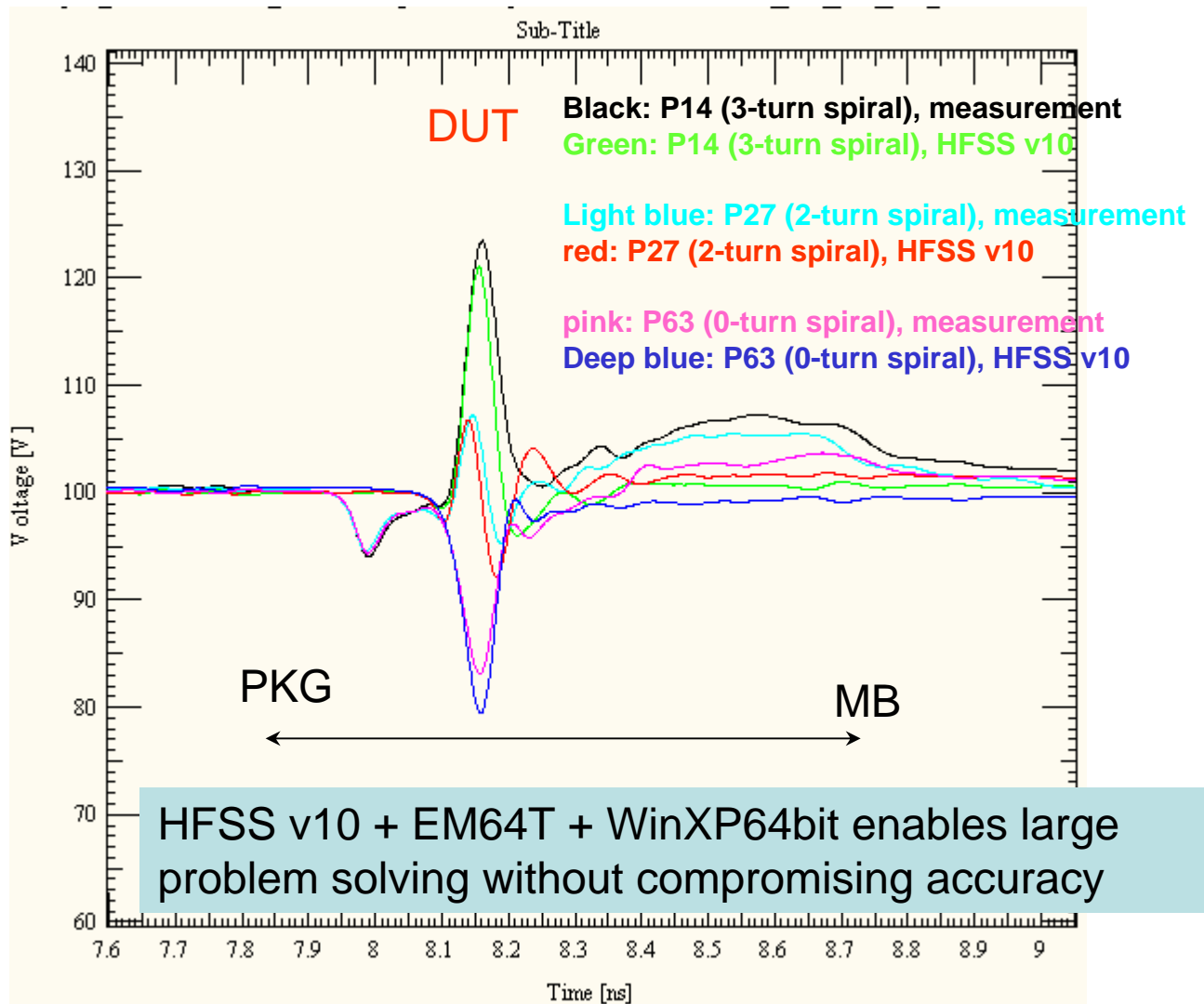
- Socket is slightly inductive
- LGA effect is very significant.



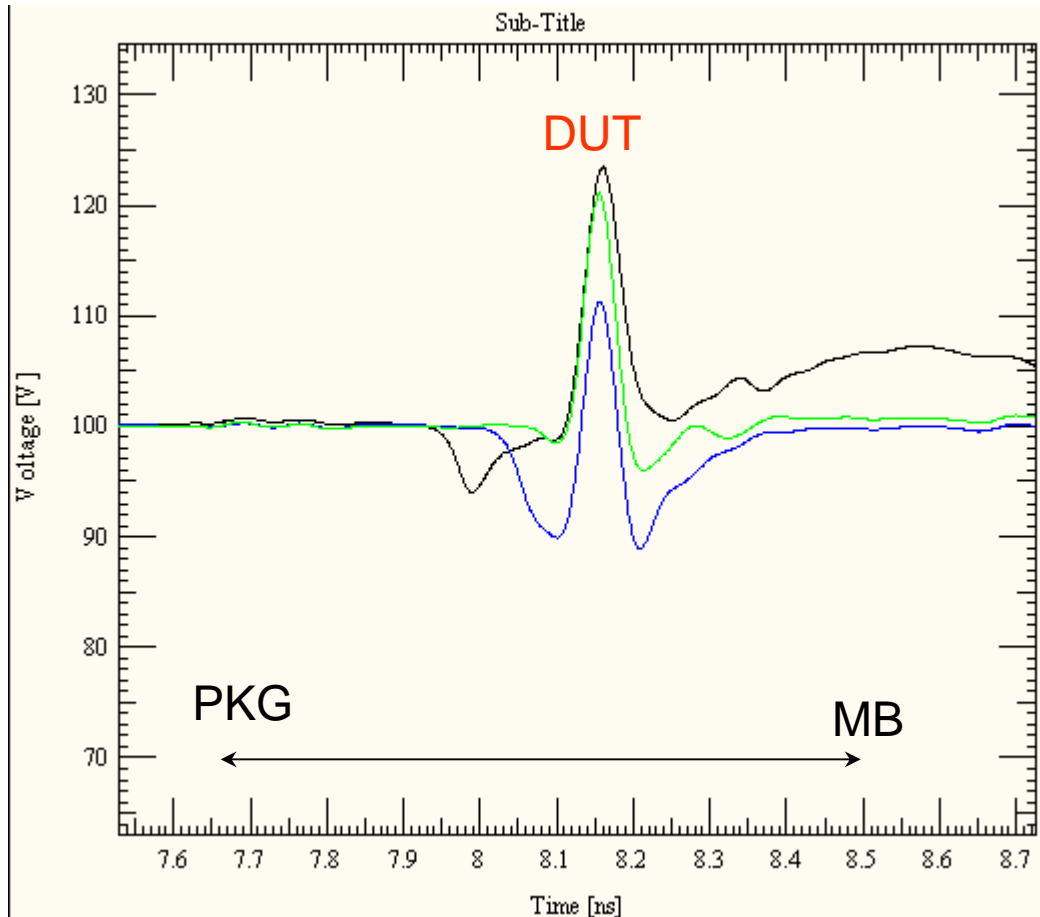
Loop back experiment



Good model correlation with HFSS v10 + EM64T + WinXP64bit



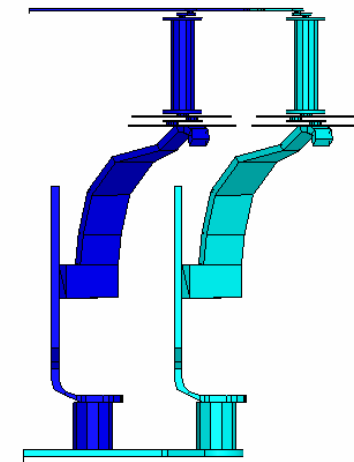
HFSS v10 + EM64T + WinXP64bit VS HFSS v9 +IA32+ Win32



Black: measured TDR of P14 (3-turn spiral)

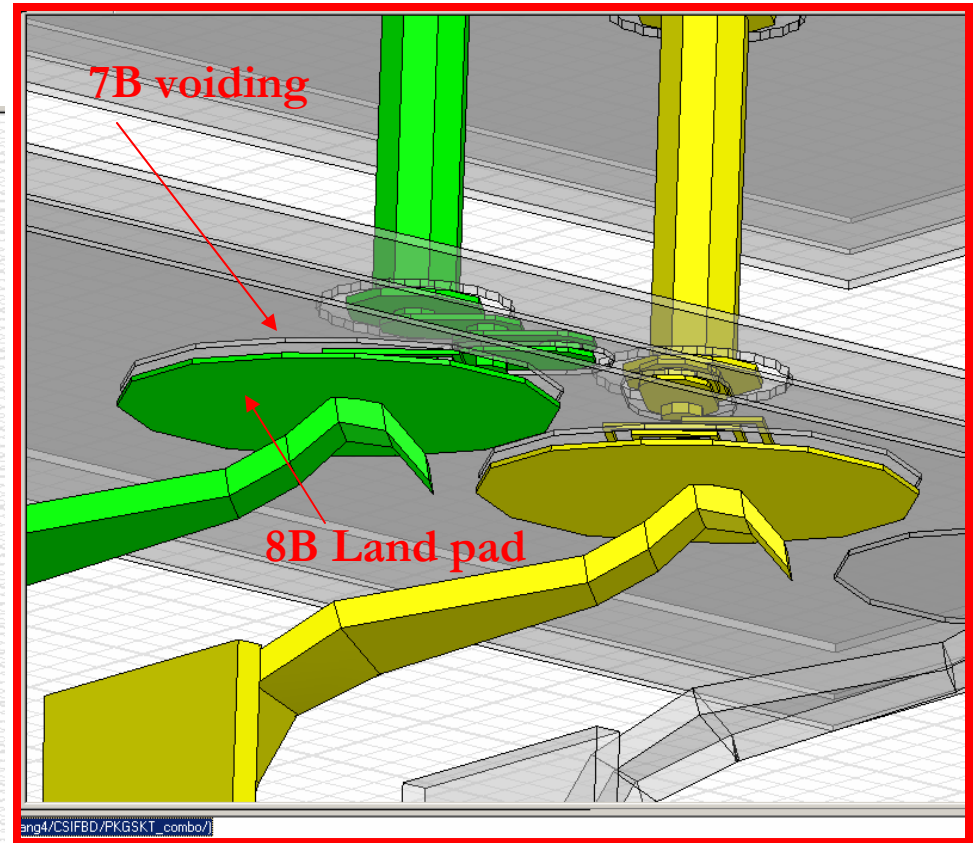
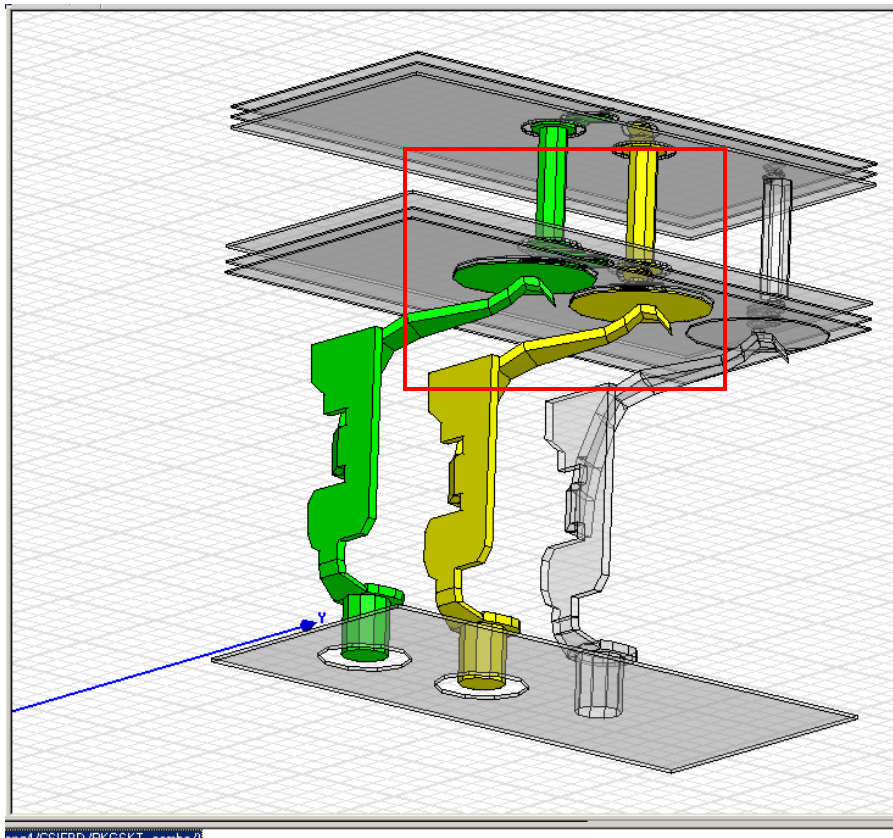
Green: combined HFSS ver.10 model with high order basis. (3-4 GB memory)

Blue: combined HFSS ver.9.2 model with low order basis function (i.e. part1+part2 model in one shot)

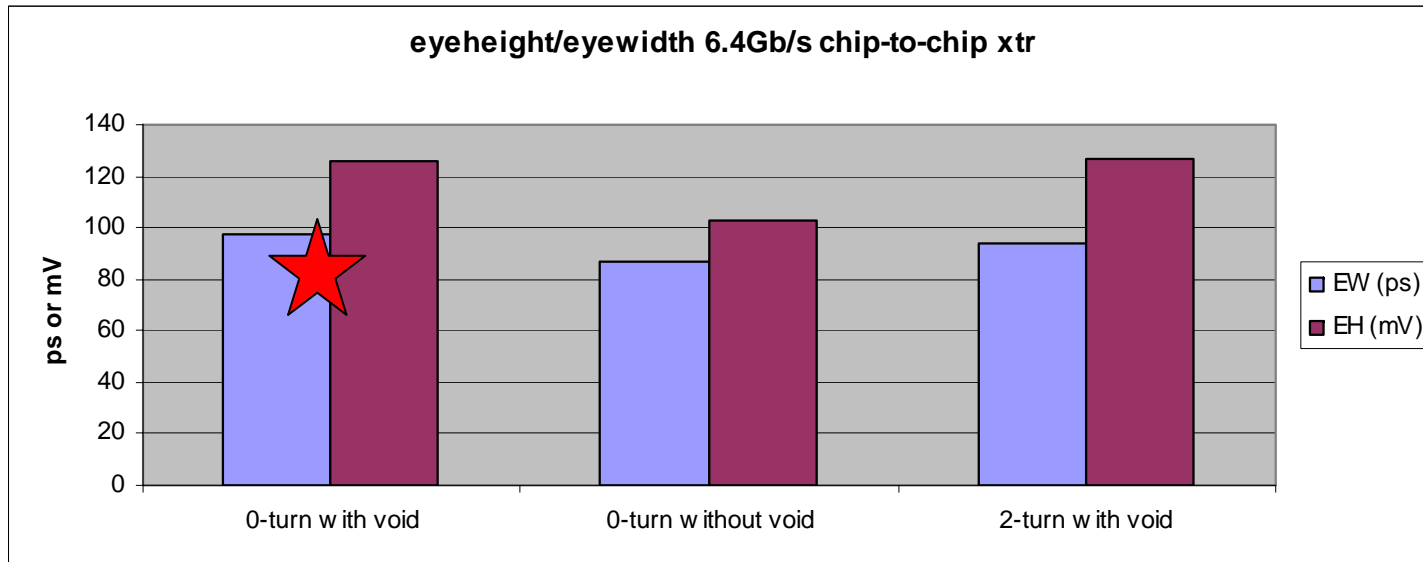


HFSS v10 + EM64T + WinXP64bit enables large problem solving without compromising accuracy

Land Pad shadow voiding



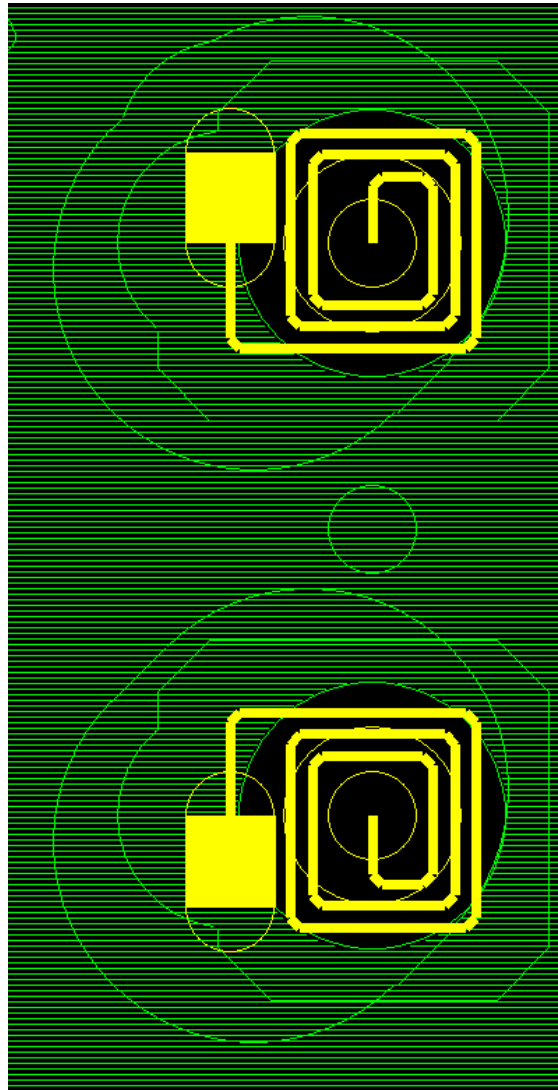
full channel simulation – package=spiralTV CPU-CPU topology, 6.4GT/s



Recommendation: 0-turn spiral + large 4B void

Spiral inductor Routing in Package

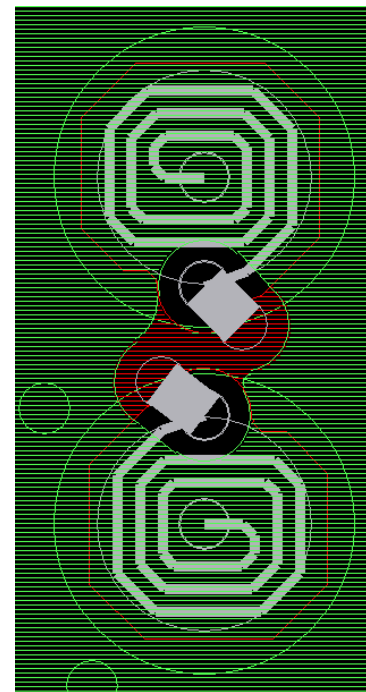
SpiralTV



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1Bci	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1-2B	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2Bco	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
2-3B	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3B	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
3-4B	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4B	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
4-5B	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Bottom	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Test package B

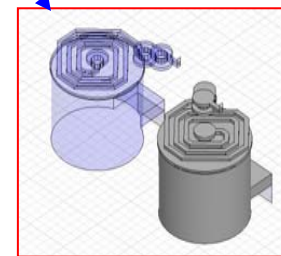
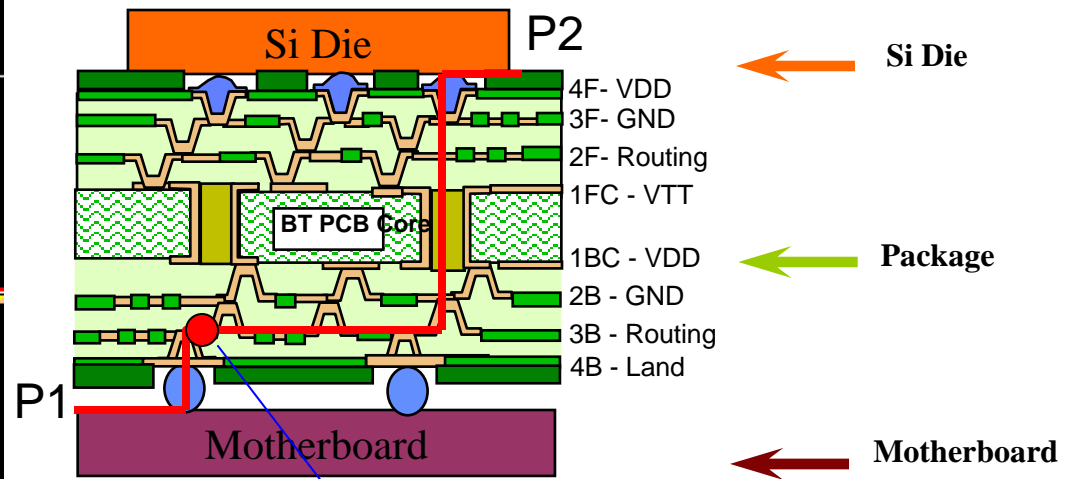
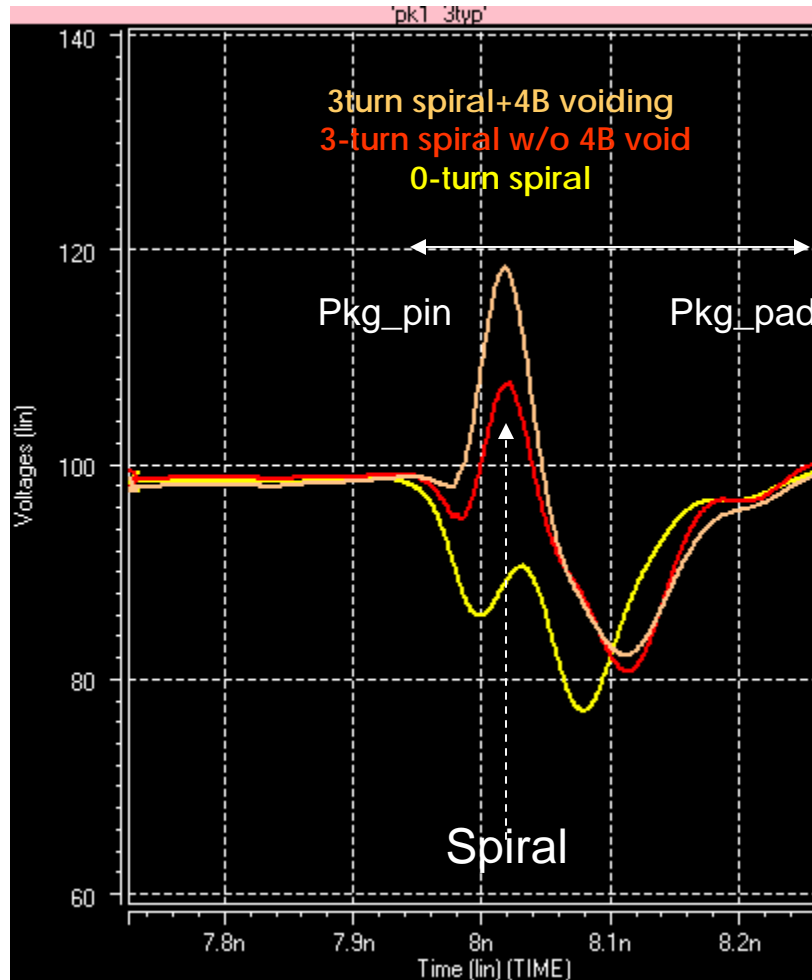
1000 um
←→



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1Bci	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1-2B	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2B	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2-3B	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3B	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3-4B	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4B	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
4-5B	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5B	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
5-6B	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Bottom	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

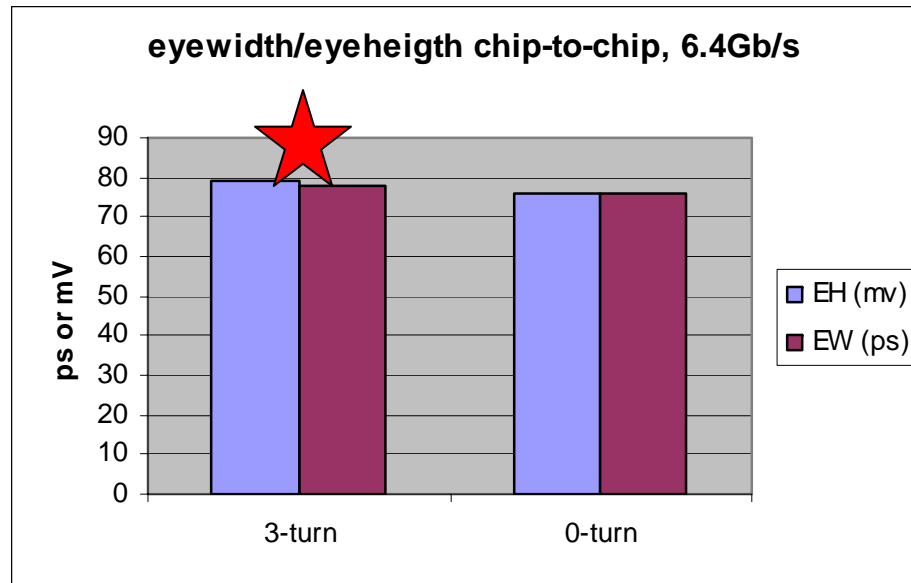
SpiralTV Lcomp is stronger than Package B because of the metal voiding.

Package B TDR simulation



Spiral inductor₃

Channel performance, package B



Recommendation: 0-turn spiral + large 4B void

summary

- HFSS v10+EM64T+Win64bit/Linux64bit allows us to solve large scale interconnect problems that cannot be done in order version. The HFSS v10 results and measurement of the spiral inductor are in good correlation.
- Mixed-scale problems such as package and socket combined model push the memory/CPU requirements to new high. We suggest Ansoft to keep improving the meshing algorithm to reduce the unknowns and simulation time. (ex, spiralTV modeling, there is only incremental difference in the spiral turns. There is a possibility to make use of the previous results and solve only the “differentials”)
- Spiral inductor in the package is effective in providing the inductance or tweaking the target impedance.