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Accurate PCB simulation model for 112Gbps Serdes Testing

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TestConX中国 China

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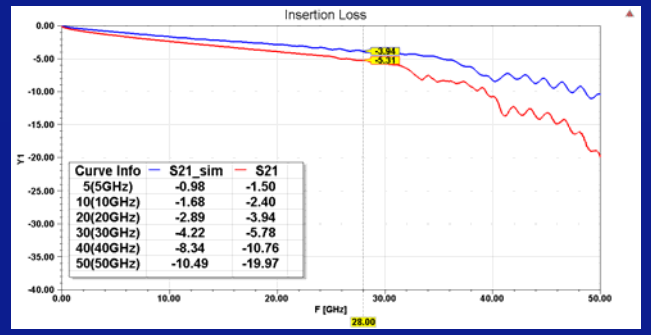
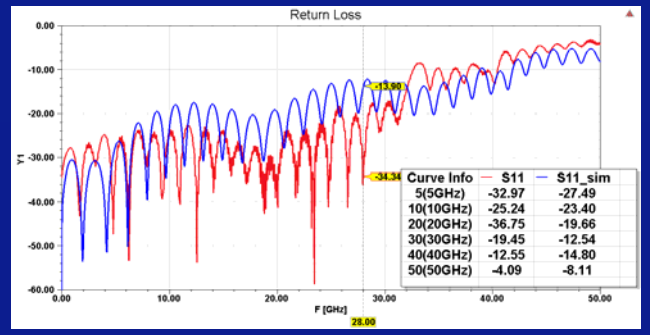
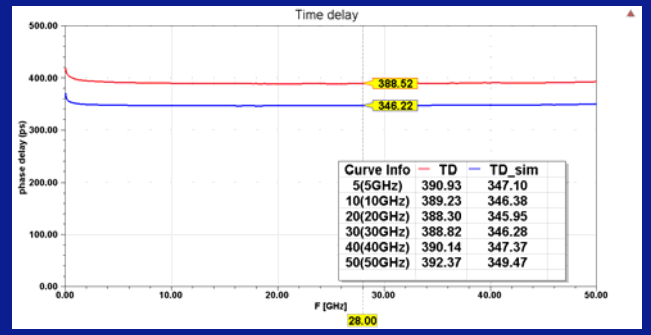
112Gbps Serdes Testing Challenge on PCB simulation

- 112Gbps Serdes is a big challenge in ATE load board design.
  - Nyquist frequency for 112Gbps PAM4 Serdes is 28GHz. A good SI (signal integrity) performance for DC-56GHz is required to guarantee the signal transmission on PCB.
  - In traditional simulation model, many assumptions are used, so simulation results can hardly match the real-world measurement over 15GHz.







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112Gbps Serdes Testing Challenge on PCB simulation

- 112Gbps Serdes is a big challenge in ATE load board design.
  - Nyquist frequency for 112Gbps PAM4 Serdes is 28GHz. A good SI (signal integrity) performance for DC-56GHz is required to guarantee the signal transmission on PCB.
  - In traditional simulation model, many assumptions are used, so simulation results can hardly match the real-world measurement over 15GHz.
  - Material properties and manufacturing variations of PCB will dominate the result accuracy of simulation.
  - Accurate simulation model is needed to get good correlation between simulation and measurement.

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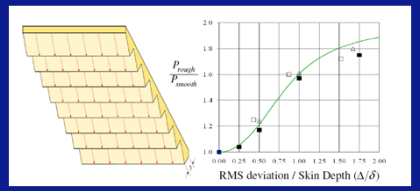
Traditional PCB simulation model

- In traditional simulation model, many assumptions are used:
  - Pure copper conductivity (5.9*10^7 S/m);
  - Design value for geometries (trace width, dielectric thickness);
  - Simple copper roughness model (Hammerstad-Jenson / RMS);
    - RMS value come from material vendor.



  - Dk is adjusted to get impedance match up with target

Accurate PCB simulation model

- Manufacturing variations
  - Copper conductivity
    - The conductivity of copper on PCB can be lower than pure copper.
  - Geometries (trace width, dielectric thickness)
    - Finished trace width can be smaller than designed value.
  - Copper surface roughness change
    - Copper surface is roughened by oxide process to get better adhesiveness in lamination.
  - Dielectric material properties (Dk/Df)
    - Datasheet values are the baseline. They might be slightly changed in PCB fabrication.

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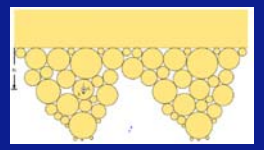
Accurate PCB simulation model

- Material characterization



$$\frac{P_{rough}}{P_{smooth}} \approx 1+\frac{3}{2}\sum_{i=1}^{i}\left(\frac{N_i 4\pi a_i^2}{A_{hex}}\right)\Big/\left[1+\frac{\delta}{a_i}+\frac{\delta^2}{2a_i^2}\right]$$

Huray model

Adjust the Dk / Df / Roughness inputs in 3D solver to get the simulated Time delay & AC resistance & insertion loss match up to S-parameter measurement

S parameter measurement

$$TD = \frac{rad(S21)}{2\pi f}$$

$$R_{AC} = Re(\frac{1}{Y_{11}})$$

? Dk

? Copper roughness

Time delay

? Copper roughness

Copper conductivity

DC measurement ✓

? Dk/Df

Trace geometry

cross-section ✓

AC resistance/ Insertion loss

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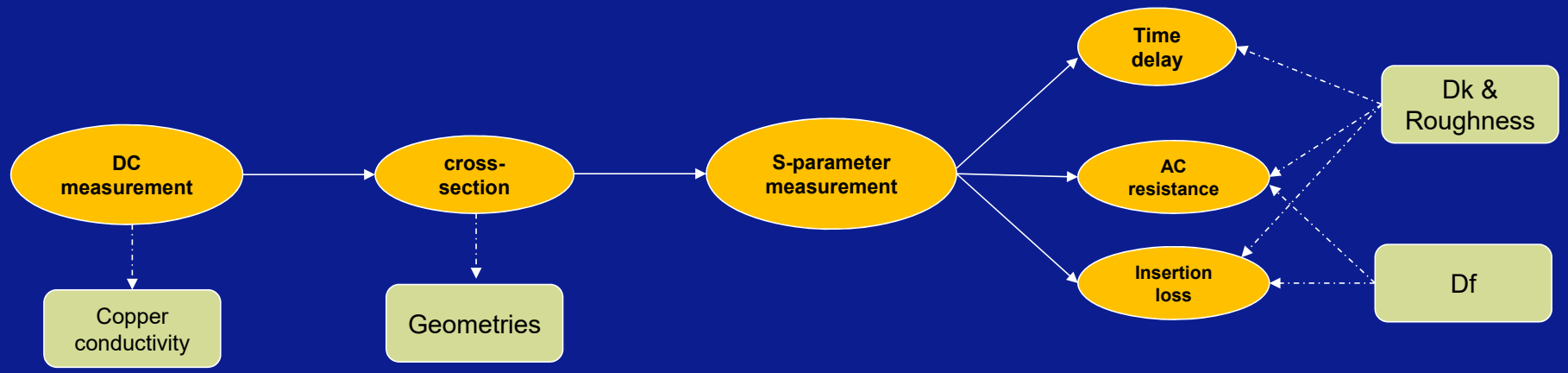
Accurate PCB simulation model

- Material characterization



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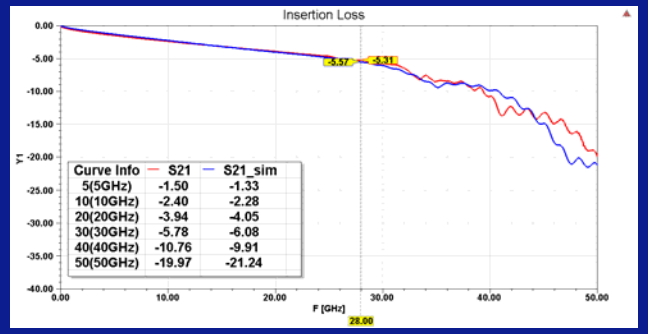
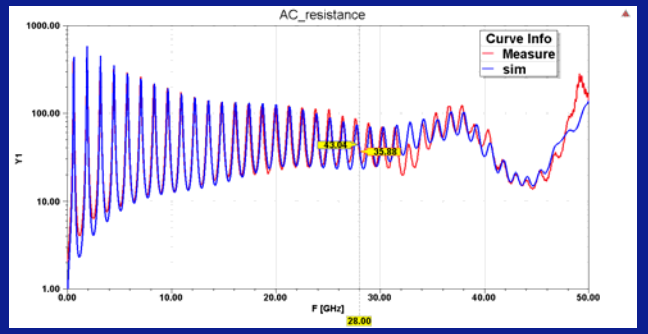
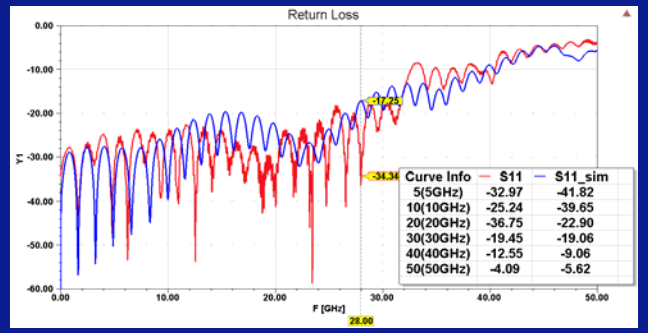
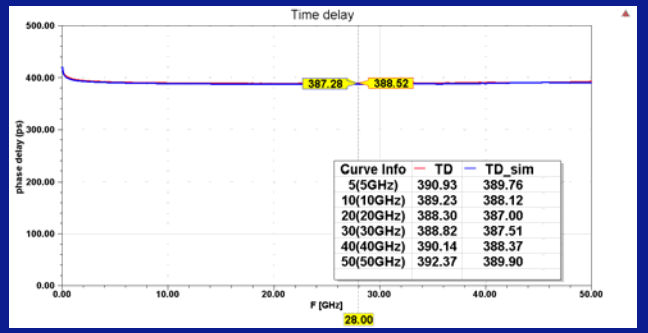
Accurate PCB simulation model

- Correlation between simulation (HFSS 2019R1) and measurement









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Conclusion

- Accurate simulation model is badly needed for 112Gbps Serdes test in ATE load board design;
- Traditional simulation model used many assumptions which result in big mismatch between simulation and measurement;
- With the help of DC measurement, cross-section and S-parameter measurement, we introduce the accurate simulation model by considering manufacturing variations and characterizing material properties.
- The accurate simulation model correlates well to measurement up to 50GHz.

Reference

- *P. G. Huray, O. Oluwafemi, J. Loyer, E. Bogatin, X. Ye Impact of Copper Surface Texture on Loss: A Model that Works, DesignCon 2010*

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