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Motivation

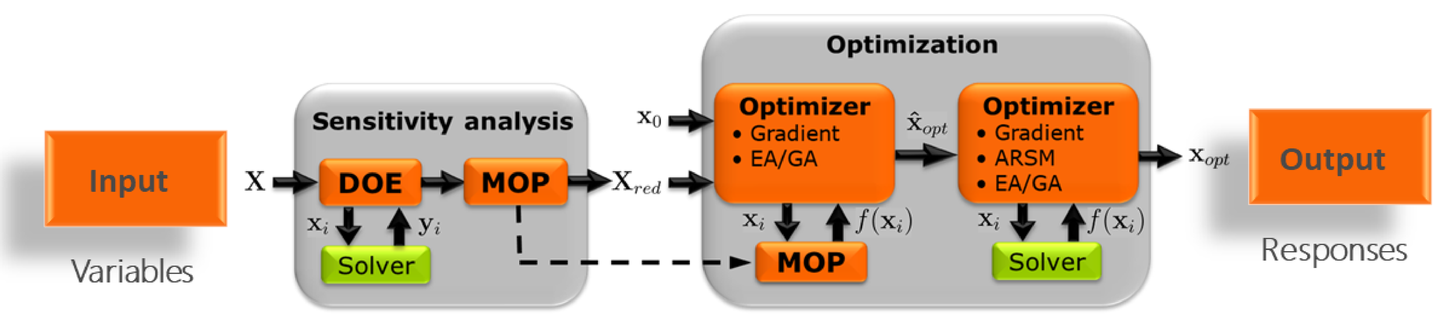
- As we all know, an accurate digital model is critial to study the packaging design. But in most cases, the simulation results are not consistent with the test results. There are three main reasons: the difference between the simulation model and the actual model, test errors, and inaccurate material parameters. Print circuit borad(PCB)/package(PKG) slicing can correct the simulation model, and test errors can also be eliminated by de-embedding and other methods. After that, the accuracy of material parameters has become a bottleneck of consistency between simulation and testing.

• Method

- Metamodel is one of the most popular design exploration strategies for nonlinear optimization and stochastic analysis and due to the intrinsic complexity of many engineering problems, using substitute model to approximately solve a problem and find reasonable design properties in smooth sub-domain can be immensely helpful. This idea is applied to the metamodel of optimal prognosis (MOP).

• Optimization Workflow - MOP

- Sensitivity analysis identifies the most important input parameters and checks plausibility of numerical results.
- Pre-optimization is performed by using the MOP Method.
- Final optimal design can be got and validated by direct solver.

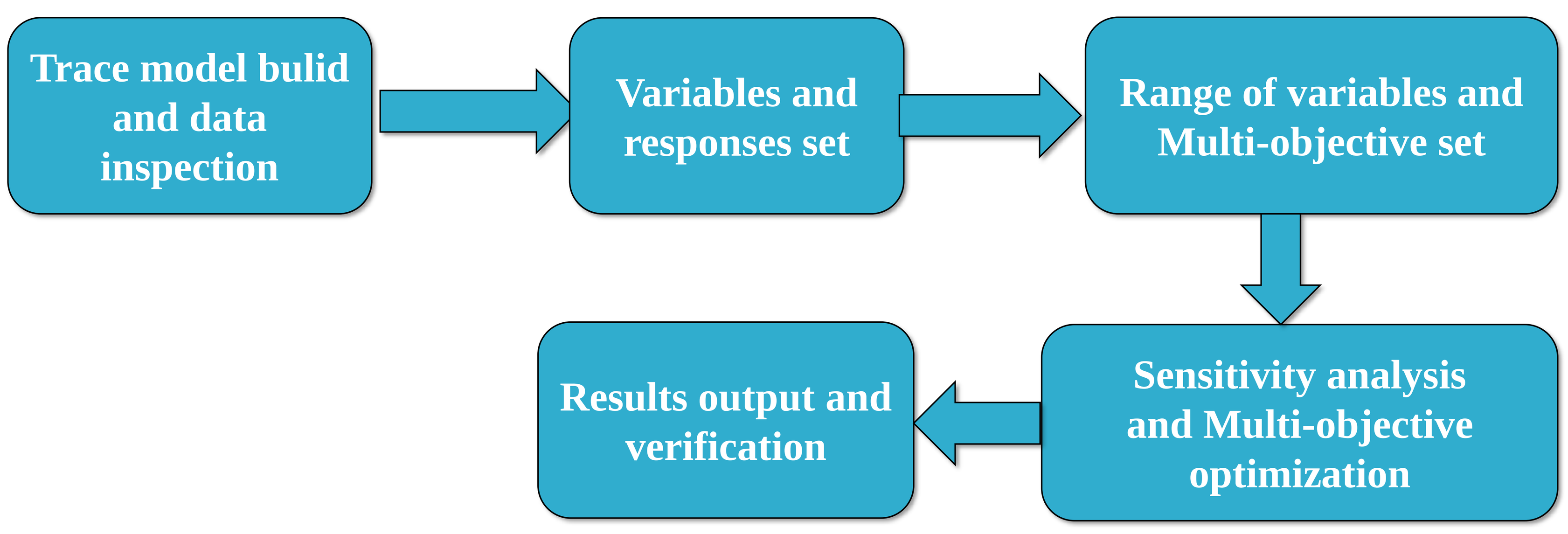


Optimization workflow in Ansys Optislang

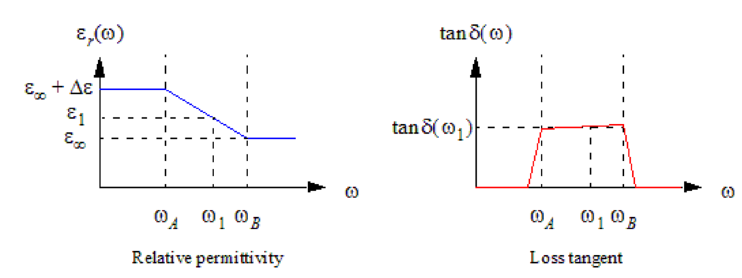
• MOP Achieved the Following Goals

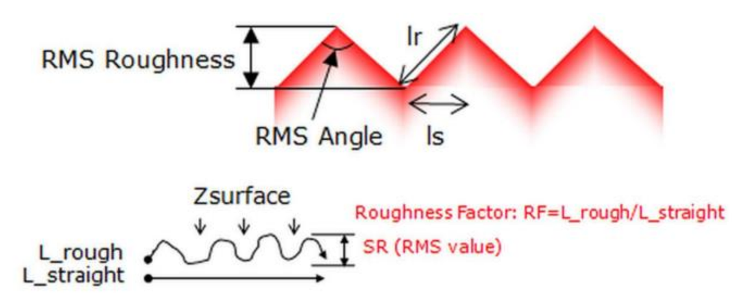
- Causal frequency-dependent dielectric constant(DK)/Loss tangent(DF).
- Copper plane conductivity and surface roughness .
- IL/RL/TDR/Degree… consistent between simulation and testing.

• Workflow of MOP implement in Ansys Optislang



• Modeling the Material Properties





$$\varepsilon = \varepsilon_\infty + \Delta\varepsilon \cdot \frac{1}{m_2 - m_1} \cdot \log_{10}\left(\frac{10^{m_2} + i\cdot f}{10^{m_1} + i\cdot f}\right) = \varepsilon_r \cdot (1 - i\cdot\tan\delta)$$

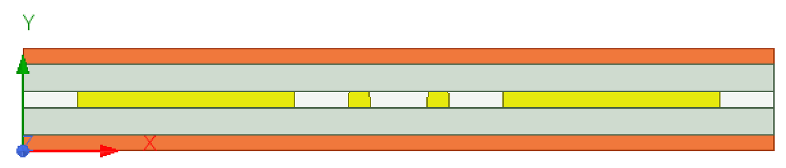
Djordjevic-Sarkar model used to model frequency dependent characteristics of dielectric materials

$$\frac{P_{Rough}}{P_{Flat}} = 1 + \frac{2}{\pi}\arctan\left[1.4\left(\frac{\Delta}{\delta}\right)^2\right](SF - 1)$$

Hammerstad-Jensen model used to model copper surface roughness

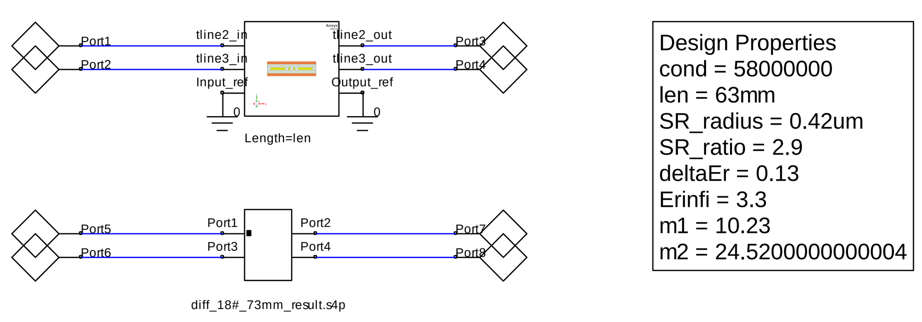
• Material Parameter Fitting Setting

Use more test samples to reduce systematic error in testing. As the above example, 5 samples traces (1#,5#,10#,15#,18#) with same material and different lengths to compare the deviations between simulation and testing data.

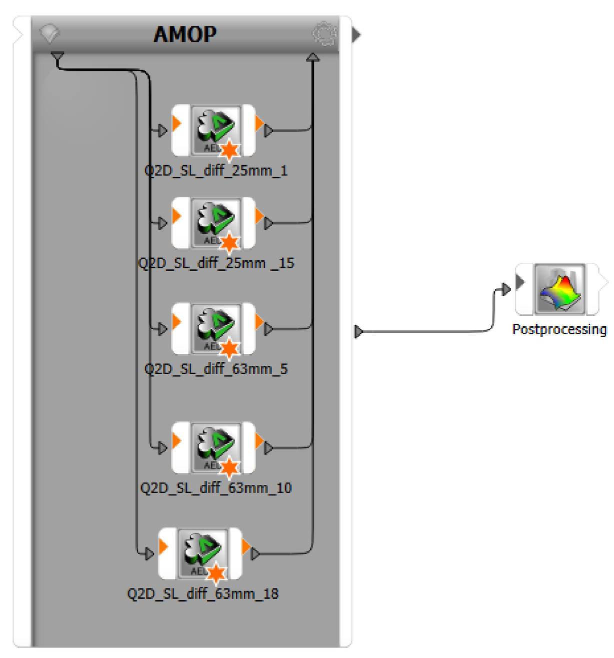


Model Trace Section in Ansys Q2D

Q2D links

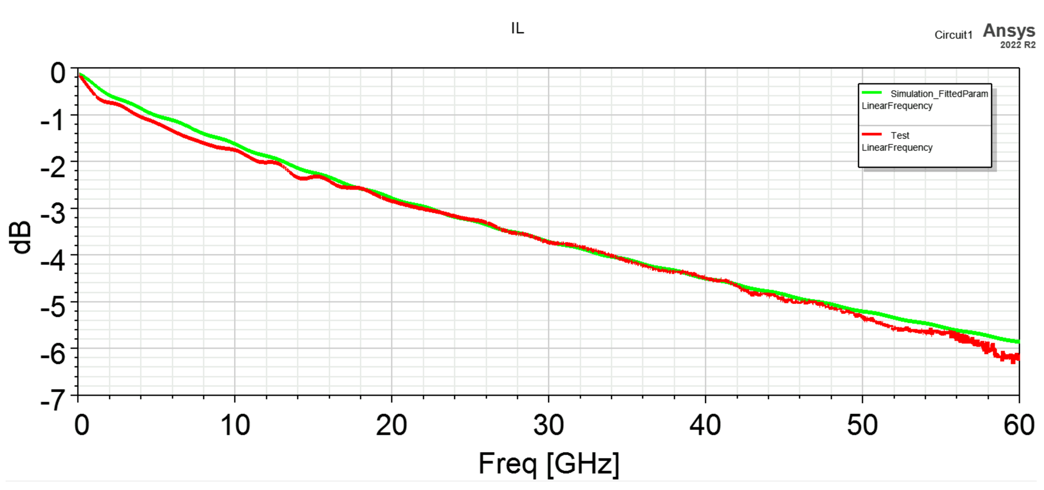


Model and compare data in Ansys Circuit

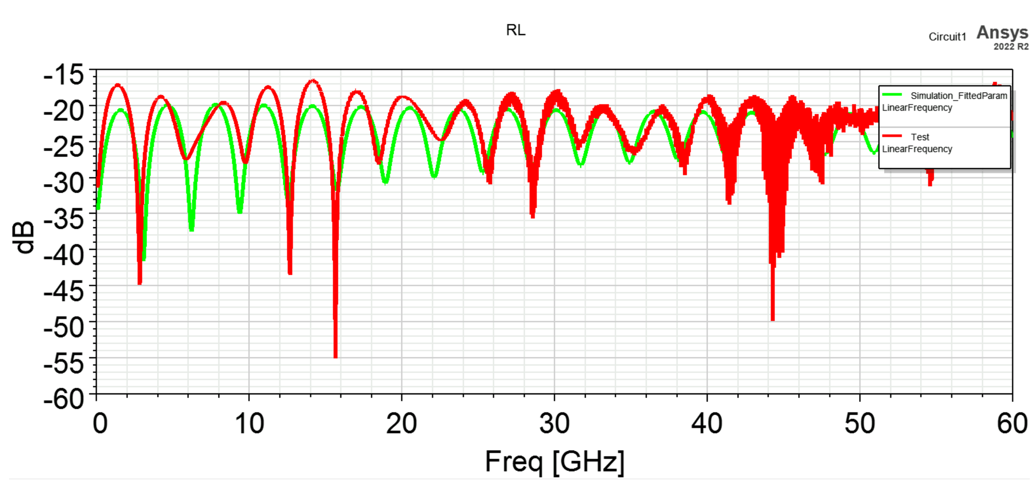


Optislang AMOP Analysis

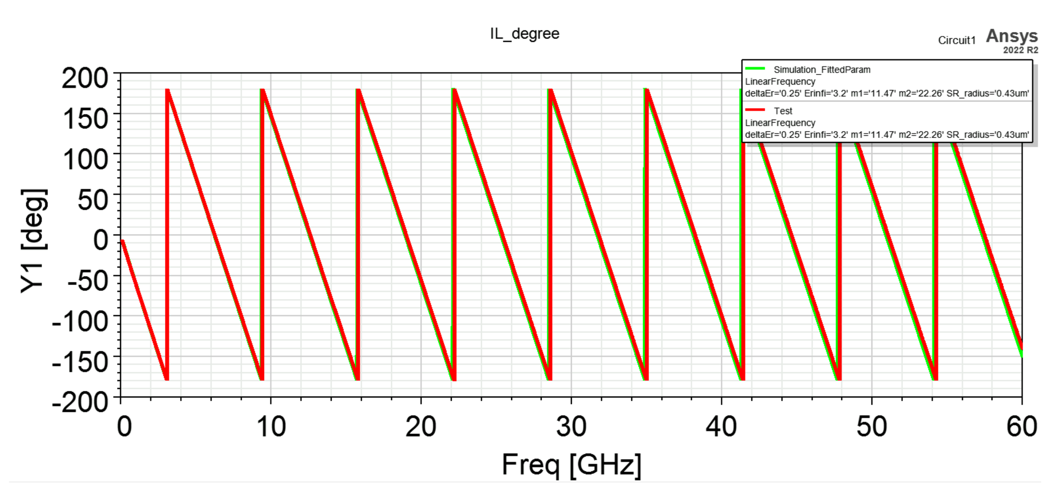
• Final Simulation Result and Testing Data



Insertion Loss



Return Loss



IL Phase

Conclusions

This paper introduce a fast and convenient way to get accurate package material parameters

- Use MOP methods for design space exploration, avoid pseudo result and give real best design.
- AMOP method automatically add improvement designs to improve the accuracy of response surface.
- Easy to handle 5-8 input parameters, capability more than 10 input material's variables.
- Less assumptions input, high reliability result output.
- Automated process, less labor consumption and higher efficiency.
- More sampling data could be considered simultaneously to reduce system measurement error.

References

1. A. R. Djordjevic, R. D. Biljic, V. D. Likar-Smiljanic and T. K. Sarkar, "Wideband Frequency-Domain Characterization of FR-4 and Time-Domain Causality," IEEE Trans. on Electromagnetic Compatibility, Nov. 2001, p. 662.
2. "Which one is better? Comparing options to describe frequency dependent losses", by E. Bogatin, D. DeGroot, P. G. Huray and Y. Shlepnev, in the DesignCon 2013