EM/Circuit Co-simulation

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Agenda

- Motivation for EM/Circuit Co-simulation
- Standard versus **Transient** Co-simulation
- Standard Co-simulation examples
  - Filter tuning
  - Antenna Array
- Transient Co-simulation examples
  - Peak detector
  - SRD generator
  - UWB balanced amplifier
- Conclusion
Motivation

- Speeding up the design process
- Avoiding Brute-Force optimization approach
- Including all layout discontinuities, housing effects, mutual coupling of the circuit element
- Including complex equivalent circuits and/or nonlinear components
- Antenna matching networks, excitation of beam-forming antenna arrays
- Exploiting of geometry symmetries of the structure - splitting up the 3D model
- Space-Mapping technique
- Quick tolerance/yield analysis without need of 3D EM simulation
- System level simulation
Standard versus Transient Co-simulation

Standard Co-simulation

N x 3D EM Simulation

Complete S-Matrix of 3D model

Transient task (TD)

Spice model extraction

Waveforms at probes, Eye-diagram

Template based Post-processing (Power Spectrum Density, etc.)

S-parameters Task (FD)

Transient Co-simulation

1 x 3D EM simulation (including circuit networks)

Waveforms at probes

Template based Post-processing (PSD, S-parameters, etc.)
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Example 1: Filter Tuning
(Standard Co-simulation)

Spacing between resonators
\(S_{12}, S_{23}, S_{34}, S_{45}\)

Length of resonators
\(L_1-L_5\)
Implementation in Design Studio
Optimization Result

C1 = 58.38 fF
C2 = -5.84 fF
C3 = -12.14 fF
C4 = -9.52 fF
C5 = -1.23 fF

C1 ≈ ΔL1, ΔL5
C2 ≈ ΔL2, ΔL4
C3 ≈ ΔL3
C4 ≈ ΔS12, ΔS45
C5 ≈ ΔS23, ΔS34

Only a few 3D simulations are required!
Example 2: Feeding Network + Antenna Array
(Standard Co-simulation)

3D model in MWS fed with DS circuit network

Type: FarField (Array)
Approximation: enabled (kR >> 1)
Monitor: farField (f=5.25) [S-Parameters1]
Component: Abs
Output: Directivity
Frequency: 5.25
Rad. effic.: -0.2988 dB
Tot. effic.: -0.3587 dB

System [S-Parameters1]:
Rad. effic.: -0.2970 dB
Tot. effic.: -0.3374 dB
Dir.: 16.09 dBi
S-Parameters Task: Combine Results

Sweeping of the beam without repeating of the 3D simulation!
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Example 3: Peak Detector
(Transient Co-simulation)
Transient task: MWS co-simulation

“0” means adaptive sampling
Example 4: SRD Pulse Generator I. (Transient Co-simulation)

DS canvas:
- circuit elements
- transient task with „MWS Co-simulation“
- probes

MWS model
Example 4: SRD Pulse Generator II.  
(Transient Co-simulation)

In order to obtain correct results using any frequency domain approach, more than 300 harmonics would need to be taken into account!
Example 5: UWB Balanced Amplifier I.
(Standard Co-simulation)

Chip transistor
Example 5: UWB Balanced Amplifier II.
(Transient Co-simulation)

DS canvas:
• circuit elements
• transient task with „MWS Co-simulation“
• probes

MWS model

20 ports
Example 5: UWB Balanced Amplifier III. (Transient Co-simulation)

Transient Co-Simulation is approx. 5x faster than the standard Co-Simulation using S-parameter matrix and spice model extraction.
Conclusions

<table>
<thead>
<tr>
<th>Standard Co-simulation</th>
<th>True Transient Co-simulation</th>
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<tbody>
<tr>
<td>▪ Fast optimization at the circuit simulator level</td>
<td>▪ Optimization only thru 3D EM simulation</td>
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<tr>
<td>▪ Complete S-matrix is needed</td>
<td>▪ Fast 3D simulation of complex structure having high number of lumped components/ports</td>
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<tr>
<td>▪ Spice model extraction is needed for transient task</td>
<td>▪ No need of spice model</td>
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<tr>
<td>▪ Suitable for steady-state analysis</td>
<td>▪ Suitable for pulse-regime analysis</td>
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<tr>
<td></td>
<td>▪ Investigation of the whole circuit including box influence.</td>
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Thank you for your attention...