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Guidance of Passive EDA models

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S-parameters Issue in Passive Devices

- S-parameters circulate widely as simulation model of Signal Integrity.

- S-parameters are different by the vendor which are provided. e.g.
  - Bandwidth
  - Upper or lower limit frequency
  - Frequency steps

- Some simulators output a wrong calculation result by these different S-parameters.
Verification of S-parameters with limit

1. Measurement of S-parameters
   They were measured between SMA-SMA connectors using Vector Network Analyzer (VNA).
   BW 10MHz-20GHz, 10MHz steps

2. Measurement of transient waveforms
   They were measured with sampling Oscilloscope and Signal Generator.

Signal Generator: 13.5 Gbps

Sampling Oscilloscope: BW 50GHz
3. Transient simulation using measured S-parameters

S-parameters bandwidth limitation

- 10MHz-3.16GHz (Sdd21 -10dB)
- 10MHz-7.82GHz (Sdd21 -20dB)
- 10MHz-11.1GHz (Sdd21 -40dB)
- 10MHz-20GHz (full parameters)

4. Comparison between measured transient waveforms and simulated transient waveforms

The measured transient waveforms
They were measured by using SG and OSC.

The simulated waveforms
They were simulated by using S-parameters which were measured using VNA.
Measured S-parameters

BW10M-3.16GHz Modal-Sparam

Sdd21(-10dB)

Sdd11

BW10M-7.82GHz Modal-Sparam

Sdd21(-20dB)

Sdd11

BW10M-11.1GHz Modal-Sparam

Sdd21(-40dB)

Sdd11

BW10M-20GHz Modal-Sparam

Sdd21(full parameters)

Sdd11

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Measured transient waveform vs. Simulated waveform using Simulator A

The results of this simulator were good match for the measurement without BW 3.16GHz.

There are unnecessary ringing.

Vertical axis is not adjustment.
Lower limit of S-parameters are 10MHz without 0Hz.

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The simulation result has the voltage offset for the result of the measurement.

Vertical axis is not adjustment.
Lower limit of S-parameters are 0Hz.
(extrapolated using 10MHz of S-parameters.)
Measurement Sim BW 11.1GHz Sim BW 7.82GHz Sim BW 3.16GHz

Using Simulator B

BW 3.16GHz, 7.82GHz and 11.1GHz did not match results of measurement. Only BW 20GHz barely matched result of the measurement except voltage offset.

Vertical axis is not adjustment.
Lower limit of S-parameters are 10MHz without 0Hz

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Using Simulator B
Vertical axis is not adjustment.
Lower limit of S-parameters are 0Hz. (extrapolated using 10MHz of S-parameters.)

Measurement vs. Simulated waveform

Sim BW 11.1GHz
Sim BW 7.82GHz
Sim BW 3.16GHz
Sim BW 20GHz

BW 3.16GHz, 7.82GHz and 11.1GHz did not match results of measurement. Only BW 20GHz matched result of the measurement.

Vertical axis is not adjustment.
Lower limit of S-parameters are 0Hz.
(extrapolated using 10MHz of S-parameters.)

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Summary of results

• There is a simulator that can execute the accurate transition analysis without 0Hz or S-parameter to 20GHz. (Simulator A)

• So that all simulators may simulate transient waveform using S-parameters accurately, they are necessary to use the band of S-parameters from 0Hz to 20GHz. (Simulator B)

• Four ports S-parameters with the band from 0Hz to 20GHz are large size of the file (928kB). Therefore, a lot of time is needed, when calculating with the simulator using the full band S-parameters (0Hz-20GHz).
Guide line for using S-parameters

It is the following items are discussed in JEITA EDA-WG.

1. Lower frequency limitation of S-parameters
   - Are S-parameters of 0Hz necessary?
   - How should extrapolate when there are no S-parameters of 0Hz?
   - How should be measured S-parameter of 0Hz?

2. Upper frequency limitation of S-parameters
   - How many harmonics at input signal wave are necessary?

3. Frequency steps
   - At least, how many are the number of frequency steps necessaries?

In these items, it is the purposes to rouse notes when using S-parameters.