Touchstone to Touchstone 2.0, Touchstone 2.0 to Touchstone too

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Overview

• Touchstone Version 2.0 ratified by IBIS April 24, 2009

• Easy upgrades/downgrades a goal
  – S-parameters the most common application
  – Minimal addition/removal of keywords
  – Transition period when tools support either original Touchstone and/or Touchstone 2.0
Background

• Touchstone issued 1984 by EEsof (now part of Agilent Technologies)
• Touchstone is de-facto format widely used
• Touchstone “Version 1.0” publicly uploaded for ICM
  – http://www.eda.org/ibis/connector/
• Touchstone Version 2.0
  – Format rules relaxed
  – Resistance per port option for PDS
  – Mixed mode features for differential setups
  – Some storage reductions available
  – Mathematical conversions documented
  – http://www.eda.org/pub/ibis/touchstone_version2.0/
  – tschk2 parser planned soon
Version “1.0” Block Arrangement

Option Line
For example, # GHZ S MA R 50

N-port Data Block
(rigid format rules)
Officially for Single-Ended Data

Optional Noise Data Block
(n=2 only)
### “Version 1.0” Fixed Format Examples

\( f = \text{frequency, } s = \text{data-pair} \)

<table>
<thead>
<tr>
<th>S1P</th>
<th>S3P</th>
<th>S4P</th>
<th>S5P</th>
<th>S6P</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>

Formatting, frequency ordering, and end of file implies number of ports and frequencies values.

Etc …
Touchstone Version 2.0 - Thirteen IBIS-like Keywords

- Required keywords (and option line) – fixed order
  - [Version] 2.0
  - #(option line)
  - [Number of Ports] <n>

- Keywords in any order
  - [Number of Frequencies] <nf> (required)
  - [Two-Port Data Order] {21_12 | 12_21} (required for n=2 only)
  - [Reference] <list of n reference resistances in port order>
  - [Matrix Format] {Full | Lower | Upper}
  - [Mixed-Mode Order] {Di,j, Ci,j, Si,j entries}
  - [Number of Noise Frequencies] <nnf> (required if noise data, n=2 only)
  - [Begin Information]/[End Information] (block reserved for future use)

- Data block keywords
  - [Network Data] (required to begin network data)
  - [Noise Data] (required if noise data exists)
  - [End] (required – End of file)
Version 2.0 Block Arrangement

[Version] 2.0
# Option Line
[Number of Ports] <n>
plus keywords as req’d/needed

[Network Data]
More flexible formatted data

[Noise Data]
(optional for n=2 only)

[End]
Touchstone to Touchstone Version 2.0
(Single-ended S-parameters only)

• Add keywords around the option line as shown
  – [Version] 2.0
  – #(option line)
  – [Number of Ports] <n>

• Add keywords in any order
  – [Number of Frequencies] <nf>
  – [Two-Port Data Order] {21_12 | 12_21} (if n = 2)
  – [Mixed-Mode Order] {Si,j entries}
    • Optional for re-ordering ports

• Add keywords around the data block
  – [Network Data]
  – [End]
[Number of Frequencies] and [Two-Port Data Order]

• [Number of Frequencies] <nf> determination
  – Documentation
  – Count the frequencies or look at frequency interval and calculate nf
  – Calculate from word count (wc) of data block
    • wc = (2 n^2 + 1) * nf
  – Estimate nf and use tschk2 to calculate
    • No Error – correct nf
    • Error – tschk2 should report expected nf

• [Two-Port Data Order] {21_12 | 12_21}
  – Only for n=2
  – Normally 21_12 for Touchstone to Touchstone 2.0
Single-ended Port Re-ordering
[Mixed Mode Order]

• Optional
  – Assumes Touchstone 2.0 processor handles [Mixed Mode Order] for re-mapping of ports
  – Formulas in the Touchstone Version 2.0 Specification

• Examples - next slides
  – 8 port connector re-mapping of the ports
  – 4 port re-mapping of the ports
  – Argument **Position** applies to data block
  – Diagonal-of-matrix centric indices represent **Ports**
  – Tools can do tranforming by indexing
Connector Re-ordering: [Mixed Mode Order] S1 S3 S5 S7 S2 S4 S6 S8

[Mixed Mode Order] S1 S5 S2 S6 S3 S7 S4 S8
[Mixed-Mode Order] S1 S3 S4 S2
(SE-1 data re-ordered to SE-2)

SE-1 uses SE-2 data notation in matrix
Touchstone 2.0 to Touchstone

• If Touchstone 2.0 file formed with tool using compatible Touchstone format rules
  – Tool coding simplicity for dual export selection
  – Then just remove keywords to convert to Touchstone
• “[Matrix Format] Full” can exist and be removed
• “[Two-Port Data Order] 12_21” may require interchanging the 12 and 21 columns with spreadsheet or program to the 21_12 order
General Translations Probably Needs Conversion Tool

• Everything would work for Y-parameters and Z-parameters except
  – Normalization differences
  – Check EDA tool normalization assumptions

• General per-port reference impedance conversions probably needs software
General Conversion Utility

• Several EDA tools have built-in conversions
  – Y-, Z-, S-parameter interchanges or choices
  – Mixed mode interchange
  – Auto port re-numbering (per physical design)

• General conversion utility possible
  – Normalizations and conversions
  – Impose Touchstone format restrictions automatically
  – Some mixed-mode port re-ordering
  – [Matrix Format] Upper and Lower conversions
  – (Future – sparse matrix manipulation)
Closure

• 13 new keywords
• Conversion of S-parameter data in Touchstone / Touchstone 2.0 formats needed to support leading/lagging EDA vendors, file producers and legacy files
• Shorter term, simple addition or removal of keywords
• Longer term, a more general conversion utility?
• Touchstone 2.0 file reference checker/parser (tschk2) to promote industrial adoption