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)

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"Version 1.0" Fixed Format Examples (f = frequency, s = data-pair)

S1P

f s
f s
f s
f …

S2P

f s s s
f s s s
f s s s
f …

S3P

f s s s
s s s
s s s
f s s s
s s s
s s s
f …

S4P

f s s s s
s s s s
s s s s
s s s s
f s s s s
s s s s
s s s s
s s s s
f …

S5P

f s s s s
s
s s s s
s
s s s s
s
s s s s
s
s s s s
s
f …

S6P

f s s s s
s s
s s s s
s s
s s s s
s s
s s s s
s s
s s s s
s s
s s s s
s s
f …

Etc …

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

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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)

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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]**

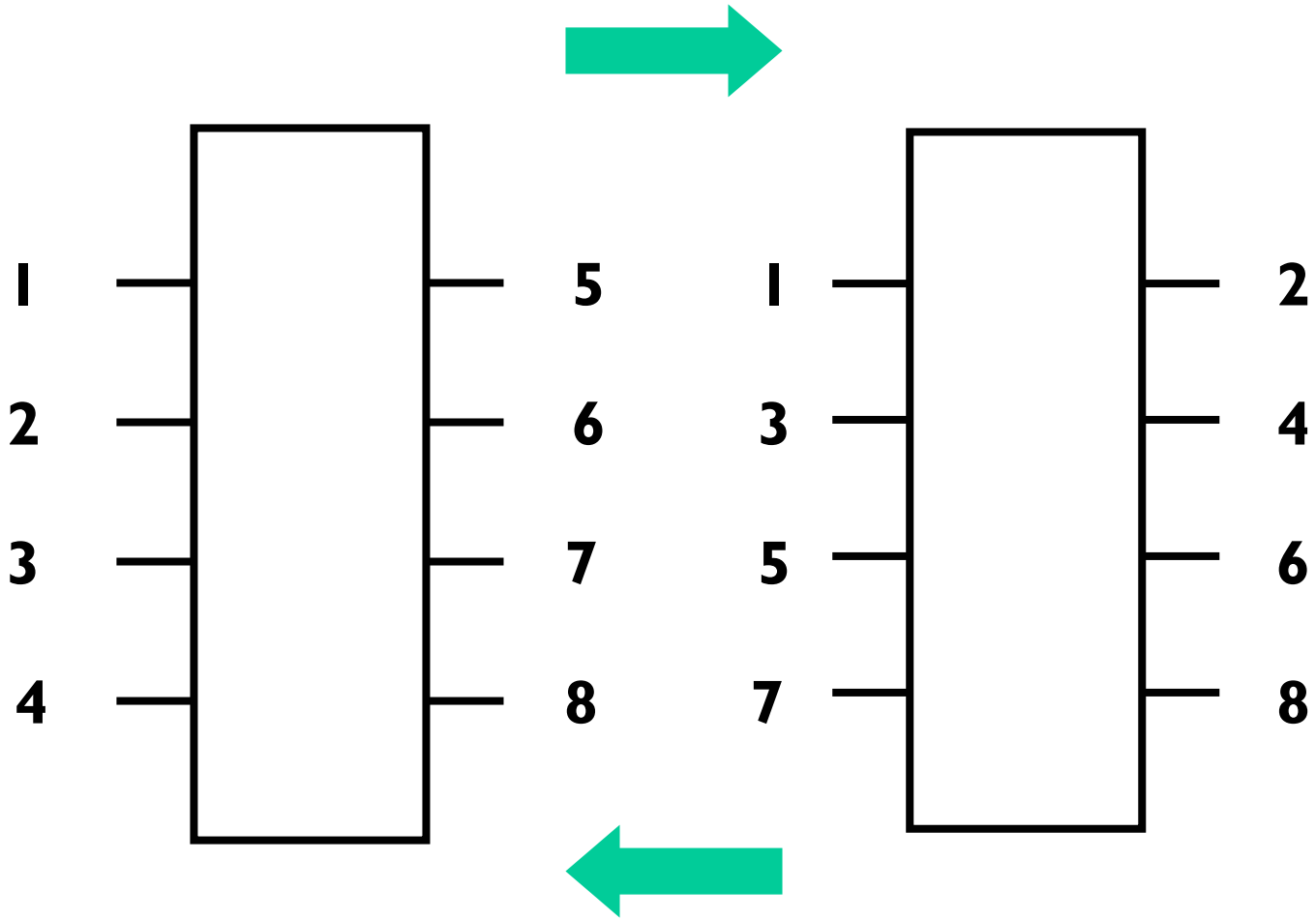
[Number of Frequencies] and [Two-Port Data Order]

- [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

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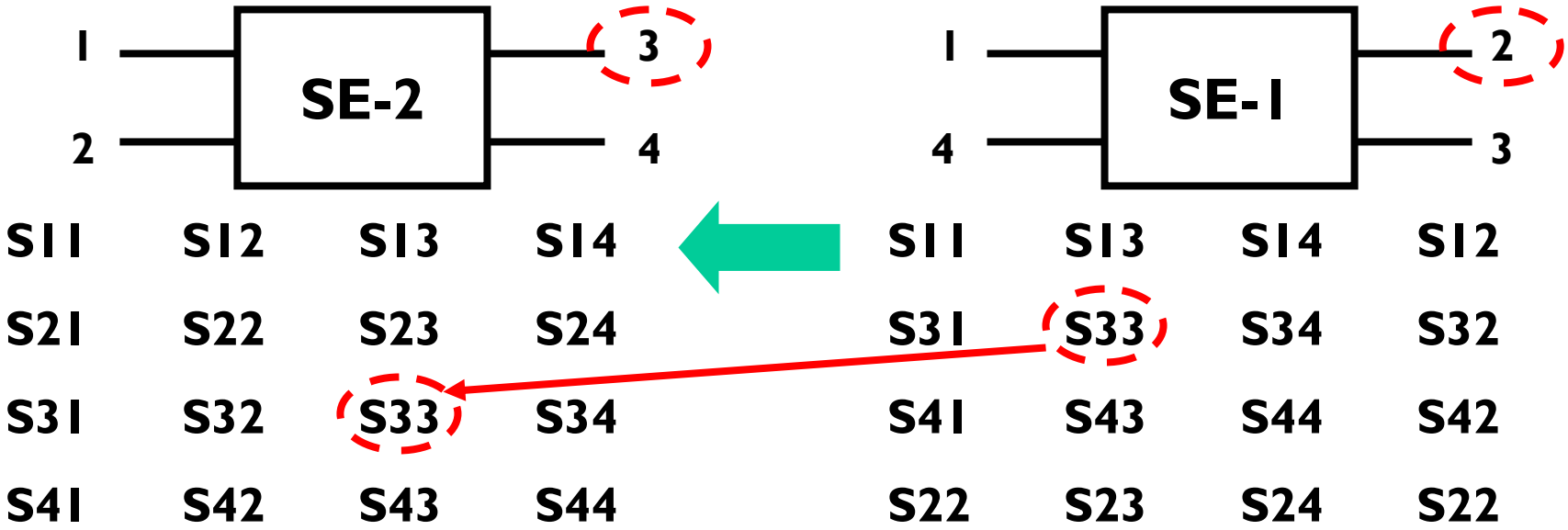
[Mixed-Mode Order] S1 S3 S4 S2 (SE-1 data re-ordered to SE-2)



pos	entry	SE-1
1	S1	1
2	S3	3
3	S4	4
4	S2	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)

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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