

Touchstone Version 2.0

Mixed-Mode Syntax - Updated

Bob Ross
bob@teraspeed.com
Asian IBIS Summit (Japan)
Tokyo, Japan
November 14, 2008

(Updated from November 11, 2008
Presentation in Shanghai, China)



Outline

- Background and Overview
- Generalized mixed-mode syntax
- (Abbreviations)
 - **SE:** single-ended
 - **MM:** mixed-mode for differential and common modes such as “Sdd11” or “Sdc12”
 - **GMM:** generalized mixed-mode for combination of SE and MM data



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Background

- Touchstone issued in 1984 by EEsof (now part of Agilent Technologies)
- Touchstone is an OPEN, de-facto format supported by nearly all companies supplying or handling S-parameter data
- Older Touchstone “Version 1.0” uploaded as public reference for ICM reference
 - <http://www.eda.org/ibis/connector/>
- Touchstone Version 2.0 extended to remove some format limitations and to add some resistance per port flexibility for PDS applications
 - <http://www.eda.org/pub/ibis/adhoc/interconnect/>



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Touchstone Version 2.0

Eight IBIS-like Keywords (so far)

- Required keywords
 - **[Version]** 2.0 (first keyword)
 - **[Number of Ports]** <n> (second keyword)
 - **[Two-Port Data Order]** {21_12 | 12_21} (for n=2 only)
 - **[Number of Frequencies]** <nf>
- Optional keywords
 - **[Reference]** <list of n reference resistances in port order>
 - **[Matrix Format]** {Full | Lower | Upper}
 - **[Mixed-Mode Order]** {Di,j, Ci,j, Si,j entries} (n entries)
 - **[Number of Noise Frequencies]** <nnf> (for n=2 only)
- Details (except [Mixed-Mode Order]) reported February, 2008
 - <http://www.eda.org/ibis/summits/feb08/ross1.pdf>



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“Version 1.0” Fixed Format Examples

(f = frequency, s = data-pair)

S1P

f s
f s
f 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
f ...

S5P

f 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 ...

S2P

f s s s s
f s s s s
f s s s s
f ...

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

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Version 1.0 Block Arrangement

Option Line
For example, # GHZ S MA R 50

N-port Data Block
(rigid format rules)
SE Data

Optional Noise Data Block
(n=2 only)



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Version 2.0 Block Arrangement

**[Version] 2.0 and [Number of Ports] <n>
Option Line and all other keywords**

**N-port Data Block
(flexible format, new line only for
each frequency)**

SE, MM or GMM data

**Optional Noise Data Block
(n=2 only)**



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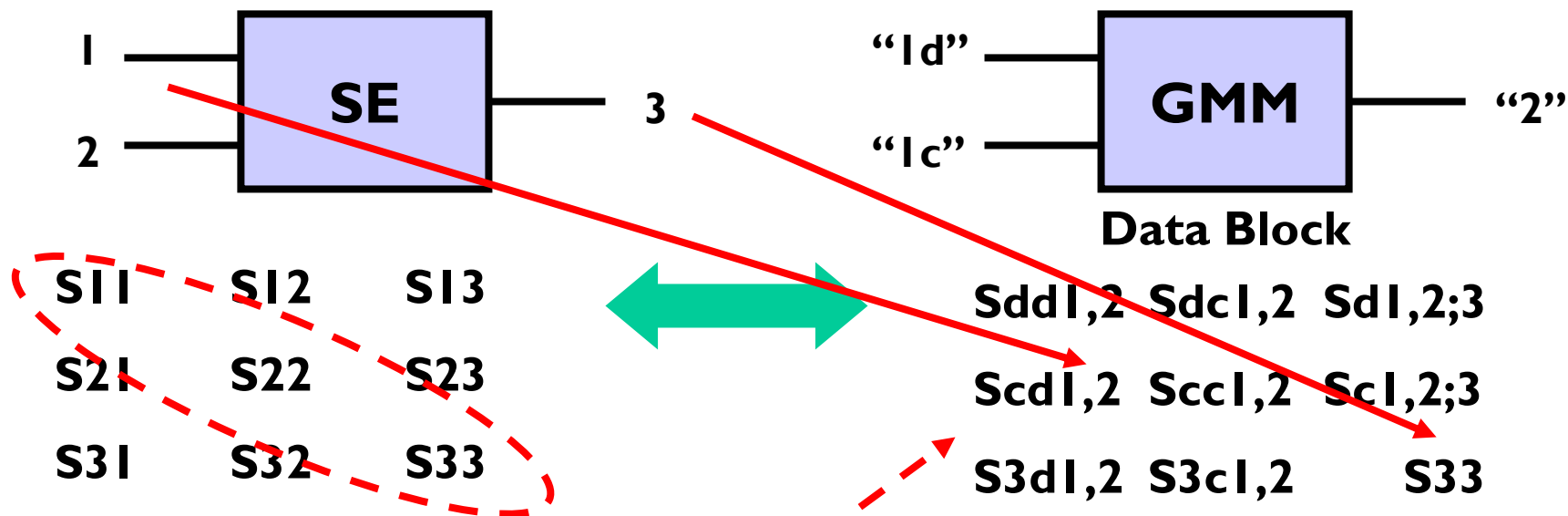
[Mixed-Mode Order] Keyword

- Applies for **S**, **Y**, **Z** n-port matrices
- Allows general **re-ordering** of ports (SE, MM, GMM)
- Main document (3 pages) and Appendix A (6+ pages) gives mathematical details
- Argument **port indices** are for new **SE ports**
 - **S<k> C<i,j> D<i,j>** for single-ended, common mode, and differential mode port numbers (1, ..., n)
- Argument **positions** apply to **data block**



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[Mixed-Mode Order] DI,2 CI,2 S3 (balun, splitter, op. amp. example)



"S" above means
n-port entry (S, Y,
or Z)

"S" argument
means Single-
ended

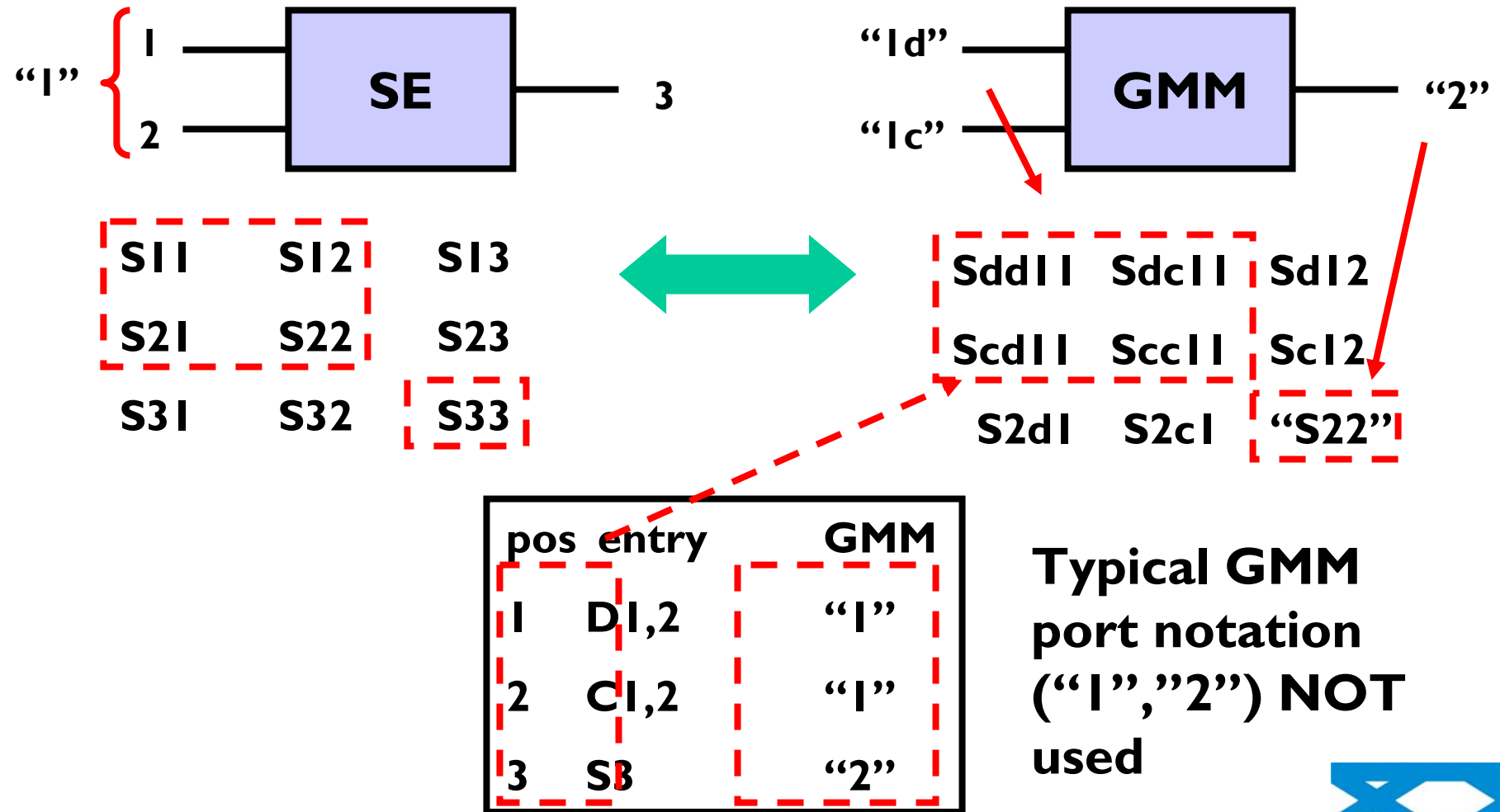
pos	entry	GMM
1	DI,2	1,2
2	CI,2	1,2
3	S3	3

SE port notation
in both blocks,
position gives
mapping

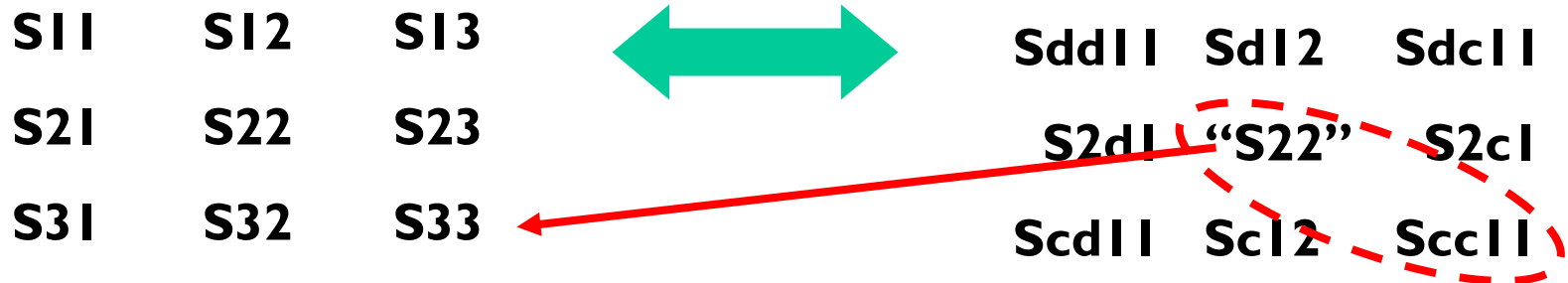
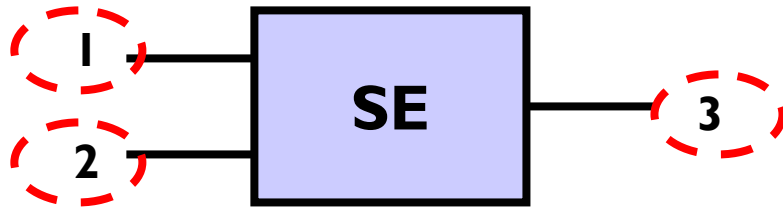


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[Mixed-Mode Order] D1,2 C1,2 S3 (with GMM port notation)



[Mixed-Mode Order] D1,2 S3 C1,2 (GMM data with new S3 C1,2 positions)



Interchange
2 and 3

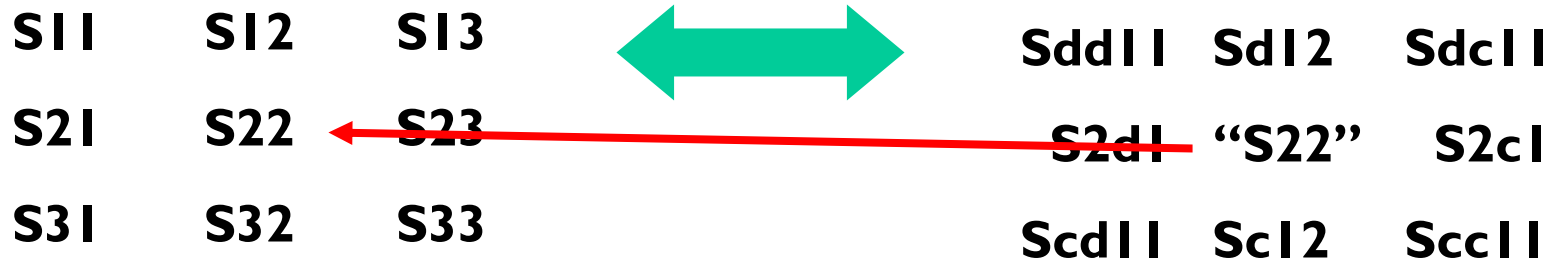
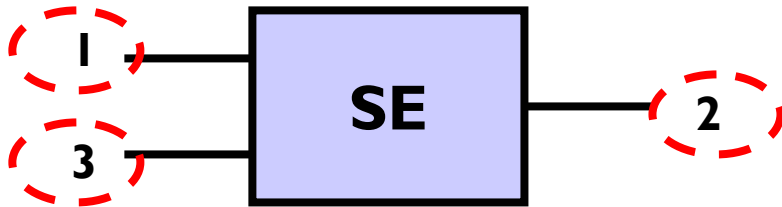
pos	entry	GMM
1	D1,2	"1"
2	S3	"2"
3	C1,2	"1"

**GMM data block
with different
positions "S22"
and "Sccl11"**



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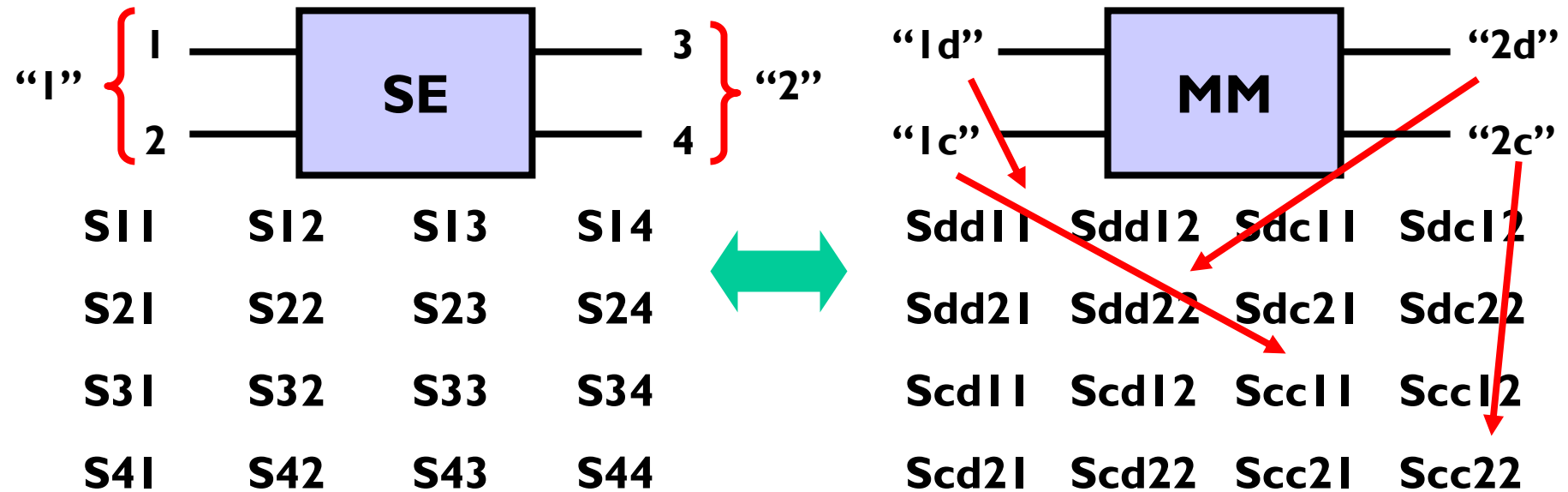
[Mixed-Mode Order] D1,3 S2 C1,3 (SE defined with new order)



pos	entry	GMM
1	D1,3	"1"
2	S2	"2"
3	C1,3	"1"

Mapping data
block to new SE
port order

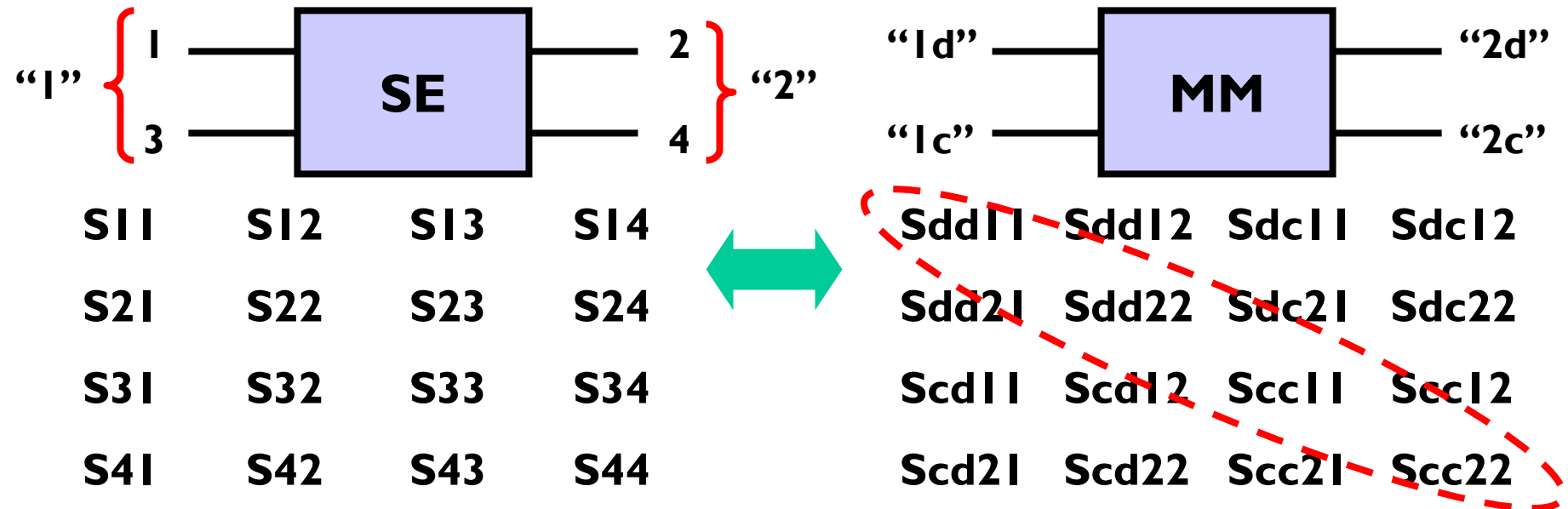
[Mixed-Mode Order] D1,2 D3,4 C1,2 C3,4 (1,2 and 3,4 port-pairs)



pos	entry	MM
1	D1,2	"1"
2	D3,4	"2"
3	C1,2	"1"
4	C3,4	"2"

**Diff Port notation
by position,
numbers for SE
ports**

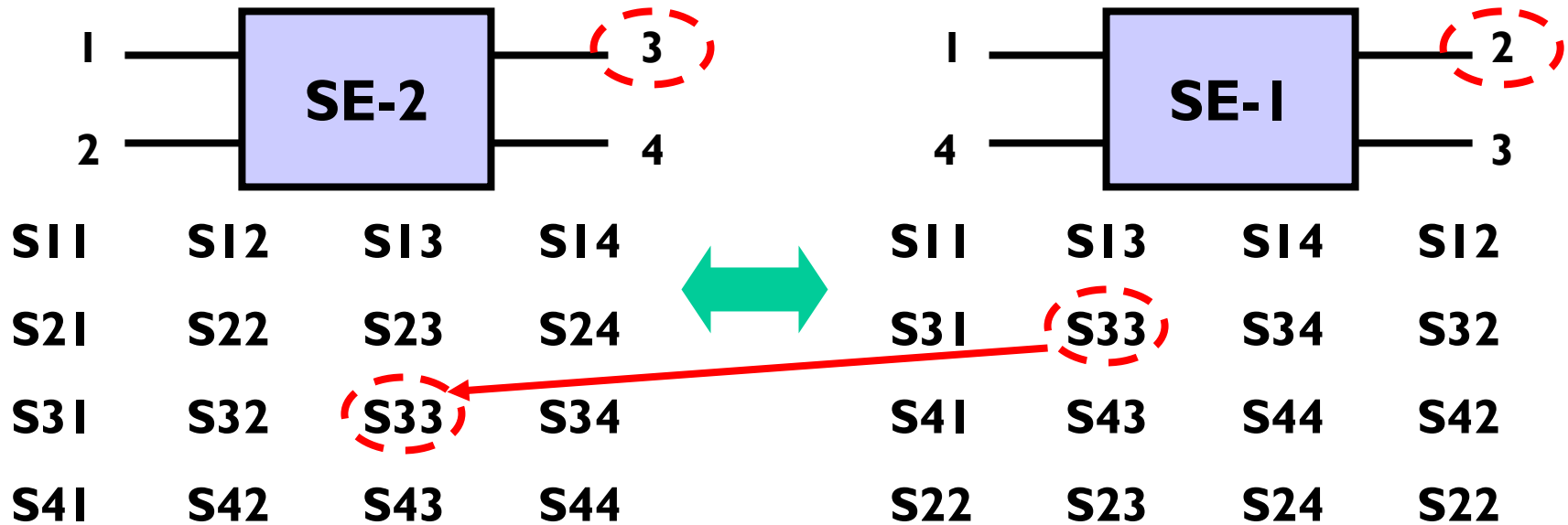
[Mixed-Mode Order] D1,3 D2,4 C1,3 C2,4 (1,3 and 2,4 port-pairs)



pos	entry	MM
1	D1,3	"1"
2	D2,4	"2"
3	C1,3	"1"
4	C2,4	"2"

Diff Ports
reference same
SE positions

[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

Closure

- Several EDA tools already implementing portions of the mixed-mode syntax
 - S, Y, Z parameters for n-ports
 - SE, MM, GMM capability
- Touchstone 2.0 provides standard, interchangeable GMM format when adopted by industry
- Minimal changes from Touchstone “1.0” and Touchstone 2.0 for easy bi-directional migration of tools over several years
- Some minor changes still being considered