Sparse Matrix Mapping in Future Touchstone 2.1

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Topics

- Brief Touchstone background through Version 2.0
- [Sparse Matrix Mapping] for Touchstone Version 2.1
  - Physical symmetry
  - Coincidentally identically data
  - Extrapolate to more ports based on physical symmetry

Touchstone Background and Update

- Touchstone issued 1984 by EEsof
  - Now part of Agilent Technologies
- Touchstone "Version 1.0" is widely used
- Touchstone Version 2.0 ratified by IBIS April 2009
  - Format rules relaxed
  - Resistance per port option for PDS
  - Mixed mode features for differential setups
  - http://www.eda.org/pub/ibis/touchstone_version2.0/
- Agilent Technologies contracted to produce tschk2 parser – available soon, free

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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)

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 frequency values.

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Touchstone Version 2.0
Thirteen IBIS-like Keywords - I

- Comments – starting with '!'
  - Start of line or in line until end of line
  - Within file or before [Version] or after [End]
  - Blank lines permitted

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

Touchstone Version 2.0
Thirteen IBIS-like Keywords -2

- Keywords in any order
  - **[Number of Frequencies]** <nf>
    - (required)
  - **[Two-Port Data Order]** {21_12 | 12_21}
    - (required for n=2 only)
  - **[Reference]** <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)

Touchstone Version 2.0
Thirteen IBIS-like Keywords - 3

- Data block keywords
  - **[Network Data]**
    - (required to begin network data)
  - **[Noise Data]**
    - (required if noise data exists)
  - **[End]**
    - (required at end of data)

Version 2.0 Block Arrangement

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

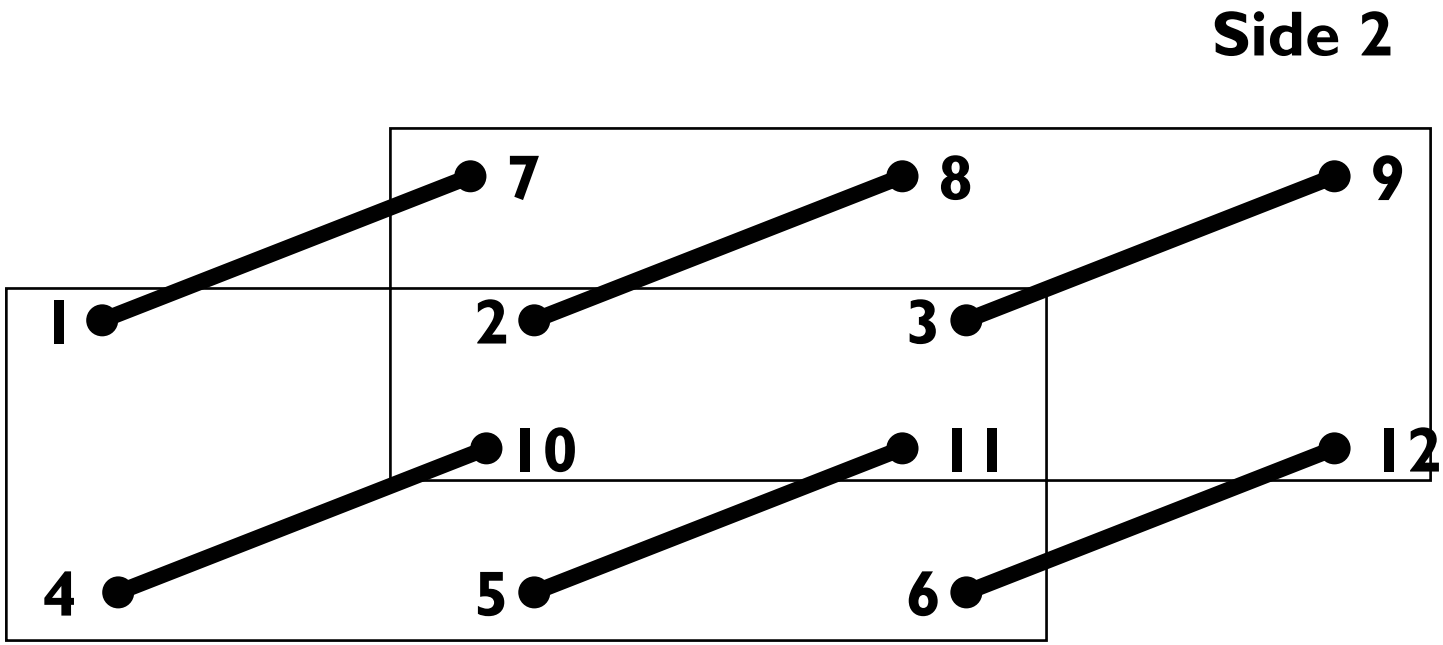
[Network Data]

More flexible formatted data

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

[End]

Example: PhysicallySymmetrical 2 by 3 Connector for Expansion



.pkg, .icm format illustrated next

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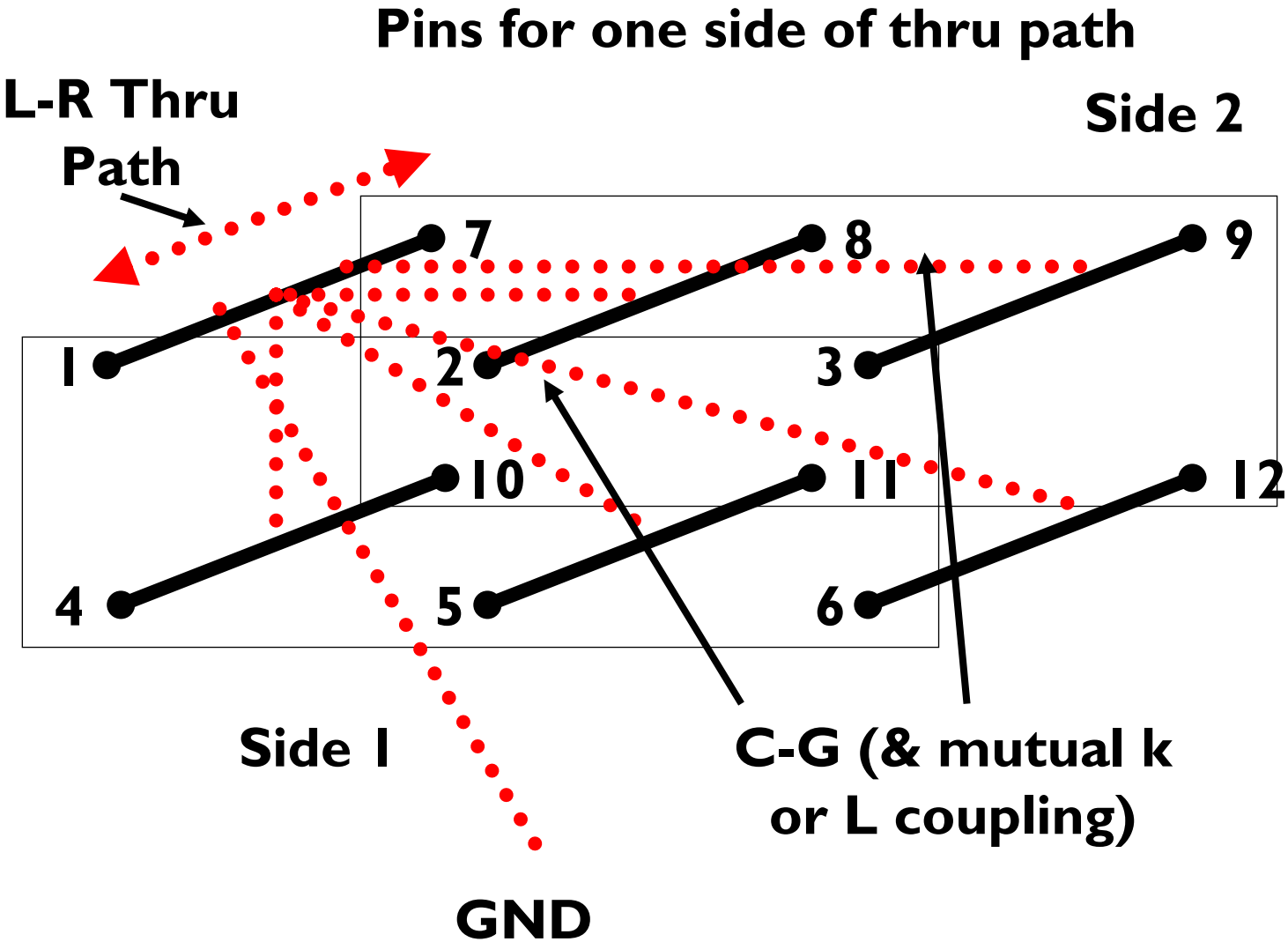
[Define Package Model] 6-pin LRC(G) from 1 to 6 and Thru Path 1-7



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6 pins in [Define Package Model] Sparse_matrix: list of R, L, C …

[Capacitance Matrix] Sparse_matrix
[Row] 1
1 6pF
2 -1pF
3 -1pF
4 -1pF
5 -1pF
6 -1pF
[Row] 2 | etc … through [Row] 6
2 6pF
3 -1pF

Etc.

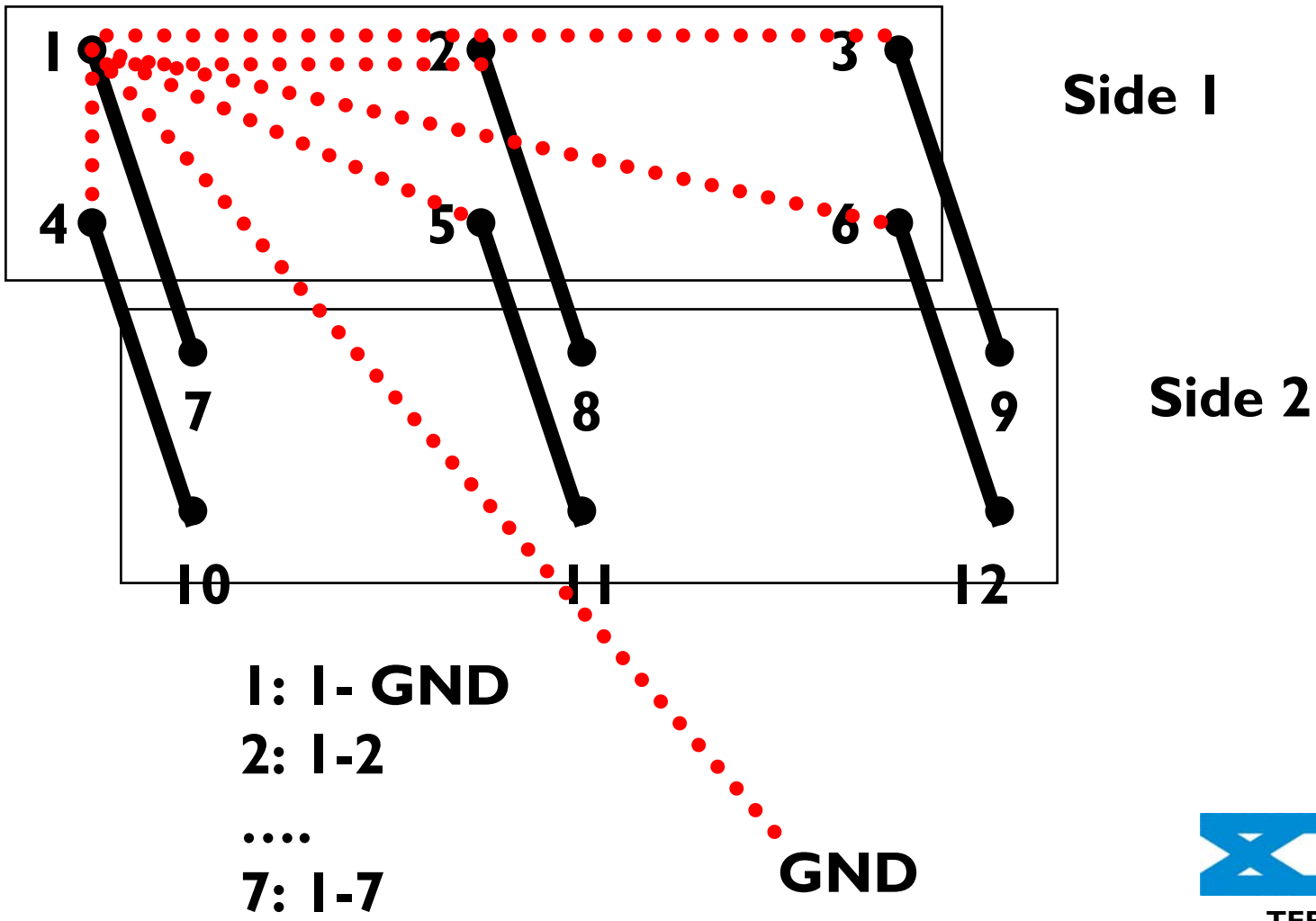
Common Format for .pkg and .icm for large package (e.g., 500 to 1000 pins)

Upper triangle (forward coupling) of single-frequency LRC(G) elements

[Sparse Matrix Mapping] Proposed in Version 2.1

- Before [Network Data]
  - **[Number of Sparse Labels]** <nl>
  - **[Sparse Matrix Mapping]** {integer-labels, index-pairs}
    - After **[Matrix Format],** if entered
    - Each integer-label locates a data-pair that can be mapped into one or more index-pair (row,column) positions in the N-port
- Data block keywords
  - **[Network Data]**
    - One data-pair column for each integer-label
  - **[End]**
- Fewer data-pairs under [Network Data]
  - Other keywords have same meaning

12-port Coupling (1: to 7:)
Physical Symmetry, Unique Coupling



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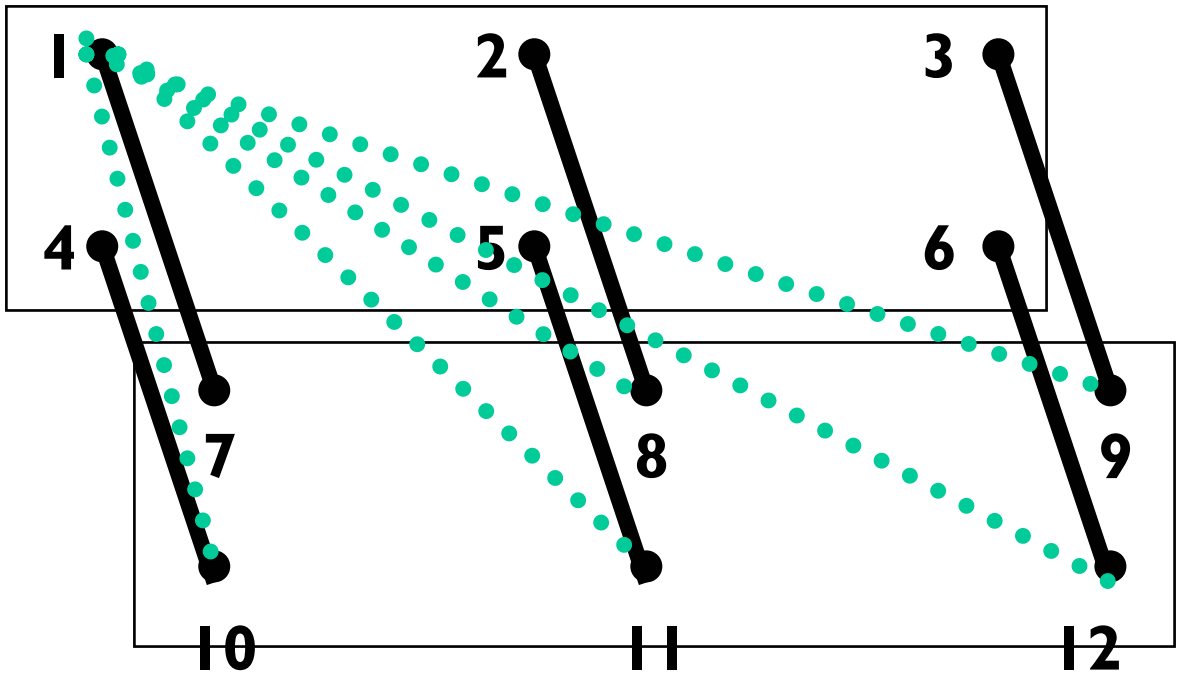
12-port Coupling (8: to 12:)
Physical Symmetry, Unique Coupling



8: 1 – 8

9: 1 – 9

….

12: 1 - 12

GND

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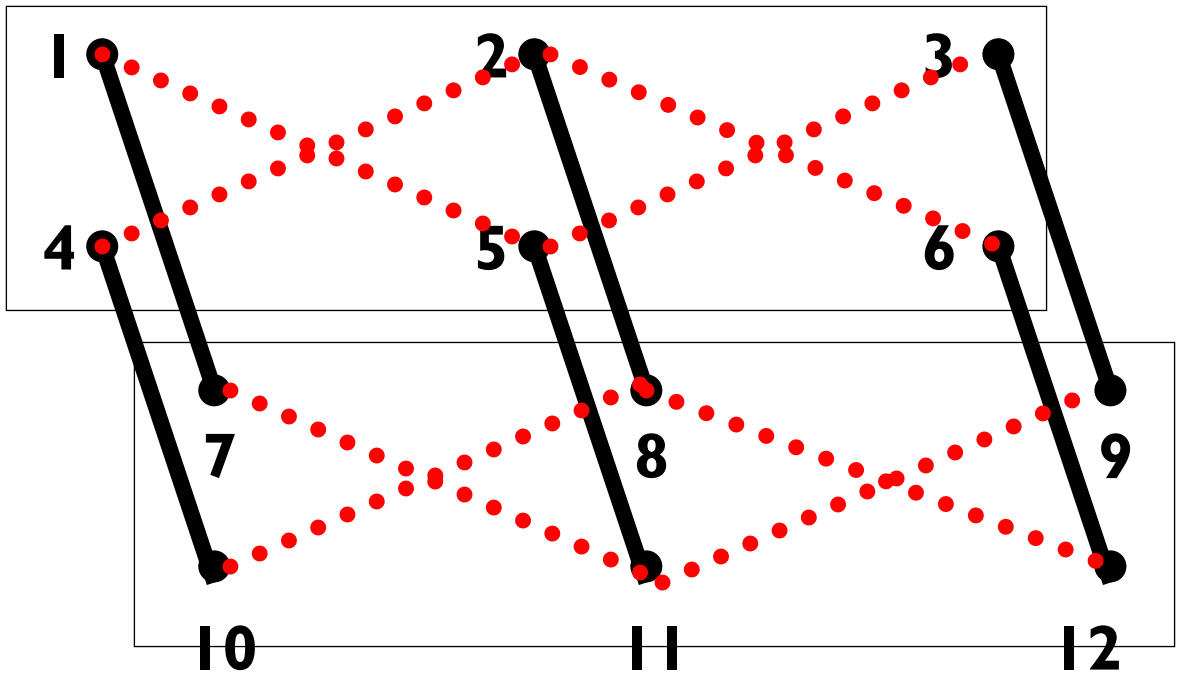
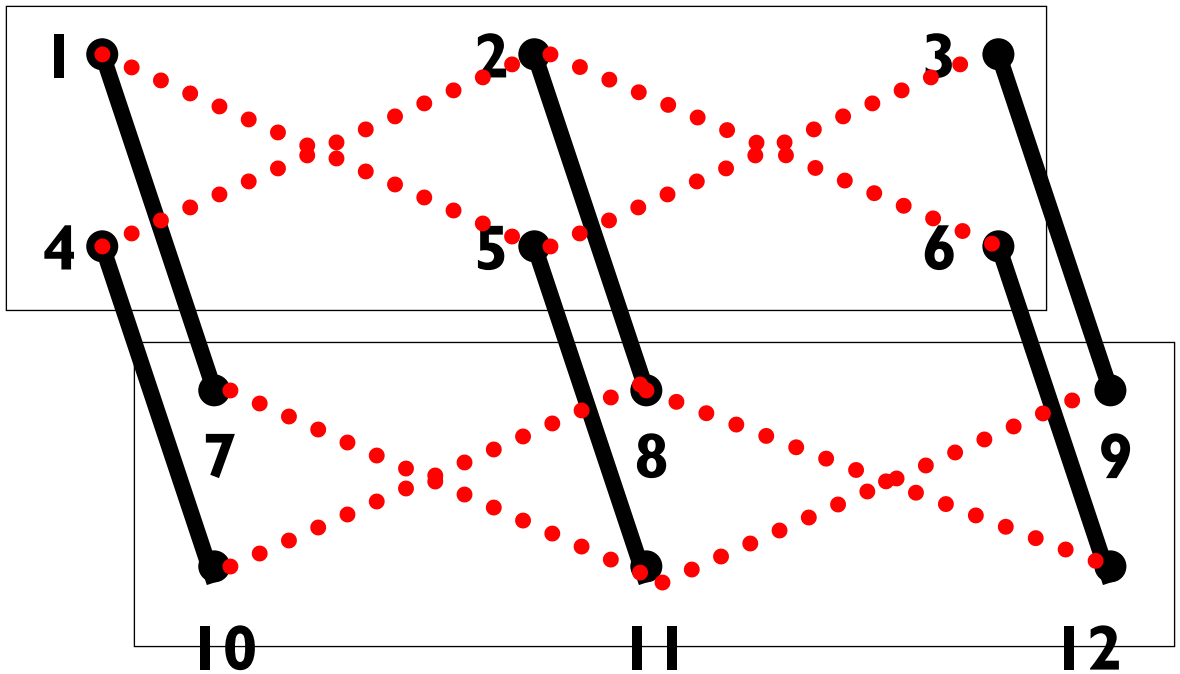
Integer-label '5:' 16 'index-pairs' to map to (row,column) of N-port



5: (1,5) (5,1) (2,4) (4,2) (2,6) (6,2) (3,5) (5,3)
(7,11) (11,7) (8,10) (10,8) (8,12) (12,8) (9,11) (11,9)

[Matrix Format] {Full | Upper | Lower} ('index-pairs')



Upper

5: (1,5) (2,4) (2,6) (3,5) (7,11) (8,10) (8,12) (9,11)

(5,1) (4,2) (6,2) (5,3) (11,7) (10,8) (12,8) (11,9)

Full

Lower

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2 by 3 Connector with 7 integer -labels and 7 data-pairs per Frequency

....

[Number of Ports] 12 ! Some keywords omitted

[Number of Sparse Labels] 7

[Matrix Format] Upper

[Sparse Matrix Mapping]

1: (1,1) (2,2) (3,3) (4,4) (5,5) (6,6) (7,7) (8,8) (9,9) (10,10) (11,11) (12,12)

2: (1,2) (2,3) (4,5) (5,6) (7,8) (8,9) (10,11) (11,12)

3: (1,3) (4,6) (7,9) (10,12) 4: (1,4) (2,5) (3,6) (7,10) (8,11) (9,12)

5: (1,5) (2,4) (2,6) (3,5) (7,11) (8,10) (8,12) (9,11)

6: (1,6) (3,4) (7,12) (9,10) 7: (1,7) (2,8) (3,9) (4,10) (5,11) (6,12)

[Network Data] ! Frequency and 7 data-pairs in MA format

<f1> <M1 A1> <M2 A2> <M3 A3> <M4 A4> <M5 A5> <M6 A6> <M7 A7>

[End]

6 Pin (12 Port) 2 by 3 Connector, Number of index-pairs per integer-label

[Matrix Format]	Upper or Lower		Full	
integer-labels	1: to 7:	1: to 12:	1: to 7:	1: to 12:
1:	12	12	12	12
2:	8	8	16	16
3:	4	4	8	8
4:	6	6	12	12
5:	8	8	16	16
6:	4	4	8	8
7:	6	6	12	12
8:		8		16
9:		4		8
10:		6		12
11:		8		16
12:		4		8
		[Sparse Matrix Mapping]		
index-pairs	48	78	84	144
(omitted)	30	0	60	0
		[Network Data]		
data-pairs	7	12	7	12
(available)	78	78	144	144

40 Pin (80 Port) 2 by 20 Connector

[Matrix Format]	Upper or Lower		Full	
integer-labels	1: to 7:	1: to 12:	1: to 7:	1: to 12:
1:	80	80	80	80
2:	76	76	152	152
3:	72	72	144	144
4:	40	40	80	80
5:	76	76	152	152
6:	72	72	144	144
7:	40	40	80	80
8:		76		152
9:		72		144
10:		40		80
11:		76		152
12:		72		144
		[Sparse Matrix Mapping]		
index-pairs	456	792	832	1504
(omitted)	2784	2448	5568	4896
		[Network Data]		
data-pairs	7	12	7	12
(available)	3240	3240	6400	6400

200 Pin (400 Port) 2 by 100 Connector

[Matrix Format]	Upper or Lower		Full	
integer-labels	1: to 7:	1: to 12:	1: to 7:	1: to 12:
1:	400	400	400	400
2:	396	396	792	792
3:	392	392	784	784
4:	200	200	400	400
5:	396	396	792	792
6:	392	392	784	784
7:	200	200	400	400
8:		396		792
9:		392		784
10:		200		400
11:		396		792
12:		392		784
		[Sparse Matrix Mapping]		
index-pairs	2376	4152	4352	7904
(omitted)	77824	76048	155648	152096
		[Network Data]		
data-pairs	7	12	7	12
(available)	80200	80200	160000	160000

Connector: 5 banks of 2 by 20 pins [Matrix Format] Upper, 1: to 7:

200 pins, banks of 40 pins each

- 456 index-pairs per 40 pin bank
- 2280 index-pairs for 5 banks
  - About 5 pages of auto-generated index-pairs
  - Not needed – 13,920 index-pairs for zeroed data-pairs
- 7 data-pairs, 7 integer-labels for 200 pins, 400 ports
- Fewer data-pairs than a full 3-port !!

Comments

- Format details still being discussed
- Port numbering shown in example was for simplicity
  - Any port ordering can be used
  - Some port orders simplify the expansion equations
- [Sparse Matrix Mapping] implies pre-processing step to move data into the full N-port
  - All other keywords apply to the N-port data
  - [Mixed-Mode Order] can also be used to re-order the ports

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Future [Sparse Matrix Mapping]

- Small files for large, physically symmetrical packages and connectors
- Advantages of N-port parameters
  - Many frequencies
  - More coupling modes and generality
  - One mapping for all frequencies
- Supports large packages with N-ports where the IBIS .pkg and .icm format is currently used
- For futureTouchstone Version 2.1

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