IBIS Interconnect Modeling Specification (ICM) Status

By

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Agenda

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ICM Refresher

- ICM = IBIS Interconnect Modeling Specification
- Purpose: to establish a human-readable standard format for exchanging interconnect modeling data
  - "Interconnect" can be connector, cable, PCB traces or even an IC package
- ICM uses a two-part format:
  - Description of model in terms of one or more sections with terminals mapped to named pin/node lists
    - *Nodal arrangement with explicit interconnections*
    - *Tree arrangement with implicit interconnections*
  - Electrical data describing each section
    - *RLGC matrix data*
    - *S-parameter data (external Touchstone® file)*

A Partial Example

Tree Description

```
[Begin ICM Model] MyModelExample7
ICM_model_type SLM_quiescent
[Tree Path Description]
  Model_pinmap = MyModelPinMapA
  Section Mult=1 SectionA
  Section Mult=1 SectionB
  Section Mult=1 SectionC
  Section Mult=1 SectionD
  Fork
    Section Mult=1 SectionF
    Model_pinmap MyModelPinMapB
  Endfork
  Section Mult=1 SectionE
  Model_pinmap MyModelPinMapC
  .
  .
  .
[End ICM Model]
```

Nodal Description

```
[Begin ICM Model] MyModelExample7
ICM_model_type MLM
[Nodal Path Description]
Model_nodemap Port1
N_section (A1 A2 A3 A4 A5 11 12 13 14 15) Len=1.0 A
N_section (11 12 13 14 15 21 22 23 24 25) Len=1.0 B
N_section (21 22 23 24 25 31 32 33 34 35) Len=1.0 C
N_section (31 32 33 34 35 s1 s2 s3 s4 s5) Len=1.0 D
N_section (s1 s2 s3 s4 s5 F1 F2 F3 F4 F5) Len=1.0 F
Model_nodemap Port3
N_section (s1 s2 s3 s4 s5 E1 E2 E3 E4 E5) Len=1.0 E
Model_nodemap Port2
[End ICM Model]
```

A more formal example is available at the end of this presentation…

ICM History

- Initial concept developed 1995 - 1997
  - IBIS Connector/Futures Subcommittee
- Sporadic revisions 1999 – 2002
- Internal Draft 1.0 released Sept. 19, 2002
- Committee Internal Drafts 1.0a – 1.0g
- Final Draft 1.0 released publicly May 16, 2003
  - See IBIS web site under “Connector Info”

What Changed in Final Draft 1.0

- Over 63 issues formally logged since Sept. 2002
  - More than two dozen additional small issues resolved
- Most changes were editorial
  - Spelling, punctuation and grammar
  - Standardization to improve software parsing
  - Name changes for consistency with IBIS 4.0
- Some technical limitations established
  - RLGC and S-parameter sections not permitted within the same model (allowed in the same file)
  - S-parameter data only to be used with [Nodal Path Description] keyword
  - Implicit use of single-ended ports for S-parameter data

More details under “Long-Term Issues”

Short-Term Future

- ICM now in IBIS Open Forum Review
  - Officially introduced at May 30 meeting
  - Minimum of three Open Forum meetings must consider the document before an official vote
  - Parser in development – tentatively available for initial testing after Open Forum approval
- Interested parties *strongly encouraged* to provide feedback and test models
  - Feel free to provide or construct ICM models using "favorite interconnects" for testing
  - Example: package which is inconvenient or impossible to describe using IBIS .PKG

Future Improvements

- After 1.0 is approved by the Open Forum, several technical issues may be considered for future revisions
  - Allow multiple types of data within a single [Begin ICM Model]/[End ICM Model] pair
    - Example: Include S-parameter AND RLGC data
  - Include frequency-dependence in RLGC data
    - Example: Matrix parameters for 1 MHz, 100 MHz, etc.
- A formal "BIRD-like" procedure will be established to document and process change proposals

Long Term Issues

- Using ICM with IBIS models
  - No explicit links to IBIS in ICM or vice-versa
  - Implied that data files are linked through tools
  - IBIS or ICM BIRDs for cross-referencing?
- Touchstone® and mixed-mode S-parameters
  - ICM maps section nodes to ports
  - Ports are implied to be single-ended
  - Touchstone® format establishes regular data format
    - *Comments, options, frequency and S, Y, Z, H, G data*
    - *Interpretation of data assumes single-ended (S12, etc.)*
  - Mixed-mode (SDD12, SCD22, etc.)?
    - *Some authors release mixed-mode Touchstone® files*
    - *Data format is standard, but interpretation is not*
  - *New Touchstone needed for mixed-/multi-mode?*

Long Term Issues

- ICM cookbook needed!
  - Need to provide guidance to model builders
  - Take approach from 1997 IBIS 2.1 Cookbook
- Cookbook topics
  - Summary of keywords
  - Explanation of key concepts
    - *Ground references*
    - *Return paths*
  - Summary of best known modeling methods
    - *Measurement vs. simulation*
  - Several complete examples

Summary

- ICM is an evolution of IBIS package and PCB modeling formats
- Official 1.0 pending Open Forum approval
  - *Please review the ICM Final Draft*
  - *Comments and test models are appreciated!*
- Thanks to the Connector Subcommittee

John Angulo
Kelly Green
Lynne Green
Arpad Muranyi
Augusto Panella
Stephen Peters
Bob Ross

and to the many other individuals and groups who contributed!

Questions and Free Discussion

BACKUP

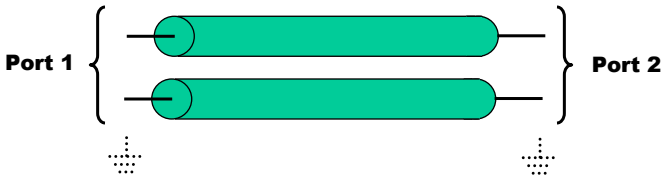
S-parameter Data Formats

- **Single-ended**
  - Data defined per node + reference: S12, S21
- **Mixed-mode (usually differential pairs)**
  - Common & Differential excitation and response
  - Data defined per node pair: SDD12, SDD21
  - Data defined per node pair + reference: SCC11
- **“Multi-mode” (not covered by any spec.)**
  - Excitation and response for n-node groups
  - Example: $SD_{12}C_{458}$

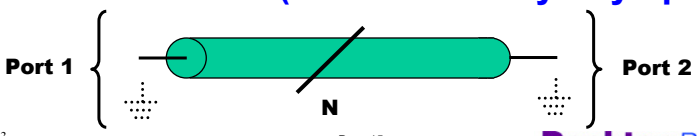
S-parameter Data Formats

- Single-ended

- Mixed-mode (usually differential pairs)



- "Multi-mode" (not covered by any spec.)



Touchstone® Variations

- Spec. defines data placement convention

```
! 4-port S-parameter data, taken at three frequency points
# GHZ S MA R 50
5.00000 0.60 161.24 0.40 -42.20 0.42 -66.58 0.53 -79.34 !row 1
```

```
4-port network description
<frequency value>  <N11> <N12> <N13> <N14>
<N21> <N22> <N23> <N24>
<N31> <N32> <N33> <N34>
<N41> <N42> <N43> <N44>
```

- Many model authors use general format, but define data placement through comments

```
# MHz  Y MA R 50
! Data is Freq SDD11   SDD12   SDD21   SDD22
!              SCC11   SCC12   SCC21   SCC22
10 1.7784797E-01   -80.863279   1.7863314E-01   99.053834
   3.8696562E-02   104.003821   3.8770346E-02   -76.072136
   2.4735915E-07   151.207214   2.4624379E-07   -29.142657
   3.1760443E-07   -166.479698  3.1562825E-07   13.585246
```

ICM Example

```
[Begin Header]
[ICM Ver]              1.0
[File Name]            iconm_hdi_202.icm
[File Rev]             1.0
[Date]                 May 29, 2003
[Source]               Results from field simulation
[Notes]                This is a test model only.
[Disclaimer]           This information is for modeling
                       purposes only, and is not guaranteed.
[Copyright]            Copyright 2003, XYZ Corp.,
                       All Rights Reserved
[Support]              http://www.VendorNameIbisModels.com
[Redistribution]       Yes
[Redistribution Text]  This file is freely redistributable.
[End Header]
```


ICM Example (2)

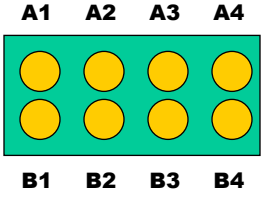
```
[Begin ICM Family]     High_Speed_Interconnect
[Manufacturer]         XYZ Incorporated
[ICM Family Description]
High Density square pin connector for use on IEEE 99999 buses.
|=====================================================================
[ICM Model List]
|   Name                  Mating       Min_Slew_Time          Image
|---------------------------------------------------------------------
My ModelExample3          Mated          100ps  HDI_202_Mated.jpg
|HDI_202_UnMatedA         Unmated_side_A 100ps  HDI_202_UnMatedA.jpg
|HDI_202_SMT_to_Cable     Mated           25ps  HDI_TEST_202_Mated.jpg
|HDI_202_SMT_to_ThruHole  Mated           25ps  HDI_202_Mated.jpg
|=====================================================================
```

ICM Example (3)

```
[Begin ICM Model] MyModelExample3          | Has a stub fork!
  ICM_Model_Type MLM
[Begin ICM Model Description]
High Density 0.1 center square pin with PCB effects
[Tree Path Description]
  Model_PinMap Baseboard_side
  Section Mult=1 SectionA
  Fork
    Section Mult=1 StubSection1
  End_fork
  Section Mult=1 SectionB
  Model_PinMap Output_side
[End ICM Model]
|                              SectionA  SectionB
|           Baseboard_side >----------+---------< Output_side
|                                     |
|                                     | StubSection1
```


ICM Example (4)

```
[ICM Pin Map] Baseboard_side
Pin_order = Row_ordered
Num_of_columns = 4
Num_of_rows = 2
Pin_list
|Pin   Name
  A1   PERR#
  A2   STOP
  A3   AD12
  A4   AD15
  B1   STOP
  B2   GND
  B3   PAR
  B4   GND
|[ICM Pin Map] Output_side omitted for clarity
[End ICM Family]
```



ICM Example (5)

```
|------------------------------------------------------------
[Begin ICM Section] SectionA
[Derivation Method] Lumped
[Inductance Matrix] Full_matrix
[Row]    1
3.04859e-07      4.73185e-08      1.3428e-08      6.12191e-09
1.74022e-07      7.35469e-08      2.73201e-08      1.33807e-08
[Row]    2
3.04859e-07      4.73185e-08      1.3428e-08      7.35469e-08
1.74022e-07      7.35469e-08      2.73201e-08
|.
|.
|.
```


ICM Example (6)

```
[Capacitance Matrix] Sparse_matrix
[Row]    1
1        2.48227e-10
2        -1.56651e-11
5        -9.54158e-11
6        -7.15684e-12
[Row]    2
2        2.51798e-10
3        -1.56552e-11
5        -6.85199e-12
6         -9.0486e-11
|.
|.
[End ICM Section]
| SectionB and StubSection1 omitted for clarity
[End]
```