# **IBIS Package Proposal**

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  - [Begin Package Model]
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# **Decisions Made**

Decisions Made	In .ibs	In EMD
Connectors	No	Yes
Cables	No	Yes
Broadband EBD	No	Yes
MCM	No	Yes
Interposers	No	Yes
3-D structures	No	Yes
Stacked Memory	No	Yes
Splits/Joins of Signal (I/O) in Package or Die	No	Yes
RDL as separate element	No	Yes
New list of supply (PDN) die pads	Yes	Yes
Separate package and on-die interconnect model	Yes	Yes
Package model can include on-die model	Yes	Yes
Broadband I/O Package Modeling	Yes	Yes
Package PDN	Yes	Yes
Broadband I/O On-Die Modeling	Yes	Yes
On-Die PDN	Yes	Yes
Interconnect coupling (crosstalk) between I/O and I/O	Yes	Yes
Interconnect coupling between I/O and PDN	Yes	Yes
Optical Interconnect	No	No

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# What These Decisions Mean

- For signal (I/O) pins there is a one to one correspondence between Pin Number, Die Pad, and Buffer.
- There is a Few to Many or Many to Few relationship between supply (PDN) pins and supply die pads, and buffer Pullup, Pulldown, Power Clamp and Ground Clamp Reference terminals.
- There MAY be a one to one correspondence between signal (I/O) Pin Numbers and Signal Names (IBIS 6.0 is not clear on this).

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### **Intent of this Proposed Syntax**

During 2013 the IBIS Package ad hoc committee had numerous meetings to determine the package and on-die interconnect needs of the IC Vendor and User community.

This is a proposed syntax that satisfies the package and on-die interconnect modeling requirements agreed to in IBIS-ATM meetings as well as alternative methods of associating interconnect models with Model Names and Model Types that satisfy the needs of the IC Vendor and User community expressed in the IBIS Package ad hoc committee.



# [Begin Package Models], [End Package Models]

Keyword: [Begin Package Models]/[End Package Models]

Required: No

*Description:* New Section within [Component] containing IBIS-ISS Package and On-Die interconnect models

Sub-Params: None

*Usage Rules:* This section within [Component] contains one or more package or on-die interconnect models. [Begin Package Models] is terminated by [End Package Models].

Example::

[Begin Package Models]



# [Begin Package Model]/[End Package Model]

Keyword:[Begin Package Model], <Package Model Name>Required:NoDescription:New Section within [Begin Package Models] that defines aninterface to a IBIS-ISS subckt or Touchstone File.

Sub-Params: Language, File, Subckt, Parameter, Ports

Usage Rules: This section within [Begin Package Models] defines an interface to a IBIS-ISS subckt or Touchstone File. The sub-parameters under [Begin Package Model] are terminated with [End Package Model]

Example::

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[Begin Package Models] [Begin Package Model] DQ1

[End Package Model] [Begin Package Model] DQ2

[End Package Model] [End Package Models]



### Language

 Sub-parameter:
 Language <language>

 Required:
 Yes

 Description:
 Language is either IBIS-ISS or Touchstone

 Usage Rules:
 This sub-parameter within [Begin Package Model] determines

 if the model is a IBIS-ISS subckt or a Touchstone file

 Examples:

 [Begin Package Model] DQ1

 Language IBIS-ISS

[End Package Model]

[Begin Package Model] DQ2 Language Touchstone



### File

Sub-parameter: File <format> <file name> {<file name> <file name> }

Required: Yes

Description: Defines the file(s) used by this package model

*Usage Rules:* <format> is either Value, DelayCorner, XtalkCorder or DelayXtalkCorder. If <format> is Value, then requires one <file name>. If <format> is DelayCorner or XtalkCorder, then requires three <file name>s. If <format> is DelayXtalkCorder, then requires nine <file name>s. If Language is Touchstone then the file(s) shall be a Touchstone I or II file.

Examples:

[Begin Package Model] DQ2 Language IBIS-ISS File Value DQ2\_.iss

[End Package Model]

[Begin Package Model] DQ3 Language Touchstone File DelayCorner DQ3\_Typ.s2p DQ3\_Slow.s2p DQ3\_Fast.s2p Parameter FBASE Value 100Meg Parameter FMAX Value 10G



### Subckt

Sub-parameter: Subckt <format> <subckt name> {< subckt name> < subckt name> } Required: Yes, if Language IBIS-ISS Description: Defines the subckts (s) used by this IBIS-ISS package file Usage Rules: <format> is either Value, DelayCorner, XtalkCorder or DelayXtalkCorder. If <format> is Value, then requires one <subckt name>. If <format> is DelayCorner or XtalkCorder, then requires three < subckt name>s. If <format> is DelayXtalkCorder, then requires nine < subckt name>s.

Examples:

[Begin Package Model] DQ1 Language IBIS-ISS File Value DQ1.iss Subckt DelayCorner DQ1\_Typ DQ1\_Slow DQ1\_Fast

[End Package Model]

[Begin Package Model] DQ2 Language IBIS-ISS File Corner DQ2\_Typ.iss DQ2\_Slow.iss DQ2\_Fast.iss Subckt Value DQ2



### **Parameter**

Sub-parameter: Parameter <parameter name> <format> <value> < value> ...

Required: No

Description: Defines a parameter passed to an IBIS-ISS subckt instance

Sub-Params: None

*Usage Rules:* <parameter name> is the name of a parameter passed to an IBIS-ISS subckt instance. Language must be IBIS-ISS. <format> is either Value, DelayCorner, XtalkCorder or DelayXtalkCorder. If <format> is Value, then requires one < parameter name>. If <format> is DelayCorner or XtalkCorder, then requires three < parameter name>s. If <format> is DelayXtalkCorder, then requires nine < parameter name>s. There may be none, one, or any number of Parameter keywords within a [Begin Package Model]

Examples:

[Begin Package Model] DQ1 Language IBIS-ISS File Value DQ1.iss Subckt Value DQ1 Parameter Length Value 1.3 Parameter Wline DelayCorner 'wline\_typ' 'wline\_fast' 'wline\_slow'



# **Corner Formats**

- DelayCorner
  - Typ Min Max
  - Typ Typical Delay
  - Min Delay (Fastest)
  - Max Max Delay (Slowest)
- XtalkCorner
  - Typ Min Max
  - Typ Typical Delay
  - Min Min Crosstalk Coupling
  - Max Max Crosstalk Coupling
- DelayXtalkCorner
  - TypTyp TypMin TypMax MinTyp MinMin MinMax MaxTyp MaxMin MaxMax
    - MinMax Min Delay Max Crosstalk Coupling



### **Enhanced Parameter Formats**

Other possible <formats> that can be considered are:

Gaussian <mean> <sigma> IntegerRange <min> <max> RealRange <min> <max> PDF <value> <probability> <value> <prob.> <value> <prob.> ... List <value> <value> <value> <value> <value> ... Each <format> requires a definition of "Typ"

Corner	<typ></typ>	
Gaussian	<mean></mean>	
IntegerRange	( <min>+<max>)/2.</max></min>	(round down)
RealRange	( <min>+<max>)/2.</max></min>	
PDF	Mean Median Mode	
List	FirstValue   MiddleVal	lue

Three types of Parameter Value Selection

1. All Parameters are Typ

This is the current IBIS Package Modeling capability

- 2. Corner Parameter are Typ|Slow|Fast (rest are Typ) Compatible with rest of IBIS using (Typ Min Max)
- 3. User/EDA tool can select any allowed value for each Parameter "AMI Flexibility" to support more than 3 corners, DOE, ...



### **Ports**

Sub-parameter:Ports <port> <port>

*Description:* Defines the node names associated with the Ports (Terminals) of an IBIS-ISS subckt or a Toushtone file

Usage Rules: Ports must be allowed <port> names that correspond to either a Component Pin, Component Die Pad, or Buffer Terminal. The order of the <ports> shall be the order of the Terminals of the IBIS-ISS subckt or Touchstone file. There may be more than one Ports keyword in a [Begin Package Model] . If there are more than one Ports record in a [Begin Package Model], then subsequent Ports records after the first Port record shall be considered continuation lines, and the <ports> shall be concatenated.

Note that the <port> names are used to associate nodes in the package model subckt instance, and are not the names of the nodes within the subckt itself. If we want to allow these names to be the node names inside of the subckt, then the syntax for <port> will need to be revised to be IBIS-ISS node name compliant.

Example::

Ports Pin.A7 Buf.A7



### Sparse\_Ports

Sub-parameter: Sparse\_Ports <port #> <port > <port \*> <po

#### Required: No

*Description:* Defines the node names associated with the Ports (Terminals) of an IBIS-ISS subckt or a Touchtone file

*Usage Rules:* Sparse\_Ports must be followed by port number and port names pairs. The port number must be a positive integer numerically less than or equal to the number of ports in the subckt, or Touchstone file. A port number may appear only once in the list of pairs. The port name must correspond to either a Component Pin, Component Die Pad, or Buffer Terminal. There may be more than one Sparse\_Ports keyword in a [Begin Package Model]. If there are more than one Sparse\_Ports record in a [Begin Package Model], then subsequent Sparse\_Ports records after the first Port record shall be considered continuation lines.

Example::

Sparse\_Ports 27 Pin.A7 54 Buf.A7



# Ports is Ports

- Package and On-Die interconnect models are between component pins, die pads and/or buffer model terminals.
- There is a 1:1 relationship between signal (I/O) Pins, Die Pads and Buffer signal terminals.
- Proposed Port naming convention uses strings Pin, Pad, Buf to indicated if component pin, die pad or buffer terminal respectively.
- Buffer models also have supply and control terminals.
- In general, there are a different number of supply (PDN) pins, supply die pads, and buffer supply terminals.



### Signal (I/O) Port Naming Rules

#### Pin I/O

Pin.<pin\_number> Pin\_Mod.<model\_name>.<n> Pin\_Mod+.<model\_name>.<n> Pin\_Mod-.<model\_name>.<n>

#### Die Pad I/O

Pad.<pin\_number>: Pad\_Mod.<model\_name>.<n> Pad\_Mod+.<model\_name>.<n> Pad\_Mod-.<model\_name>.<n>

#### **Buffer Terminal I/O**

Buf.<pin\_number> Buf\_Mod.<model\_name>.<n> Buf\_Mod+.<model\_name>.<n> Buf\_Mod-.<model\_name>.<n>

Notes: +/- indicate non-inverting/inverting side of differential pairs Ports with same <n> are connected

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### Model Type Package Models

Pin I/O

Pin\_Type.<type>.<n> Pin\_Type+.<type>.<n> Pin\_Type-.<type>.<n> Pad I/O Pad\_Type.<type>.<n> Pad\_Type+.<type>.<n> Pad\_Type+.<type>.<n> Buf\_Type.<type>.<n> Buf\_Type+.<type>.<n> Buf\_Type+.<type>.<n> Buf\_Type+.<type>.<n>

- Notes
  - <type>
    - I Buffers that can be Input
    - O Buffers that can be Output
    - IO Buffers that can be either Input or Output
  - Ports with same <n> are connected
  - All Ports with same <n> must have same <type>



# Package Precedence Rules

- 1. Match by Pin, Pad, and Buf Ports
- 2. Match by Pin\_Mod, Pad\_Mod, Buf\_Mod Ports
- 3. Match exactly by I, O, IO Ports
  - I Input
  - O Output IO I/O
- 4. Match by I, O, IO Ports
  I Input or I/O
  O Output or I/O
  IO Input, Output, I/O



## **Example Default Model**

[Begin Package Models]

[Begin Package Model] Single\_Ended Language Touchstone File DelayCorner SE\_Typ.s2p SE\_Fast.s2p SE\_Slow.s2p Ports Pin.IO.1 Buf.IO.1 [End Package Model]

[Begin Package Model] Differential Language Touchstone File DelayCorner Diff\_Typ.s4p Diff\_Fast.s4p Diff\_Slow.s4p Ports Pin.IO+.1 Pin.IO-.1 Buf.IO+.1 Buf.IO-.1 [End Package Model]



## Supply (PDN) Port Naming Rules

### Pin PDN

Pin.<pin\_number>
Pin\_Sig.<signal\_name>

### **Die Pad PDN**

Pad.<die\_supply\_pad\_name> Pad\_Sig.<signal\_name>

| Supply (Power/Ground) Signal Name

### **Buffer Terminal Supply (PDN)**

Buf\_PUR.<pin\_number> Buf\_PDR.<pin\_number> Buf\_PCR.<pin\_number> Buf\_GCR.<pin\_number> Buf\_EXTREF.<pin\_number> Buf\_Sig.<signal\_name> | Pullup Reference
| Pulldown Reference
| Power Clamp Reference
| Power Clamp Reference
| External reference voltage port
| Supply (Power/Ground) Signal Name



### **Unconnected Port Naming Rules**

**Several Options** 

R.<value>

Connect this node to GND with a resistance of <value>

<value> can be either

Non-negative IBIS number

Treated as Resistance in Ohms

Blank

Can only be used when Language Touchstone Simulator shall use the Tstonefile reference resistance of the port in ohms.

S.<file>.<subckt>

<subckt> shall be a single Port sub-circuit in IBIS-ISS <file>

0 (Zero)

If Language is IBIS-ISS If Language Touchstone

Equivalent to R.1Meg Tstonefile reference resistance of the port in ohms.

For Sparse\_Ports, will need an additional parameter: Unused\_Port\_Termination 0 | R.<value> | S.<file>.<subckt>



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### **Miscellaneous Port Rules**

The model creator is responsible for the data in each package model (Language, File, Subckt, Parameter, and Ports) are consistent and follow the following rules:

- Package Models may have the following combinations of Ports:
  - Pins and Pads (Package only models)
  - Pads and Buffer(On-Die only Models)
  - Pins and Buffer (combined package and on-die models.
  - Pins, Pads and Buffer
- There may be independent signal (I/O) and supply (PDN) package models.
- Coupled (crosstalk) package models may contain some channels (signals) that ports are specified by pin number (e.g. Pin.A7), and other channels (signals) are specified by Model Name or Model Type (e.g. Pin\_Mod.DQ.2, Pin\_IO.IO.3)

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# **Crosstalk Victims/Aggressors**

- Coupled crosstalk interconnect models have some channels that are strongly coupled to many channels, while some channels are strongly coupled to few channels.
- EDA tool will need to know which channels do have full crosstalk, and which channels should be treated as aggressors.
- This is supported in this proposed syntax by inserting the letter "V\_" at the beginning of each port name that should be treated as a Victim. E.g.
  - Ports Pin.A6 V\_Pin.A7 Pin.A8 Buf.A6 V\_Buf.A7 Buf.A8



# While we are at it

- Allow all Pin Names (aka Pin number) in IBIS Component and EBD to be more than 8 characters.
  - Pin\_names in [Pin List] cannot exceed 8 characters
  - Pin names in [Pin] cannot exceed 5 characters
- Allow upper and lower case file names
- Allow lines longer that 120 characters, e.g.,
  - 256 characters
  - 512 characters
  - 1000 characters
  - 4000 characters



### Functionality Supported in this Proposal

- Default Component Broadband Package Models
  - Single Ended with and without crosstalk
  - Differential with and without crosstalk
- Delay and crosstalk corners
- Model Name and Model Type Package Models
- Uncoupled and Crosstalk Models
- Ability to have separate or combined package and on-die models
- Ability to have separate or combined PDN and I/O models
- Enhanced parameter formats to support DOE
- Direct support for Touchstone data
- Support for different number of Supply (PDN) Pins and Die Pads
- Models are fully supported in all major EDA simulators
- NEXT and FEXT crosstalk models



# **Next Steps**

- 1. Alternative Proposals
  - 1. BIRD 125/145 (being withdrawn)
  - 2. BIRDS 163, 164, 165 (replaces 125/145)
- 2. Evaluation of this proposal with alternatives
  - 1. Which proposals solves the IC Vendor, and User problems?
    - 1. Functionality
    - 2. Ease of writing models and IBIS files
    - 3. Ease of parsing IBIS files and using models
  - 2. IC Vendors and Users need to define package model scenarios, and proponents should implement IBIS files for these scenarios to demonstrate the feasibility of each of the proposals.
- 3. Next steps
  - 1. Review Syntax
  - 2. Make EMD Syntax similar

