**BUFFER ISSUE RESOLUTION DOCUMENT (BIRD)**

**BIRD NUMBER: *Draft 3, May 24, 2014***

**ISSUE TITLE:** *Interconnect Modeling Using IBIS-ISS*

**REQUESTOR:**  *Walter Katz, Signal Integrity Software, Inc.*

**DATE SUBMITTED:** *{date you sent the original document, for new BIRDs}*

**DATE REVISED:** *{date(s) you sent any revisions to the document}*

**DATE ACCEPTED BY IBIS OPEN FORUM: *{****leave blank; for administrative use only}*

**STATEMENT OF THE ISSUE:**

This BIRD enhances IBIS interconnect models to support Broadband and Coupled package and on-die interconnect using IBIS-ISS and Touchstone models.

**ANALYSIS PATH/DATA THAT LED TO SPECIFICATION:**

Definitions:

IBIS Interconnect modeling makes several assumptions:

1. Interconnect Models can either be IBIS-ISS subckts or Touchstone Files
2. If two points are “Connected” then there is either a low resistance DC electrical path between the two points, or a small insertion loss at Nyquist frequency between the two points.
3. For each I/O Pin, there is a Die Pad and Buffer I/O that are “Connected”.
4. For each POWER or GND Signal\_name, all pins, die pads and buffer supply terminals that use that Signal\_name are “Connected”
5. The Ports (or Terminals) of Interconnect Models are Pins, Die Pads, Buffer I/O or Buffer supply terminals.
6. An Interconnect Model may represent a single connection between Pins and Buffers, Pins and Die Pads, or Die Pads and Buffers. An Interconnect Model may also represent multiple connections between Pins and Buffers, Pins and Die Pads, or Die Pads and Buffers.

**ANY OTHER BACKGROUND INFORMATION:**

{*These documents will be archived, so use this section to add any detail that is not part of the section above or the changed text itself , but should not be lost.}*

*Keyword:* [Interconnect Model Selector]

*Required:* No

*Description:* Used to pick an interconnect model for this component.

*Usage Rules:* Interconnet Models are IBIS-ISS subckts or Toucshstone files that are interconnect models between the Pins, Die Pads and Buffers of a Component.

A component may have none, one or more [Interconnect Model]. If there are any [Interconnect Model]s, they must be listed in this section.

The section under the [Interconnect Model Selector] keyword must have two fields. The fields must be separated by at least one white space. The first field lists the [Interconnect Model] name (up to 40 characters long). The second field is the name of the file containing the [Interconnect Model]. If the [Interconnect Model] is in this IBIS file, then the second field must be “\*”.

The first entry under the [Interconnect Model Selector] keyword shall be considered the default by the EDA tool.

*Example:*

[Interconnect Model Selector]

QS-SMT-cer-8-pin-pkgs\_iss \*

QS-SMT-cer-8-pin-pkgs\_sNp QS-SMT-cer-8-pin-pkgs\_sNp.ipkg

[End Interconnect Model Selector]

*Keyword:* [Interconnect Model]

*Required:* No

*Description:* Marks the beginning of an interconnect model description.

*Usage Rules:* The length of the package model name must not exceed 40 characters in length. Blank characters are not allowed.

*Example:*

[Interconnect Model] QS-SMT-cer-8-pin-pkgs\_iss

*Keyword:* [Manufacturer] Allow or Require

*Keyword:* [Description] Allow or Require

Same requirements as in IBIS if separate file.

*Keyword:* **[Begin Interconnect Model] <Interconnect Model Name>**

*Subparameter:* **Source <IBIS-ISS | Touchstone>**

*Subparameter:* **File <file name> {<file name> <file name>}**

*Subparameter:* **Subckt <subckt name> {< subckt name> < subckt name>}**

*Subparameter:* **Parameter <name> <param value> {<param value > <param value >}**

*Subparameter:* **Unused\_Port\_Termination <resistance>**

*Subparameter:* **Number\_of\_Ports <# ports> | Made into a Subparameter**

*Subparameter:*  **Port <Field 1> <Field 2> <Field 3> <Field 4> {<Field 5> <Field 6> <Field 7>}**

*Subparameter:*  **Ports <Port 1> < Port 2> < Port 3> < Port 4> …**

*Keyword:* **[End Interconnect Model]**

*Keyword:* [**End Interconnect Model**]

*Required:* Yes, to end the [**Interconnect Model**] keyword

*Description:* Indicates the end of the interconnect model data.

*Other Notes:* In between the [Interconnect Model] and [End Interconnect Model] keywords is the package model data itself. The data is any number of interfaces to either IBIS-ISS models or Touchstone files.

*Example:*

[End Interconnect Model]

We need a careful discussion on how Pin Mapping is used in conjunction with Ports that have Signal\_name.

We need a carefull discussion on when package models are Pre-Layout only.

We need a carefull discussion on precedence rules if more than one model can be used to represent interconnect.

Port/Terminal/Node

Reference Node in Definition of Touchstone Data

**If Touchstone then # terminals =N+1 for an sNp, and reference will always be last terminal.**

**S2p would have ports 1 2 Ref**

Interaction with Circuit Call and External Circuit?

Interaction with Define Package Model, or are they **mutually exclusive.**

Precedence Rules?

*Subparameter:* **Source <IBIS-ISS | Touchstone>**

*Required:* Yes for each [Begin Interconnect Model]/[End Interconnect Model] group

*Description:* Indicates if the model is an IBIS-ISS subckt or a Touchstone file.

*Other Notes:*

*Example:*

Source IBIS-ISS

*Subparameter:* **File <file name> {<file name> <file name>}**

*Required:* Yes for each [Begin Interconnect Model]/[End Interconnect Model] group

*Description:* Defines the file(s) containing the model.

*Other Notes:* The Files must be either IBIS-ISS files or Touchstone files.

Either 1 or three <file name>s are allowed. If three …

*Example:*

File my\_file.iss

File my\_file\_typ.iss my\_file\_min.iss my\_file\_max.iss

*Subparameter:* **Subckt <subckt name> {< subckt name> < subckt name>}**

*Required:* Yes if Source IBIS-ISS.

*Description:* Defines the subckt(s) in the File.

Either 1 or three <subckts name>s are allowed.If three … If three values, and if File has three values then the first, second and third values must be paired with the first second and third value of File.

*Other Notes:*

*Example:*

Subckt my\_subckt

Subckt my\_subckt\_typ my\_subckt\_slow my\_subckt\_fast

*Subparameter:* **Parameter <name> <param value> {<param value > <param value >}**

*Required:* No, but legal only if Language is IBIS-ISS.

*Description:* Defines the parameters that are to be passed into an instance of the IBIS-ISS subckt. <name> is the name of the parameter.

Either 1 or three <file name>s are allowed. If three …

String parameters shall be enclosed in “’”.

*Other Notes:* One must watch there m and M’s when entering parameter value scale factors. Please consider the following table of parameter values and how IBIS and IBIS-ISS evaluate them:

Param IBIS IBIS-ISS

1m 1e-3 1e-3

1M 1e6 1e-3

1meg 1e-3 1e6

1Meg 1e6 1e6

Parameter values shall assume the IBIS interpretation. It is recommended that when generating these parameter records, that model makers use the 1m and 1Meg constructs to avoid any possible confusion by an EDA tool or User.

Parameters are not passed into a Touchstone file; however, there are two optional reserved parameters that are used in conjunction with Language Touchstone. They are FBASE and FMAX. They must have one value. See the IBIS-ISS manual to understand how FBASE and FMAX should be used in conjunction with Touchstone files.

*Examples:*

Parameter Length 11. 12. 9.

Parameter Tstonefile ‘abc.s2p’

If three …

File, Subckt, and Parameter may have one or three values. If three values, then they are Typ, Min and Max value.

There is no rule that Min <= Typ <= Max

Min shall imply slow interconnect

Max shall imply fast interconnect

The model maker might choose to associate Typ/Min/Max values with crosstalk magnitude, impedance, or other Corner conditions not necessarily associated with delay, velocity of propagation or length of interconnect. We might want to have \_Tip subparameters, e.g.

Parameter\_Tip Length “Typical” “Long Slow” “Short Fast”

File\_Tip “Typical Xtalk” “Min Xtalk” “Max Xtalk”

Subckt\_Tip “Typical” “Long Slow” “Short Fast”

*Keyword:* **Unused\_Port\_Termination <resistance>**

*Required:*  No

*Description:* Defines the termination that is to be applied to the Ports of a subckt or Touchstone file that are not being used in each [Begin Interconnect Model]/[End Interconnect Model] group.

*Other Notes:* If this subparameter is defined the EDA should connect the unused Ports to GND through a **<resistance>** ohm resistor.

If this parameter is not defined and if Language is IBIS-ISS, then the EDA tool should connect the unused Ports to GND through a 1Meg ohm resistor. If Language is Touchstone, then the EDA tool should connect the unused Ports to GND through a resistor with the Touchstone File reference resistance of the Port.

*Example:*

[Unused\_Port\_Termination] 50

*Keyword:* **Number\_of\_Ports <# ports> | Made into a Subparameter**

*Required:*  Yes, for each [Begin Interconnect Model]/[End Interconnect Model] group

*Description:* The number of ports (terminals) of the IBIS-ISS subckt or Touchstone file.

*Other Notes:*

*Example:*

Number\_of\_Ports 2

*Subparameter:*  **Port <Field 1> <Field 2> <Field 3> <Field 4> {<Field 5> <Field 6> <Field 7>}**

*Required:* An Interconnect Model must either have Port subparameter records, or one or more Ports subparameter records for each [Begin Interconnect Model]/[End Interconnect Model] group. The subparameters Port and Ports are mutually exclusive.

*Description:* Each Port record contains information on a port (or terminal) of an IBIS-ISS subckt (or Touchstone file).

The logic here requires VERY careful review!

<Field 1> Port Number. This must be an integer number greater or equal to 1 and less than or equal to the number of ports ([Number of Ports], of the IBIS-ISS subckt (or Toucshtone file). Two [Port] records may not have the same Port Number. If a Port Number does not exist in any of the [Port] records then the port is unused, and should be terminated according to the Unused\_Port\_Termination\_ Rules.

<Field 2> Shall be either Pin Pad or Buffer. This describes if the Port is at a Pin, Die Pad, or at the Buffer.

<Field 3> Shall be either Pin\_name, Signal\_name, Model\_name or Default.

<Field 4> If <Field 3> is Pin\_name, Signal\_name or Model\_name then <Field 4> shall be either a legal Pin\_name, Signal\_name or Model\_name respectively. If <Field 3> is Default then <Field 4> shall be NA.

<Field 5> If the connection on this port is to a Buffer signal terminal then <Field 3> is Model\_name or Default <Field 5> shall be either Diff\_pos, Diff\_neg or SE, otherwise it shall be NA. If the connection on this port is to a Buffer supply terminal, then <Field 5> shall be either Pullup\_Reference, Pulldown\_Reference , Power\_Clamp\_Reference , Ground\_Clamp\_Reference or External\_Reference.

<Field 6> Is the channel number. A channel is either a single connection or two connections that form a differential pair. If there is only one channel in the model then <Field 6> may be NA.

<Field 7> Shall contain Aggressor or NA. If NA, then this channel accurately represents that channel through path and crosstalk from all of the other channels. If Aggressor than the channel only accurately represents the crosstalk to all of the NA (Victim) channels.

*Other Notes:*

Fields at then end of a Port record that are NA are optional

If <Field 2> is Buffer, and the port connects to ths

*Example:*

Port 1 Pin    Pin\_name M8 NA NA NA

Port 1 Pin    Pin\_name M8

Port 1 Pad Pin\_name M8

Port 1 Buffer Pin\_name M8

Port 1 Buffer Pin\_name M8 Pullup\_Reference

Port 1 Pin Model\_name DQ

Port 1 Pin Model\_name DQS Diff\_pos

Port 1 Pin Default NA SE

Port 1 Pin Model name DQ SE

Port 1 Buffer Pin\_name M8 NA 2

Port 1 Buffer Pin\_name M8 NA 3 Aggressor

Port 1 Buffer Signal\_name VDDQ

*Subparameter:*  **Ports <Port 1> < Port 2> < Port 3> < Port 4> …**

*Required:* An Interconnect Model must either have Port subparameter records, or one or more Ports subparameter records for each [Begin Interconnect Model]/[End Interconnect Model] group. The subparameters Port and Ports are mutually exclusive.

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

*Usage Rules:* <port> names 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 Interconnect Model]/[End Interconnect Model] group. If there are more than one Ports record the subsequent Ports records after the first Ports record shall be considered continuation lines, and the <port>s 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. Unconnected ports shall be named “NC” The following are the port naming rules for connected ports. The Ports subparameter is not as general as the Port subparameter. It does not allow associating ports with Victim/Aggressor, Model Name or Default.

Signal (I/O) Port Naming Rules

Pin

Pin:<Pin\_name>

Die Pad

Pad:<Pin\_name>

Buffer (I/O)

Buf:<Pin\_name>

Supply (POWER and GND) Port Naming Rules

Pin

Pin:<Pin\_name>

Pin\_SIG:<Signal\_name>

Die Pad

Pad:<die\_supply\_pad\_name>

Pin\_SIG:<Signal\_name>

Buffer

Buf\_PUR:<Pin\_name> | Pullup Reference

Buf\_PDR:<Pin\_name> | Pulldown Reference

Buf\_PCR:<Pin\_name> | Power Clamp Reference

Buf\_GCR:<Pin\_name> | Power Clamp Reference

Buf\_EXTREF:<Pin\_name>> | External reference voltage port

Buf\_SIG.<Signal\_name> | Supply (Power/Ground) Signal Name

*Examples:*

Ports Pin:A7 Buf:A7

Ports Pin:A7 Pad:A7

Ports Pad:A7 Buf:A7

Ports Pin\_SIG:VDD Buf\_SIG:VDD

Ports Pin\_SIG:VDD Pin\_SIG:VSS Buf\_PUR:A7 Buf\_PDR:A7

*Keyword:* **[Die Supply Pads]**

*Required:* No

*Description:* This begins a section in [Component] that contains one line of data for die pads supply nodes. IBIS assumes that for I/O pins (pins that have a Model\_name that is not POWER, GND or NC), there is a one to one correspondence between a Pin, Die Pad and Buffer I/O. There are no such assumptions for POWER and GND pins. A POWER or GND Signal\_name may have a different number of Pin nodes, die pad nodes and buffer nodes. If the model maker chooses to make separate package and on-die power distribution networks (PDN), then he must supply a list of nodes (and their associated Signal\_name) that can be used to mate the package and on-die PDN models.

*Sub-Params:* ?

*Usage Rules:*  TBD

*Other Notes:* The data in this section consists of a list of die pad node names and their corresponding Signal\_names that can be used to mate package and on-die PDN networks.

*Example:*

[Die Supply Pads]

VDD1 VDD

VDD2 VDD

VDD3 VDD

VSS1 VSS

VSS2 VSS

*Keyword:* **[End Die Supply Pads]**

*Required:* Yes.

*Description:* Indicates the end of the [Die Supply Pads] data.

*Other Notes:*

*Example:*

[End Die Supply Pads]

**Examples**

[Define Package Model]

[ISS Model Data]

[Begin ISS Model] IOA3

Language Touchstone

File Value ioA3.s2p

Number\_of\_Ports 2

Port 1 Pin Pin\_name A3

Port 2 Buffer Pin\_name A3

Terminals Pin:A3 Buf:A3

Nodes Pin:A3 Buf:A3

[End ISS Model]

[Begin ISS Model] IOA7

| This model uses I/O pin A7

Language Touchstone

File Value ioA7.s2p

Number\_of\_Ports 2

Ports Pin.A7 Buf.A7

[End ISS Model]

[Begin ISS Model] IOB3C3

Language Touchstone

File Value ioB3C3.s4p

Number\_of\_Ports 4

Port 1 Pin Pin\_name B3

Port 2 Buffer Pin\_name B3

Port 3 Pin Pin\_name C3

Port 4 Buffer Pin\_name C3

[End ISS Model]

[Begin ISS Model] IOA3

Language IBIS\_ISS

File Value io.iss

Subckt io

Parameter Length Value 10. | 10mm

Number\_of\_Ports 2

Port 1 Pin Pin\_name A3

Port 2 Buffer Pin\_name A3

[End ISS Model]

[Begin ISS Model] DQS

Language Touchstone

File Value DQS.s4p

Number\_of\_Ports 4

Port 1 Pin Model\_name DQS Diff\_pos

Port 2 Buffer Model\_name DQS Diff\_pos

Port 3 Pin Model\_name DQS Diff\_neg

Port 4 Buffer Model\_name DQS Diff\_neg

[End ISS Model]

[Begin ISS Model] VDDQ

Language IBIS\_ISS

File Value vddq.iss

Subckt vddq

Number\_of\_Ports 2

Port 1 Pin Signal\_name VDDQ

Port 2 Buffer Signal\_name VDDQ

[End ISS Model]

[Begin ISS Model] VDDQ\_A3

Language IBIS\_ISS

File Value vddq\_a3.iss

Subckt vddq\_A3

Number\_of\_Ports 2

Port 1 Pin Signal\_name VDDQ

Port 2 Buffer Pin\_name A3 Pullup\_Reference

[End ISS Model]

[Begin ISS Model] IOA3

Language Touchstone

File Value ioA3.s10p

Number\_of\_Ports 10

Port 1 Pin Pin\_name A3

Port 2 Buffer Pin\_name A3

Port 3 Pin Model\_name DQ NA 1 Aggressor

Port 4 Buffer Model\_name DQ NA 1 Aggressor

Port 5 Pin Model\_name DQ NA 2 Aggressor

Port 6 Buffer Model\_name DQ NA 2 Aggressor

Port 7 Pin Model\_name DQS Diff\_pos 3 Aggressor

Port 8 Buffer Model\_name DQS Diff\_pos 3 Aggressor

Port 9 Pin Model\_name DQS Diff\_neg 3 Aggressor

Port 10 Buffer Model\_name DQS Diff\_neg 3 Aggressor

[End ISS Model]

[End ISS Model Data]

[End Package Model]