IBIS BIRD to support Final_Stage_Subckt

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Final_Stage_Subckt

The goal is to specify a Spice subckt to be used instead of C_Comp by adding new [Model] keywords [Final_Stage_Subckt] and [Diff_Final_Stage_Subckt]. [Final_Stage_Subckt] defines the interface Spice subckt between the pad of a "B" element and the die-pad connected to the package model of the component. [Diff_Final_Stage_Subckt] defines the interface Spice subckt between the active high and low pads of two single ended "B" elements or one differential external model and the die-pads connected to the package of the component.

The document is more-or-less in IBIS documentation format, but I will start off by demonstrating the simplicity of this method with two examples, one for the "Branch C_Comp" requirement presented to IBIS in 2004, and one for on-die S-Parameters currently required for 6 and 10 Gbps SerDes Tx and Rx models.

Branch C-Comp Example

```
[Final_Stage_Subckt]
File_Subckt  typ  branch_c_comp.mod  branch_c_comp
Ports A_signal
Parameter typ R .05
Parameter min R .07
Parameter max R .04
```

SerDes On-Die S-Parameters

```
[Diff_Final_Stage_Subckt]
File_Subckt  typ  on_die_diff.mod  on_die_diff_typ
File_Subckt  min  on_die_diff.mod  on_die_diff_min
File_Subckt  max  on_die_diff.mod  on_die_diff_max
Ports A_pad_pos A_signal_pos A_pad_neg A_signal_neg
```

BIRD

Keyword: [Final_Stage_Subckt]
Required: No
Description: Used to define the Spice subckt between the pad of a "B" element and the package model of the component.
Sub-Params: File_Subckt, Ports, Parameter
Usage Rules: If a [Final_Stage_Subckt] is specified in a model, then simulations should insert a Spice model defined by the File_Subckt record between the pad of the [Model] "B" element and the die-pad of the component package model in-lieu of the [Model] C_Comp. The sub-param Ports define the ports of this Spice subckt, and the sub-param Parameter defines the parameters passed to the Spice subckt. The Spice subckt shall be written in either IBIS_Interconnect_Spice or IBIS_Buffer_Spice language defined elsewhere. Onle one [Final_Stage_Subckt] is allowed in any one [Model] section.

Sub-Param: File_Subckt <corner> <file name> <subckt name>
Required: Yes
Description: Used to define, for each process corner, the subckt name, and the file containing the subckt.

<corner> Shall have the values of typ, min or max.

1. Each [Final_Stage_Subckt] must have one File_Subckt record with <corner>=typ that should be used for the typical process corner.
2. Each [Final_Stage_Subckt] may have one File_Subckt record with <corner>=min that should be used for the slow process corner. If not specified then the typ subckt shall be used.
3. Each [Final_Stage_Subckt] may have one File_Subckt record with <corner>=max that should be used for the fast process corner. If not specified then the typ subckt shall be used.

<file name> The name of an ASCII file that contains the subckt.
<subckt name> The name of the subckt in <file name>

The subckt shall consist of all records in <file name> between (and including) records

subckt <subckt name> …
.ends <subckt name>

Sub-Param: Ports <port name> <port name> …
Required: Yes
Description: Used to define the ordered list of ports of <subckt name>

The Ports Sub-Param must have at least one <port name>

<port name>

1. Each <port name> must be one of the following
    a. A_signal
    b. A_pad
    c. A_drive
    d. A_enable
    e. A_gnd
    f. A_puref
    g. A_pcref
    h. A_pdref
    i. A_gcref
    j. A_extref
2. These reserved port names are implied under the native IBIS [Model] keyword. A_gnd is a universal reference node, Under the [Model] description, power and ground reference ports are created and connected by IBIS-compliant tools as defined by the [Power Clamp Reference], [GND Clamp Reference], [Pullup Reference], [Pulldown Reference] and/or [Voltage Range] keywords. The A_signal port is connected to the die pad, to drive or receive an analog signal. The A_pad port is connected to the port of the IBIS "B" element, or the A_signal port of a multi-lingual model.

Usage Rules:

1. A_signal is a required <port name>.
2. If A_pad is not present, then the A_signal is connected to both the IBIS "B" element and the die pad.
3. A_drive shall be an analog signal between 0V and 1V. A_drive should have a rise time and fall time derived from the models dV/dt_r and dV/dt_f. If polarity is Non-Inverting then 0V shall be low, and 1V shall be high. If polarity is Inverting then 0V shall be high, and 1V shall be low.
4. A_enable shall be an analog signal between 0V and 1V. A_enable should have a rise time and fall time derived from the models dV/dt_r and dV/dt_f. If Enable is Active-High then 0V shall be in-active, and 1V shall be active. If Enable is Active-Low then 0V shall be active, and 1V shall be in-active.

Sub-Param: Parameter <corner> <parameter name> <parameter value>
Required: No
Desciption: Used to define parameters passed to the subckt.

<corner> Shall have the values of typ, min or max.

1. Each <parameter name> must have one Parameter record with <corner>=typ that should be used for the typical process corner.
2. Each <parameter name> may have one Parameter record with <corner>=min that should be used for the slow process corner. If not specified then the typ value shall be used.
3. Each <parameter name> may have one Parameter record with <corner>=max that should be used for the fast process corner. If not specified then the typ value shall be used.

< parameter name > The name of the parameter.

< parameter value > The value of the parameter.

Allowed values are:

1. Integer numbers
2. E format (scientific notation)
3. IBIS/Spice format
    a. Follows IBIS rules
    b. 1.E6 should be Meg instead of M

Examples:

Branch C_Comp

In IBIS [Model] seciton

```
[Final_Stage_Subckt]
File_Subckt typ branch_c_comp.mod branch_c_comp
Ports A_signal
Parameter typ R .05
Parameter min R .07
Parameter max R .04
```

In file branch_c_comp.mod

```
.subckt branch_c_comp pad R=.05
R1 pad pad_c 'R'
C_comp pad_c 0 V(vccomp)
E_ccomp vccomp 0 PWL(1) pad_c 0 (1p,0v 1p,1v 5p,4v)
.ends branch_c_comp
```

On die s-parameter

In IBIS [Model] seciton

```
[Final_Stage_Subckt]
File_Subckt typ on_die.mod on_die_typ
File_Subckt min on_die.mod on_die_min
File_Subckt max on_die.mod on_die_max
Ports A_pad A_signal
```

In file on_die.mod

```
.subckt on_die_typ A_pad A_signal
s1 A_pad A_signal 0 mname=on_die_typ
.model on_die_typ S TSTONEFILE='on_die_typ.s2p'
.ends on_die_typ
*
.subckt on_die_min A_pad A_signal
s1 A_pad A_signal 0 mname=on_die_min
.model on_die_typ S TSTONEFILE='on_die_min.s2p'
.ends on_die_min
*
.subckt on_die_max A_pad A_signal
s1 A_pad A_signal 0 mname=on_die_max
.model on_die_typ S TSTONEFILE='on_die_max.s2p'
.ends on_die_max
```

Keyword:	[Diff_Final_Stage_Subckt]
Required:	No
Description:	Used to define the Spice subckt between the pads of 2 “B” elements used differentially and the package model of the component.
Sub-Params:	File_Subckt, Ports, Parameter
Usage Rules:	If a [Diff_Final_Stage_Subckt] is specified in a model, simulations should insert a Spice model defined by the File_Subckt record between the pads of the [Model] active high and low “B” element and the die-pads of the component package model in-lieu of the [Model] C_Comp. The sub-param Ports define the ports of this Spice subckt, and the sub-param Parameter defines the parameters passed to the Spice subckt. The Spice subckt shall be written in either IBIS_Interconnect_Spice or IBIS_Buffer_Spice language defined elsewhere. Onle one [Diff_Final_Stage_Subckt] is allowed in any one [Model] section. If a [Model] has both a [Final_Stage_Subckt] and a [Diff_Final_Stage_Subckt], the EDA tool should use the [Diff_Final_Stage_Subckt] when the [Model] is used differentially, and [Final_Stage_Subckt] if it is used signal endedly.

Sub-Param: File_Subckt <corner> <file name> <subckt name>
Required: Yes
Description: Used to define, for each process corner, the subckt name, and the file containing the subckt.

<corner> Shall have the values of typ, min or max.

1. Each [Diff_Final_Stage_Subckt] must have one File_Subckt record with <corner>=typ that should be used for the typical process corner.
2. Each [Diff_Final_Stage_Subckt] may have one File_Subckt record with <corner>=min that should be used for the slow process corner. If not specified then the typ subckt shall be used.
3. Each [Diff_Final_Stage_Subckt] may have one File_Subckt record with <corner>=max that should be used for the fast process corner. If not specified then the typ subckt shall be used.

<file name> The name of an ASCII file that contains the subckt.

<subckt name> The name of the subckt in <file name>

The subckt shall consist of all records in <file name> between (and including) records

subckt <subckt name> …
.ends <subckt name>

Sub-Param: Ports <port name> <port name> …
Required: Yes
Description: Used to define the ordered list of ports of <subckt name>

The Ports Sub-Param must have at least one <port name>

<port name>

1. Each <port name> must be one of the following
    a. A_signal_pos
    b. A_signal_neg
    c. A_pad_pos
    d. A_pad_neg
    e. A_drive
    f. A_enable
    g. A_gnd
    h. A_puref
    i. A_pcref
    j. A_pdref
    k. A_gcref
    l. A_extref
2. These reserved port names are implied under the native IBIS [Model] keyword. A_gnd is a universal reference node, Under the [Model] description, power and ground reference ports are created and connected by IBIS-compliant tools as defined by the [Power Clamp Reference], [GND Clamp Reference], [Pullup Reference], [Pulldown Reference] and/or [Voltage Range] keywords. The A_signal_pos and A_signal_neg ports are connected to the die pads, to drive or receive the analog signala. The A_pad_pos and A_pad_neg ports are connected to the ports of the high and low IBIS “B” element, or the A_signal_pos and A_signal_neg ports of a multi-lingual model.

Usage Rules:

1. A_signal_pos and A_signal_neg are required <port name>.
2. A_pad_pos and A_pad_neg must be both present or both not be present. If A_pad_pos and A_pad_neg are not present then the A_signal_pos is connected to both the pos IBIS “B” element and the pos die pad, and the A_signal_neg is connected to both the neg IBIS “B” element and the neg die pad.
3. A_drive shall be an analog signal between 0V and 1V. A_drive should have a rise time and fall time derived from the models dV/dt_r and dV/dt_f. If polarity is Non-Inverting then 0V shall be low, and 1V shall be high. If polarity is Inverting then 0V shall be

high, and 1V shall be low. (Note that low and high apply to the pos side, and the neg side has the opposite of the pos side.

4. A_enable shall be an analog signal between 0V and 1V. A_enable should have a rise time and fall time derived from the models dV/dt_r and dV/dt_f. If Enable is Active-High then 0V shall be in-active, and 1V shall be active. If Enable is Active-Low then 0V shall be active, and 1V shall be in-active.

Sub-Param: Parameter <corner> <parameter name> <parameter value>
Required: No
Desciption: Used to define parameters passed to the subckt.
<corner> Shall have the values of typ, min or max.

1. Each <parameter name> must have one Parameter record with <corner>=typ that should be used for the typical process corner.
2. Each <parameter name> may have one Parameter record with <corner>=min that should be used for the slow process corner. If not specified then the typ value shall be used.
3. Each <parameter name> may have one Parameter record with <corner>=max that should be used for the fast process corner. If not specified then the typ value shall be used.

< parameter name > The name of the parameter.
< parameter value > The value of the parameter.

Allowed values are:

1. Integer numbers
2. E format (scientific notation)
3. IBIS/Spice format
    a. Follows IBIS rules
    b. 1.E6 should be Meg instead of M

Examples:

On die s-parameter

In IBIS [Model] seciton

```
[Diff_Final_Stage_Subckt]
File_Subckt typ on_die_diff.mod on_die_diff
Ports A_pad_pos A_signal_pos A_pad_neg A_signal_neg
```

In file on_die_diff.mod

```
.subckt on_die_diff pad_pos signal_pos
+                   pad_neg signal_neg
s1 pad_pos pad_neg signal_pos signal_neg 0
+  mname=on_die_diff
.model on_die_diff S TSTONEFILE='on_die_diff.s4p'
.ends on_die_diff
```