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BIRD ID#: 122
ISSUE TITLE: IBIS-AMI New Reserved Parameters for Analog Modeling
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DATE REVISED:
DATE ACCEPTED BY IBIS OPEN FORUM:

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STATEMENT OF THE ISSUE:

Model developers and EDA vendors building IBIS-AMI models using the IBIS 5.0 specification have come across a number of modeling issues that are not addressed in IBIS 5.0. In order to deliver models and EDA tools that meet end-user demands for model accuracy and functionality, EDA vendors have defined "extensions" to add new capabilities to IBIS-AMI models. Unfortunately, EDA vendors have had to use proprietary (and different) syntax to add these capabilities to models, limiting model portability between different EDA tools.

This BIRD proposes new syntax for the .ami control file that improves model functionality and accuracy. Including this syntax in the IBIS standard will allow creation of accurate, compliant IBIS-AMI models that are readily portable between commercial EDA simulators.

The parameters defined in this document are to be added in Section 6c of the IBIS 5.0 specification as new Reserved_Parameters.

Broadband Analog Model
Tstonefile, Nodemap

Equivalent-Circuit Analog Model
Voh, Vol, Rt, Rs, Cc, Vt, Tr, Tf, Trf, Rd, Cd,
Voh_L, Vol_L, Rt_L, Rs_L, Cc_L, Tr_L, Tf_L,
Voh_H, Vol_H, Rt_H, Rs_H, Cc_H, Tr_H, Tf_H

Note that all of the parameters defined in this BIRD **may** be declared in the Model_Specific section of the .ami file to allow the use of some legacy models. However, using these parameters in the Model_Specific section of the .ami file is considered legacy use and will likely be deprecated in IBIS versions beyond 5.1.

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The following text is added immediately before Table 1 on page 148:

Analog Model Parameters

The analog portion of an IBIS-AMI model is used by the EDA tool to derive the impulse response of the analog channel. Nominally, the simulation uses the traditional IBIS [Model] data from the .ibs file. This provides the highest level of model portability between EDA tools but does not always provide the highest level of simulation accuracy. These parameters define two additional levels of information that can be used to model the analog buffer.

The EDA tool is expected to use the following precedence for determining the data to be used to model the analog buffer:

1. Broadband Analog Model
2. Equivalent-circuit Analog Model
3. [Model] declaration in .ibs file

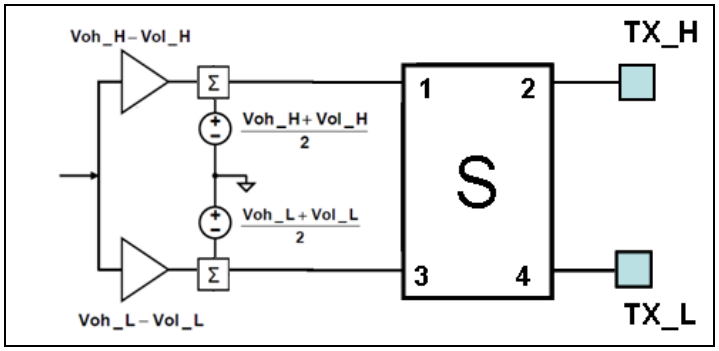
The lowest precedence data (#3) is REQUIRED and therefore should always be present in the .ibs file. Either method #1 or #2 (or both) may also be specified in the model's .ami file, in which case the EDA tool is expected to use the model data according to the defined order of precedence, which reflects the relative accuracy of each of these three methods.

Broadband Analog Model Parameters

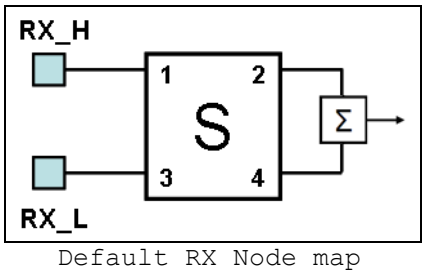
"Tstonefile" is an AMI parameter of Type String and Usage Info that specifies the relative path from the directory containing the .ibs and .ami files to a Touchstone file that is to be used as the analog model for the device when determining the impulse response of the channel. This is used in place of the analog model described in the IBIS (.ibs) file for the buffer. The S-parameter file represents the analog buffer model only and should not contain any package model data.

When **Tstonefile** is used to describe a TX analog buffer, the S-parameter file is connected between an input voltage source and the TX die pad. The TX die pad ports are connected to the same nodes in the circuit netlist as a traditional IBIS output model would be. The value of the voltage source is expected to be defined using the Voh/Vol and Trf parameters. The Voh/Vol and Trf parameters are defined in the Equivalent Analog Circuit Model Parameter section and are shared between the Equivalent Circuit Analog Model and the Broadband Analog Model.

When **Tstonefile** is used to describe an RX analog buffer, the S-parameter file is connected between the RX die pad and the output nodes used by the simulator to derive the differential impulse response for the network.



Default TX node map



Default RX Node map

TX Example:

```
(Tstonefile (Usage Info)(Type String)
   (Corner "NC.s4p" "WC.s4p" "BC.s4p")
   (Description "Driver on-die S-parameter file")
)
```

Note that **Tstonefile** can be declared using different formats. The example above declares Tstonefile using format Corner so that different analog models are used for typ, slow and fast cases.

The default TX and RX node maps assume that the high-speed serial channel flows from left to right, and that analog model S parameters flow from left to right. Transmitter input ports are assumed to be the left hand (Near) ports 1 and 3, while the pad ports are assumed to be the right hand (Far) ports 2 and 4. Receiver pad ports are assumed to be the left hand (Near) ports 1 and 3, while the output ports are assumed to be the right hand (Far) ports 2 and 4.

Transmitter Default Port Map

Port	Description
1	Input true port
2	Pad true port
3	Input complement port
4	Pad complement port

Receiver Default Port Map

1	Pad true port
2	Output true port
3	Pad complement port
4	Output complement port

For S parameter files that follow this convention, the first and third rows of the four-port matrix [S11, S12, S13, S14, S31, S32, S33, S34] for a transmitter are not used, and may be set to all zeros. Similarly, the second and fourth columns [S12, S22, S32, S42, S14, S24, S34, S44] of the four-port matrix for a receiver are not used, and may be set to all zeros. Other port mappings are supported through the use of the optional parameter **Nodemap**.

"Nodemap" is an AMI parameter of Type String, Usage Info and format Value that is used to override the default node mapping for on-die S parameters. The defined string consists of a sequence of letter/number pairs. The letter refers to the side the port is on and the number indicates the port number. The letter N refers to the left hand or Near side and the letter F refers to the right hand or Far side. The specific format for each case is

```
TX four port: N<Input true>N<Input comp>F<Pad true>F<Pad comp>
RX four port: N<Pad true>N<Pad comp>F<Die true>F<Die comp>
```

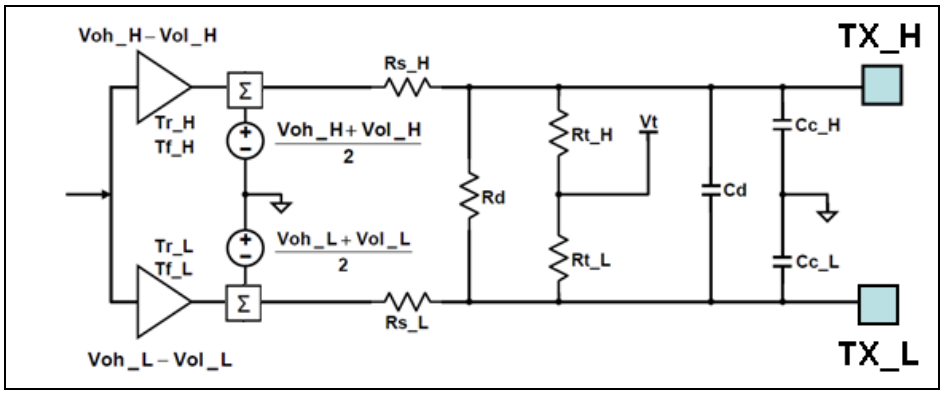
Default TX node map example:

```
(Nodemap (Usage Info)(Type String)(Value "N1N3F2F4")
   (Description "Default nodemap for on-die TX")
)
```

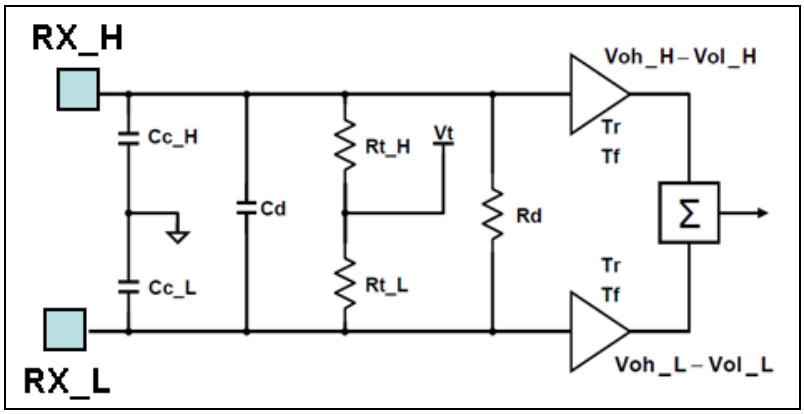
The above example defines the default node mapping the EDA tool would assume for a **Tstonefile** if **Nodemap** were not defined.

Equivalent-Circuit Analog Model Parameters

The AMI parameters listed below are of Type Float and Usage Info. They correspond to equivalent circuits that should be used in place of the TX or RX analog model described in the IBIS (.ibs) file.



TX Analog Buffer Equivalent Circuit



RX Analog Buffer Equivalent Circuit

All voltages are in volts, all resistances in ohms, all capacitances in farads, and all rise/fall times in seconds.

"Voh": Output voltage for logic 1 (Default 1.0)
"Vol": Output voltage for logic 0 (Default 0.0)
"Vt": Termination voltage (Default 0.0)
"Tr": 20%-80% rise time (Default 0.0)
"Tf": 80%-20% fall time (Default 0.0)
"Trf": 20%-80% rise/fall time) (Implies Tr = Tf = Trf) (Default 0.0)
"Rt": Termination resistance (Default 1e+6)
"Rd": Differential termination resistance (Default 100)
"Rs": Series output resistance (Default 50.0)
"Cc": Single ended common mode termination capacitance (Default 0.0)
"Cd": Differential termination capacitance (Default 0.0)

For each of the parameters Voh, Vol, Rt, Rs, and Cc, there are two additional parameters defined: one with "**_H**" appended to the parameter name and one with "**_L**" appended to the parameter name. When these suffixes are attached to the name, they refer to "high" side and "low" side, respectively. When these suffixes are omitted, the same element value applies to both the "high" side and the "low" side.

Example:

```
(Voh (Usage Info)(Value 0.9)(Type Float)
   (Description "Output open circuit high voltage")
)
(Vol (Usage Info)(Value 0.0)(Type Float)
   (Description "Output open circuit low voltage")
)
(Trf (Usage Info)(Value 40e-12)(Type Float)
   (Description "20%-80% output rise time")
)
(Rs (Usage Info)(Value 47.75)(Type Float)
   (Description "Single-ended output resistance")
)
(Cc (Usage Info)(Value 0.5e-12)(Type Float)(Default 0.5e-12)
   (Description "Output Capacitance")
)
```

This defines an output model with a 900mV supply voltage, a 20-80% rise time of 40ps, an output impedance of 47.75 Ohms and a output capacitance of 0.5pF.

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ANALYSIS PATH/DATA THAT LED TO SPECIFICATION

The parameters defined in this BIRD came from commercial IBIS-AMI model development efforts where new functionality was needed to meet customer expectations for model functionality, accuracy and performance. The parameters in this BIRD were defined by SiSoft and its semiconductor partners. These parameters are being contributed to IBIS to ensure IBIS-AMI model accuracy and portability.

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ANY OTHER BACKGROUND INFORMATION:

This BIRD is being requested by the following IBIS users and model developers, in conjunction with the authors:

Cisco Systems: Upen Reddy, Doug White
Ericsson: Anders Ekholm
Broadcom: Yunong Gan
IBM: Adge Hawes
TI: Alfred Chong, Srikanth Sundaram

BIRDs 121 through 124 split the concepts and changes of BIRD 119 into separate documents.

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