**BUFFER ISSUE RESOLUTION DOCUMENT (BIRD)**

**BIRD NUMBER:** 158.6\_draft3

**ISSUE TITLE:** *AMI Ts4file Analog Buffer Models*

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

The IBIS 5.1 specification provided limited capability for describing the frequency-dependent behavior of SerDes transmitter analog output networks or receiver analog input networks. This made it difficult to model device’s insertion and return losses accurately, both of which are key factors in determining Inter-Symbol Interference (ISI) and overall signal quality. The IBIS 6.0 specification addressed those issues via IBIS-ISS modeling within [External Model] and [External Circuit] buffer descriptions, though the approach was not as simple and straightforward as proposed here. This BIRD assumes that the Tx analog output and Rx analog input networks are described using linear 4-port network data and that the data is developed in a manner consistent with the subcircuits and parameters defined below. The subcircuits used to instantiate the transmitter and receiver on-die 4-port parameters are shown on the following pages. These subcircuits are treated as standard templates that are used whenever the AMI parameters defined in this document are used in the .ami file. This BIRD defines the following new AMI reserved parameters: Ts4file, Ts4file\_Boundary, Tx\_V, Tx\_R, and Rx\_R.

**ANY OTHER BACKGROUND INFORMATION:**

BIRD 158.6 was updated as agreed in review meetings:

1. The reserved parameter Ts4File is described using the “file reference” terminology, introduced in BIRD 186.3.
2. Additional text relating to the package and on-die interconnect modeling has been added to eliminate potential confusion and to clarify the intent.
3. The use of the term “step response” is avoided as it is not used in the current specification.
4. Various straightforward editorial changes.

The following text is to be added as a new sub-section 10.x within the section “10 ALGORITHMIC MODELING”.

10.x ALTERNATIVE AMI ANALOG BUFFER MODELING

This section discusses an alternative analog buffer modeling technique, specifically designed for AMI applications. The approach uses 4-port analog circuit data provided in a Touchstone file specified by the AMI parameter named Ts4file. (Note: Ts4file implies a restricted Touchstone format where the number of ports is four and the port numbering is predefined.)

# Transmitter Analog Circuit



For logic level 1 Vp=Tx\_V / 2 and Vn=-Tx\_V / 2 where Tx\_V is a reserved parameter (defined below). For logic level 0 Vp=-Tx\_V / 2 and Vn=Tx\_V / 2. The step stimulus is a differential voltage waveform Vp - Vn when the logic level is switched from 0 to 1. This may be used to determine the impulse response needed for the AMI flow. For Tx models that have the reserved parameter Ts4file, the reserved parameter Tx\_V is required and the reserved parameter Tx\_R is optional. For a Tx buffer, the transmitter circuit defines the analog buffer model between the zero-impedance stimulus input voltage source and the buffer terminals.

Ports 1, 2, 3 and 4 of the 4-port network are between the nodes 1, 2, 3 and 4 and the common reference node Ref, respectively. Ports 1 and 3 are at the stimulus source side, and ports 2 and 4 are the transmitter analog buffer model’s output. Furthermore, ports 1 and 2 correspond to the non-inverting signal path and ports 3 and 4 to the inverting signal path.

# Receiver Analog Circuit



Ports 1, 2, 3 and 4 of the 4-port network are between the nodes 1, 2, 3 and 4 and the common reference node Ref, respectively. Ports 1 and 3 are the receiver analog buffer model’s input, and the waveforms at ports 2 and 4 are the differential input to the Rx algorithmic model. Furthermore, ports 1 and 2 correspond to the non-inverting signal path and ports 3 and 4 to the inverting signal path. For Rx models that have the reserved parameter Ts4file, the reserved parameter Rx\_R is optional. For an Rx buffer, the receiver circuit defines the analog buffer model between the buffer terminals and a high impedance probe at the input to the Rx Algorithmic model.

The IBIS AMI flow requires that the EDA tool generates the impulse response of the entire analog circuitry between the Tx and Rx algorithmic models, including the Tx and Rx analog buffer models. Typically, the Touchstone file data specified here will be used to describe only the analog behavior of the buffer itself including the on-die interconnect, but excluding the effects of the package, as illustrated in the following figure.



 by means of the parameter Ts4fileshallofAlso and the user, specified by the parameter Ts4file, reserved AMI parameter Ts4file\_Package\_Options shall be used to specify the source of the remaing model up to the “pin” terminals. The options include the use of the package definition associated with the [Model] keyword (via [Component] and [Pin] information) or the use of a separate 4-port network data pointed to by the reserved AMI parameter Ts4file\_Package\_Data.

By definition, the placement of the Ts4file information within .ami files makes the Ts4file data exclusively limited to AMI applications. If the same electrical behavior is desired for non-AMI applications of the same IBIS model (the one referencing the Algorithmic Model) the model maker can optionally provide an equivalent description using the [External Model] keyword. However, the latter is not needed if the model is intended for AMI applications only.

## Reserved Parameter DEFINITIONs

*Parameter:* **Ts4file**

*Required:* No

*Direction:* Tx, Rx

*Descriptors*:

Usage: Info, Dep

Type: String

Format: Value, List, Corner

Default: <string literal>

Description:<string >

*Definition:* This parameter provides the file reference for a 4-port Touchstone file to be used in the Analog Circuit. See the Analog Circuit definitions above for the port order associated with the Touchstone file data.

*Examples:*

(Ts4file (Usage Info)(Type String)(Corner “typ.s4p” “min.s4p” “max.s4p”))

*Parameter:* **Ts4file\_Boundary**

*Required:* No, illegal when the parameter **Ts4file** is not present.

*Direction:* Tx, Rx

*Descriptors*:

Usage: Info, Dep

Type: String

Format: Value

Default: <string literal>

Description:<string >

*Definition:* This parameter provides the information about what the 4-port Touchstone file data represents. The data may describe the buffer only, or include the on-die interconnect and/or the package information also. The value can be one of the following three strings: “buffer”, “pad”, or “pin”. If this parameter is not specified, the default is equivalent to “pad”.

*Examples:*

(Ts4file\_Boundary (Usage Info)(Type String)(Value “pad”))

*Parameter:* **Ts4file\_Package\_Options**

*Required:* Yes, when the parameter **Ts4file** is present and the parameter **Ts4file\_Boundary** is either not present or is present and its value is different from “pin”. Otherwise, illegal.

*Direction:* Tx, Rx

*Descriptors*:

Usage: Info, Dep

Type: String

Format: Value, List

Default: <string literal>

Description:<string >

*Definition:* This parameter provides the information about the options in modeling the remaining circuitry up to the “pin” terminals. The values can be one or more of the following "IBIS\_file\_package\_data”, “ts4file\_package\_data”, “user\_defined”. For "IBIS\_file\_package\_data” the EDA tool will use the package model provided in the IBIS file. For “ts4file\_package\_data” the EDA tool will cascade the 4-port network described by the AMI parameter Ts4file\_Package\_Data in a fashion shown in the diagram above as the “Package” block. For “user\_defined” option the user may augment the channel circuitry by the package model of the user’s choice.

*Examples:*

(Ts4file\_Package Options (Usage Info)(Type String)(Value “ts4file\_package\_data”))

*Parameter:* **Ts4file\_Package\_Data**

*Required:* Yes, if the parameter **Ts4file\_Package\_Options** is present and its value or one of its values is “ts4file\_package\_data”. Otherwise illegal.

*Direction:* Tx, Rx

*Descriptors*:

Usage: Info, Dep

Type: String

Format: Value, List, Corner

Default: <string literal>

Description:<string >

*Definition:* This parameter provides the file reference for a 4-port Touchstone file to be used to model the circuitry between the model specified by the parameter Ts4file and the “pin” terminals. See the Analog Circuit definitions above for the port order associated with the Touchstone file data.

*Examples:*

(Ts4file\_Package\_Data (Usage Info)(Type String)(Corner “typPackage.s4p” “minPackage.s4p” “maxPackage.s4p”))

*Parameter:* **Tx\_V**

*Required:* Yes, if the .ami file is defined for the Tx direction and **Ts4file** parameter is defined. Otherwise, illegal.

*Direction:* Tx

*Descriptors*:

Usage: Info, Dep

Type: Float

Format: Value, List, Corner, Range, Increment, Steps

Default: <numeric\_literal>

Description:< string >

*Definition:* This parameter defines the voltage swing of the stimulus input to the transmitter circuit.

*Examples:*

(Tx\_V (Usage Info)(Type Float)(Range 1.0 0.5 1.0))

*Parameter:* **Tx\_R**

*Required:* No, illegal if parameter **Ts4file** is not defined.

*Direction:* Tx

*Descriptors*:

Usage: Info, Dep

Type: Float

Format: Value, List, Corner, Range, Increment, Steps

Default: <numeric\_literal>

Description:<string>

*Definition:* This parameter is optional and defines the value Tx\_R in ohms of the series resistors shown in the Fig. XX. It can only be present if the .ami file is defined for the Tx direction. If this parameter is not present in the .ami file, the value of Tx\_R defaults to zero.

*Examples:*

(Tx\_R (Usage Info)(Type Float)(Value 0.0))

*Parameter:* **Rx\_R**

*Required:* No, illegal if parameter **Ts4file** is not defined.

*Direction:* Rx

*Descriptors*:

Usage: Info, Dep

Type: Float

Format: Value, List, Corner, Range, Increment, Steps

Default: <numeric\_literal>

Description:<string>

*Definition:* This parameter is optional and defines the value of Rx\_R in ohms of the resistors shown in Fig. XX. It can only be present if the .ami file is defined for the Rx direction. If this parameter is not present in the .ami file, the value of Rx\_R defaults to infinity, or a reasonable approximation thereof.

*Examples:*

(Rx\_R (Usage Info)(Type Float)(Value 1.0e6))

The following three tables need to be added and renumbered appropriately.

Table – General Rules and Allowable Usage for General Reserved Parameters

| **Reserved Parameter** | **General Rules** | **Allowable Usage** |
| --- | --- | --- |
| **Required** | **Default** | **Info** | **In** | **Out** | **Dep1** | **InOut** |
| Ts4file | No | -- | X |  |  | X |  |
| Ts4file\_Boundary | No | -- | X |  |  | X |  |
| Ts4file\_Package\_Options | Yes/No | -- | X |  |  | X |  |
| Ts4file\_Package\_Data | Yes/No | -- | X |  |  | X |  |
| Tx\_V | Yes/No | -- | X |  |  | X |  |
| Tx\_R | No | 0 | X |  |  | X |  |
| Rx\_R | No | Infinity | X |  |  | X |  |

Table – Allowable Data Types for General Reserved Parameters

| **Reserved Parameter** | **Data Type** |
| --- | --- |
| **Float** | **UI** | **Integer** | **String** | **Boolean** |
| Ts4file |  |  |  | X |  |
| Ts4file\_Boundary |  |  |  | X |  |
| Ts4file\_Package\_Options |  |  |  | X |  |
| Ts4file\_Package\_Data |  |  |  | X |  |
| Tx\_V | X |  |  |  |  |
| Tx\_R | X |  |  |  |  |
| Rx\_R | X |  |  |  |  |

Table – Allowable Data Formats for General Reserved Parameters

| **Reserved Parameter** | **Data Format** |
| --- | --- |
| **Value** | **Range** | **Corner** | **List** | **Increment** | **Steps** | **Gaussian** | **Dual-Dirac** | **DjRj** | **Table** |
| Ts4file | X |  | X | X |  |  |  |  |  |  |
| Ts4file\_Boundary | X |  |  |  |  |  |  |  |  |  |
| Ts4file\_Package\_Options | X |  |  | X |  |  |  |  |  |  |
| Ts4file\_Package\_Data | X |  | X | X |  |  |  |  |  |  |
| Tx\_V | X |  |  |  |  |  |  |  |  |  |
| Tx\_R | X |  |  |  |  |  |  |  |  |  |
| Rx\_R | X |  |  |  |  |  |  |  |  |  |