**BUFFER ISSUE RESOLUTION DOCUMENT (BIRD)**

**BIRD NUMBER:** 158.6\_draft7

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

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**DATE ACCEPTED:**

**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.

WMK> I removed all reference to pad and pin terminals.

WMK> Fixed figures, and removed addtion text that had referenced pad and pin terminals.

**ANY OTHER BACKGROUND INFORMATION:**

BIRD 158.5 was updated as agreed in review meetings:

1. The name of reserved parameter “Ts4File\_Includes” is changed to “Ts4file\_Boundary”.
2. The example following that parameter is updated to illustrate just that parameter.
3. Various straightforward editorial changes.

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. The use of the term “step response” is avoided as it is not used in the current specification.
3. 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 ideal step stimulus is a differential voltage waveform V(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 (default is 0.0 Ohms). For a Tx buffer, the transmitter circuit defines the analog buffer model between the zero-impedance stimulus input voltage source and the buffer terminals.

The slope of an ideal step stimulus is infinite, this should be implemented in simulators as steep as possible.

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.

Note: The triangle ground symbol for a “Signal Ground”.

Wmk> It does not simbolize Node 0.

WMK> We might push this definition to the introduction part of IBIS, since this symbol should be used in other graphics in IBIS.

# 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 the high impedance 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.



The Tx or Rx analog circuits specified in the AMI file by means of the parameter Ts4file shall be used as a direct replacement of the corresponding analog model described by the [Model] keyword.

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:* **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 |  |
| 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 |  |
| 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 |  |  |  |  |  |  |
| Tx\_V | X |  |  |  |  |  |  |  |  |  |
| Tx\_R | X |  |  |  |  |  |  |  |  |  |
| Rx\_R | X |  |  |  |  |  |  |  |  |  |