**BUFFER ISSUE RESOLUTION DOCUMENT (BIRD)**

**ISSUE TITLE:** *AMI Touchstonefile ® Analog Buffer Models*

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

The IBIS 5.1 specification provides limited capability for describing the frequency-dependent behavior of a SerDes transmitter’s analog output driver or receiver’s analog input termination network. This makde it difficult to model a device’s insertion and return loss 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 termination network 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 new AMI Reserved Parameters Ts4file, Tx\_V, Tx\_R, Rx\_R.

**ANY OTHER BACKGROUND INFORMATION:**

# Transmitter Driver Analog Circuit



The voltages of the voltage sources correspond to V=Tx\_V for logic level 1, and V=-Tx\_V for logic level 0.The Step Response Stimulus is a differential voltage waveform between the nodes SRC\_pos and SRC\_neg when both voltage sources are synchronously switched from a logic level 0 to a logic level 1. It may be used to determine the impulse response needed for the AMI flow, as described later.

Transition time in switching between the logic levels in the two ideal voltage sources is zero.

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. The ports 1 and 3 are at the Tx side, and ports 2 and 4 are connected to the channel. Furthermore, the ports 1 and 2 correspond to the positive signal path and the ports 3 and 4 to the negative signal path.

# Receiver Analog Termination 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. The ports 1 and 3 are connected to the channel, and the ports 2 and 4 serve as the differential input to the Rx algorithmic model.

The IBIS AMI flow requires that the EDA tool generates an Impulse Response of the channel. This Impulse Response characterizes the differential response of the Tx analog buffer model, the Tx package model, the interconnect between the Tx component and the Rx component (the channel), the Rx package model and the Rx analog buffer model. The Touchstone file defined in this BIRD is to be used for either the Tx analog buffer excluding the Tx package model and/or the Rx analog buffer model excluding the Rx package model. The following figure illustrates the entire setup when both Tx and Rx use the Ts4file parameter.



#### For discussion: The model maker may want to inform the user and the EDA tool that the Ts4file includes the package. Then a separate parameter is needed. Alternatively, the model maker may provide the s4p data of the package.

Note that when the Reserved Parameter Ts4file is defined in the AMI model the Tx or the Rx schematic shown above is to be used in lieu of the analog buffer model and the pachage defined in the .ibs file. For Tx models that have the Reserved Parameter Ts4file, the Reserved Parameter Tx\_V is required and the Reserved Parameters Tx\_R are optional. For Rx models that have the Reserved Parameter Ts4file, the Reserved Parameter Rx\_R is optional. In other words, for a Tx buffer, the Transmitter Circuit defines the analog buffer model between the zero impedance stimulus input voltage source and the channel. For an Rx buffer, the Receiver Circuit defines the analog buffer model between the channel and a high impedance probe at the input to the Rx Algorithmic model. Given that the Touchstone 4-port model is LTI there are many methods of generating an Impulse Response of the channel to be used in AMI modeling that will give the identical result within numerical accuracy of the technique chosen. One technique commonly used in EDA tool simulation is to generate the Channel Step Response by applying the Step Response Stimulus s calculating the time derivative of that step response. When both Tx and Rx Ts4file parameters are present the Channel Step Response is measured between the SRC-pos/SRC\_neg input and a high impedance differential probe between ports 2 and 4 of the Rx 4-port network. When only either Tx or Rx has the Ts4file parameter present then the other component’s contribution to the Channel Step Response (or just the cimpulse response) follows the .ibs file description, as has been the case before this BIRD has been introduced.

## 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 contains the name of 4-port Touchstone file to be used in the Analog Model Circuit. The If the file contains 4-port S-parameter data they can be measured at any reference impedance. See the Analog Circuit Definitions above for the port order associated with the Touchstone file.

*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.

*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 input to the transmitter circuit.

*Examples:*

(Tx\_V (Usage Info)(Type Float)(Range 1. .5 1.))

*Parameter:* **Tx\_R**

*Required:* No

*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 of the Tx\_R series resistor in ohms. 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

*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. 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))