**BUFFER ISSUE RESOLUTION DOCUMENT (BIRD)**

**BIRD NUMBER: 197.4**

**ISSUE TITLE:** New AMI Reserved Parameters DC\_Offset and NRZ\_Threshold

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**DATE ACCEPTED:**

**DEFINITION OF THE ISSUE:**

AMI modeling is now being applied to single-ended channels (e.g. DDR5). The current input to AMI\_Init is an Impulse Response. This forces all AMI simulations to be centered around the mid-level of the signal of a single-ended port. A receiver (Rx) DLL may need to know the input single-ended voltage levels (e.g. to handle saturation in a DFE summer). The DLL may also need to provide EDA tools a voltage offset to be added to the DLL’s AMI\_GetWave output waveform by EDA tools to form the complete waveform at the Rx algorithmic model output. Moreover, with the inclusion of single-ended signal, it becomes more prominent that the Rx model needs to provide the threshold voltage used by EDA tools to determine the NRZ logic level at the Rx algorithmic model output. This BIRD proposes two new AMI Reserved Parameters, DC\_Offset and NRZ\_Threshold, to address these issues.

**SOLUTION REQUIREMENTS:**

The IBIS specification must meet these requirements:

Table 1: Solution Requirements

|  |  |
| --- | --- |
| Requirement | Notes |
| 1. Allow the Rx model to recover the single-ended signal at the Rx input. 2. Allow the Rx model to convey to EDA tools a voltage offset to be added to the AMI\_GetWave output waveform. 3. Allow the Rx model to convey to the EDA tool the threshold to be used when detecting the NRZ logic level at the Rx algorithmic model output. |  |

**SUMMARY OF PROPOSED CHANGES:**

Add new AMI Reserved Parameters DC\_Offset and NRZ\_Threshold.

**PROPOSED CHANGES:**

*Parameter:* **DC\_Offset**

*Required:* No, and illegal before AMI\_Version X.x

*Direction:* Rx

*Descriptors:*

Usage:                   In, InOut

Type:                     Float

Format:                  Value

Default:                 <numeric\_literal>

Description:<string>

*Definition:* The input value of DC\_Offset is the mean value of the steady state high and low voltages of the analog channel step response at the Rx pad. The output value of DC\_Offset returned by Rx AMI\_Init is to be added to the Rx AMI\_GetWave output waveform by EDA tools to form the complete waveform at the Rx algorithmic model output.

*Usage Rules:* If the impulse response was generated by differentiating the analog channel step response, then the input value of DC\_Offset should be the same as the average of the step response initial and final voltages.

Both default input and output values of DC\_Offset are 0.0 Volt. If the parameter is defined as Usage In, the output value of DC\_Offset is accordingly assumed to be 0.0 Volt.

It is assumed that the waveform input to the Rx AMI\_GetWave function is the physical Rx input waveform minus the input value of this DC\_Offset. The Rx AMI\_GetWave function may choose to reconstruct the physical input waveform by adding the input value of DC\_Offset to the input waveform.

*Other Notes:*

1. It is the responsibility of the EDA tool to determine the input value of DC\_Offset. The EDA tool may use any method to do this.
2. It is the responsibility of the Rx algorithmic model to determine the output value of DC\_Offset.

*Example:*

DC\_Offset (Usage InOut) (Type Float) (Value 0.5)

(Description “The EDA tool is responsible for determining the input value sent to the executable model. The executable model is responsible for returning the output value to the EDA tool.”)

*Parameter:* **NRZ\_Threshold**

*Required:* No, and illegal before AMI\_Version X.x

*Direction:* Rx

*Descriptors:*

Usage:                   Out

Type:                     Float

Format:                  Value

Default:                 <numeric\_literal>

Description:<string>

*Definition:* The threshold voltage EDA tools use to detect the NRZ logic level in the complete waveform at the Rx algorithmic model output, i.e. the Rx AMI\_GetWave output waveform plus the output value of DC\_Offset returned by Rx AMI\_Init.

*Usage Rules:* The EDA tool uses this voltage in conjunction with Rx clock information to detect the NRZ logic level when the complete waveform at the Rx algorithmic model output is sampled.

* If the sampled voltage is *higher* than **NRZ\_Threshold + Rx\_Receiver\_Sensitivity**, the logic level is 1.
* If the sampled voltage is *lower* than **NRZ\_Threshold – Rx\_Receiver\_Sensitivity**, the logic level is 0.
* If the sampled voltage does *not* fall into one of the above regions, the logic level is unchanged from the previous sample.

The algorithmic model’s AMI\_Init and AMI\_GetWave functions are expected to output the value of NRZ\_Threshold for the EDA tool to use during waveform and eye processing.

*Other Notes:* If this parameter is not in the .ami file, then its default value will be 0.0 Volts.

*Example:*

NRZ\_Threshold (Usage Out) (Type Float) (Value 0.002)

(Description “Threshold voltage to be used to detect the NRZ logic level at the Rx output.”)

Add the following sentence:

“If the model’s logic threshold is not zero, it may be reported as a non-zero value using the parameter NRZ\_Threshold.”

on page 207 after the sentence:

“The algorithmic model’s logic threshold may be non-zero, for example to model the differential offset of a receiver. However, that offset will usually be small compared to the input or output differential voltage.”.

**BACKGROUND INFORMATION/HISTORY:**

Typographical updates made in BIRD197.1, based on feedback from Open Forum and ATM review.

BIRD197.2 contains additional editorial changes.

BIRD197.3 contains editorial changes to the verbiage related to the usage of the words “single-ended”.

BIRD197.4 changes the DC\_Offset Usage from In to In or InOut.

Example 1: the complete waveform at the Rx algorithmic model output ranges within [-0.4, 0.6]. The threshold is 0.05.

Rx model 1:

* + Rx AMI\_Init returns DC\_Offset of 0.1
  + Rx AMI\_GetWave returns output waveform ranges within [-0.5, 0.5]
  + Rx returns NRZ\_Threshold of 0.05

Rx model 2 (equivalent to Model 1):

* + Rx AMI\_Init returns DC\_Offset of 0.0
  + Rx AMI\_GetWave returns output waveform ranges within [-0.4, 0.6]
  + Rx returns NRZ\_Threshold of 0.05

Example 2: the complete waveform at the Rx algorithmic model output ranges within [0.0, 1.0]. The threshold is 0.55.

Rx model 1:

* + Rx AMI\_Init returns DC\_Offset of 0.5
  + Rx AMI\_GetWave returns output waveform ranges within [-0.5, 0.5]
  + Rx returns NRZ\_Threshold of 0.55

Rx model 2 (equivalent to Model 1):

* + Rx AMI\_Init returns DC\_Offset of 0.4
  + Rx AMI\_GetWave returns output waveform ranges within [-0.4, 0.6]
  + Rx returns NRZ\_Threshold of 0.55