**BUFFER ISSUE RESOLUTION DOCUMENT (BIRD)**

**BIRD NUMBER:** 188.1

**ISSUE TITLE:** Expanded Rx Noise Support for AMI

**REQUESTOR:**  Michael Mirmak, Intel Corporation

**DATE SUBMITTED:** December 13, 2016

**DATE REVISED:** January 17, 2017

**DATE ACCEPTED:**  February 17, 2017

**DEFINITION OF THE ISSUE:**

IBIS 6.1 defines separate uniform and random (Gaussian) jitter Reserved Parameters for Tx and Rx devices as Tx\_Dj, Tx\_Rj, Rx\_Dj and Rx\_Rj, respectively. However, the receiver noise Reserved Parameter Rx\_Noise covers only random (unbounded Gaussian) noise. A more complete definition of receiver noise would include a parameter for bounded uniform noise, and would ideally use names for both noise parameters that parallel the naming convention for jitter.

**SOLUTION REQUIREMENTS:**

The IBIS specification must meet these requirements:

Table : Solution Requirements

|  |  |
| --- | --- |
| Requirement | Notes |
| 1. Bounded (uniform) Rx Noise must be supported by IBIS-AMI, separately from the existing Gaussian random Rx Noise parameter.
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| 1. The existing Rx\_Noise Reserved Parameter must be clarified as referring to unbounded Gaussian random noise, as is already done for Tx\_Rj and Rx\_Rj.
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| 1. The ranges for the unbounded Gaussian and bounded uniform random multipliers of the noise value in the equations to be used by EDA tools should be clearly stated.
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**SUMMARY OF PROPOSED CHANGES:**

For review purposes, the proposed changes are summarized as follows:

Table : IBIS Keywords, Subparameters, AMI Reserved\_Parameters, and AMI functions Affected

|  |  |  |
| --- | --- | --- |
| Specification Item | New/Modified/Other | Notes |
| The Reserved Parameter Rx\_UniformNoise is defined | New |  |
| The Reserved Parameter Rx\_GaussianNoise is added as an alternate name for Rx\_Noise. | Modified | This is a modification of the existing parameter Rx\_Noise, to clarify its relationship to the new Reserved Parameter Rx\_UniformNoise |
| The range for gaussian\_rand() and the meaning of the Rx\_Noise equation are clarified. | Other | The text of the Rx\_Noise parameter definition is clarified to define the range for gaussian\_rand(), with the output and input to the equations made explicit. |

**PROPOSED CHANGES:**

*The definition of Rx\_Noise on page 228 of the existing IBIS 6.1 specification should be changed from:*

*Parameter:* **Rx\_Noise**

*Required:* No, and illegal before AMI\_Version 6.0

*Direction:* Rx

*Descriptors*:

Usage: Info, Out, Dep

Type: Float

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

Default: <numeric\_literal*>*

Description:<string>

*Definition:* The standard deviation, in volts, of a white Gaussian random process, which is to be added by the EDA tool to the signal measured at the sampling latch of a receiver.

*Usage Rules:* If Rx\_Noise is Usage Out, then the EDA tool shall use the value returned by Rx AMI\_Init if Rx AMI\_GetWave is not used. If Rx AMI\_GetWave is used, then the EDA tool may apply the value returned by each AMI\_GetWave call to the waveform returned by that call to AMI\_GetWave, or use the average value of Rx\_Noise returned by all calls to AMI\_GetWave (after Ignore\_Bits), or the value of Rx\_Noise returned by the last call to AMI\_GetWave.

*Other Notes:* Time is calculated as follows:

wave(t) = wave(t) + Rx\_Noise \* gaussian\_rand()

Where wave(t) is the waveform returned by Rx AMI\_GetWave.

*Example:*

 (Rx\_Noise (Usage Info) (Value 0.010) (Type Float)

 (Description "Rx amplitude noise at sampling latch in volts."))

*… to:*

*Parameter:* **Rx\_Noise, Rx\_GaussianNoise**

*Required:* No, and Rx\_Noise is illegal before AMI\_Version 6.0; Rx\_GaussianNoise is illegal before AMI\_Version 6.2

*Direction:* Rx

*Descriptors*:

Usage: Info, Out, Dep

Type: Float

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

Default: <numeric\_literal*>*

Description:<string>

*Definition:* The standard deviation, in volts, of an unbounded white Gaussian random process, which is to be added by the EDA tool to the signal measured at the sampling latch of a receiver.

*Usage Rules:* If Rx\_Noise is Usage Out, then the EDA tool shall use the value returned by Rx AMI\_Init if Rx AMI\_GetWave is not used. If Rx AMI\_GetWave is used, then the EDA tool may apply the value returned by each AMI\_GetWave call to the waveform returned by that call to AMI\_GetWave, or use the average value of Rx\_Noise returned by all calls to AMI\_GetWave (after Ignore\_Bits), or the value of Rx\_Noise returned by the last call to AMI\_GetWave.

*Other Notes:* The output voltage waveform is calculated as follows:

Output\_wave(t) = wave(t) + Rx\_Noise \* gaussian\_rand()

where wave(t) is the waveform returned by Rx AMI\_GetWave and gaussian\_rand() is a function that returns floating point numbers between -inf and +inf. The distribution of these numbers shall be a white Gaussian distribution centered at 0.0 with a standard deviation of 1.0.

Rx\_GaussianNoise is permitted and recommended as an equivalent name for Rx\_Noise in AMI\_Version 6.2 and higher.

*Example:*

 (Rx\_Noise (Usage Info) (Value 0.010) (Type Float)

 (Description "Rx amplitude noise at sampling latch in volts."))

*Immediately after, a new Reserved Parameter should be added:*

*Parameter:* **Rx\_UniformNoise**

*Required:* No, and illegal before AMI\_Version 6.2

*Direction:* Rx

*Descriptors*:

Usage: Info, Out, Dep

Type: Float

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

Default: <numeric\_literal*>*

Description:<string>

*Definition:* The worst-case half peak-to-peak variation, in volts, of a bounded uniform random process which is to be added by the EDA tool to the signal measured at the sampling latch of a receiver.

*Usage Rules:* If Rx\_UniformNoise is Usage Out, then the EDA tool shall use the value returned by Rx AMI\_Init if Rx AMI\_GetWave is not used. If Rx AMI\_GetWave is used, then the EDA tool may apply the value returned by each AMI\_GetWave call to the waveform returned by that call to AMI\_GetWave, or use the average value of Rx\_UniformNoise returned by all calls to AMI\_GetWave (after Ignore\_Bits), or the value of Rx\_UniformNoise returned by the last call to AMI\_GetWave.

*Other Notes:* The output voltage waveform is calculated as follows:

Output\_wave(t) = wave(t) + 2 \* Rx\_UniformNoise \* rand()

where wave(t) is the waveform returned by Rx AMI\_GetWave and rand() is a function that returns floating point numbers between -0.5 and +0.5 with white uniform distribution.

*Example:*

 (Rx\_UniformNoise (Usage Info) (Value 0.010) (Type Float)

 (Description "Rx uniform amplitude noise at sampling latch in
 volts."))

**BACKGROUND INFORMATION/HISTORY:**

This was submitted by Michael Mirmak of Intel Corp. as a draft for review by the IBIS Advanced Technology Modeling Task Group on November 10, 2016.

Draft 2 changes the names of Rx\_Dn and Rx\_Rn to Rx\_BoundedUniform and Rx\_Gaussian, at the suggestion of participants in the IBIS-ATM Task Group.

Draft 3 changes the names of Rx\_BoundedUniform and Rx\_Gaussian to Rx\_BoundedUniformNoise and Rx\_UnboundedGaussianNoise, respectively, at the suggestion of participants in the IBIS-ATM Task Group.

Draft 4 changes the names of Rx\_BoundedUniform and Rx\_Gaussian to Rx\_UniformNoise and Rx\_GaussianNoise, respectively, at the suggestion of participants in the IBIS-ATM Task Group. This draft was submitted to the IBIS Open Forum and became BIRD 188 on December 13, 2016.

BIRD188.1 was submitted on January 17, 2017, to clarify the use of Rx\_GaussianNoise as the recommended name in place of Rx\_Noise, to correct capitalization in the sentence fragments following equations, and to improve indentation of an AMI syntax example. It was transmitted by Michael Mirmak of Intel Corp. December 16, 2016 but not posted at that time due to an oversight. BIRD188 without these changes was accepted January 6, 2017, necessitating a revote for the BIRD188.1 update.