**BUFFER ISSUE RESOLUTION DOCUMENT (BIRD)**

**BIRD NUMBER:** *178.3*

**ISSUE TITLE:** *Specifying Buffer Directionality for AMI*

**REQUESTOR:**  *Michael Mirmak, Intel Corp.*

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**DATE ACCEPTED BY IBIS OPEN FORUM:** *July 31, 2015*

**STATEMENT OF THE ISSUE:**

The 6.0 specification strongly implies that only input-only and output-only [Model]s may be associated with AMI data using the [Algorithmic Model] keyword pair. However, there is no explicit prohibition on using any model type with [Algorithmic Model] except Terminator, Series, and Series\_Switch.

The ibischk 6.01 parser correctly generates no errors if an [Algorithmic Model] keyword pair is associated with a model of Model\_type I/O. However, the association of an I/O buffer with either a Tx or Rx AMI file creates an ambiguous situation: the model, EDA tool, and user have no way currently to communicate, either in traditional IBIS or using AMI Reserved Parameters, the directionality state of the buffer at any one time.

Most serial-differential interface buffers support only a single direction of operation. However, algorithmic modeling is an attractive option for higher speed single-ended interfaces that support BER analysis and equalization, such as DDR4, which include bi-directional buffers. Unambiguous directionality is needed for consistent modeling and simulation of such interfaces using IBIS-AMI techniques.

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

Two new Subparameters, “Executable\_Tx” and “Executable\_Rx”, are defined for the [Algorithmic Model] keyword, to specify the direction associated with the associated .ami files. These are assumed to be parsed for consistency with the Model\_type defined for the associated analog [Model]. These are also assumed to be parsed for consistency with the Reserved Parameters used in the associated .ami file.

Ideally, an error would be generated for buffers, with associated Algorithmic Models, where conflicting Model\_type and Reserved Parameter definitions are present. In addition, an error should be generated for .ami files that contain both Tx and Rx Reserved Parameters.

**ANY OTHER BACKGROUND INFORMATION:**

The intent of this set of rule changes is ensure the EDA tool is “aware” of the associated models’ capabilities, to prevent cases where a channel is connected only to Rx endpoints with no Tx in the channel, or only to Tx endpoints with no receiving or 3-state device capable of receiving present or configured to do so.

These changes are assumed to be unaffected by the Polarity [Model] subparameter.

Thanks to Walter Katz of Signal Integrity Software (SiSoft) for his suggestions in an earlier verison of this proposal.

Draft 2 incorporates rules for the two restrictions on DLL and .ami file support that were the consensus of the IBIS ATM Task Group:

1) DLLs may be configured to support both TX and RX directions in a single DLL, or separate DLLs may be provided for each direction supported by a model.

2) Each direction shall have a separate associated .ami file.

In addition, a new subparameter, “Direction”, is added for [Algorithmic Model]. The AMI\_Model\_Direction parameter is removed.

Draft 3 removes the AMI\_Model\_Type keyword as redundant, and adds more stringent rules in the specification regarding statement of assumed direction(s) supported by each Reserved Parameter. Note that Direction must be stated as shown in Table 2 in this proposal for all existing and any future Reserved Parameters, if this BIRD is approved. Having direction stated in the actual Reserved Parameter definitions for each parameter may be desireable.

Pursuant to an IBIS Advanced Technology Modeling Task Group discussion, Draft 4 removes “Direction” and adds “ExecutableTx” and “ExecutableRx”. This draft also restores the prohibition on multiple [Algorithmic Model] keyword sections for a given [Model]. Finally, the issue title has been changed to reflect the absence of “Reserved Parameters” in the current proposal.

The BIRD was approved for forwarding to the IBIS Open Forum without objection by the IBIS-ATM Task Group on June 2, 2015, with the use of “\_” in the “Executable\_Tx” and “Executable\_Rx”, requirement that 3-state buffers use only “Executable” and support for either “Executable\_Tx” or “Executable\_Rx” or both for I/O buffers.

BIRD 178.1 is issued to change the implied Table 2 requirement that Executable\_Tx and Executable\_Rx both be present for I/O Model\_types.

BIRD178.2 is issued to update the Reserved Parameter tables to reflect PAM-4 Reserved Parameters defined in BIRD175.3.

BIRD178.3 is issued as the result of two editorial amendments proposed during consideration and voting on the BIRD in the IBIS Open Forum. The first change is to replace Supported Directions “Any” with “Rx, Tx”, “Rx-only” with “Rx”, and “Tx-only” with “Tx” in the text and tables. The second is to add a “Direction” line to the summary text for each Reserved Parameter in the main body of the specification document.

BIRD178.3 was approved unanimously during the July 31, 2015 IBIS Open Forum teleconference.

For each Reserved Parameter add one of the following Direction lines, as documented in Table 1 below, positioned before the *Descriptors* heading:

*Direction:* Rx

*Direction:* Tx

*Direction:* Rx, Tx

Add the following text at the end of section 10.7, “Reserved Parameter and Data Type Rule Summary Tables”:

…

AMI parameter file Reserved Parameters and [Model] Model\_type subparameter declarations shall be mutually consistent. Additionally, both Reserved Parameters and Model\_type subparameter arguments shall be consistent with the associated [Algorithmic Model] Executable\_Tx and Executable\_Rx subparameters if present (i.e., for I/O-capable buffers that can handle both Tx and Rx functions).

To maintain consistency with the directionality of the associated buffer, only certain Reserved Parameters are may be combined in the same .ami file. Tx and Rx Reserved Parameters shall not be present in the same .ami file. Further, Tx Reserved Parameters shall not be present in .ami files associated with [Algorithmic Model] Executable\_Rx subparameters; similarly Rx Reserved Parameters shall not be present in .ami files associated with [Algorithmic Model] Executable\_Tx subparameters.

The directions supported for each Reserved Parameter are shown in Table 1 below. The Model\_type and permitted associated subparameter arguments for the [Algorithmic Model] keyword are shown in Table 2.

Table 1 – Defined Directions for Reserved Parameters

| **Reserved Parameter** | **Supported Direction(s)** |
| --- | --- |
| AMI\_Version | Rx, Tx |
| DLL\_ID | Rx, Tx |
| DLL\_Path | Rx, Tx |
| GetWave\_Exists | Rx, Tx |
| Ignore\_Bits | Rx, Tx |
| Init\_Returns\_Impulse | Rx, Tx |
| Max\_Init\_Aggressors | Rx, Tx |
| Model\_Name | Rx, Tx |
| Modulation | Rx, Tx |
| PAM4\_Mapping | Rx, Tx |
| PAM4\_UpperThreshold | Rx |
| PAM4\_CenterThreshold | Rx |
| PAM4\_LowerThreshold | Rx |
| PAM4\_UpperEyeOffset | Rx |
| PAM4\_CenterEyeOffset | Rx |
| PAM4\_LowerEyeOffset | Rx |
| Repeater\_Type | Rx |
| Resolve\_Exists | Rx, Tx |
| Rx\_Clock\_PDF | Rx |
| Rx\_Clock\_Recovery\_DCD | Rx |
| Rx\_Clock\_Recovery\_Dj | Rx |
| Rx\_Clock\_Recovery\_Mean | Rx |
| Rx\_Clock\_Recovery\_Rj | Rx |
| Rx\_Clock\_Recovery\_Sj | Rx |
| Rx\_DCD | Rx |
| Rx\_Dj | Rx |
| Rx\_Noise | Rx |
| Rx\_Receiver\_Sensitivity | Rx |
| Rx\_Rj | Rx |
| Rx\_Sj | Rx |
| Supporting Files | Rx, Tx |
| Tx\_DCD | Tx |
| Tx\_Dj | Tx |
| Tx\_Jitter | Tx |
| Tx\_Rj | Tx |
| Tx\_Sj | Tx |
| Tx\_Sj\_Frequency | Tx |
| Use\_Init\_Output | N/A (illegal combination) |

Table 2 – [Algorithmic Model] Subparameter and [Model] Model\_Type Interaction

| **[Model] Model Type** | **[Algorithmic Model] Executable Subparameters Permitted** |
| --- | --- |
| Input  Input\_ECL | Executable only  Executable\_Tx and Executable\_Rx are not permitted |
| I/O  I/O\_open\_drain  I/O\_open\_sink  I/O\_open\_source  I/O\_ECL | Executable illegal  Executable\_Tx and/or Executable\_Rx are required |
| Terminator | N/A (illegal) |
| Output  Output\_ECL | Executable only  Executable\_Tx and Executable\_Rx are not permitted |
| 3-state  3-state\_ECL | Executable only  Executable\_Tx and Executable\_Rx are not permitted |
| Open\_sink  Open\_drain  Open\_source | Executable only  Executable\_Tx and Executable\_Rx are not permitted |
| Series | N/A (illegal) |
| Series\_switch | N/A (illegal) |
| Input\_diff | Executable only  Executable\_Tx and Executable\_Rx are not permitted |
| Output\_diff | Executable only  Executable\_Tx and Executable\_Rx are not permitted |
| I/O\_diff | Executable illegal  Executable\_Tx and/or Executable\_Rx are required |
| 3-state\_diff | Executable only  Executable\_Tx and Executable\_Rx are not permitted |

Add the following updated text under the “Keyword Definitions” section of Chapter 10:

*Keywords:* [Algorithmic Model], [End Algorithmic Model]

*Required:* No

*Description:* Used to reference an executable model file and accompanying parameter definition file. This executable model file encapsulates signal processing functions, while the parameter definition file includes configuration information for the model and EDA tool. In the case of a receiver, the executable model file may additionally include clock and data recovery functions. The executable model file can receive and modify waveforms with the analog channel, where the analog channel consists of the transmitter output stage, the transmission channel itself and the receiver input stage. This data exchange is implemented through a set of software functions. The signature of these functions is elaborated in Section 10.2 of this document. The function interface must comply with the ANSI "C" language.

Note that, while the file is described here as an “executable model file”, the file is a compiled library of functions that may or may not be itself executable.

*Sub-Params:*  Executable, Executable\_Tx, Executable\_Rx

*Usage Rules:* The [Algorithmic Model] keyword must be positioned within a [Model] section and it may appear only once for each [Model] keyword in a .ibs file. It is not permitted under the [Submodel] keyword or in [Model]s which are of Model\_type Terminator, Series or Series\_switch.

The [Algorithmic Model] always processes a single waveform regardless whether the model is single ended or differential. When the model is differential, the waveform passed to the [Algorithmic Model] must be a difference waveform.

[Algorithmic Model], [End Algorithmic Model]:

Begins and ends an algorithmic model section, respectively.

Executable:

Three entries follow the Executable subparameter on each line:

Platform\_Compiler\_Bits File\_Name Parameter\_File

The Platform\_Compiler\_Bits entry provides the name of the operating system, compiler and its version and the number of bits the executable model file is compiled for. It is a string without white spaces, consisting of three fields separated by an underscore (“\_”). The first field consists of the name of the operating system followed optionally by its version. The second field consists of the name of the compiler followed by optionally by its version. The third field is an integer indicating the platform architecture. If the version for either the operating system or the compiler contains an underscore, it must be converted to a hyphen “-”. This is so that an underscore is only present as a separation character in the entry.

The architecture entry can be either “32” or “64”. Examples of Platform\_Compiler\_Bits:

Linux\_gcc3.2.3\_32

Solaris5.10\_gcc4.1.1\_64

Solaris\_cc5.7\_32

Windows\_VisualStudio7.1.3088\_32

HP-UX\_accA.03.52\_32

The EDA tool will check for the compiler information and verify if the executable model file is compatible with the operating system and platform.

Multiple occurrences, without duplication, of Executable are permitted to allow for providing executable model files for as many combinations of operating system platforms and compilers for the same algorithmic model.

The File\_Name provides the name of the executable model file. The executable model file should be in the same directory as the.ibs file.

The Parameter\_File entry provides the name of the parameter definition file, which shall have an extension of .ami. This must be an external file and should reside in the same directory as the .ibs file and the executable model file. See Section 10.3 for details.

Executable is prohibited if the Model\_type for the associated [Model] is “I/O”, “I/O\_open\_drain”, “I/O\_open\_sink”, “I/O\_open\_source”, or “I/O\_ECL”.

Executable\_Tx, Executable\_Rx:

The Executable\_Tx and Executable\_Rx subparameters are alternatives to the Executable subparameter, for I/O-capable buffers. The arguments (fields) supported are syntactically identical to the Executable subparameter. At least one Executable\_Tx or one Executable\_Rx subparameter is required if the Model\_type for the associated [Model] is “I/O”, “I/O\_open\_drain”, “I/O\_open\_sink”, “I/O\_open\_source”, or “I/O\_ECL”. For all other Model\_types where [Algorithmic Model] is supported, only the Executable subparameter is permitted. In these cases, the direction of the associated [Algorithmic Model]s shall be assumed by the EDA tool to follow the [Model] Model\_type declaration.

It is assumed that the [Model] Model\_type, use of [Algorithmic Model] Executable\_Tx and/or Executable\_Rx subparameters, and .ami file Reserved\_Parameter directions are consistent (e.g., that a [Model] of Model\_type I/O shall have associated [Algorithmic Model] Executable\_Tx and/or Executable\_Rx subparameters, each with unique .ami file associations where the .ami files use only Tx-capable and only Rx-capable Reserved Parameters, respectively).

For any given I/O [Model], the [Algorithmic Model] Executable\_Tx and Executable\_Rx subparameters present shall each refer to unique .ami files (Parameter\_Name argument). A single executable may be configured to process both transmit and receive waveform information and so may be used for both directions; unique parameter files are required for each direction, however.

The EDA tool is responsible for determining, through interaction with the user, the particular direction and associated files to use for a given simulation.

*Examples:*

Example of Executable in [Algorithmic Model]:

[Algorithmic Model]

| The Model\_type for the associated [Model] is something other than "I/O"

| or its variants

Executable Windows\_VisualStudio\_32 tx\_getwave.dll tx\_getwave\_params.ami

Executable Solaris\_cc\_32 libtx\_getwave.so tx\_getwave\_params.ami

|

[End Algorithmic Model]

Example of Executable\_Tx and Executable\_Rx for Bi-directional Model in [Algorithmic Model]:

[Algorithmic Model]

| The Model\_type for the associated [Model] must be "I/O"

| "I/O\_open\_drain", "I/O\_open\_sink", "I/O\_open\_source", or "I/O\_ECL".

|  
Executable\_Tx Windows\_VisualStudio\_32 tx\_getwave.dll tx\_getwave\_params.ami  
Executable\_Tx Solaris\_cc\_32 libtx\_getwave.so tx\_getwave\_params.ami  
|  
Executable\_Rx Windows\_VisualStudio\_32 rx\_getwave.dll rx\_getwave\_params.ami  
Executable\_Rx Solaris\_cc\_32 libtx\_getwave.so rx\_getwave\_params.ami  
|  
[End Algorithmic Model]