**BUFFER ISSUE RESOLUTION DOCUMENT (BIRD)**

**BIRD NUMBER: *Draft 5 March 17, 2015***

**ISSUE TITLE:** *C\_comp Model Using IBIS-ISS*

**REQUESTOR:**  *Walter Katz, Signal Integrity Software, Inc.*

*Randy Wolff, Micron Technology, Inc.*

**DATE SUBMITTED:** *{date you sent the original document, for new BIRDs}*

**DATE REVISED:** *{date(s) you sent any revisions to the document}*

**DATE ACCEPTED BY IBIS OPEN FORUM:**

**STATEMENT OF THE ISSUE:**

The current C\_comp model is either a single capacitance or optionally up to four capacitors attached to a [Model]’s power and ground reference terminals. This simple C\_comp model is not accurate enough for high speed buffers. This BIRD enhances IBIS to allow an alternative C\_comp Model using an IBIS-ISS subcircuit or Touchstone file. An enhanced C\_comp Model would allow modeling of effects such as frequency and voltage dependencies.

**STATEMENT OF THE RESOLVED SPECIFICATIONS:**

A new keyword [C\_comp Model] shall be positioned after [C Comp Corner]. In the tree diagram under [Model] and after [C Comp Corner], add:

│ ├── **[C\_comp Model]** Param, File\_TS, File\_ISS

│ │ Number\_of\_Terminals, Terminal

After the keyword [C Comp Model] add:

*Keywords:* **[C\_comp Model], [End C\_comp Model]**

*Required:* No

*Description:* Defines an enhanced C\_comp model referenced in an external file using either the Touchstone or IBIS-ISS languages. The [C\_comp Model] has ports compatible with the [Model] keyword or has ports compatible with the [Model] keyword plus additional ports connecting between the [Model] and the pad and/or at the input buffer.

*Sub-Params:* Param, File\_TS, File\_ISS, Number\_of\_Terminals, Terminal

*Usage Rules:* If [C\_comp Model] is present, it overrides [C Comp Corner] or any other C\_comp\* representations.

*Other Notes:*

modelssDPA [C\_comp Model] may also contain series elements modeling on-die interconnect between the buffer and the Die Pad. Use of an on-die interconnect model and/or [C\_comp Model]with series elements in the signal path - -A\_signal --

* ----
* --d[]Figure 15[][M]

The effect of series elements in a [C\_comp Model] may need to be de-embedded from I-V waveform data in the [Model].

Subparameter Definitions:

Unless noted below, no subparameter requires the presence of any other subparameter. Each subparameter is optional.

Param:

The Param subparameter is optional and only legal for File\_ISS references. Param shall be followed by four arguments: a string argument, param\_name, which is the name of the parameter to be passed into the IBIS-ISS subcircuit; and three numerical values or three string values (surrounded by double quotes) located in the typ, min, and max columns. Several Param lines are permitted as long as each of the param\_name entries is unique within that [C\_comp Model] keyword. Each Param line shall have a typ entry. Either or both the min and max entries may be NA, in which cases the typ entry is used. The typ, min, and max parameters are, by default, associated with the corner\_name Typ, Min, and Max files and their corresponding circuit\_names. However, the EDA tool is expected to support passing any of the Param typ, min, or max values, as selected by the User or EDA tool, into any File\_ISS corner\_name file. The Param values associated with any param\_name shall all be numerical or all string values (or NA). If possible, the Param min and max values should represent slow and fast interconnect conditions. Because of parameter interactions, this may not always be possible.

*Other Notes:* The numerical value rules follow the scaling conventions in Section 3, GENERAL SYNTAX RULES AND GUIDELINES. The EDA tool is responsible for translating IBIS specified parameters into IBIS-ISS parameters. For example, 1 megohm, represented as 1M in Param would be converted to 1meg (1x is not recommended) in IBIS-ISS. The value 1Kohm is 1 ohm in IBIS and would therefore be passed into IBIS-ISS as 1 ohm, even though 1K is 1 kilohm in IBIS-ISS. Quoted string parameters are converted to the string parameter syntax in IBIS-ISS. For example, the Param value “typ.s2p” is converted to str(‘typ.s2p’) in IBIS-ISS.

The base unit of frequency is hertz, and the base unit of length is meter. Values can be passed in terms of other base units of length if scaling conversions are added to the IBIS-ISS .subckt definition. For example, the intended value of 10 mils might be entered as the Param value of 10 if the conversion to 10 mils is done through multiplication within the .subckt.

*Examples:*

| Param param\_name typ min max

Param abc 2m 1m 2m

Param def 4k NA NA

Param ts\_file “typ.s2p” “min.s2p” “max.s2p” | used in IBIS-ISS

File\_TS:

Either File\_TS or File\_ISS is required for a [C\_comp Model]/[End C\_comp Model] group.File\_TS is followed by three entries for typ, min, and max file names. The typ entry is required and shall point to a Touchstone file located in the same directory as the .ibs file and representing typical conditions. The min and max entries may point to the same file or other files representing minimum (slow) and maximum (fast) models or contain NA. If the entry is NA, the typical file entry shall be used.

*Examples:*

| file\_type typ min max

File\_TS c\_comp\_typ.s8p c\_comp\_min.s8p c\_comp\_max.s8p

| file\_type typ min max

File\_TS c\_comp\_typ.s4p c\_comp\_min.s4p NA

File\_ISS:

Either File\_TS or File\_ISS is required for a [C\_comp Model]/[End C\_comp Model] group*.* The File\_ISS subparameter is followed by three string arguments consisting of corner\_name, file\_name, and circuit\_name (.subckt name). The IBIS-ISS (.iss) file shall be located in the same directory as the .ibs file. The corner\_name shall be Typ, Min, or Max. File\_ISS for the Typ corner\_name is required, and File\_ISS for the Min and Max corner\_names are optional. If present, each File\_ISS shall have a unique corner\_name. If File\_ISS for either the Min or Max corner\_name is missing, the File\_ISS for the Typ corner\_name shall be used to describe the missing corner\_name file reference. The Min and Max file\_names should represent slow and fast model conditions respectively.

*Examples:*

| file\_type corner\_name file\_name circuit\_name (.subckt name)

File\_ISS Typ c\_comp.iss c\_comp\_typ

File\_ISS Min c\_comp.iss c\_comp\_min | in same file as net.sp

File\_ISS Max c\_comp\_max.iss c\_comp\_max | in separate file

[]equal to or two

Terminal:

Two or more Terminal subparameters may appear under a given [C\_comp Model] keyword. At least one signal and one reference Terminal subparameter is required. Each Terminal record contains information on a single terminal of an IBIS-ISS subckt (or Touchstone file).

The Terminal subparameter is followed by two arguments: Terminal\_number and Terminal\_Location.

Terminal\_number shall be a positive, non-zero integer and less than or equal to the number of terminals in the Number\_of\_Terminals argument. The same Terminal\_number shall not appear more than once for a given [C\_comp Model]. All Terminals must be present for a given [C\_comp Model].

A [C\_comp Model] can either replace C\_comp by connecting a single terminal of the [C\_comp Model] at the same location that the [Model]’s C\_comp connects (see Figure X), or it can replace C\_comp with a model containing series elements (see Figure Y). In this case, the [C\_comp Model] will require a terminal at the output of the buffer (A\_signal) and a terminal at an internal buffer node (A\_signal\_I).

Figure X

Figure Y

Some Input and/or I/O buffers contain series elements between the Die Pad and the input buffer circuit that may provide isolation or filtering. If it is desired to view the analog input waveform at the input buffer, the [C\_comp Model] can contain the terminal A\_receive. The terminal A\_receive is analogous to the terminal my\_receive of an [External Model] as seen in Figure 24.

Terminal\_Location is a string and shall have one of the values A\_signal, A\_signal\_I, A\_signal\_pos, A\_signal\_pos\_I, A\_signal\_neg, A\_signal\_neg\_I, A\_receive, A\_puref, A\_pdref, A\_pcref, A\_gcref or A\_extref.

* A\_signal indicates this terminal connects to the [Model]’s signal terminal. This is the location that is either at the Die Pad, or there may optionally be on-die interconnect between this terminal and the Die Pad.
* A\_signal\_I is used when there is a series component to the [C\_comp Model].
* A\_signal\_pos indicates this terminal connects to the positive (non-inverting) side of a differential [Model]’s signal terminal. This is the location that is either at the Die Pad, or there may optionally be on-die interconnect between this terminal and the Die Pad.
* A\_signal\_pos\_I is used when there is a series component to the differential [C\_comp Model].
* A\_signal\_neg indicates this terminal connects to the complementary (Inverting) side of the [Model]’s signal terminal. This is the location that is either at the Die Pad, or there may optionally be on-die interconnect between this terminal and the Die Pad.
* A\_signal\_neg\_I is used when there is a series component to the differential [C\_comp Model].
* A\_receive is used when there is a series component to the input buffer.
* A\_puref indicates this terminal connects to the [Model]’s pullup reference.
* A\_pdref indicates this terminal connects to the [Model]’s pulldown reference.
* A\_pcref indicates this terminal connects to the [Model]’s power clamp reference.
* A\_gcref indicates this terminal connects to the [Model]’s ground clamp reference.
* A\_extref indicates this terminal connects to the [Model]’s external reference.

*Other Notes:*

For a [C\_comp Model] using File\_TS with N ports, N is either determined from the N in the .sNp file name extension for a Touchstone 1 file or from the [Number of Ports] record in a Touchstone 2 file. The [Number of Terminals] in the [C\_comp Model] shall be N+1. Terminal rules are described below:

* The EDA tool shall use the Terminal\_Location specified in the Terminal “N+1” record as the reference node for each of the N ports.
* Terminal/Port Mapping
  + Terminal              Port
  + 1                              1
  + 2                              2
  + …
  + N                             N
  + N+1 reference
* All Ports shall be connected through the Terminal record.
* It shall be an error if Terminal N+1 is not specified to a Buffer terminal that is not on a connection to a Signal\_name that is POWER or GND

*Examples:*

[C\_comp Model]

File\_ISS Typ A.iss A

Param Value C 1pF 2pF 0.5pF

Number\_of\_Terminals 2

Terminal 1 A\_signal

Terminal 2 A\_gcref

[End C\_comp Model]

[C\_comp Model]

File\_TS C\_typ.s2p C\_min.s2p C\_max.s2p

Number\_of\_Terminals 3

Terminal 1 A\_signal\_I

Terminal 2 A\_signal

Terminal 3 A\_gcref

[End C\_comp Model]

[C\_comp Model]

File\_ISS Typ B.iss B

Number\_of\_Terminals 7

Terminal 1 A\_signal\_I

Terminal 2 A\_signal

Terminal 3 A\_puref

Terminal 4 A\_pdref

Terminal 5 A\_pcref

Terminal 6 A\_gcref

Terminal 7 A\_receive

[End C\_comp Model]

[C\_comp Model]

File\_TS C\_typ.s4p NA NA

Number\_of\_Terminals 5

Terminal 1 A\_signal\_pos\_I

Terminal 2 A\_signal\_neg\_I

Terminal 3 A\_signal\_pos

Terminal 4 A\_signal\_neg

Terminal 5 A\_gcref

[End C\_comp Model]

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

The following section should be appended to the end of the IBIS document.

**RULES OF PRECEDENCE**

The EDA tool shall either use C\_comp or [C\_comp Model], but not both. The user and EDA tool may assume that the [C\_comp Model] is more accurate than C\_comp.

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

Inadequacies with the C\_Comp\* model have been known for a long time. Some presentations on C\_comp improvements include:

<http://www.eda.org/ibis/summits/oct04/mirmak2.pdf>

<http://www.eda.org/ibis/summits/jan15/wolff.pdf>

BIRD79 was an effort to improve C\_comp modeling: <http://www.eda.org/ibis/birds/bird79.txt>.