

BUFFER ISSUE RESOLUTION DOCUMENT (BIRD)

BIRD NUMBER: *Draft ~~65 March-April 6324197~~, 2015*
ISSUE TITLE: *C_comp Model Using IBIS-ISS*
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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:



After the keyword [C Comp ~~Model~~Corner] 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 IBIS-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:

IBIS-ISS interconnect models allow for on-die interconnect circuits between the IBIS buffer and the Die Pad. A [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 shall assume that V-T and I-V curves are measured at the A_signal terminal of the [Model]. If there is no on-die interconnect model, then this is the “Pad” in legacy IBIS models. If there is on-die interconnect, and an associated on-die interconnect model, then the I-V and V-T curves are assumed to be measured at the node between the [Model] and on-die interconnect.

- If the V-T and I-V curves are measured in a test fixture that includes the on-die interconnect, package and test fixture itself, then all of the on-die interconnect, package and test fixture shall be de-embedded to give the V-T and I-V curves as if generated using the following simulation method.
- If the V-T and I-V curves are generated by SPICE simulation it shall be assumed that the SPICE model shall include the [C_comp Model] and that the terminal of the SPICE model shall connect the Device Under Test (DUT, Figure 15) directly to the Test Fixture. When using the [C_comp Model], the [Model] may not use L_dut, R_dut and C_dut.

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

Param:

The ~~Param~~-subparameter Param is optional and only legal ~~for with the~~ File IBIS-ISS subparameter documented below. Param is illegal with the File TS subparameter documented below. ~~references.~~ Param shall be followed by ~~four~~ several arguments: an unquoted string argument giving the name of the parameter to be passed into the IBIS-ISS subcircuit, a reserved word for the parameter format, and other arguments based on the parameter format to be passed into the IBIS-ISS subcircuit. Valid entries for format are:

Value – A single numerical value or string value.

Corner – Three numerical values or three string values (surrounded by double quotes) located in the typ, min, and max columns. A typ value is required. 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 respectively. 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 IBIS-ISS corner name file.

~~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 parameter names is unique within the ~~at~~ [C_comp Model]/[End C_comp Model]

~~keywordgroup. 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 megaohm, would be represented as 1M in Param value according to The Section 3 rules, but would be converted by the EDA tool to case-insensitive 1meg (1X is not recommended) or 1E6 for IBIS-ISS use. Quoted string parameters in IBIS are converted to the string parameter syntax in IBIS-ISS. For example, the Param value "typ.s2p" would be converted to str('typ.s2p') in IBIS-ISS. 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 | <u>format</u> | typ | min | max |
| Param | _____ | abc | Corner | 2m | 1m | 2m |
| Param | _____ | def | Value | 4kk | NA | NA |
| Param | _____ | ts_file | Corner | "typ.s2p" | "min.s2p" | "max.s2p" used in IBIS-ISS |

File_TS:

Either File_TS or ~~File_ISS~~ File IBIS-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 |

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| | | | |
|-----------|----------------|----------------|-----|
| file_type | typ | min | max |
| File_TS | c_comp_typ.s4p | c_comp_min.s4p | NA |

File_ISSFile IBIS-ISS:

Either File_TS or File_ISSFile IBIS-ISS is required for a [C_comp Model]/[End C_comp Model] group. The File_ISSFile IBIS-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_ISSFile IBIS-ISS for the Typ corner_name is required, and File_ISSFile IBIS-ISS for the Min and Max corner_names are optional. If present, each File_ISSFile IBIS-ISS shall have a unique corner_name. If File_ISSFile IBIS-ISS for either the Min or Max corner_name is missing, the File_ISSFile IBIS-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) |
| <u>File_ISSFile IBIS-ISS</u> | —Typ | c_comp.iss | c_comp_typ |
| <u>File_ISSFile IBIS-ISS</u> | —Min | c_comp.iss | c_comp_min in same file as net.sp |
| <u>File_ISSFile IBIS-ISS</u> | —Max | c_comp_max.iss | c_comp_max in separate file |

Number_of_Terminals:

The Number_of_Terminals subparameter is required and defines the number of terminals associated with the [C_comp Model]. The subparameter name is followed by a single integer argument equal to or greater than two on the same line, separated from the subparameter name by whitespace. Only one Number_of_Terminals subparameter may appear for a given [C_comp Model] keyword.

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).

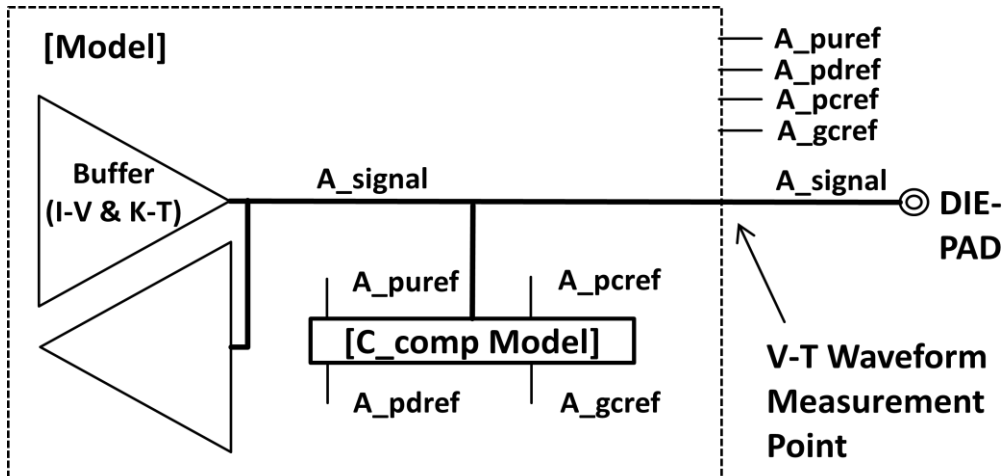


Figure X

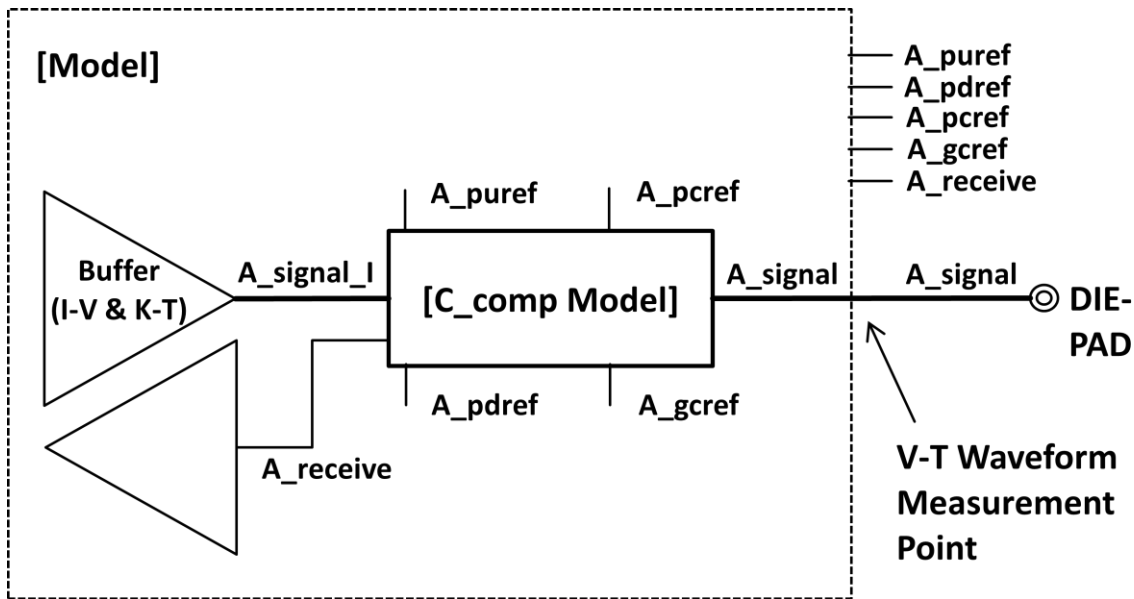


Figure Y

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. If the buffer is differential, then terminals A_receive_pos and A_receive_neg can be used as seen in Figure Z.

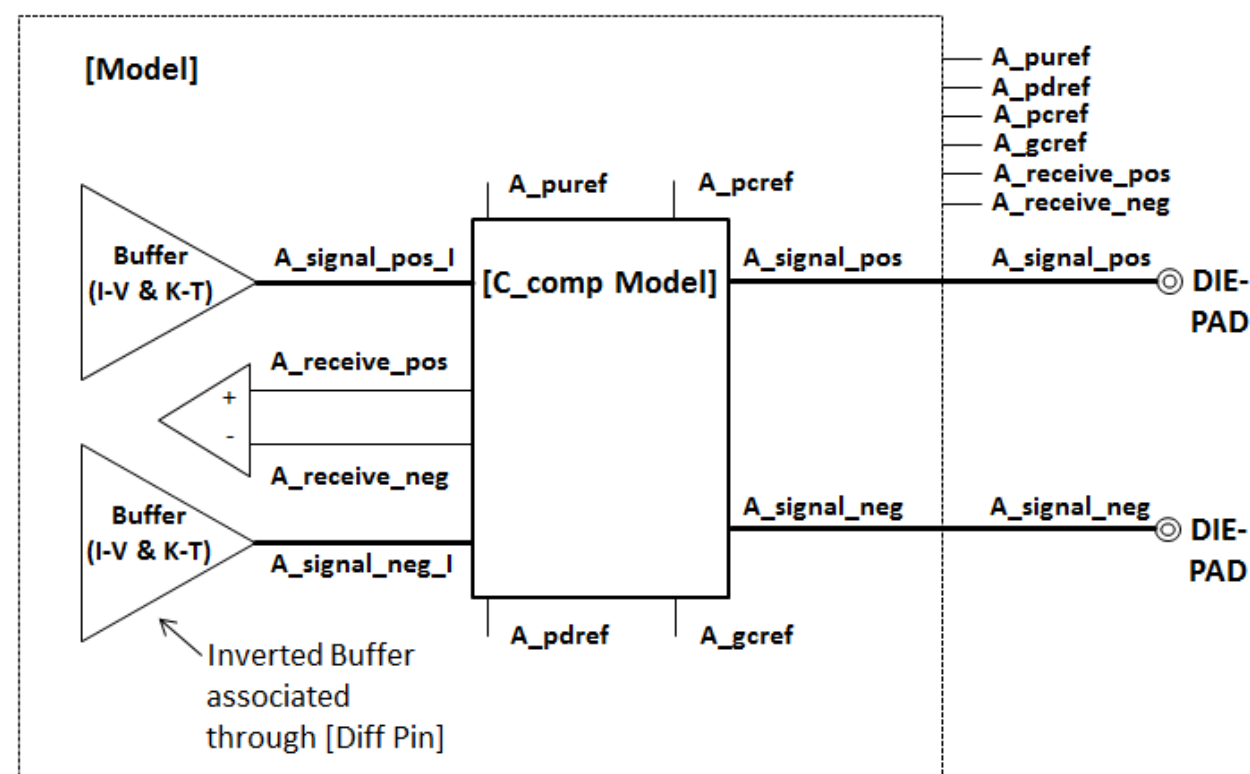


Figure Z

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_receive_pos, A_receive_neg, 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_receive_pos is used when there is a series component to a differential input buffer and is associated with the positive (non-inverting) side.
- A_receive_neg is used when there is a series component to a differential input buffer and is associated with the complementary (inverting) side.
- 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

| | |
|-------------------|-------------|
| ○ <u>Terminal</u> | <u>Port</u> |
| ○ 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_ISSFile IBIS-ISS Typ A.iss A
Param ValueC Corner 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_ISSFile IBIS-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]
```

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```
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>.

ANY OTHER BACKGROUND INFORMATION:

{These documents will be archived, so use this section to add any detail that is not part of the section above or the changed text itself, but should not be lost.}
