SiQual℠ Technical White Paper

A Critique of IBIS Models Available For Download On the Web Part I

18735 SW Boones Ferry Road
Tualatin, OR 97062-3090

22 January 2002

A Critique of IBIS Models Available For Download On the Web Part I

by
Jim Bell
and Dan Grogan

1. Introduction

This paper is the first in a series of white papers that will document SiQual's progress in studying the question of how best to automate the process of detection and repair of IBIS files. The goals of this project are:

1) To scope the severity of the problems with IBIS models available on the Web
2) To identify typical errors and warnings that will likely be found in these models.
3) To identify the probable cause(s) for each class of errors
4) To identify what models can be repaired, or make usable in a reduced capacity by removing the offending section (i.e. - waveform tables)
5) To develop automated methods to diagnose model problems, identify their source, and fix the issue, indicate that the problem cannot be fixed, or provide direction to a human to potentially fix the problem.

-

IBIS (Input Output Buffer Information Specification) behavioral modeling has become a popular method to relate Input/Output device characteristics through V/I data without disclosing any circuit/process information. By using IBIS models, you can reduce the amount of time needed for simulation, and proprietary data can remain proprietary. IBIS models are well suited for rapid simulation of large-scale systems. With most current generation IBIS simulators, the board files can be read directly, and the IBIS models plugged directly into the routed board for post-route analysis.

But how good are these IBIS models that are so easily acquired from vendor web sites? Design and signal integrity engineers already have a healthy suspicion about vendor-supplied models, but exactly how pervasive is the problem? To answer this question, we downloaded every readily available IBIS model off the vendor web sites listed in the IBIS Forum model directory for an evaluation. After gathering statistical data, the modeling engineers at SiQual[SM] pinpointed the root causes of the most common IBISCHK3 errors and warnings.

2. Collecting the IBIS Files

2.1 The Rules

As with all papers presenting results of an analysis, some rules need to be established prior to data gathering in order to establish the scope of the data.

1. **Any IBIS file is valid as long as it can be turned into an ASCII text file.** Different companies have different ways of storing their IBIS files on the Web. Some compress their files, while others offer the file as a web page. Some mistakenly have ASCII files with a .zip suffix or vice versa. A few are UNIX files. As long as the file could eventually be converted into a DOS-readable ASCII text file it became part of the analysis. All others were thrown away.
2. **Other than UNIX2DOS file conversion, no IBIS file content modifications are allowed.**
3. **EBD files will not be evaluated.** The EBD files we found were exports from ICX, and their supporting IBIS files were available in a separate directory on the manufacturer's web site.
4. **IBISCHK3 results are to be categorized by the IBISCHK3 error or warning reported, not by the underlying cause.** No attempt has been made to seek out and document the root cause as to why IBISCHK3 reported any particular error or warning. The analysis is only based on the contents found in each IBISCHK3 report file generated.
5. **Multiple errors or warnings of the same type within a file shall be counted as one.** Necessary to level the statistical playing field.

2.2 The Process

Figure 2-1 illustrates the process flow from file download to having a full set of IBISCHK3 reports.

2.2.1 Download all freely available IBIS models from the web

Every company web site listed on the IBIS forum models page was visited. If their models were free to all or available after filling in an electronic form, they were downloaded. As each site's download was completed, files were decompressed and/or converted as required and placed into a directory.

2.2.2 Run IBISCHK3 on all models

Using various in-house scripts, the IBIS model files in each manufacturer's directory were tested using version 3.2.8 of IBISCHK3. The resulting report file names were then appended with an .err suffix (filename.ibs.err) and placed into an error report subdirectory.

The last step was to append a 3-letter manufacturer identifier to the beginning of the error report file names (mfg.filename.ibs.err) and move them into a single master report directory for our analysis.

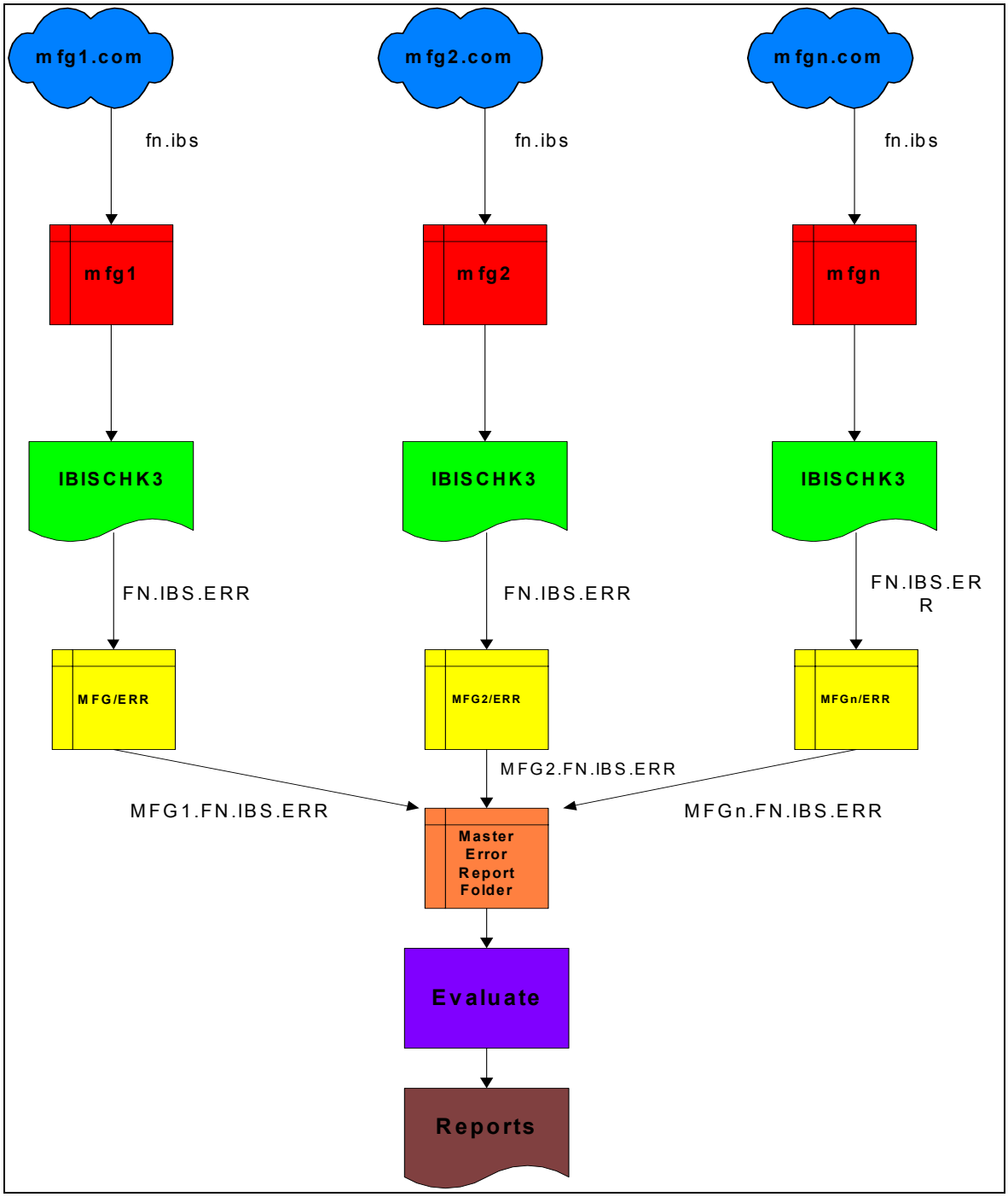

Figure 2-1: Web-to-Report Process Flow

3. Analyzing the IBISCHK3 Results

3.1 Analysis of Individual IBISCHK3 Errors and Warnings

The next task for the analysis was to break down Errors and Warnings by frequency of occurrence. A Perl script was created to detect and count unique text strings within IBISCHK3's Error and Warning messages. Multiple detections of a particular error or warning within an IBISCHK3 report file were counted only once. To make sure the script was accurate the number of errors and warnings detected were compared to the reported number of errors and warnings whenever possible.[1] The others were verified manually.

The results are shown in the bar chart in Figure 3-1. Non-monotonic warnings lead the pack with at least one occurrence in 1821 files out of 4548 files evaluated (40%). There are methods that can be used to remove non-monotonicity from curves, which will be described in a later section on IBIS model data repair.

The second highest number of hits shows that roughly 1/3 of the IBIS files' names didn't match the name shown on the [File name] keyword line, 1365 out of 4548 tested (30%).

The third highest number of hits is the warning "*parameter* should not be specified for model type Output (or Input, 3-state, etc.)", with 992 hits. Be wary of IBIS files from vendors that do not conform to basic IBIS syntax.

The fourth highest number of hits is the warning message indicating that a VI table minimum value never becomes zero, with 679 hits. This will also be discussed in the section on reparability of IBIS data table problems.

The fifth highest number of hits is the detection of illegal characters embedded in the file, with 586 hits. The source of the error within these IBIS files was usually an orphaned control character code 'ctl-d', the carriage return character. In DOS files, a carriage return character should never be without a matching Line Feed character 'ctl-a'. We examined some of these files using the UNIX file dump utility 'od' to make the control characters visible and found double carriage return characters followed by a line feed character. The UNIX 'tr' utility with the squeeze option (or any equivalent utility) can be used to remove the extra carriage return characters from a file.

The sixth and seventh highest number of hits occurs for the 'VI / VT table mismatches under equivalent loads' warning or error, with 545 and 542 hits respectively. The report should change from a warning to an error if the mismatch is greater than 10%[2]. This problem will also be discussed in the section on reparability of IBIS data table problems.

[1] Certain errors prevent IBISCHK3 from continuing, such as an illegal IBIS version, in which case there is no summary of errors and/or warnings at the end of the report.
[2] At the time of this writing there is a bug report open against IBISCHK ver3.2.8 to fix the error percentage calculation.

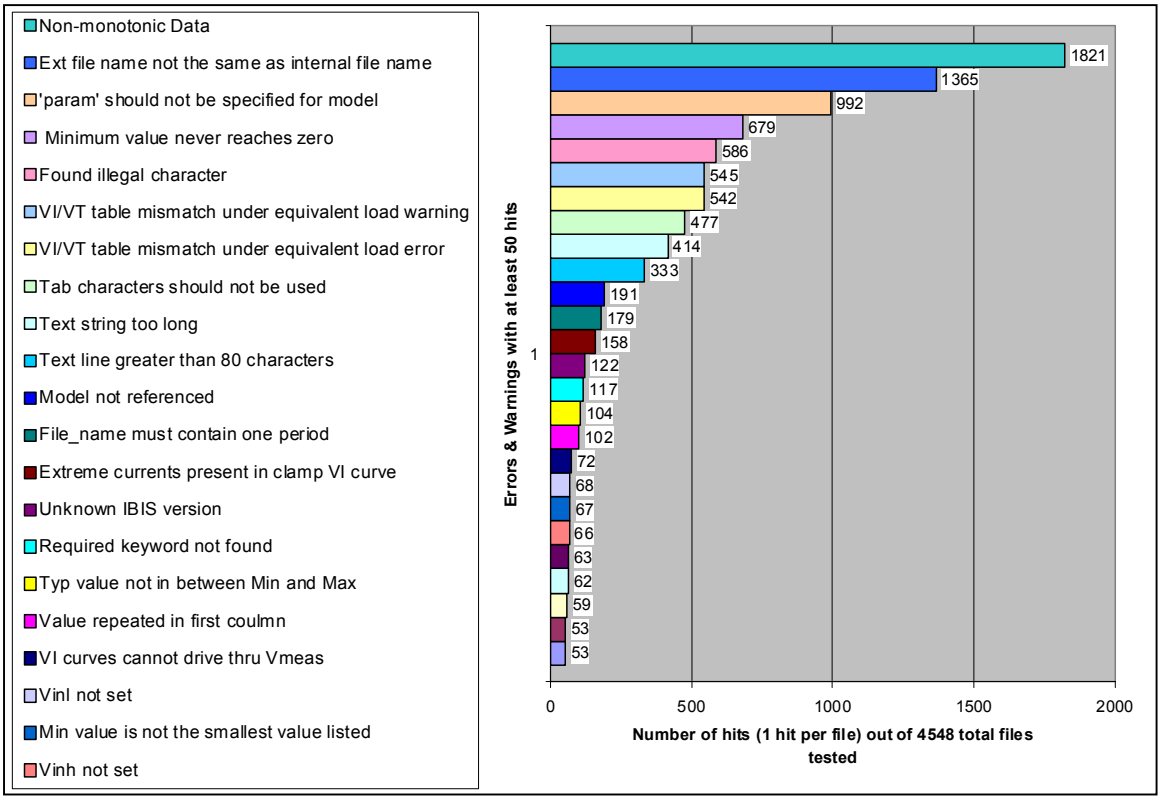

Figure 3-1: Total Number of Hits of the Errors or Warnings Reported by IBISCHK3

3.2 Analysis of Errors and Warnings By Category

The next step was to evaluate the resulting error report files and classify each type of error and warning found to determine which type occurs most often. The following categories were chosen for our analysis:

1. **Extraction Errors and Warnings.** Errors and warnings that point to mistakes being made during the data extraction or measurement process.
2. **Structural Errors and Warnings.** Any message dealing with the structural aspects of the file (i.e.: Missing pieces and extra pieces).
3. **Non-monotonicity Warnings.** Any non-monotonic data warning.
4. **Syntax Errors and Warnings.** Miscellaneous errors and warnings that confuse the parser (e.g. Text strings that are too long, illegal characters, orphaned lines and data, etc.).
5. **Don't care.** Errors and warnings that were to be excluded from this analysis for one reason or another. These are:

a. "IBIS files should not contain tab characters"

b. "Component '*compName*' contains a blank character"

c. "File name must end in .ibs". This warning refers to the file name given on the [File name] keyword line, and was placed into this category so as to not double count syntax errors. Just before this warning we always saw the warning message "File name too long. Truncating to 12 characters". Unfortunately IBISCHK3 truncates the file name from the right, usually deleting the .ibs file name extension in the process.

d. "File name opened *'external_file_name*.ibs' not the same as File_name *'keyword_file_name*.ibs' and "File name *'external_file_name*.ibs' Does Not Match Internal Name *'keyword_file_name*.ibs'. The former is one of the other errors generated when the file name given on the [File name] keyword line gets truncated to the legal number of characters (See the next section on IBISCHK3 anomalies discovered). Besides, the error is so rampant among some vendors' IBIS files that we had to get it out of the syntax category.

See Appendix A for a complete description of all errors and warnings found by category.

3.3 IBISCHK3 Anomalies Discovered

While gathering the data for this analysis a few IBISCHK3 bugs were discovered, which did skew the results somewhat. The bugs are in the process of being reported to the IBIS committee. They are:

1. "File_name Too Long" truncation to the legal number of characters creates new errors "File Name Opened Not The Same As File_name" and "File_name Must Contain a Period".
2. Orphaned Carriage Return Character (control-d) Error In Line 0 Not Always Counted In Total Errors.
3. Conversion to space of orphaned Carriage Return Character (control-d) error in Line 0 sometimes creates new error "IBIS Version Cannot Be Determined. Exiting."

3.4 Conclusions

As you can see from the pie charts below, there are a large number of questionable IBIS files out there on the web in all categories. Almost 70% of the IBIS files downloaded had at least one IBISCHK3 error or warning reported of significance, requiring the end user to correct the anomaly before use.

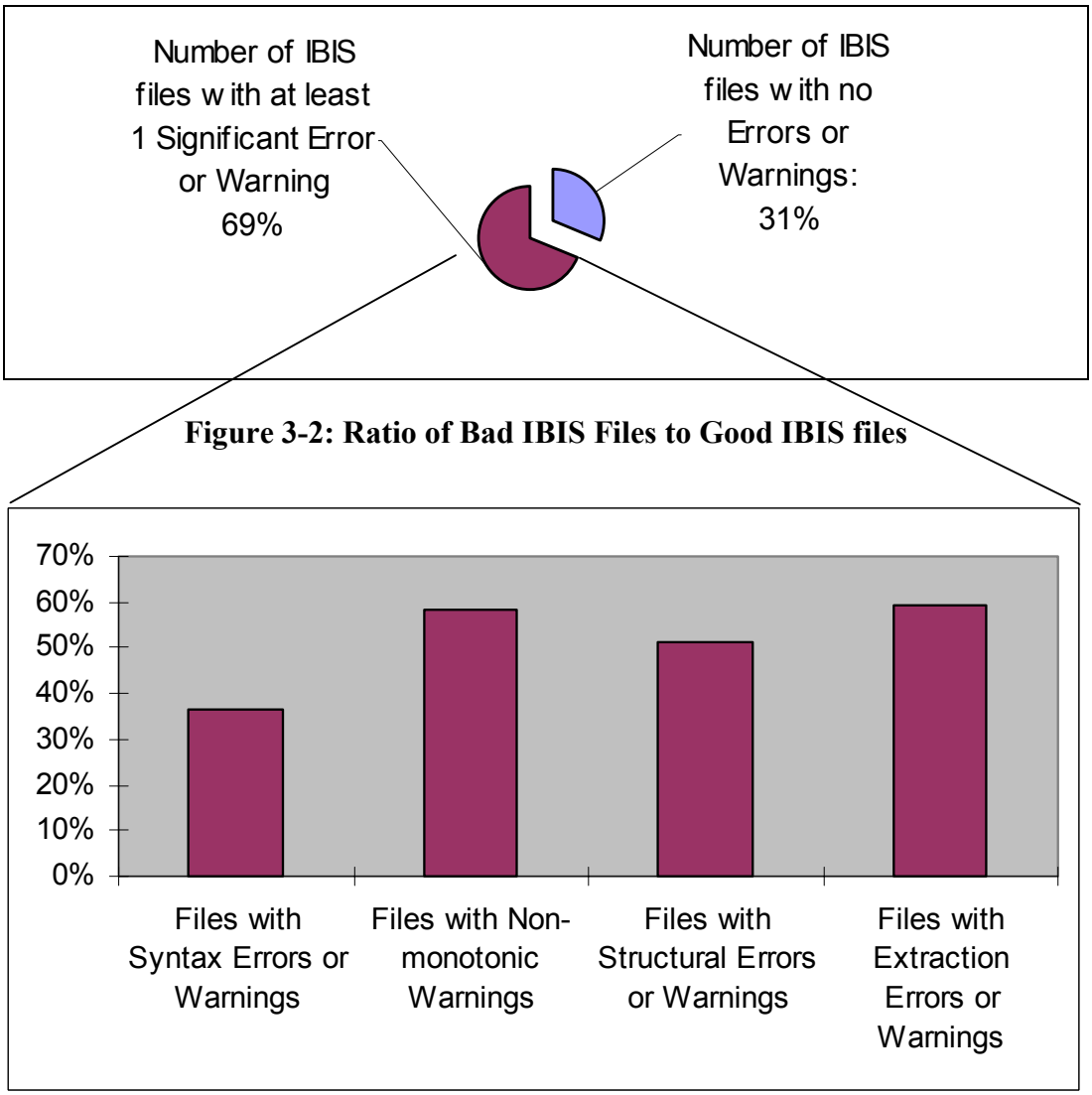

Figure 3-2: Ratio of Bad IBIS Files to Good IBIS files

Figure 3-3: Breakdown of Errors and Warnings By Category

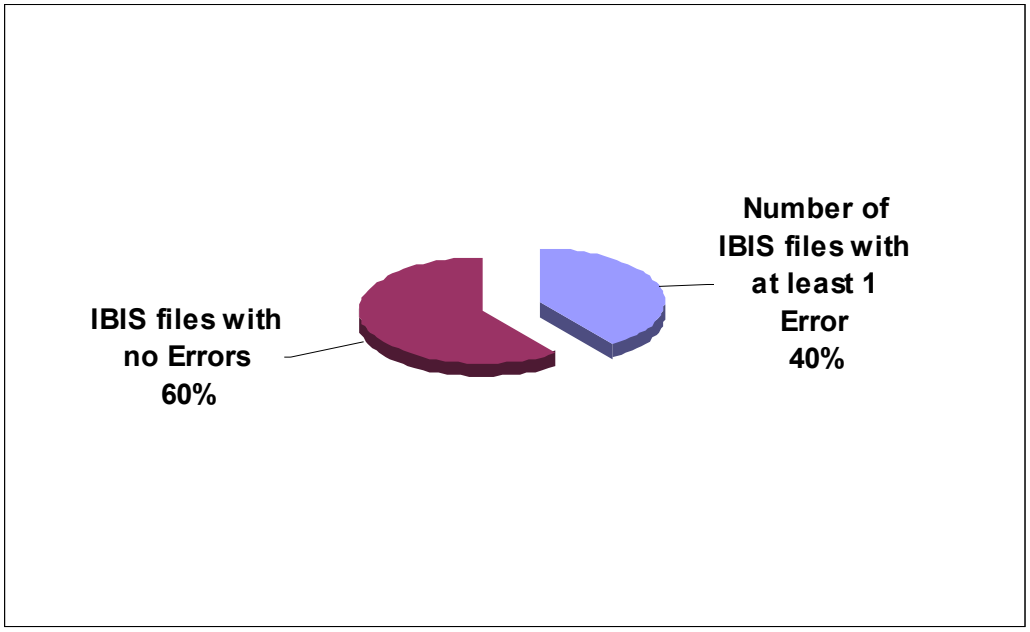

Figure 3-4: Percentage of IBIS Files With At Least One Error

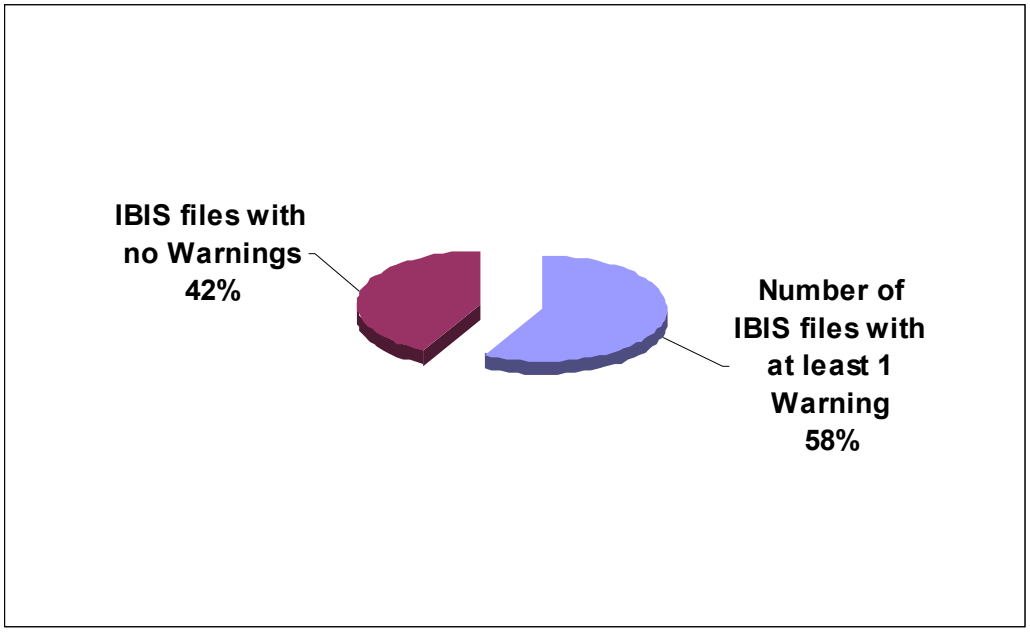

Figure 3-5: Percentage of IBIS Files With At Least One Warning

4. Repairing the Top Five IBIS Model VI / VT Data Problems

Our analysis showed that the following were the 5 data-related errors and warnings that will be found in many of the public IBIS files.

- Non-monotonic table data
- VI Minimum table value never reaches zero
- VI / VT table mismatch under equivalent loading conditions
- Extreme currents present in VI table
- VI curve cannot drive through Vmeas

The following sub-sections will describe the cause of each of these problems and whether or not the end user can repair the anomaly.

4.1 Non-monotonic Behavior In Data Tables

From the results of the first part of our analysis, it was obvious that many vendor models exhibit non-monotonic behavior. There are three reasons a data table may have non-monotonic behavior:

Case I: Clamps Are Saturated

The IBIS specification requires that VI curves extend to 2X the device voltage. In SPICE this sometimes creates some bizarre behavior since most active devices were never designed to operate in these regions. Figure 4-1 is a good example of non-monotonic behavior in a real clamp model.

This class of non-monotonic behavior can be repaired by removing the offending points and then cleaning up the curve. Figure 4-2 shows the pulldown after the table has been repaired. This type of non-monotonic behavior in IBIS tables has come up so often at SiQual [SM], we wrote a utility that automatically repairs the curves.

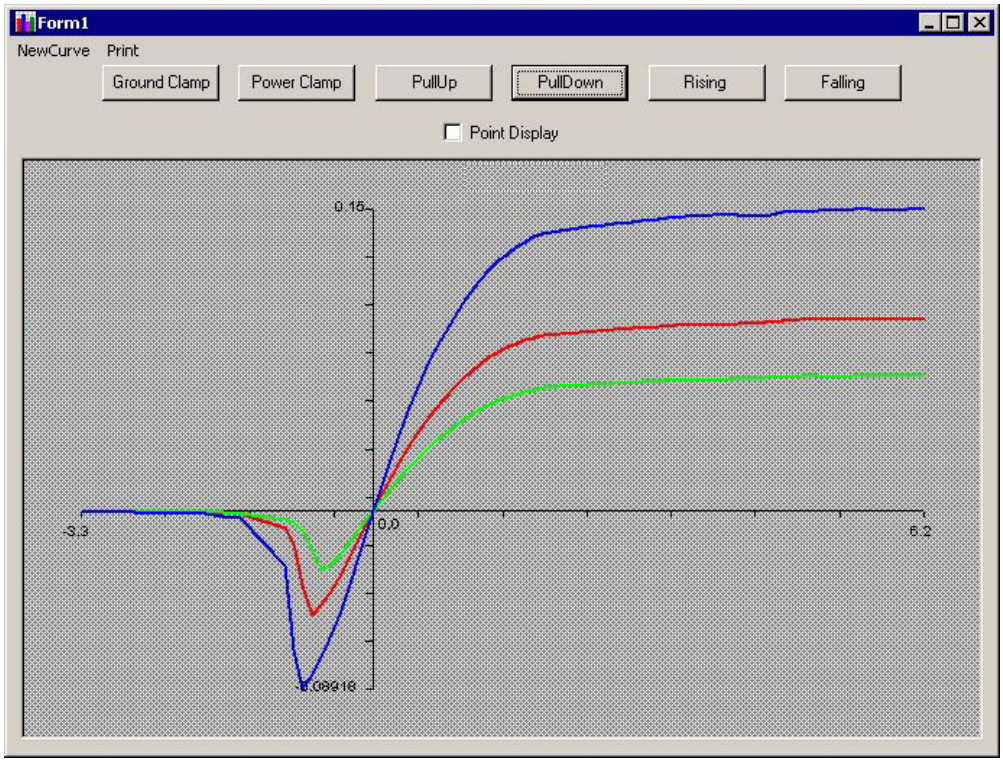

Figure 4-4-1: View of Non-monotonic Pulldown Curves

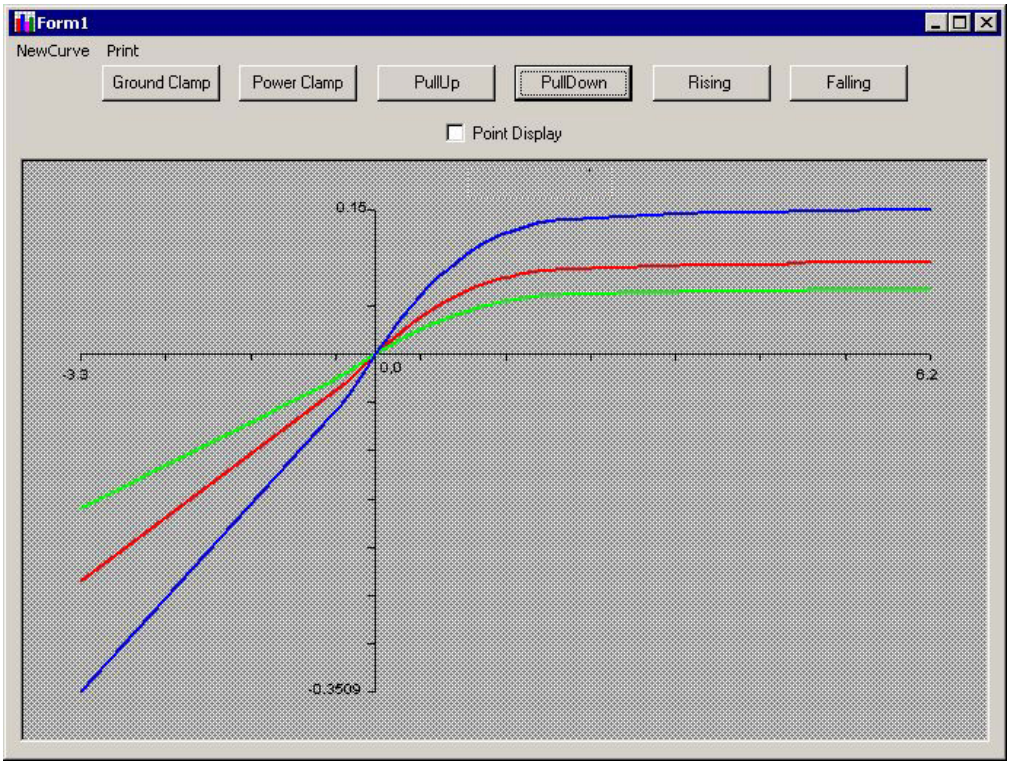

Figure 4-4-2: View of Repaired Pulldown Curves

Case II: Older Versions of SP2IBIS Only Allow 2 Digits After the Decimal Point

The truncation that occurs as a result of this restriction creates points within the curve that are of equal value. You will have to re-extract the model using the most current conversion of SP2IBIS to correct this problem.

Case III: The Device Really Is Non-monotonic

Some devices really do exhibit non-monotonic behavior (Figure 5-3). You can use a waveform viewer to spot the location in the file and a text editor to smooth out the curve, but be careful. Many a model has been ruined when using this method.

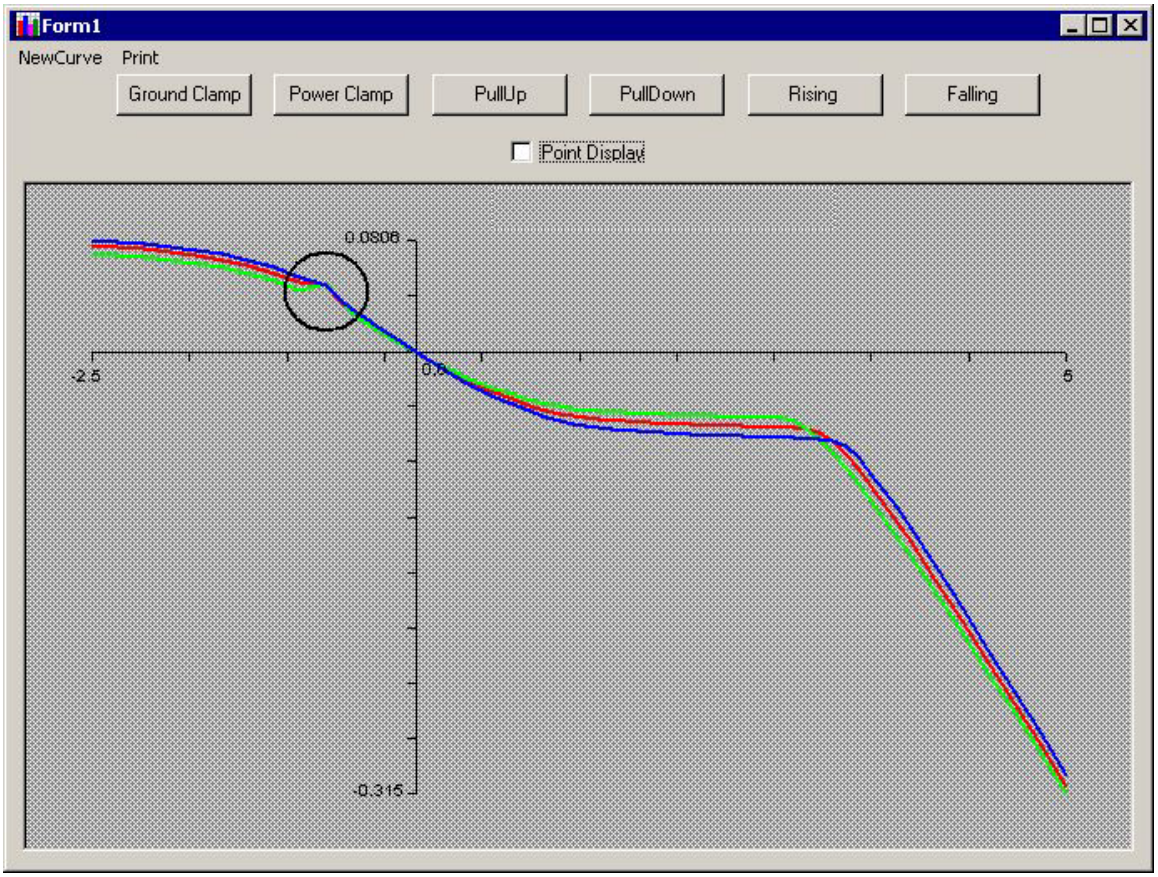

Figure 5-3: Pullup Curve Exhibiting Natural Non-monotonic Behavior

4.2 VI Table Minimum Value Never Becomes Zero

VI table minimum values that never reach zero are typically caused by clamp leakage current entering into the VI table extraction process. The best way to fix this problem is to delete the offset from each VI table value. This can be done by importing the table into a spreadsheet program and have it do the math for you, or by writing your own script utility to do the work.

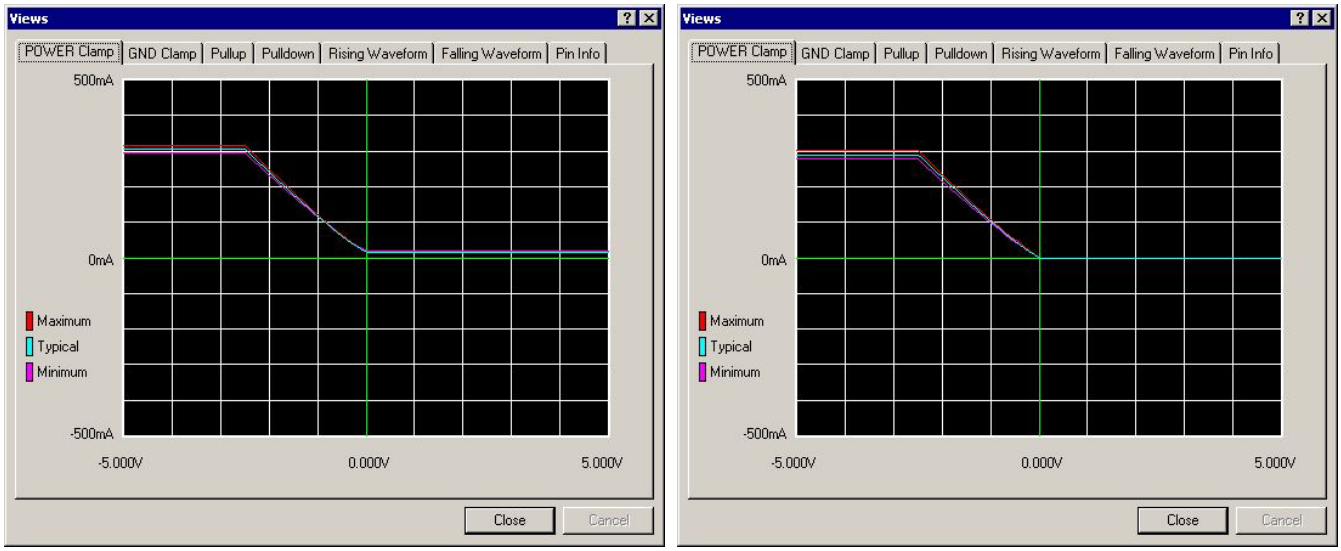

Figure 4-3: Power clamp with Leakage Current Level Shift, Before and After Repair

4.3 VI and VT Table Mismatched Under Equivalent Loading Conditions

Waveform data extractions are done under a known load condition. IBISCHK3 uses this load and the voltage in the waveform data table to verify the same currents are described in the model's VI table at that voltage point. An error or warning is issued by IBISCHK3 when the currents do not agree. The report becomes an error if the difference is greater that 10%.

Reasons for this failure are many and varied. The more common cases SiQual[SM] has seen are:

Case 1: Incorrect test load used during data extraction.
Case 2:Waveform simulation time wasn't long enough.
Case 3: Not all current sources accounted for.
Case 4: Bad SPICE simulation setup conditions (Temp, Voltage, Process deck incomplete, Wrong process deck, etc.)

None of the cases shown above can be successfully corrected by the end user. Re-extraction of one or more tables will be necessary after finding the source of the mistake. The model can still be used with reduced accuracy by removing the waveform data table and instead using the dv/dt values.

4.4 Extreme Currents Present In VI Table

There are 3 possible causes why this type of error may occur:

Case 1: Just as in certain non-monotonic data behavior, extreme currents can wind up in VI curve data when the device is simulated in SPICE outside its normal operating range. If this is the case, either remove the offending data from the table or adjust the end values to fit the good part of the curve. This case is the most common one seen by SiQual[SM] engineers.

Case 2: Error during V/I table extraction, such as an incorrect test load (e.g.: 5 Ohms instead of 5 Kohms). The model will have to be re-extracted with the error corrected.

Case 3: The table voltage range went well beyond what is required for the part. Example -5V to 7.5V instead of –2.5V to 5V for a 2.5V part. Fix this by removing all V/I lines beyond the range of -VCC to 2xVCC.

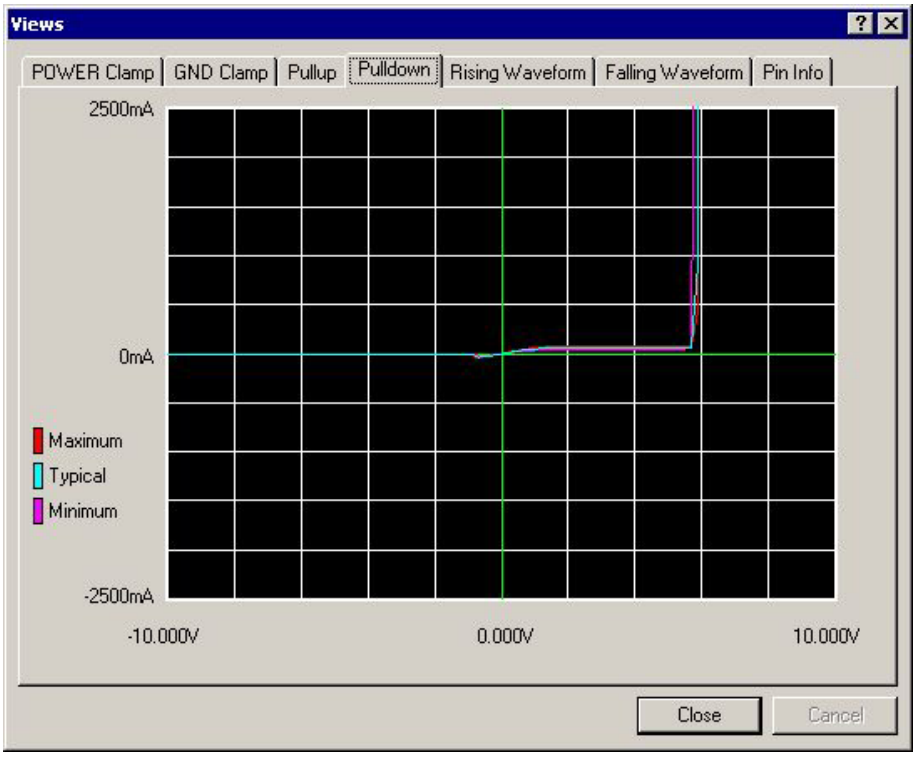

Figure 4-4: Example of VI Curve With Extreme Currents Outside the Device's Operating Range

4.5 VI Curve Cannot Drive Through Vmeas

There are several possible reasons that these errors may occur:

Case 1: The part was measured with bad V/I fixture values, which in turn caused a bad V/I table extraction. Re-extraction will be necessary.

Case 2: Bad V/I table data. Look for excessive negative currents in the positive voltage table section of the pulldown curve. Also, there may not be enough points in the waveform tables to fully define the rising and falling edges.

Case 3: The value for Vref is incorrect. Correct the value.

Case 4: The model creator did not include min and max fixture voltages in his waveform table extractions.

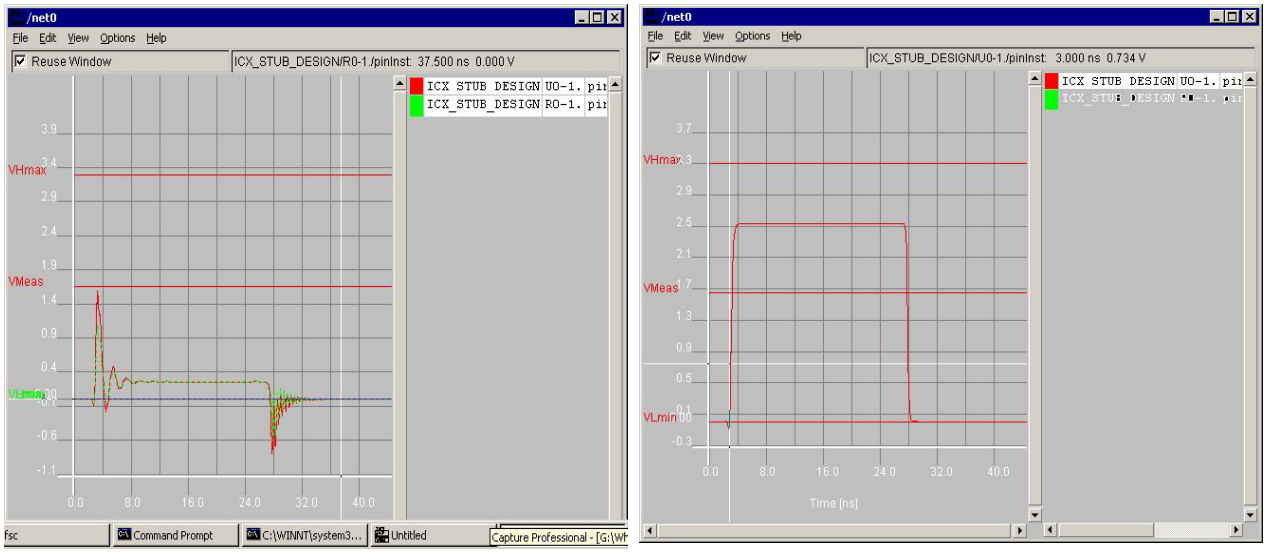

Figure 5-1: Waveform That Cannot Drive Through Vmeas, Before and After Repair

5. Summary

In this paper we have shown the analysis results from running public web-downloadable IBIS files through the IBISCHK3 Golden Parser. Based on the results from Section 3, 74% of the IBIS files need some sort of correction before they can be used, and 40% of the IBIS files are in serious condition, containing errors that, if left uncorrected, will either prevent you from importing the model into your simulator, or seriously effect the accuracy of your simulation.

We have shown that many of the common IBISCHK3-detected errors and warnings can be repaired, or at least made usable with reduced accuracy.

6. Future Work

6.1 Analysis For IBISCHK3-undetected Model Errors

As good as the IBISCHK3 Golden Parser is, it cannot catch everything that can be wrong with an IBIS model. The engineers at SiQual[SM] routinely discover and correct bad values, time shifted edges in waveform data, and many other errors. We find these errors by:

- Examining the IBIS file contents
- Viewing the table waveforms
- Simulating the model attached to the manufacturer's test load

For the next phase of this project SiQual[SM] will determine how many IBIS files available on the Web are likely to have an error not detectable by the IBISCHK3 Golden Parser. A statistical sample of IBIS model files will be chosen at random from among the IBIS files that have already been downloaded from vendor web sites. These model samples will

then be reviewed using SiQual[SM] standard procedure. The results will be presented in the next white paper of this series along with a discussion of the errors most commonly found.

Bios

Jim Bell currently works as a Signal Integrity Engineer for SiQual[SM] Inc., an interconnect engineering company serving companies worldwide. One of Jim's past contracts was with the Interconnectix Business Unit of Mentor Graphics, where he provided technical assistance regarding high-speed board design. Before joining SiQual[SM], Jim was employed at Intel Corporation in their Servers Group, designing high-speed multi-processor computer systems. A graduate of Northern Arizona University with a BSEE, he has over 12 years of experience designing high-speed digital signal processing and computer systems.

Dan Grogan is currently a Senior Engineer with SiQual[SM] Inc. He has a BS in BioChemistry from Marietta College and an MS in Materials Science and Engineering from Washington State University. He spent 10yrs with Tekronix doing process development on very high speed integrated circuits, and several years with Wacker Siltronic slicing and polishing silicon.

Appendix A - IBISCHK3 Errors and Warnings Detected, By Category

Notes:

1. Variable data begins with a percentile (%).
2. Fixed string variables are separated by a backslash (e.g. typ\min\max).
3. %extFileName refers to the DOS file name. %intFileName refers to the name found on the [Filename] keyword line inside the file.

Extraction Errors & Warnings

ERROR - First Typical Value Cannot Be 'NA' for POWER Clamp\ Pulldown Beginning at Line %lineNumber

ERROR (line %lineNumber) - 'POWER_clamp' Definition Missing 'I(Typ\Min\Max)' Data

ERROR (line %lineNumber) - ' ' not allowed for dV/dt_r\dV/dt_f Typical value

ERROR (line %lineNumber) - dV must be greater than 0 in a Ramp specification

ERROR\WARNING - Model %modelName: The [Falling\Rising Waveform] with [R_fixture]=%rVal Ohms and [V_fixture_min]=%vVal V has TYP\MIN\MAX column DC endpoints of %vVal V and %vVal v, but an equivalent load applied to the model's I-V tables yields different voltages (%vVal v and %vVal v), a difference of percentVal% and percentVal%, respectively.

WARNING - Model '%modelName': %typ\min\max AC %rising\falling Endpoints (%voltageV, %voltageV) not within %voltage V (2%) of (%voltageV, %voltageV) on VI curves for %waveformResFixture Ohms to %V_fixture/V_fixture_min/V_fixture_max value V.

WARNING - Model '%modelName': %typ\min\max VI curves cannot drive through Vmeas=%VmeasV given load Rref=%Rref Ohms to Vref=%Vref V.

WARNING - Model %modelName: $pulldown\pullup has %increasing\decreasing Current.

WARNING - Model '%modelName': Currents <> 0.0mA in 'Pulldown' for Open_source device.

WARNING - Model '%modelName': Currents <> 0.0mA in 'Pullup' for Open_drain\Open_sink device.

WARNING - Model '%modelName': Extreme currents present in %typ\min\max %POWER_clamp\GND_clamp VI Curve (%current A @ %voltage V).

WARNING - Model %modelName: Pulldown has Decreasing Current

WARNING - Model %modelName: POWER Clamp\Pullup has Increasing Current

WARNING - Model %modelName: POWER Clamp : Minimum value never becomes zero

WARNING - Model '%modelName': MIN\TYP\MAX Rising\Falling Ramptime %rampTime unusually large (> 1.000e+006nsec)

WARNING (line %lineNumber) - Model %modelName: C_comp min value is not the smallest value listed

WARNING (line %lineNumber) - Model %modelName: C_comp max value is not the largest value listed

WARNING - Submodel %subModelName: V_trigger_f (Typ) is less than the end of Falling Waveform

WARNING - Submodel %subModelName: V_trigger_r (Typ) is greater than the end of Rising Waveform

WARNING - CMPT '%componentName', Pin '%pinNumber': Pin Inductance %pinInductancenH greater than 1000nH.

WARNING - CMPT '%componentName ', Pin '%pinNumber': Pin Capacitance %pinCapacitancepF greater than 1000pF.

WARNING (line %lineNumber) - Typ value is not in between min and max.

Structural Errors & Warnings

ERROR (line %lineNumber) - IBIS Version Cannot Be Determined. Exiting.

ERROR - Missing Keyword: %keyword

Component Section

ERROR - Required keyword '%keyword' not defined for Component '%componentName '.

ERROR - Unable to find Pin keyword data for Component '%componentName'.

Pin Data Section

ERROR (line %lineNumber) - Pin keyword column count must be 3 or 6, found %number columns.

ERROR (line %lineNumber) - Each line of Pin data must contain either 3 or 6 columns.

ERROR (line %lineNumber) - Incorrect Number of Line Items (%number) For Pin Data: Expecting 3 or 6

ERROR - Component '%componentName': Pin Mapping Pin '%pinName' not previously declared in Pin section.

ERROR (line %lineNumber) - Signal name not found.

WARNING - Pin %pinNumber is %pinName. Should not have any references in Pin Mapping

WARNING - Pin %pinNumber is a GND pin. Usually only has Pulldown_ref in Pin Mapping

WARNING - Pin %pinNumber is a POWER pin. Usually only has Pullup_ref in Pin Mapping

Package Section

ERROR - Unable to find Package Model '%modelName' for Component '%componentName'

ERROR (line %lineNumber) - Detected the start of an orphan R/L/C section

ERROR (line %lineNumber) - Required sub-parameter %R_pkg\L_pkg\C_pkg not found.

Model Section

ERROR (line %lineNumber) - Model Name Previously Defined ("%modelName")

ERROR (line %lineNumber) - Model Name '%modelName' Undefined For Pin '%pinNumber'

ERROR - Component '%componentName': Model '%modelName' for Pin '%pinNumber' not defined.

ERROR (line %lineNumber) - Model name not found.

ERROR (line %lineNumber) - No minimum\maximum Value Was Provided for Pullup\POWER Clamp

ERROR (line %lineNumber) - '%GND_clamp\POWER_clamp\PULLUP\PULLDOWN' Definition Missing '%I(Typ)\I(Min)\I(Max)' Data

WARNING - Model '%modelName': Model_type %Input\I/O\I/O_open_drain\I/O_open_sink\I/O_open_source' must have '%Vinl\Vinh' set.

WARNING - [Model] %modelName has no description of the buffer's low state DC drive characteristics (no [Pulldown] table). This warning can be silenced by using an open source Model_type or by adding a [Pulldown] table.

WARNING - Model %modelName not referenced in any [Pin], [Model Selector], [Driver Schedule] or [Series Pin Mapping] sections. No more warnings will be generated for un-referenced models.

WARNING (line %lineNumber) – Vinl\Vinh\S_overshoot_high\ S_overshoot_low\D_overshoot_high\D_overshoot_low\D_overshoot_time should not be specified for model type Output\Open_drain\Open_sink\3-state

WARNING (line 85) – Vmeas\Vref\Cref\Rref should not be specified for model type Input

WARNING - Model Selector: '%modelSelName' has only one model defined

WARNING - Model '%modelName': The [Driver_Schedule] has only one model defined

WARNING - [Model] %modelName has no description of the buffer's low state DC drive characteristics (no [Pulldown] table). This warning can be silenced by using an open source Model_type or by adding a [Pulldown] table.

WARNING - [Model] %modelName has no description of the buffer's high state DC drive characteristics (no [Pullup] table). This warning can be silenced by using an open drain Model_type or by adding a [Pullup] table.

Waveform Section

ERROR - Model '%modelName': Ramp Not Defined

ERROR - Require at least 2 Data Points for Rising Waveform Beginning at Line %lineNumber

ERROR (line %lineNumber) - No typical\minimum\maximum Value Was Provided for Rising\Falling Waveform

ERROR (line %lineNumber) - More than 100 data points provided for Rising\Falling Waveform table

Non-monotonicity Warning

WARNING (line %lineNumber) - %Pullup\Pulldown\POWER Clamp\GROUND Clamp' %Minimun\Typical\Maximum' data is non-monotonic.

Syntax Errors & Warnings

ERROR (line %lineNumber) - Illegal IBIS_Version '%ascii_string'.

ERROR (line %lineNumber) - More Pin Numbers names than Number of pins.

ERROR (line %lineNumber) - Orphaned Keyword '%ibisKeyword'. Needs a 'Model'

ERROR (line %lineNumber) - Unknown data after Package keyword.

ERROR (line %lineNumber) - Data for unknown keyword. %data

ERROR (line %lineNumber) - Keywords Must Begin In Column 1

ERROR (line %lineNumber) - Zero length value for keyword 'Package_Model'.

ERROR (line 17) - Data on this line appears to be for the Component keyword, which does not allow data on subsequent lines.

ERROR (line %lineNumber) - Duplicate '%ibisKeyword' keyword.

ERROR (line %lineNumber) - Exceeds 80 characters.

ERROR (line %lineNumber) - File_name '%intFileName' contains a character '%nonDOSchar' that is illegal for DOS.

ERROR (line %lineNumber) - File_name string '%intFileName' is too long, truncating to 24 characters.

ERROR (line %lineNumber) - File_Rev string '%intFileRev' is too long, truncating to 70 characters.

ERROR (line %lineNumber) - Found illegal character with code %cntlCode. Control character

ERROR (line %lineNumber) - Found illegal character with code %code. Not 7bit ASCII

ERROR (line %lineNumber) - Found illegal character with code %code. Not 7bit ASCII. Converting to space

ERROR (line %lineNumber) - Found NULL character in input, converting to space.

ERROR (line %lineNumber) - Found illegal Control character with code %controlCode. Converting to space

ERROR (line %lineNumber) - Invalid GROUND_clamp\POWER_clamp\PULLUP\PULLDOWN Voltage Value ("%nonNumeric").

ERROR (line %lineNumber) - Invalid Keyword. %nonKeyword.

ERROR (line %lineNumber) - Orphan Data Line.

ERROR (line %lineNumber) - Pin string '%pinName' is too long, truncating to 5 characters.

ERROR (line %lineNumber) - Unknown Line Among Model Data.

ERROR (line %lineNumber) - Non-comment line exists after 'End' keyword.

WARNING (line %lineNumber) - Value %number repeated in the First Column

Don't Care Errors & Warnings

ERROR (line %lineNumber) - File name opened '%extFileName' not the same as File_name '%intFileName'.

ERROR (line %lineNumber) - File name ("%extFileName') Does Not Match Internal Name ("%intFileName").

ERROR (line %lineNumber) - File name Requires 'ibs' Extension

ERROR (line %lineNumber) - File_name '%intFileName' contains an upper case character '%upperCaseChar'.

WARNING (line %lineNumber) - IBIS files should not contain tab characters.

WARNING (line %lineNumber) - Component '%compName' contains a blank character.

Appendix B – References

I/O Buffer Information Specification, Version 3.2

IBIS committee: IBIS help and knowledge share