SharkSim Simulation and Correlation User Guide

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Inside This Manual

Overview

This document describes the Simulation and Correlation add-on module for SharkSim. The Simulation and Correlation module allows the user to simulate the IBIS buffer model into various test loads and correlate the simulation results to existing [Test Data] in the IBIS file.

SharkSim Documentation

The SharkSim application documentation is divided into separate User Guides as listed below.

SharkSim Editor and Viewer Guide. Describes how to load and view IBIS simulation models as well as general application features.

SharkSim Quality Checker Guide. Describes how to use the Quality Checker feature to validate IBIS simulation models.

SharkSim SPICE to IBIS Guide. Describes how to translate SPICE to IBIS simulation models using the built-in translation GUI features and also how to build a full IBIS file.

SharkSim Simulation and Correlation Guide. Describes how to simulate IBIS buffer models and view the results. Also describes how to use existing [Test Data] to perform full correlation.

Customer Support

Customers can view the HTML help file any time from within the application by selecting the **Help** icon. The user guides are also in PDF format in the application release directory.

Customers can also visit www.sharksim.com to get full support for the application through additional tutorials, white papers, videos, forums, and contact information of the SharkSim developers.

Naming Conventions

Many different naming conventions are used when talking about the IBIS Specification. For all of the SharkSim User Guides the following conventions have been followed:

IBIS File. This refers to the overall IBIS file with a .ibs extension.

IBIS Buffer Model. This refers to the individual keyword [Model] types in the overall IBIS file. The buffer models as listed by the [Model] keyword are the actual sections where the IBIS data is stored for each [Model] type.

IBIS keywords [keyword]. The IBIS Specification specifies special keywords using the format [keyword] and the User Guides use the same format to highlight the fact that a keyword is being used.

Many engineers interchange 'IBIS File' and 'IBIS Model'. Sometimes an engineer will be talking about the full IBIS file with .ibs extension yet will call it an IBIS model. The SharkSim User Guides have tried to distinguish between IBIS File and IBIS Buffer Model to make the terminology easier to understand.

Standard Load Simulations

Overview

The Standard Load section of the Simulation and Correlation GUI allows the user to automatically assign a manufacturers test load to an output IBIS buffer model and run the simulations without leaving the SharkSim application by integrating to an existing SPICE application tool. The results can be viewed in the IBIS Correlation Data Viewer and can be correlated to existing [Test Data] in the IBIS file.

A standard load simulation is useful for calculating the flight time of an interconnect in a simulation for a setup or hold timing analysis. The IBIS sub-keywords Vmeas, Vref, Cref, and Vref are used to define this test load in the IBIS file. SharkSim will automatically create the simulation load based upon these parameters and run the simulations.

Opening the Simulation and Correlation GUI

The Simulation and Correlation GUI can be opened from the navigation menu item **Correlate | IBIS Model Correlation**. By default the **Standard Load** GUI tab is already open.

Selecting an IBIS Buffer Model

The user can select an IBIS buffer model from the existing IBIS file using the **Select Model** pull down selection box. The selected IBIS buffer model name and model type will be displayed in the **Model Name** and **Model Type** data fields.

Setting the Output Enable

If the **Model Type** is a three-state output or an input/output that requires an enable than the user can set the **Enable** drop down box to be active high or active low.

Defining the Simulation Load

SharkSim reads in the test load parameters of the selected IBIS buffer model and places them in the Vmeas, Cref, Rref, and Vref data fields for the Typical corner. If the [Model Spec] parameters are available, they will over-ride the IBIS buffer model parameters and the Typical/Minimum/Maximum data fields will be populated. The user can edit these data parameters as well. The user can also use the **copy min/max** checkbox to copy the Simulation Load settings from the Typ column to both the Min and Max columns.

If there are no parameters available in the IBIS buffer model the default values will be used:

Vmeas = 0 Volts

Cref = 0 pF

Rref = 10 Giga Ohms

Vref = 0 Volts

The IBIS Specification describes the allowed combinations of the different test load parameters and one of the valid combinations should be used. The Vmeas parameter should always be defined. A few examples are given below.

Example Standard Load 1: Cref = 15pF Vmeas = 1.65V

In this example only the Vmeas and Cref value is specified. If the Rref and Vref parameters are not used, than the Rref value can be set to a very large value (to look like an open) and the Vref value can be set to ground.

Example Standard Load 2: Cref = 15pF Rref=500 Ohms Vmeas = 1.65V

In this example the Vmeas, Rref and Cref values are specified. Since the Rref value is specified but no Vref it is assumed that the Rref value should be set to ground so the Vref value should be set to 0 Volts.

Series Switch Models

Analog switches in IBIS models can be modeled with the Series_switch or Series model type. Most EDA simulation tools will allow you to simulate the analog switch model but may not include the buffer capacitance unless it's modeled in a specific way. By default HSPICE does not include the buffer capacitance using the standard IBIS B-element. Now users have the option of adding the buffer capacitance using the **Series Ccomp** data field. The buffer capacitance entered here will be added to the output of the analog switch model. (This also applies to MSIM and Eldo simulators).

Differential Support

SharkSim supports differential IBIS buffer models by using the selected IBIS buffer model as both the non-inverting and inverting output. This assumes symmetrical single-ended outputs. To enable this feature the user can select the **enable Differential** checkbox. Only the differential output signal will be plotted in the viewer with this option selected.

Process Corner Setting

The user can select the **only TYP corner** checkbox to only run simulations for the Typical process corner.

Including Package Parasitics

The user can select the **include package** checkbox to add the global R_pkg, L_pkg, and C_pkg parasitic values from the IBIS file to the simulation results.

Defining Input Source

The input source for the IBIS buffer model needs to be defined by the user. The following parameters are available:

Vlow

The low switching voltage value of the input source. This is set to 0 Volts by default for integration with Synopsys HSPICE.

Vhigh

The high switching voltage value of the input source. This is set to 1 Volt by default for integration with Synopsys HSPICE.

IBIS data is considered a behavioral model and Synopsys HSPICE requires a digital 0 and 1 switching pattern for the input of IBIS buffer models.

Delay

The amount of time to delay the start of switching the input source.

Edge

The rise and fall time of the input source. The same value is used for both rise and fall times.

Pulse Width

The pulse width of the input source signal.

Period

The period of the input source signal.

Sim Length

The total transient simulation time.

Input Source

The user has the option to select from three different input source types. The input source parameters are used for all three types.

Edge. A rising and falling PWL pattern.

Pulse. A repeating pulse pattern.

PRBS. A user defined Pseudo-Random Bit Sequence. If this option is selected the user must enter in the PRBS string using only 0 and 1in the **PRBS** data field. The user can also load a text file containing only the PRBS sequence using the **Load** button.

System Load Simulations

Overview

The System Load section of the Simulation and Correlation GUI allows the user to automatically assign an existing [Test Data] load to an IBIS buffer model and run the simulations without leaving the SharkSim application by integrating to an existing SPICE application tool. The results can be viewed in the IBIS Correlation Data Viewer and can be correlated to existing [Test Data] in the IBIS file.

A system load simulation is useful for correlating the IBIS buffer model to a set of data either from simulation or measurement. The user can select from a wide range of simulation loads including transmission line loads.

Opening the Simulation and Correlation GUI

The Simulation and Correlation GUI can be opened from the navigation menu item **Correlate | IBIS Model Correlation**. By default the **Standard Load** GUI tab is already open so the user should click on the **System Load** tab.

Selecting an IBIS Buffer Model

The user can select an IBIS buffer model from the existing IBIS file using the **Select Model** pull down selection box. The selected IBIS buffer model name and model type will be displayed in the **Model Name** and **Model Type** data fields.

Setting the Output Enable

If the **Model Type** is a three-state output or an input/output that requires an enable than the user can set the **Enable** drop down box to be active high or active low.

Selecting an Existing Test Load

If the IBIS buffer model contains existing [Test Data] information than the user can select the **Test Load** to load an existing [Test Data] load.

Series Switch Models

Analog switches in IBIS models can be modeled with the Series_switch or Series model type. Most EDA simulation tools will allow you to simulate the analog switch model but may not include the buffer capacitance unless it's modeled in a specific way. By default HSPICE does not include the buffer capacitance using the standard IBIS B-element. Now users have the option of adding the buffer capacitance using the **Series Ccomp** data field. The buffer capacitance entered here will be added to the output of the analog switch model. (This also applies to MSIM and Eldo simulators).

Enabling Differential Support

If the IBIS buffer to be tested is differential the user can check the **enable Differential** checkbox to properly simulate and display the differential voltage instead of the single-ended voltage.

Process Corner Setting

The user can select the **only TYP corner** checkbox to only run simulations for the Typical process corner.

Including Package Parasitics

The user can select the **include package** checkbox to add the global R_pkg, L_pkg, and C_pkg parasitic values from the IBIS file to the simulation results.

Defining the Test Load

By selecting the **Define Test Load** data button the user can use the Test Load GUI to define a test load to run the simulations into. If the existing IBIS buffer model has [Test Data] created from the SharkSim application than the user can select the **populate Test Data fields from Model** checkbox to automatically populate the Test Load data.

The user can select whether the topology is single-ended or differential using the **Select Topology** drop down box and select the type of load Standard or Transmission Line using the **Select Load** drop down box.

Select Test Load

There are 27 different test load options to choose from. These are predefined test loads that are a subset of the available test load combinations allowed by the IBIS specification. This subset of test loads should accommodate almost any design including single-ended or differential buffers. Below are the different available loads to choose from:

Capacitive: A capacitor to ground.

RC Series: A series resistor and capacitor to ground.

RC Parallel: A resistor and capacitor to ground.

LC Series: A series inductor and capacitor to ground.

Pullup: A resistor to a voltage source.

Pullup with Cap: A resistor to a voltage source and a capacitor to ground.

Pulldown: A resistor to a voltage source.

Pulldown with Cap: A resistor to a voltage source and a capacitor to ground.

Thevenin: A resistor to a voltage source V_{term1} and resistor to a voltage source V_{term2}.

Rdiff: A differential resistor placed between the inverting and non-inverting output pins of a differential buffer.

TLine with Cap: An ideal lossless transmission line with a capacitor to ground.

TLine with Rcvr: An ideal lossless transmission line with an IBIS input buffer model.

Series TLine with Cap: A series resistor with an ideal lossless transmission line and a capacitor to ground.

Series TLine with Rcvr: A series resistor with an ideal lossless transmission line and an IBIS input buffer model.

TLine with RC Parallel: An ideal lossless transmission line with a resistor and capacitor to ground.

TLine with Pullup: An ideal lossless transmission line with a resistor to a voltage source.

TLine with Pullup and Cap: An ideal lossless transmission line with a resistor to a voltage source and a capacitor to ground.

TLine with Pullup and Rcvr: An ideal lossless transmission line with a resistor to a voltage source and an IBIS input buffer model.

TLine with Pulldown: An ideal lossless transmission line with a resistor to a voltage source.

TLine with Pulldown and Cap: An ideal lossless transmission line with a resistor to a voltage source and a capacitor to ground.

TLine with Pulldown and Rcvr: An ideal lossless transmission line with a resistor to a voltage source and an IBIS input buffer model.

TLine with Thevenin: An ideal lossless transmission line with a resistor to a voltage source V_{term1} and resistor to a voltage source V_{term2}.

TLine with Thevenin and Rcvr: An ideal lossless transmission line with a resistor to a voltage source V_{term1} and resistor to a voltage source V_{term2} and an IBIS input buffer model.

TLine with Rdiff: Two ideal single-ended lossless transmission lines with a differential resistor placed between the inverting and non-inverting output pins of a differential buffer.

TLine with Rdiff and Cap: Two ideal single-ended lossless transmission lines with a differential resistor placed between the inverting and non-inverting output pins of a differential buffer and a capacitor to ground on each differential output.

Input Test Load: An ideal voltage source (defined in Input Source section) with a series resistor and an ideal lossless transmission line connected to the SPICE input.

Black Box Load: Any SPICE compatible subcircuit load connected to the output buffer pin with an IBIS input buffer model.

Test Load Parameters

There are some extra test load parameters beyond the load variables (such as resistor R1, etc.) that need to be defined.

Test Data Name: The name of the [Test Data] that will appear in the IBIS file.

Test Load Name: The name of the [Test_load] that will appear in the IBIS file.

Driver Model: The name of the **Driver_model** that will appear in the IBIS file. This has to be the name of an output type buffer in the same IBIS file.

Receiver Model: If used this has to be the name of an input type buffer in an IBIS file that is specified in Receiver File.

Receiver File: If used this has to be a compliant IBIS file with the appropriate input type buffer specified.

Black Box Model: If used this has to be an HSPICE compatible subcircuit file with a .sp extension.

Input Source

The user must specify the input source parameters to be used as the input stimulus for the test load data generation.

Vlow: Input low voltage.

Vhigh: Input high voltage.

Delay: Input source delay time.

Edge: Input source edge rate. (Same for both rising and falling.)

Pulse Width: Input source pulse width.

Period: Input source period.

Sim Length: Overall test data generation simulation length.

Source: The user can select between three different input source types:

Edge: A rising and falling edge.

Pulse: A repeating 0101… pattern.

PRBS: A PRBS pattern as specified by user.

PRBS Pattern Load: The user can specify the PRBS pattern by entering it manually in the data field or by loading a .txt text file with only a ‘0’ or ‘1’used for the pattern definition.

Running Simulations

Overview

To run simulations and generate simulation data for either the Standard Load or System Load interfaces the Generate Netlists, Run SPICE, and View Data buttons are to be used.

Generating Netlists

By selecting the **Generate Netlists** button HSPICE compatible netlists in .sp extension will be created in the working directory. These netlists are in unencrypted ASCII format and can be modified by the user.

Running SPICE

By selecting the **Run SPICE** button the generated netlists will be submitted to the external SPICE application and simulated. The SPICE application path can be set in the general editor **View | Preferences** GUI window.

Viewing Data

By selecting the **View Data** button the **IBIS Correlation Data Viewer** will open allowing the user to view and save the simulated data as well as correlate to existing [Test Data].

Using the Data Viewer

Overview

The IBIS Correlation Data Viewer loads the simulation results from the Standard Load and System Load simulations. The viewer allows the user to correlate the data to existing [Test Data] as well as some measurement and graphing functions.

Waveform Viewer

The Waveform Viewer loads the simulated results of the IBIS buffer model into the specified test load when the viewer is first opened. Labels are given to the IBIS buffer model simulations as ibis_* prefixes. The test load data from the existing IBIS buffer model is given labels as test_* prefixes.

The waveform viewer supports any type of waveform whether it is a PWL, Pulse, or PRBS type pattern. The IBIS Specification version 4.2 officially only supports rising and falling waveforms.

Zooming In/Out

The user can right-click on the waveform viewer area and select different **Zoom In** and **Zoom Out** options for the graph as well as an **Auto Range** feature. The user can also use the left mouse button to click and drag to zoom in and out.

Highlighting a Waveform

The user can highlight a waveform by leaving the mouse cursor over the waveform for a few seconds and a popup dialog will appear with the waveform label name and the current X and Y coordinates.

Saving Waveforms

The user can right-click on the waveform viewer area and select **Save as** to save the current graph as a PNG image file. The user can also use the **Save Image** button at the bottom of the GUI window.

Correlation Results

The IBIS Correlation Waveform Viewer takes a set of four measurements on both the IBIS and Test waveforms and provides a correlation error percentage value for the difference. The Test Data waveforms are used as the original source for the correlation calculation. For Pulse and PRBS patterns the first rising and falling edge found are used for the measurements. The error percentages are calculated when a set of Test Data is loaded in the viewer. The four measurements are:

Vlow. The steady state low voltage of the output.

Vhigh. The steady state high voltage of the output.

Trise. The 20 to 80 percent measured time for the rising edge.

Tfall. The 20 to 80 percent measured time for the falling edge.

These four measurements help the user determine the accuracy of the IBIS buffer model as compared to the source data in the Test Data. This is a useful feature to simulate and correlate different test loads to validate the accuracy of the IBIS buffer model.

There are various correlation methods available for correlating the IBIS buffer model simulation results to the source Test Data and SharkSim displays both the absolute measurements and error percentages. This has proven to be an accurate and efficient methodology to use when correlating IBIS buffer models. The user can also overlay the waveforms for an additional level of correlation.

Selecting Test Data

The user can select existing [Test Data] data sets from the IBIS buffer model and use that data to correlate the IBIS buffer model simulations. The **Model** drop down box selects the IBIS buffer model and the **Test Data** drop down box selects the [Test Data] data set from the IBIS buffer model.

Saving Correlation Data

The user can select the **Save Correlation Data** button to save the Correlation Results data columns including the error percentages to a text file with a .correlate extension. The correlate file is an ASCII text file with the results formatted as a text table and can be used in other parts of the SharkSim application.

Graphing Options

Using the **Graphing Options** panel the user can perform some advanced graphing features as described below.

Selecting a Waveform

Using the **Select Waveform** drop down box the user can select any IBIS buffer model or Test Data waveform.

Show/Hide a Waveform

With a waveform selected the user can select the **Show/Hide waveform** checkbox to turn the waveform on or off. If the waveform is hidden there will not be an asterisk * symbol next to it.

Shifting Waveforms Using Time Offset

With a waveform selected the user can enter a positive or negative value in nanoseconds in the **Time offset** data field to shift the waveform by the entered time amount. The user must select the **Update** button to apply the changes. The waveform starting point is shifted to the entered value. For example, if 5ns is entered the beginning of the waveform will be shifted to start at 5ns.

Setting Thresholds

The user can enter voltage threshold values for the listed thresholds to be displayed on the graph in the viewer. The user must enable the **Show/Hide thresholds** in order to apply the thresholds to the graph viewer window. If a threshold value has changed the user can select the **Update** button to apply changes.

By default the threshold line color is white. The user can specify a different color by entering the threshold value along with a color as in the following example:

‘1.25 blue’

The voltage threshold value is followed by a color with a space in-between. The valid color choices are **white**, **yellow**, **red**, **green**, **blue**, **pink**, and **orange**.

Advanced Features

Overview

This section describes some of the advanced features of the SharkSim application in further detail.

SPICE Integration

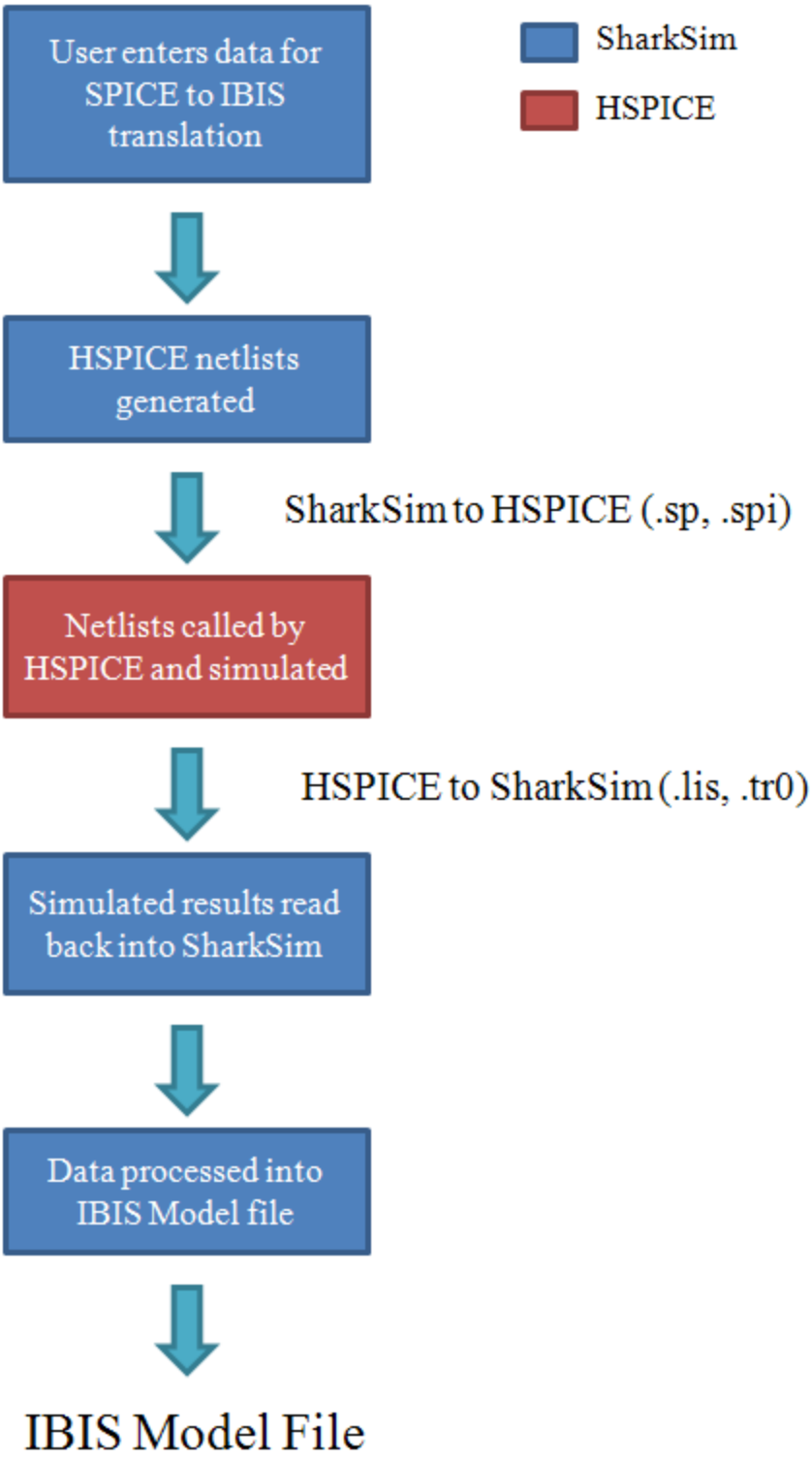
The SharkSim application allows the user to call external SPICE applications to take advantage of some of the advanced features in the application such as the SPICE to IBIS translation features and the IBIS Simulation and Correlation features. SharkSim supports Synopsys HSPICE by default and can be configured to support other SPICE applications as well. A separate license is required for all external SPICE applications.

HSPICE Integration and Support

The SharkSim application can use the Synopsys HSPICE engine to automatically create HSPICE netlists, run simulations, and then extract data from the .lis files and process the data into a formatted IBIS file.

The overall flow is that SharkSim generates different types of HSPICE netlist files in .sp format and will then call the HSPICE simulator externally to simulate the generated netlists. The output data files in .lis format will be read in by the SharkSim application and the data will be processed and formatted in various model formats.

The flow diagram below describes the interoperability between SharkSim and Synopsys HSPICE for the generation of IBIS files.


User enters data for SPICE to IBIS translation
SharkSim
HSPICE
HSPICE netlists generated
SharkSim to HSPICE (.sp, .spi)
Netlists called by HSPICE and simulated
HSPICE to SharkSim (.lis, .tr0)
Simulated results read back into SharkSim
Data processed into IBIS Model file
IBIS Model File

Other SPICE Application Support

The SharkSim application can use any external SPICE application to run simulations and process the data into various model formats. The user can set the SPICE application executable path in the **Preferences** section of the application.

Currently SharkSim supports Synopsys HSPICE compatible executable calls and formats by default. As of version 2.0 SharkSim also supports Mentor Graphics Eldo as well but currently does not include support for Cadence Spectre since it does not have a built in IBIS element. If support is needed for a non-compatible SPICE application the user should contact SharkSim support.