



## IBIS Open Forum Minutes

Meeting Date: **August 19, 2021**

Meeting Location: **IBIS Virtual Summit with DesignCon 2021**

### VOTING MEMBERS AND 2021 PARTICIPANTS

ANSYS	Curtis Clark*, Wei-hsing Huang
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Broadcom	(Yunong Gan)
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Cisco Systems	(Stephen Searce)
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Huawei Technologies	(Hang (Paul) Yan)
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Instituto de Telecomunicações	(Abdelgader Abdalla)
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Keysight Technologies	Radek Biernacki*, Fangyi Rao, Pegah Alavi*, Todd Bermensolo*
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Marvell	Steve Parker
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Maxim Integrated	Tushar Pandey*, Pawan Sai*, Yan Liang*
Micron Technology	Randy Wolff*, Justin Butterfield*, Aniello Viscardi, Akshay Shivaji Chaudhari*, Dragos Dimitriu*
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ZTE Corporation	Bowen Shen, Changgang Yin, Dongdong Ye Liqiang Meng, Xiaoxuan Liu
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Zuken USA	Lance Wang*

### OTHER PARTICIPANTS IN 2021

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RTC	Ken Whigham
Simberian	Yuriy Shlepnev*
Teradyne	Tao Wang
University of Illinois, Urbana	Jose Shutt-Ainé, Xinying Wang

In the list above, attendees at the meeting are indicated by \*. Those submitting an email ballot for their member organization for a scheduled vote are indicated by ^. Principal members or other active members who have not attended are in parentheses. Participants who no longer are in the organization are in square brackets.

## UPCOMING MEETINGS

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NOTE: "AR" = Action Required.

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## **OFFICIAL OPENING**

The IBIS Virtual Summit with DesignCon 2021 took place on Thursday, August 19, 2021, as an online virtual meeting. About 33 people representing 21 organizations attended.

The notes below capture some of the content and discussions. The meeting presentations and other documents are available at:

<https://ibis.org/summits/aug21b/>

Start times and durations listed in these minutes refer to the meeting recording linked at:

[https://ibis.org/summits/aug21b/summit\\_recording.mp4](https://ibis.org/summits/aug21b/summit_recording.mp4)

(Start time: 0:00, Duration: 2:00)

Randy Wolff opened the summit by welcoming everyone and thanking them for joining. He expressed appreciation for the support of the DesignCon organizers, and the hope that we would be meeting in person next year.

## **IBIS CHAIR'S REPORT**

Randy Wolff (Micron Technology, USA)  
(Start time: 2:30, Duration: 13:50)

Randy Wolff provided a report on ongoing activities of the IBIS Open Forum. He shared a list of the new features (BIRDS) expected in the upcoming IBIS 7.1. Looking to the future, Randy mentioned possible new directions for IBIS, including the modeling of new signaling technologies and power delivery networks. He encouraged everyone to consider working with an IBIS task group and or drafting a BIRD if they had ideas for enhancements to IBIS.

## **CHECKING AND CONVERTING TOUCHSTONE FILES WITH TSCHK2**

Mike LaBonte (The MathWorks, USA)  
(Start time: 16:50, Duration: 22:10)

Mike LaBonte gave a brief historical overview of the Touchstone specification and the TSCHK2 parser, which had recently been updated. He showed examples of using TSCHK2 to check syntax, inspect the contents, and convert Touchstone files between version 1 and version 2

formats. New options for controlling numerical precision and whitespace allowed converted files to be either compact or easy to read. Mike showed the TSCHK web pages and described the bugs fixed in the recent version 2.0.1 release.

Bob Ross noted that the original motivation for the Touchstone specification was because IBIS files were linking with Touchstone files. Working with Agilent, the proprietary format was converted to a public specification. Michael Schäder asked if there were plans to add features such as port extraction and passivity and causality checking. Mike said that was unlikely, partly to avoid competing with IBIS members producing such tools. Randy Wolff said it was possible the future of the Touchstone specification and tschk2 would come up in IBIS Interconnect Task Group meetings, once it reconvened, and the previous efforts to poll users on that topic might be revisited.

## **EXPECTATIONS FOR IBIS 7.1**

Michael Mirmak (Intel Corp.)  
(Start time: 39:10, Duration: 15:20)

Michael Mirmak described the process of producing the IBIS 7.1 specification draft, which the IBIS Editorial Task Group had been working on since February. There were new technical features as well as significant work on clarification. Michael described changes in the areas of C\_comp modeling, on-die power distribution networks, Electrical Descriptions of Modules (EMD), a more powerful successor to Electrical Board Description (EBD), and a few other new IBIS-AMI developments related to DC offset, back-channel, eye centering, and clock forwarding. A more detailed presentation could be expected in a future IBIS Summit, after ratification of IBIS 7.1.

Tushar Pandey asked if SI tools could use the new IBIS-ISS format. Michael said IBIS-ISS was derived from a portion of the HSPIICE syntax, donated by Synopsys for use in the IBIS Specification. He said several EDA tools would support it. He said it should be possible to extract the complex AC behavior of devices, and therefore it should be possible to at least validate an IBIS-ISS description of buffer capacitance.

## **NEW WAY TO IMPROVE POWER SUPPLY INDUCED JITTER SIMULATION ACCURACY FOR IBIS MODEL**

Yifan Ding \*, Yin Sun \*\*, Zhiping Yang \*\*\*, Chulsoon Hwang \*  
(\*Missouri S&T, USA; \*\*Zhejiang University, China, \*\*\*Google (Waymo), USA)  
(Start time: 55:10, Duration: 29:25)

Yifan Ding said the current power-aware IBIS model was unable to account for the delay effects of power supply noise. To address that, their approach was to use time-averaged supply voltage to alter the  $K_d(t)$  and  $K_u(t)$  curves that control switching behavior. They had modified their initial proposal after the IBIS Advanced Technology Modeling Group (ATM) provided feedback. It was found that some existing IBIS tools differed significantly in the  $K_u(t)$  and  $K_d(t)$  curves extracted from IBIS waveforms. A correction had been made to adjust the initial and steady state voltages, to produce a more accurate model. Power supply-induced jitter was modeled as a jitter sensitivity in ps/V, which would become a new PSIJ IBIS-AMI reserved

parameter. In the overclocking case where the propagation delay was greater than the switching time, it would be necessary to use delay elements that would store the switching times and set the Ku/Kd adjustments to take place in the correct time frames. It was found that accuracy relative to full transistor SPICE simulation had been improved.

Bob Ross asked if the [Rising Waveform]s had been correlated to each other, against a master rising edge, and likewise for [Falling Waveform]s. Yifan confirmed that they were. Randy Wolff asked if the PSIJ value was a single number. Yifan said it had to be calculated for each case. Bob Ross asked if there might be different values for the Typ, Min, and Max corners. Yifan showed the equations for extracting Ku(t) and Kd(t), which had B and A coefficients that accounted for process variation in the two equations with two unknowns.

### **FSV: AN INTRODUCTION**

Alistair Duffy \*, Gang Zhang \*\*

(\*De Montford University (President, IEEE EMC Society), UK; \*\*Harbin Institute of Technology, China)

(Start time: 1:24:50, Duration: 41:05)

Alistair Duffy said he hoped to have in-person meetings in the future, and that the FSV presentation combined with Yuriy Shlepnev's following presentation would help people understand validation techniques. The need for validation of simulation results appeared in the 1990s while developing a simulator. Comparisons at the time were usually visual. Attempts at numeric correlation using techniques that looked at peaks and troughs often produced ambiguous results. The Cooper-Harper technique was tried, to add some objectivity to subjective visual evaluations. People were asked to evaluate amplitude vs. frequency data using a "six bin" method, and histograms of their responses were produced. It was found that groups seemed to provide good assessments in aggregate, despite strong individual variations. Alistair introduced the metrics of FSV. The Amplitude Difference Metric (ADM) corresponded to near DC measurements, filtered from the data set. The Feature Difference Measurement (FDM) took the first and second derivatives of the faster changing data. The Global Difference Measure (GDM) combined ADM and FDM in a root-sum-square equation. All three metrics could be combined to provide a single figure metric, which was compared to the visual survey results in histogram form. Agreement was good overall. Transient data features, relative to a time domain event, were looked at in separate time regions, which could be found algorithmically. Taking the derivative was helpful for evaluating step responses. A testcase involving a microstrip with ground plane variation was used to generate data to be compared. It was found that FSV could be useful for making relative assessments between SI & PI analysis cases, but pass/fail decisions would require human judgement. In closing, Alistair mentioned a ScholarOne opportunity for the upcoming T-SPI.

Bob Ross said there had been FSV presentations in previous IBIS summit meetings, such as one in 2011 by Antonio Orlandi of University of L'Aquila. Bob asked about availability of software licenses for FSV. Alistair said Gang Zhang had developed reference software, and that could be discussed.

### **COMPARISON OF INTERCONNECT MODEL VALIDATION WITH FSV AND SPS METRICS**

Alistair Duffy\*, Gang Zhang\*\*, Yuriy Shlepnev\*\*\*

(\*De Montford University, UK; \*\*Harbin Institute of Technology\*\*, China; \*\*\*Simberian, USA)  
(Start time: 2:07:45, Duration: 26:35)

Yuriy Shlepnev thanked Alistair Duffy and Gang Zhang for collaborating, and Bob Ross for the idea to do the comparison presentation. Yuriy said there was a need for formal validation with operating frequencies and data rates increasing. Either Feature Selective Validation (FSV) or S-Parameters Similarity (SPS) could be used. Yuriy gave an overview of SPS, which had been introduced in more detail in the previous IBIS Summit. An SPS of 100 meant identical inputs. Both SPS and FSV had been calculated for the comparison between measured and computed S-parameters for 23 interconnect configurations, at three frequencies. In most cases the SPS and FSV results were comparable. In some cases, FSV found poor correlation and SPS found acceptable correlation. In one case that may have been due to S-parameters with small magnitudes for high insertion loss cases producing small difference values. Yuriy said scaling might be appropriate. FSV mirrored human perception. The simplicity of SPS may make it easier to use for large datasets.

Radek Biernacki asked about the impact of normalization for S-parameters with different reference impedances. Yuriy said that a difference in normalization would immediately produce poor SPS, although it would have less impact if the two S-parameters contained the same frequency points. Randy Wolff asked if Yuriy intended to investigate the scaling that would make SPS work better for high insertion loss cases. Yuriy said he did, although he expected that to complicate the method. His preference was to ensure the method could be automated so that it could easily be applied to large and disparate data sets.

## **SECRETS OF IBIS-AMI SAMPLING**

Hansel Dsilva\*, Michael Mirmak\*\*, Todd Bermensolo\*\*\*, Adam Gregory\*\*\*\*  
(\*Achronix Semiconductor, \*\*IBIS Enthusiast, \*\*\*Keysight Technologies, \*\*\*\*Samtec; USA)  
(Start time: 2:34:40, Duration: 24:25)

Hansel Dsilva began by thanking the EDA vendors that had contributed to the work. The lack of sampling information for the IBIS-AMI AMI\_Init flow had been identified in the 2020 DesignCon IBIS Summit. To perform tests, an IBIS-AMI model that received inputs from files instead of an IBIS-AMI simulator was created, to allow comparing EDA tools to a reference MATLAB script. Hansel described the entire test fixture. Two different Mueller-Muller clock recovery mechanisms were tested, one modified to remove pre-cursor effects. In time domain simulation, EDA tools well matched the time domain reference clock positioning relative to the eye, using the unmodified Mueller-Muller clock recovery. No EDA tools matched the modified Mueller-Muller clock recovery well, however, except in the cases where the clock times output of the Rx IBIS-AMI models was used. Clock phase placement for statistical analysis was good when Rx\_Decision\_Time was used. Hansel showed comparisons of modified and unmodified Mueller-Muller results. It was recommended to use any sampling information provided by the receiver IBIS-AMI model. However, variation in eye height and eye width could be seen across EDA tools.

Bob Ross asked if the modified Mueller-Muller model produced less accurate results. Hansel felt that was not the case.

## **GDDR6X IBIS MODELING**

Randy Wolff \*, Arpad Muranyi \*\*

(\*Micron Technology, USA; \*\*Siemens EDA, USA)

(Start time: 3:01:45, Duration: 36:45)

Randy Wolff said the GDDR6X changed DDR signaling from NRZ to single ended PAM4. It had been found that NRZ was not useful even at 28 Gb/s. SPICE simulation was slow, and the IBIS behavioral model was not well suited for transient simulation of PAM4, because a fundamental assumption of IBIS was that devices have two states. The IBIS-AMI PAM4 flow required characterizing full swing behavior to derive impulse responses, but for better accuracy an approach with four states and separate characterization of the different edge transitions between them was desirable. Arpad Muranyi said he had revisited VHDL-AMS and Verilog-A models produced for the IBIS Macromodel Task Group in 2005 and 2006, to produce four-state models. An integer vector parameter was used to describe the sequence of four logic states, using the D\_drive port as a clock. This model could still have jitter. Two sets of I-V curves were used, for 60ohm and 120ohm behavior. Arpad wrote a MATLAB script to derive K-t from V-t. Verilog-A did not encounter discontinuities going from state to state, an initial concern. Randy said that for testing they converted S-parameters to SPICE, so that all tools would get the same results for the channels. An IBIS-AMI model with an ideal Tx did not match SPICE results as well as the Verilog-A model did. Adding non-ideal IBIS behavior, and then separate IBIS behavior for each edge helped further. Randy proposed that IBIS could have new PAM4 model types based on the idea.

## **NEXT GENERATION IBIS-AMI MODELING**

Walter Katz (The MathWorks, USA)

(Start time: 3:38:50, Duration: 32:00)

Walter Katz described an implementation of crosstalk cancelation technology, which would cancel only far end crosstalk (FEXT), defined using the strict IEEE 802.3 definition of FEXT. Crosstalk cancellation used a scaled and delayed filter output. Implementation of this would require a new IBIS BIRD. Zhiping Yang asked if the requirement that the aggressor and victim impulse responses had to be the same meant that the channels had to be identical. Walter said he had done what the standard allowed, which was a single impulse response input.

Walter then described an IBIS-AMI test fixture for testing 65 different channel models downloaded from the IEEE 802.3ck website. The serdes models had FFE, CTLE, AGC, and DFE elements, with various controls. Walter had found optimum control settings for each channel, using maximized Channel Operating Margin (COM) as the goal criterion. Two genetic algorithms had provided the best results, although only one of those was suitable for firmware implementation. An adaptive FFE algorithm provided good results with much faster execution. Walter discussed some challenges related to using IBIS-AMI back-channel modeling, noting for example that the back-channel training flow did not allow for changing impulse response during training.

Walter discussed BIRD205, "New AMI Reserved Parameter for Sampling Position in AMI\_Init Flow", which introduced the Rx\_Decision\_Time IBIS-AMI parameter. He said hardware used various methods for eye centering, and IBIS did not specify how to model that. He showed that

a DFE would distort the left side of an eye opening, causing the maximum eye height to not appear at the center of the eye.

Discussing BIRD213, "Extending IBIS-AMI for PAMn Analysis", Walter noted that it had not yet been approved by the IBIS Open Forum. He showed an example of a PAM3 eye diagram.

Moving on to BIRD204, "Clock Forwarding Modeling", Walter said using the clock from a DQS signal would include all of its impairments. He showed an example circuit and results, noting that clock forwarding only affected time domain analysis.

Walter then showed an example of using IBIS-AMI to model a 112 Gb/s PAM4 model set in which the Rx used an analog to digital convertor (ADC), leaving much of the signal processing to be handled by digital logic. Since the ADC cannot operate at 112 Gb/s, it was necessary to interleave four of them. The CDR was a challenge because only one point was sampled per unit interval. Walter said it was important to verify that the hardware implementation would match the model. The histogram that normally would show an eye looked very different because there were not enough samples to produce an eye. Walter said that posed challenges evaluating performance, suggesting that it would be possible to report the Signal-to-Noise Ratio (SNR) using new IBIS-AMI Out parameters.

## **CLOSING REMARKS**

(Start time: 4:11:00, Duration: 1:20)

Randy Wolff thanked Bob Ross for organizing the Summit, the IBIS board, the presenters, the attendees, and DesignCon. The next IBIS Open Forum meeting would be held August 27.

## **NEXT MEETING**

The next IBIS Open Forum teleconference meeting would be held on August 27, 2021. The following teleconference meeting was tentatively scheduled for September 17, 2021.

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## **NOTES**

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- To inquire about joining the IBIS Open Forum as a voting Member.
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- To report bugs or request enhancements to the free software tools: `ibischk6`, `tschk2`, `icmchk1`, `s2ibis`, `s2ibis2` and `s2iplt`.

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Information on IBIS technical contents, IBIS participants and actual IBIS models are available on the IBIS Home page:

<http://www.ibis.org/>

Check the IBIS file directory on ibis.org for more information on previous discussions and results:

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## SAE STANDARDS BALLOT VOTING STATUS

Organization	Interest Category	Standards Ballot Voting Status	Standards Ballot Voting Status			
			July 16, 2021	August 6, 2021	August 12, 2021	August 19, 2021
ANSYS	User	Active	X	-	X	X
Applied Simulation Technology	User	Inactive	-	-	-	-
Broadcom Ltd.	Producer	Inactive	-	-	-	-
Cadence Design Systems	User	Active	X	X	-	-
Celestica	User	Inactive	-	-	-	-
Cisco Systems	User	Inactive	-	-	-	-
Dassault Systemes	User	Inactive	-	-	-	X
Ericsson	Producer	Inactive	-	-	-	-
Google	User	Active	X	X	X	-
Huawei Technologies	Producer	Inactive	-	-	-	-
Infineon Technologies AG	Producer	Inactive	-	-	-	-
Instituto de Telecomunicações	User	Inactive	-	-	-	-
Intel Corp.	Producer	Active	X	X	X	X
Keysight Technologies	User	Active	X	X	-	X
Luminous Computing	General Interest	Inactive	X	-	-	-
Marvell	Producer	Inactive	-	X	-	-
MathWorks (SiSoft)	User	Active	X	X	X	X
Maxim Integrated	Producer	Inactive	-	-	-	X
Micron Technology	Producer	Active	X	X	X	X
MST EMC Lab	User	Active	-	-	X	X
NXP	Producer	Inactive	-	-	-	X
SerDesDesign.com	User	Inactive	-	-	-	-
Siemens EDA (Mentor)	User	Active	X	X	X	X
Synopsys	User	Active	-	X	-	X
Teraspeed Labs	General Interest	Active	X	X	X	X
Xilinx	Producer	Inactive	-	-	-	-
ZTE Corp.	User	Inactive	-	-	-	-
Zuken	User	Active	X	-	X	X

Criteria for SAE member in good standing:

- Must attend two consecutive meetings to establish voting membership
- Membership dues current
- Must not miss two consecutive meetings (voting by email counts as attendance)

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