

# IBIS Open Forum Minutes

Meeting Date: **May 16, 2012**

Meeting Location: **SPI-E IBIS Summit, Sorrento, Italy**

## VOTING MEMBERS AND 2012 PARTICIPANTS

Agilent	Radek Biernacki, Yoji Sekine, Fangyi Rao
Altera	David Banas, Hsinho Wu, Masashi Shimanouchi
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ANSYS (Ansoft)	Flavio Calvano*
Apple Computer	(Matt Herndon)
Applied Simulation Technology	Norio Matsui
Cadence Design Systems	Terry Jernberg, Jilin Tan, Dennis Nagle Ambrish Varma
Cisco Systems	David Siadat, Mike Sapozhnikov
Ericsson	Anders Ekholm, Zilwan Mahmud, Mattias Lundquist
Foxconn Technology Group	(Sogo Hsu)
Freescale	(Jon Burnett)
Green Streak Programs	(Lynne Green)
Huawei Technologies	Xiaoqing Dong
IBM	Adge Hawes, Greg Edlund
Infineon Technologies AG	(Christian Sporrer)
Intel Corporation	Michael Mirmak, Udy Shrivastava, Stewart Gilbert Eddie Frie
IO Methodology	Lance Wang*
LSI	Brian Burdick
Maxim Integrated Products	Hassan Rafat, Mahbubul Bari
Mentor Graphics	Arpad Muranyi, Vladimir Dmitriev-Zdorov
Micron Technology	Randy Wolff*, Aniello Viscardi*, Francesco Madonna* Antonio Prisco*
Nokia Siemens Networks GmbH	Eckhard Lenski*, Evis Minga*
QLogic	(James Zhou)
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Sigrity	Raymond Chen, Yingxin Sun, Sam Chitwood Ben Franklin*, Srdjen Djordjevic*
Synopsys	Andy Tai, Scott Wedge, Hany Elhak, Ted Mido
Teraspeed Consulting Group	Bob Ross, Tom Dagostino
Texas Instruments	Casey Morrison, Pegah Alavi, Valerie Chang Modesto Garcia, Karl Muth
Toshiba	(Yasumasa Kondo)
Xilinx	Harry Fu
ZTE	(Huang Min)
Zuken	Michael Schaefer

## OTHER PARTICIPANTS IN 2012

Aruba Networks	Amir Motamedi
Avago Technologies	Sanjeev Gupta, Amolak Badesha
Bayside Design	Elliot Nahas
Cavium	Johann Nittmann
Enterasys	Robert Haller
Exar Corporation	Helen Nguyen
Granite River Labs	Jiang Xu, Johnson Tan
Hewlett-Packard	Ting Zhu
High Speed Design Center	Ben Chia
Hitachi	Yutaka Uematsu*
Instituto de Telecomunicações	Wael Dghais*, Hugo Teixeira*
KEI Systems	Shinichi Maeda
Luxshare-ICT	Alan Kinningham, Steven Wong
MK Resolutions	Olga Chervyakova
Nvidia	Eric Hsu
Politecnico di Torino	Stefano Grivet-Talocia*
Research In Motion	Yi Cao
Sony	Kenji Yasoda
ST Microelectronics	Davide Pandini*
TechAmerica	(Chris Denham)
Université de Brest	Mihai Telescu*, Cherif Diouf*
University of Illinois	Thomas Comberiate, José Schutt-Ainé*
Vitesse Semiconductor	Sirius Tsang

In the list above, attendees at the meeting 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

The bridge numbers for future IBIS teleconferences are as follows:

Date	Meeting Number	Meeting Password
June 1, 2012	205 475 958	IBIS

For teleconference dial-in information, use the password at the following website:

<https://ciscosales.webex.com/ciscosales/j.php?J=205475958>

All teleconference meetings are 8:00 AM to 9:55 AM US Pacific Time. Meeting agendas are typically distributed seven days before each Open Forum. Minutes are typically distributed within seven days of the corresponding meeting. When calling into the meeting, follow the prompts to enter the meeting ID. For new, local international dial-in numbers, please reference the bridge numbers provided by Cisco Systems at the following link:

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NOTE: "AR" = Action Required.

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## **OFFICIAL OPENING**

The IBIS Open Forum Summit was held in Sorrento, Italy at the Parco dei Principi – Sorrento Hotel following the 2012 SPI conference. About 18 people representing 11 organizations attended.

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

<http://www.eda.org/ibis/summits/may12/>

Lance Wang welcomed all the participants and thanked the co-sponsors Micron Technology, Nokia Siemens Networks and Zuken. He asked all the participants to introduce themselves. There were a wide variety of people from many countries and organizations including academia and industry.

## **IBIS MODELING USING LATENCY INSERTION METHOD (LIM)**

José Schutt-Ainé\*, Jilin Tan\*\*, Ping Liu\*\*, Feras Al-Hawari\*\*, Ambrish Varma\*\*, \*University of Illinois at Urbana-Champaign, \*\*Cadence Design Systems, USA

José Schutt-Ainé presented. He noted the use of a different approach to simulation. The usual Newton-Raphson method makes a guess for a solution and iterates until the solution converges. Sometimes this method locks into oscillations and the solution will not converge. The Latency Insertion Method (LIM) has convergence advantages. It does not use matrix formulations. Each branch must have an inductor, and each node must have a shunt capacitor. LIM is easy to code and is fast. LIM has no convergence issues, but it suffers from stability issues.

LIM can be applied to IBIS. First,  $K_u$  and  $K_d$  coefficients must be solved from the V-t waveforms. Then, a LIM formulation can be used for the circuit simulation. José also showed an example of modeling gate modulation effects (BIRD98.3).

Eckhard Lenski asked where the problems with non-convergence of Newton-Raphson on slide 28 came from. José responded that he did not discover specific issues with the IBIS models, just that the solution would not converge.

A question was asked if the package parasitics might cause problems with  $K_u/K_d$  solutions, leading to failures of the Newton-Raphson method. José noted that Newton-Raphson non-convergence is very common.

## **SSO NOISE AND CONDUCTED EMI: MODELING, ANALYSIS, AND DESIGN SOLUTIONS**

Patrice Joubert Doriol#, Aurora Sanna#, Akhilesh Chandra##, Cristiano Forzan#, and Davide Pandini#, STMicroelectronics, #Italy, ##India

Davide Pandini summarized that he would discuss the use of IBIS models to solve signal integrity and power integrity challenges. Conducted EMI coming from signals is a problem at ST. EMC measurements for compliance were traditionally done at the end of the design flow, and if the design had issues, new mask sets would be very expensive. EMC-aware design is the goal, creating EMC models and doing EMC simulation before fabrication. Some noise can be injected on a stable victim from a switching aggressor. This causes conducted emissions on the victim I/O signal. Davide summarized the full SSO analysis flow. He showed a micro-controller design for an automotive application. Skewing of the I/O timing achieved a significant reduction in the amplitude of several harmonics. Skews of 10ns were possible due to the slow working frequencies of the technology. Reducing the I/O drive strength also further reduced the SSO noise. The gate-level SSO flow compared well to the Spice-level simulation.

IBIS 4.0 models did not work well for the SSO simulations, but IBIS 5.0 models compared well to Spice up to 2GHz in frequency domain analysis. He concluded that IBIS 5.0 can be used for reliable SSO and EMI analysis.

Eckhard Lenski asked what kind of package models were used. Davide replied that the models were RLC. Lance Wang asked how the frequency domain analysis waveforms were generated. Davide responded that an FFT of the time domain waveforms was used. Stefano Grivet-Talocia asked why the frequency matched only to 2GHz. Lance commented that it might be from poor modeling of C\_comp frequency dependence. Davide added that the V-t waveforms look like they match well, but zooming in, there are some differences.

## **VERSATILE SURROGATE MODELS FOR IC BUFFERS**

Cherif Diouf\*, Mihai Telescu\*, Igor Stievano\*\*, Flavio Canavero\*\*, P. Clostre\*, N. Tanguy\*, \*Université Européenne de Bretagne, Université de Brest, France; \*\*Politecnico di Torino, Italy

Mihai Telescu presented modeling work of the authors. IC buffers are highly non-linear systems. Behavioral modeling techniques include IBIS and Mπlog. Previous approaches to modeling include Mπlog plus the use of Volterra series and constraints to improve static behavior. He introduced the theoretical framework for a new modeling approach. The model for a driver was implemented in Spice and validated against two different system loads. A model of cascaded drivers was then used to have a more non-linear system and was compared against the previous loads. Correlation was acceptable with room for improvement. There is ongoing research on more complex and recent buffers. They are working to tune the method to the needs of the industry. They would like feedback on the complexity versus the versatility desired.

Wael Dghais asked if the weighting factors on slide 12 were related to the K coefficients in IBIS algorithms. Mihai responded that they were not related. Mihai clarified for Lance Wang that a least-squares method was used to determine the coefficients to fit the equations to the Spice results of the training simulations. Mihai clarified for Randy Wolff that the training simulations on slide 11 must be given ranges that will incorporate desired system loads, but more feedback is desired in this area.

## **TOWARDS REAL TIME S-PARAMETER QUALIFICATION AND MACROMODELING**

Stefano Grivet-Talocia, Politecnico di Torino, Italy

Stefano Grivet-Talocia introduced S-parameters and their use in SI/PI simulations. S-parameters must be qualified by looking for issues with passivity and causality. Circuit simulators assume that models are causal, so when non-causal S-parameters are used, they lead to unpredictable results. A generalized Hilbert transform can be used for generating a causality check error function. Macromodeling can be used to very accurately model S-parameter responses with rational function fitting of poles and zeros. He described a method developed to take advantage of multi-core processors to create the vector-fit macromodels quickly and efficiently. Passivity of the macromodel can be checked by looking at the eigenvalues. Computation of the eigenvalues works well with parallel processing.

Stefano described the HPM service developed by Politecnico di Torino that is an online resource for creating S-parameter macromodels.

Randy Wolff asked about support of IBIS-ISS as an output. Stefano said that support of this would be easy to add if there is a need. Lance Wang asked about support of Touchstone 2.0. Stefano responded that mixed mode support is not available yet, but it is being worked on. Mihai Telescu asked about use of the modeling to fix passivity and causality issues. Stefano responded that the macromodeling can fix issues, but it doesn't guarantee that the model is a better model of the original system than the original Touchstone file with its issues. Also, if the input data is highly non-causal, the macromodel will not be a good fit to the original S-parameters.

## **IMPACT OF ACCURATE PDN MODEL ON IBIS SI AND PI SIMULATIONS**

Antonio Girardi and Aniello Viscardi, Micron Semiconductor Italia S.r.l., Italy

Randy Wolff presented for the authors. An investigation of several power supply decoupling models was carried out on a LPDDR2 memory device. 20 I/Os were switched in an SSO simulation that included a coupled package model and a system load model. IBIS 5.0 driver models included BIRD95 and BIRD98 data tables. Four cases of PDN models were simulated including a case with no power supply decoupling, a capacitive-only model, an RC model, and a vector-fit decoupling model. The C-only model created a resonance with the package inductance that led to unrealistic ringing in the voltage waveform at the power pad. The RC model was created manually, and the addition of the ESR to the C-only model led to good agreement between behavioral simulation and Spice simulation. The vector-fit decoupling model was created automatically and led to a closer match than the RC model. The vector-fit model was a Spice subcircuit created from the S11 PDN response. Randy noted that there was not a large difference between the RC and the vector-fit models in the case shown, but there could be cases where the vector-fit model provides much better results than the RC, manually-fitted model.

Randy clarified that the vector-fit subcircuit model could be easily made IBIS-ISS compliant and currently would need to be included externally to an IBIS 5.0 model. He noted in response to a question from Eckhard Lenski that Micron is currently looking into providing IBIS 5.0 models for

certain memory devices.

## **DDR4 IBIS POWER INTEGRITY SIMULATION**

Randy Wolff\*, Lance Wang\*\*, \*Micron Technology, \*\*IO Methodology, USA

Randy Wolff began with an overview of the new DDR4 memory technology. He noted that he wanted to look at potential issues with Power Integrity modeling of DDR4 with IBIS 5.0. Overclocking was a concern with the faster bit rates compared to DDR3. An automated IBIS 5.0 buffer extraction tool was used to create the I-V, V-t and I-t data tables. Randy noted that the tool used a best-points-fit algorithm, although this was not a major benefit with 1000 points available for the V-t and I-t tables. However, it is inevitable that customers will ask for an IBIS 3.2 compliant model, and in that case it will be necessary to remove the I-t data and limit the V-t data to 100 points. A best-points-fit algorithm will be needed for this.

Overclocking was a concern, because the bit length at DDR4-1600 is 625ps and the [Composite Current] data was 750ps long in the typical corner and 850ps long in the slow corner. These lengths also required windowing of the data from tables that were 1.2ns in length. Data windowing may be automatic in some simulators, but may require manual adjustment in others. Simulations did reveal overclocking problems at DDR4-1600. The model was then simulated at DDR4-1866, and the problems got much worse. Manual windowing of the data tables was necessary, but a bug was found where the voltage waveforms looked ok, but the current waveforms were shifted in time. Other simulations revealed reasonable correlation between Spice and IBIS results. Randy also noted that a vector-fit decoupling model might improve correlation.

Eckhard Lenski asked if it was now necessary to warn customers about overclocking issues. Randy responded that one problem is that he can't test the models in every simulator, so the vendors need to step forward and provide more testing and validation. Known overclocking issues should be mentioned in model quality reports. Randy added that even in overclocking situations, the pre-driver current will always be there, so it must not be ignored.

## **MORE EXPERIENCES WITH IBIS-AMI MODELS**

Eckhard Lenski, Nokia Siemens Networks GmbH, Germany

Eckhard Lenski gave an overview of IBIS-AMI model usage. He noted that a good documentation file must accompany the model to help the user. He described the boundaries between the Tx, channel and Rx models. He also showed the IBIS-AMI parameters and Tx and Rx elements. His experiences using the models have varied, including issues such as models not working in both Windows XP and 7, models with the package model inside the .dll file, incomplete .ami files, mis-alignment of values between the .ibs file and the .ami file, and documentation that does not match the model.

Randy Wolff added that his first and recent experience using an IBIS-AMI model revealed very poor documentation as well. Stefano Grivet-Talocia asked about LTI assumptions with AMI modeling. Discussion confirmed that the convolution used in AMI model processing requires LTI assumptions. Modeling of non-LTI effects in the AMI models is not perfect and the methods are hidden within the .dll file.

## **EFFICIENT TABLE-BASED I-Q BEHAVIORAL MODEL FOR HIGH-SPEED DIGITAL BUFFERS/DRIVERS**

Wael Dghais\*, Hugo Teixeira\*, T.R. Cunha, J.C. Pedro, Universidade de Aveiro, \*Instituto de Telecomunicações, Portugal

Wael Dghais presented. He showed the structure of a digital I/O buffer. A new model creates an output impedance I-Q model. Q-V curves are extracted using AC simulation. I-V/C-V and I-V/Q-V models showed similar accuracy, but the I-V/Q-V model was faster to simulate. The new models showed better accuracy and matching to the transistor level model than the IBIS model. The models contain data tables very similar to IBIS models.

Lance Wang asked about implementing the model in simulation. Wael confirmed that it requires changing the algorithms in the simulator as well as extracting a new data table. The approach does complement existing IBIS, using similar I-V data extracted from simulation. Mihai Telescu made some comments about this approach versus the Mπlog modeling. Mπlog modeling works with continuous time, whereas IBIS and this approach work in discrete time.

## **AD HOC PRESENTATION**

Stefano Grivet-Talocia on request from Lance Wang presented on details of rational curve fitting algorithms. The slides used were a subset of his presentation "Passive Macromodeling" given at EMC Europe on 8/9/2008 in Hamburg, Germany.

## **CLOSING REMARKS**

Lance Wang closed the meeting by thanking the co-sponsors and the presenters. He also thanked all the attendees for making the meeting a success. The meeting concluded at approximately 6:00 PM.

## **NEXT MEETING**

The next IBIS Open Forum teleconference will be held June 1, 2012 from 8:00 to 10:00 AM US Pacific Standard Time.

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## **NOTES**

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To report ibischk parser BUGs as well as tschk2 parser BUGs. The BUG Report Form for ibischk resides along with reported BUGs at:

<http://www.eda.org/ibis/bugs/ibischk/>  
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The BUG Report Form for tschk2 resides along with reported BUGs at:

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<http://www.eda.org/ibis/bugs/s2ibis/bugs2i.txt>  
<http://www.eda.org/ibis/bugs/s2ibis2/bugs2i2.txt>  
<http://www.eda.org/ibis/bugs/s2iplt/bugsplt.txt>

Information on IBIS technical contents, IBIS participants and actual IBIS models are available

on the IBIS Home page:

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

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

<http://www.eda.org/ibis/directory.html>

To create an account on the TechAmerica KAVI workspace, check out:

<http://workspace.techamerica.org/kwspub/join/>

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## IBIS CURRENT MEMBER VOTING STATUS

### I/O Buffer Information Specification Committee (IBIS)

Organization	Interest Category	Standards Ballot Voting Status	March 30,	April 20,	May 11,	May 16,
			2012	2012	2012	2012
Advanced Micro Devices	Producer	Inactive	-	-	-	-
Agilent Technologies	User	Active	X	X	X	-
Altera	Producer	Active	X	-	X	-
ANSYS	User	Inactive	-	-	-	X
Apple Computer	User	Inactive	-	-	-	-
Applied Simulation Technology	User	Inactive	-	-	-	-
Cadence Design Systems	User	Inactive	X	-	-	-
Cisco Systems	User	Inactive	-	-	-	-
Ericsson	Producer	Active	X	X	X	-
Foxconn Technology Group	Producer	Inactive	-	-	-	-
Freescale	Producer	Inactive	-	-	-	-
Green Streak Programs	General Interest	Inactive	-	-	-	-
Huawei Technologies	Producer	Inactive	-	-	-	-
IBM	Producer	Active	X	X	X	-
Infineon Technologies AG	Producer	Inactive	-	-	-	-
Intel Corp.	Producer	Active	X	X	X	-
IO Methodology	User	Active	X	-	X	X
LSI	Producer	Inactive	-	-	-	-
Maxim Integrated Products	Producer	Inactive	-	-	-	-
Mentor Graphics	User	Active	X	X	X	-
Micron Technology	Producer	Active	-	-	X	X
Nokia Siemens Networks	Producer	Active	X	X	-	X
QLogic	Producer	Inactive	-	-	-	-
Signal Integrity Software	User	Active	X	X	X	-
Sigrity	User	Active	X	X	-	X
Synopsys	User	Inactive	-	-	-	-
Teraspeed Consulting	General Interest	Active	X	X	X	-
Texas Instruments	Producer	Inactive	-	-	-	-
Toshiba	Producer	Inactive	-	-	-	-
Xilinx	Producer	Inactive	-	-	-	-
ZTE	User	Inactive	-	-	-	-
Zuken	User	Inactive	-	-	-	-

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- MUST ATTEND TWO CONSECUTIVE MEETINGS TO ESTABLISH VOTING MEMBERSHIP
- MEMBERSHIP DUES CURRENT
- MUST NOT MISS TWO CONSECUTIVE MEETINGS

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