IBIS Open Forum Minutes

Meeting Date: **January 31, 2013**
Meeting Location: **DesignCon IBIS Summit, Santa Clara, CA, USA**

VOTING MEMBERS AND 2013 PARTICIPANTS

Agilent	Radek Biernacki*, Pegah Alavi*, Heidi Barnes*, Fangyi Rao*, Colin Warwick*
Altera	David Banas*, Hsinho Wu*
ANSYS	Luis Armenta*
Applied Simulation Technology	Fred Balistreri*, Norio Matsui*
ARM	(Vipul Patel)
Cadence Design Systems	Terry Jernberg, Joy Li*, Yingxin Sun*, Ambrish Varma*, Kevin Yao*
Ericsson	Anders Ekholm*, Martina Fiammengo*
Foxconn Technology Group	(Sogo Hsu)
Freescale	Jon Burnett*
Huawei Technologies	(Jinjun Li)
IBM	Greg Edlund*, Adge Hawes*
Infineon Technologies AG	(Christian Sporrer)
Intel Corporation	Michael Mirmak*, Mohammad Bapi*, Stewart Gilbert*, Ravindra Rudraraju*
IO Methodology	Lance Wang*
LSI	(Brian Burdick)
Maxim Integrated Products	Hassan Rafat*, Mahbubul Bari*, Ron Olisar*
Mentor Graphics	Arpad Muranyi*, Ed Bartlett*, Vladimir Dmitriev-Zdorov*
Micron Technology	Randy Wolff*
Nokia Siemens Networks GmbH	(Eckhard Lenski)
QLogic	James Zhou*
Signal Integrity Software	Walter Katz*, Mike LaBonte*, Mike Steinberger*, Todd Westerhoff*
Synopsys	John Ellis*, Ted Mido*, Scott Wedge*
Teraspeed Consulting Group	Bob Ross*, Tom Dagostino*
Texas Instruments	(Pavani Jella)
Toshiba	(Yasumasa Kondo)
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Zuken	Masaud Raeisi*, Reinhard Remmert*

OTHER PARTICIPANTS IN 2013

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Granite River Labs	Vamshi Kandalla*, Miki Takahashi*
Hewlett-Packard	Yongjin Choi*, Ting Zhu*

KEI Systems	Shinichi Maeda*
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Nvidia	Eric Hsu*
Qualcomm	Scott Powers*
TechAmerica	(Chris Denham)
University of Illinois	Tom 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
February 22, 2013	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:

http://www.cisco.com/web/about/doing_business/conferencing/index.html

NOTE: "AR" = Action Required.

OFFICIAL OPENING

The IBIS Open Forum Summit was held in Santa Clara, California at the Santa Clara Convention Center during the 2013 DesignCon conference. About 56 people representing 28 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/jan13/

Michael Mirmak welcomed everyone to the Summit, opening the meeting at 8:30AM. He thanked the sponsors including Agilent Technologies for providing the food as well as DesignCon. Michael asked all the participants to introduce themselves. There was a large cross section of model users and developers.

CHAIR'S STATUS REPORT

Michael Mirmak, Intel

Michael Mirmak began by noting the new IBIS 5.1 specification released in August of 2012. Many BIRDs filed in the last year remain open. The ibischk5 parser update was released just two months after the specification release. He graded our progress on items presented one year ago at DesignCon. International Summit attendance continues to be good. A new BIRD template for the IBIS 5.1 format is in use. Looking ahead, we need to clear the decks for IBIS 6.0. The 19 BIRDs now open need to be resolved. There will be no DAC Summit this year, so elections will be done electronically.

USING X-PARAMETERS TO GENERATE IBIS MODELS

Tom Comberiate, José Schutt-Ainé, University of Illinois at Urbana-Champaign

Tom Comberiate began by noting that X-Parameters is a registered trademark of Agilent Technologies. Tom's motivation was to provide a method for exchange of an X-parameter file (.xnp) to a model generator for creation of an IBIS model while protecting IP. He started with a basic inverter. One rule he followed was to only generate X-parameter data that could be measured with a real NVNA. X-parameters are generated with a harmonic balance simulation. First, I-V curves are generated. Next, V-t curves are simulated, where an ideal input step is approximated with a sinusoid where the frequency is adjusted to achieve the desired rise/fall times. He ended up with two .xnp files that could then be used to generate IBIS I-V and V-t data. The I-V curves between s2ibis3 and x2ibis flows agreed well. The V-t curves have a reasonable match. Future work is to include second order effects and improve the approximation of the ideal step for V-t curve generation.

Bob Ross asked if the number of harmonics is a variable or a consequence of the variation for V-t curves. Tom responded that he can choose the number, but he chose 7 harmonics to keep the size of the .xnp file smaller.

David Banas commented on slide 20, noting that the X-parameter file format is similar to Touchstone, but it is only one frequency. Tom added that it includes the harmonics of the fundamental frequency.

Radek Biernacki inquired about the impact of power level on accuracy. Tom responded that he chose the power level to cover the 0 to VCC range. Changing to other power levels does have some effect. He'll explore this in a future paper.

Mike Steinberger asked what the goal of using X-parameters is. Jose responded that he is looking for a way to use X-parameters to generate more accurate IBIS models. X-parameters might eventually replace on-die S-parameters because they handle non-linear effects well.

Arpad Muranyi asked what this would look like in IBIS. Tom said that the X-parameters wouldn't be in the IBIS file, they would be converted to IBIS format.

Another question was how to handle capacitors in the model (C_comp). Tom noted that capacitance is not handled in this version of the model.

Scott Wedge asked if source/load termination impedances are a problem. Tom responded that he is following the NVNA rule where the source/load impedances used are 50 ohms, so that might be a limitation.

IBIS QUALITY STATUS REPORT
Mike LaBonte*, Bob Ross**, SiSoft*, Teraspeed Consulting Group**

Mike LaBonte noted that the number of regular Quality meetings has decreased, but this is a testament to the increased quality of IBIS models overall. Primary topics of discussion are the IQ specification, AMI quality, waveform validation, and the IBIS parser. The IBIS quality specification is at version 2.0, and there are no plans to update this currently. Development of an AMI quality checklist has been suspended while major IBIS-AMI specification changes are in progress. The group has been developing a set of IBIS correlation test waveforms. They also looked into using a Figure of Merit test to measure correlation. The group recently filed ibischk5 BUG140. They are developing a document describing all the warning messages, algorithms and command line usage of the IBIS parser as well as a parser source code reference. Mike encouraged participation in the task group, as attendance has been low.

COMBINED I-V TABLE CHECKS (BUG140)
Bob Ross*, Yingxin Sun**, Joy Li**, Teraspeed Consulting Group*, Cadence Design Systems**

Bob Ross began by describing BUG140, where unexpected non-monotonic warnings are issued for combined I-V tables. There is no specification requirement that individual or combined I-V tables be monotonic. Combined table checks were added to the IBIS parser following BUG94. Non-monotonicity often occurs outside of normal simulation regions (clamp regions) and is not a problem for simulation software. Bob walked through a simple example to demonstrate how piecewise linear interpolation methods can cause non-monotonicities when combining two data sets. Bob then showed two test case examples from BUG140. The Quality task group discussed several options for fixes including using more complicated SPLINE fitting algorithms. The final resolution was to change the warning to a note.

Arpad Muranyi commented that it would be nice to try other higher order fitting algorithms on the same test cases to see if the algorithms fix the issue. Others commented that the errors might decrease, but the problem might still exist. Lance Wang noted that there are times where non-monotonicities cause problems, so it is important to investigate these warnings or notes.

Michael Mirmak commented that as soon as we put quality checks in the parser, we doom ourselves to dealing with issues like this. There is room for ongoing discussion on how much data we provide on these issues.

Greg Edlund commented that a good fix might be to ignore data after a certain number of

significant digits.

Arpad commented that perhaps the wrong choice was made long ago to require subtraction of currents when creating a model and it might have been better to leave that to be done in the EDA tools.

NEW AMI API TO RESOLVE MODEL PARAMETER DEPENDENCIES
Fangyi Rao, Radek Biernacki, Agilent Technologies

Radek Biernacki began by stating that model vendors need a flexible mechanism to implement parameter dependency according to their proprietary formulae and pass the dependent parameter values to EDA tools. Some vendors may need to conceal the dependency formula. One existing solution for dependency tables is BIRD150 that puts the data in the .ami file. Radek is proposing BIRD155 that puts the dependencies in the .dll file. This BIRD proposes a new API, AMI_ResolveDependentParam, that includes four input and output arguments. A new Reserved Parameter, ResolveDependentParam_Exists, is also proposed. Radek noted the need to split the Out parameters into two complementary subsets of parameters, one handled by the Resolve function and the other by the Init function. He then defined the Usage type of independent and dependent parameters and walked through a simulation flow using the new API. Radek listed many advantages to the BIRD155 proposal and noted that he considers it a replacement to BIRD150.

David Banas commented that some models are easier to use if choosing analog parameters first, while some are easier to use if selecting AMI parameters first. Will the user have the ability to choose a methodology? Radek responded that this BIRD doesn't change the methodology.

Walter Katz responded to the presentation by saying that there is an absolute need for dependency tables. There was three years ago. It is debatable whether dependency needs to be in the .ami or .dll file. Editing an .ami file to add jitter parameters creates complications with dependencies. Walter would like to see IC vendors show support for this proposal before it moves forward.

END TO END LINK ANALYSIS AND OPTIMIZATION WITH MID-CHANNEL-REDRIVER AMI MODELS
Mahbubul Bari*, Ron Olisar*, Hassan Rafat*, Sharon Mang*, Fangyi Rao**, Ming Yan**, Maxim Integrated Products*, Agilent Technologies**

Ron Olisar began by noting that more channels are requiring mid-channel-redrivers. However, these are non-linear, so they are not currently supported in the current IBIS-AMI simulation flow which requires linear time-invariant channels.

Mahbubul Bari then presented some information on the redrivers. Redrivers equalize signals from an upstream channel and retransmit them into a downstream channel. They are noisy and non-linear. Defining a redriver AMI model requires combining two back-to-back regular AMI models for the receiver and transmitter parts of the device. Redrivers could be cascaded in a channel. Mahbubul then described the redriver simulation flow. He showed several comparisons of model performance between Spice simulation and IBIS-AMI based simulation.

Random jitter in the model can be implemented using a Gaussian voltage noise source before and after the non-linear transfer functions.

Ron then presented an example of a channel simulation with an AMI redriver model. The redriver model allowed for an internal node between the Rx and Tx models to be probed. He noted that an S-parameter could be used to model the transfer function of the redriver, but that cannot capture non-linearities or noise floor effects. He also showed how crosstalk could be included when using the redriver models. Next up, our collective task is to make redriver methodology in IBIS-AMI a reality.

Walter Katz asked if the BIRD requires that if the Rx has an AMI_Getwave, the Tx would require AMI_Getwave. Mahbubul responded no, it wouldn't have to require that. Walter commented that they need to explicitly define the flows to handle all the permutations. He added that a redriver is a non-retimed device. There are retimers in use, so we should look at defining a retimer flow. Mahbubul responded yes, and we need to consider the differences from the backchannel proposal.

Todd Westerhoff asked if we could model non-linear behavior in an impulse response, could an Init-only flow be defined, and would that be supported? Ron thought that could be possible.

IBIS-ATM TASK GROUP REPORT
Arpad Muranyi, Mentor Graphics

Arpad Muranyi began by showing all the BIRDs that made it into the IBIS 5.1 specification. Three more BIRDs have been approved recently in the IBIS Open Forum. BIRDs under discussion cover three topics including analog proposals, AMI enhancements, and backchannel and repeater proposals.

AMI MODEL-TO-HARDWARE CORRELATION
Greg Edlund, IBM

Greg Edlund introduced his correlation project. For TX hardware measurements, he took a SerDes demo board and controlled it from a PC, drove from a test board through a mini-SAS cable to a cable test board and then made measurements on a real time oscilloscope. For Rx eye measurements, the Tx drives directly into the Rx on the SerDes test board, and the Rx paints an eye that is output to the PC. His first model to hardware correlations for the Tx had too much difference in parameters such as eye height and eye width. He looked into whether the measured S-parameters of the package had too little low frequency content. One inconsistency was that the Tap 0 was not completely off in hardware. Also, the scope and hardware were measuring the eye heights at different points. A few other parameters were adjusted as well. After these adjustments, the simulation and measurement agreed much better.

Things got trickier with the Rx. Correlation with the Rx model was not possible due to the hardware having gain control and the model not yet implementing those algorithms. Also, more work needs to be done to get data out of the Rx and calculate parameters for correlation to the simulation.

Walter Katz commented that some differences seen in the PRBS-7 pattern with the 0.6m cable come from the time domain simulation having one million bits and only getting down to a BER of 1E-6 while the scope is capturing a lot more data and shows a greater BER. Running the simulation with more bits might correlate better. He also commented that correlation should look better with longer channels where the channel loss attenuates any high frequency effects.

Ambrish Varma asked if Greg had changed any jitter parameters to improve the correlation. Greg said he did not change these parameters.

In response to another question Greg clarified that he did not correlate clock recovery behavior. Greg asked the attendees if one can add power supply noise to an AMI model. Mike Steinberger responded that you can characterize duty cycle distortion due to power supply noise and add this into the simulation after the channel impulse response characterization.

INTERCONNECT TASK GROUP STATUS UPDATE
Michael Mirmak, Intel

Michael Mirmak noted that the Interconnect task group was reconvened in September of 2012 to tackle the task of making IBIS package modeling sufficient for today's industry needs. IBIS, IBIS-ISS and Touchstone need to be integrated. Proposals are being discussed that are intended to address modeling requirements for various interconnect types from multi-chip modules to cables to on-die interconnect. The task group is waiting to analyze a specification called Si2 being disclosed publicly in late February. The group is also working with the ATM task group to resolve the nature of the [Model] stimulus.

Walter Katz noted that Si2 may be delayed due to some recent patent infringement claims. Walter commented that the group made great progress in defining the requirements of interconnect modeling. More work needs to be done to analyze the proposals in detail and make sure they meet the needs of the IC vendors.

SERDES CHANNEL SIMULATION FLOWS AND ALGORITHMS USING IBIS 5.1 AMI MODELS
James Zhou, QLogic

James Zhou began with a brief history of the AMI reference flow. He noted his presentation only related to the time domain reference flow. He introduced the basic concepts of IBIS-AMI flows using Init and GetWave functions. He showed system equations derived from basic signals and systems theory. Arpad Muranyi pointed out that the equations presented did not agree with established flows in IBIS-AMI. James commented that this was the reason he was making this presentation – to clear up some confusion. He went on to describe the IBIS 5.0 flow and noted the problems with double counting where the Tx and Rx models can both attempt to automatically optimize the channel performance without knowing what each other is doing. The IBIS 5.1 flow is fundamentally different. James summarized the four paths the simulator will follow based on the states of the Reserved Parameters Tx GetWave_Exists and Rx GetWave_Exists.

James noted a potential issue for double counting in the IBIS 5.1 specification. Walter Katz commented that the case shown by James should not be used. It has been learned in the last three years that the Tx should not optimize the eye at the input to the Rx, as this will over equalize the channel and the Rx will have to undo some of what the Tx did, introducing noise in the Rx. The Tx should optimize the eye at the input to the Rx latch. James finished by proposing a solution for double counting.

USING PYTHON TO DEBUG IBIS-AMI MODELS
David Banas, Altera

David Banas noted that current options for debugging IBIS-AMI models include running a full blown, GUI based simulation in a IBIS-AMI capable simulator or using one of the command line tools available. David has developed a third option called PyIBIS-AMI written in the Python language. He showed a live demonstration of the program. He initialized the model, viewed an impulse response which was faulty, and showed how to tweak parameters of the model to validate a hypothesis.

Mike Steinberger asked how David was able to debug the problem in his model code. David noted that the Python program was able to isolate the issue to a particular section of code that was injecting noise at the bit rate.

David concluded his live demonstration and noted that he has plans for improvements to the code including a GUI tool. There are 300 downloads of his code so far.

Michael Mirmak asked if David had just shown a simulator. David responded that the program is a glorified wrapper around a DLL that puts the power of Python at his fingertips, such as plotting tools. Michael asked if there is a way to code an AMI model in Python. David responded yes, but there is a performance issue. You can create a DLL. Mike Steinberger added that you can embed Python in a C wrapper, but you take two orders of magnitude of a performance hit.

Adge Hawes asked why David used Python. David noted that he has been using it instead of Matlab. The numerical processing libraries are very powerful.

Mike Steinberger commented that he runs any code through memory management checkers. What do you do with this code? David responded that any released code is run through ValGrind, but he does not know what loads the DLL.

OPEN DISCUSSION AND AD HOC PRESENTATIONS

IBIS-AMI PARAMETERS IN MATLAB/OCTAVE
Adge Hawes, IBM

Adge Hawes noted that IBM IBIS-AMI models use multidimensional parameters. They need n-dimensional data storage. The Format List currently used is not user friendly. N-dimensional variable types in Matlab and Octave are structures, matrices, character arrays or cells.

Parameter structure fields are name, attr, comment, dim and value. He showed an example of a complicated parameter. With these parameter definitions, Octave/Matlab scripts can generate and process parameters such as for HSSCDR or BIRD150 and BIRD155 structures.

Mike Steinberger asked if processing of text in Octave has improved in the last ten years. Adge noted that the cell structure has made this much better. Mike asked if Adge had considered this for writing his parameter parsing C code. Adge responded no. Mike commented that he has a way to take an AMI file and create the code necessary to parse the variables present in the file.

Mike LaBonte asked if the ladder type corresponds to BIRD 150. Adge replied yes, ladder means change half way in between one value and the next, so it works with dependency tables.

WHAT'S WRONG WITH IBIS?

Arpad Muranyi, Mentor Graphics

Arpad Muranyi noted that we have spent a long time discussing analog modeling proposals. We have different interpretations of fundamental IBIS concepts, and we debate issues of deprecation and making large changes to the specification as opposed to incremental ones. We seem to favor a more fundamental overhaul of the specification. Two main categories of improvements are analog buffer modeling and package and on-die interconnect modeling. There are several issues with [Model] such as them being single ended, no support for on-die interconnect, stacked die or scaling or parameterization, C_comp modeling is insufficient, [External Model] and [External Circuit] are not popular, and there is no support for pre- versus post- layout modeling. [Package] also has many issues such as RLC modeling not having frequency dependencies, lack of coupling, one-to-one pin to pad mapping and no support for stacked packages. He suggested that to address all the issues, the best choice seems to be to start over with a cleaner and better syntax in a parallel fashion with existing IBIS. He concluded with a call for action to make a planned effort to create an improved and flexible IBIS specification for the long term while making only minimal changes in the short term.

Radek Bernacki asked Arpad to comment on what was good with [Model]. Arpad said that he liked I-V curves and that this presentation was pessimistic, but meant to show that there are many problems to resolve.

INTERCONNECT MODELING STATUS

Walter Katz, SiSoft

Walter Katz started by giving a history of presentations he has made related to interconnect modeling, including the EMD proposal. He noted that we need a lot more capability than what is currently in the IBIS specification. A complex on-die model could have coupling and modeling of complicated pathways from the die pads to the buffers as well as power supply parasitics modeling. The EMD proposal (Electronic Module Description) is built upon the EBD syntax. Walter used a parameter tree syntax in EMD. A new concept is Extended_Nets that tell you what nodes are strongly connected together. He showed some example syntax for a connector and a multi-chip module. He showed that on-die interconnect modeling can be simple for non-IBIS-AMI models. For AMI modeling, IC vendors combine the on-die interconnect and the buffer reactive load into a single .s4p, but this is not currently supported by IBIS. Walter

concluded that his proposal addresses many interconnect modeling requirements.

OPEN DISCUSSION

Walter Katz commented that BIRD 122 to use Touchstone files for Tx and Rx interconnect modeling has been used by industry for some time, but each EDA tool has different syntax for using this solution. One IC vendor asked several companies to come up with a solution, and that proposal will be introduced to the IBIS Open Forum shortly. Arpad Muranyi asked what form the proposal would be made in, i.e. is a BIRD needed. Todd Westerhoff described that it uses BIRDs 116-118, the jitter BIRD 123.5 and BIRD122, and it is just a document detailing how to effectively use these BIRDs. Arpad noted that he was interested in the details to see how there is a way out of the current stalemate. Todd commented that SiSoft proposed BIRD122, but others wanted something more generic. All that is needed is a simple circuit to instantiate on-die interconnect. BIRDs 116-117 allows one to instantiate a subcircuit and define parameters, then BIRD118 can be used to define a specific usage for AMI. Arpad added that BIRDs 116-118 are useful to help fix legacy IBIS too.

CONCLUDING ITEMS

Michael Mirmak thanked the sponsor Agilent Technologies, the presenters, organizers and attendees.

The meeting concluded at approximately 4:45 PM.

NEXT MEETING

The next IBIS Open Forum teleconference will be held February 22, 2013 from 8:00 to 10:00 AM US Pacific Time.

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NOTES

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This meeting was conducted in accordance with the TechAmerica Legal Guides and TechAmerica Manual of Organization and Procedure.

The following e-mail addresses are used:

majordomo@eda.org

In the body, for the IBIS Open Forum Reflector:
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IBIS Users' Group Reflector (ibis-users@eda.org)
State your request.

ibis-info@eda.org

To obtain general information about IBIS, to ask specific questions for individual response, and to inquire about joining the IBIS Open Forum as a full Member.

ibis@eda.org

To send a message to the general IBIS Open Forum Reflector. This is used mostly for IBIS Standardization business and future IBIS technical enhancements. Job posting information is not permitted.

ibis-users@eda.org

To send a message to the IBIS Users' Group Reflector. This is used mostly for IBIS clarification, current modeling issues, and general user concerns. Job posting information is not permitted.

ibis-bug@eda.org

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/
http://www.eda.org/ibis/bugs/ibischk/bugform.txt

The BUG Report Form for tschk2 resides along with reported BUGs at:

http://www.eda.org/ibis/tschk_bugs/
http://www.eda.org/ibis/tschk_bugs/bugform.txt

icm-bug@eda.org

To report icmchk1 parser BUGs. The BUG Report Form resides along with reported BUGs at:

http://www.eda.org/ibis/icm_bugs/
http://www.eda.org/ibis/icm_bugs/icm_bugform.txt

To report s2ibis, s2ibis2 and s2iplt bugs, use the Bug Report Forms which reside at:

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/

IBIS – TECHAMERICA STANDARDS BALLOT VOTING STATUS

I/O Buffer Information Specification Committee (IBIS)

Organization	Interest Category	Standards Ballot Voting Status	November 30, 2012	December 21, 2012	January 11, 2013	January 31, 2013
Agilent Technologies	User	Active	X	X	-	X
Altera	Producer	Active	X	X	-	X
ANSYS	User	Active	X	-	X	X
Applied Simulation Technology	User	Inactive	-	-	-	X
ARM	Producer	Inactive	-	-	-	-
Cadence Design Systems	User	Active	X	-	X	X
Ericsson	Producer	Active	-	-	X	X
Foxconn Technology Group	Producer	Inactive	-	-	-	-
Freescale	Producer	Inactive	-	-	-	X
Huawei Technologies	Producer	Inactive	-	-	-	-
IBM	Producer	Active	X	X	X	X
Infineon Technologies AG	Producer	Inactive	-	-	-	-
Intel Corp.	Producer	Active	X	X	X	X
IO Methodology	User	Active	X	X	X	X
LSI	Producer	Inactive	-	X	-	-
Maxim Integrated Products	Producer	Inactive	-	-	-	X
Mentor Graphics	User	Active	X	X	X	X
Micron Technology	Producer	Active	X	X	X	X
Nokia Siemens Networks	Producer	Inactive	-	-	-	-
QLogic	Producer	Inactive	-	-	-	X
Signal Integrity Software	User	Active	X	X	X	X
Synopsys	User	Inactive	-	-	-	X
Teraspeed Consulting	General Interest	Active	X	X	X	X
Texas Instruments	Producer	Inactive	-	-	-	-
Toshiba	Producer	Inactive	-	-	-	-
Xilinx	Producer	Inactive	-	-	-	-
ZTE	User	Inactive	-	-	-	-
Zuken	User	Inactive	-	-	-	X

CRITERIA FOR MEMBER IN GOOD STANDING:

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

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