Getting the Most from IBIS-AMI: Tips & Secrets from the Experts

Panel Discussion: Tuesday January 31, 2017, 4:45-6pm

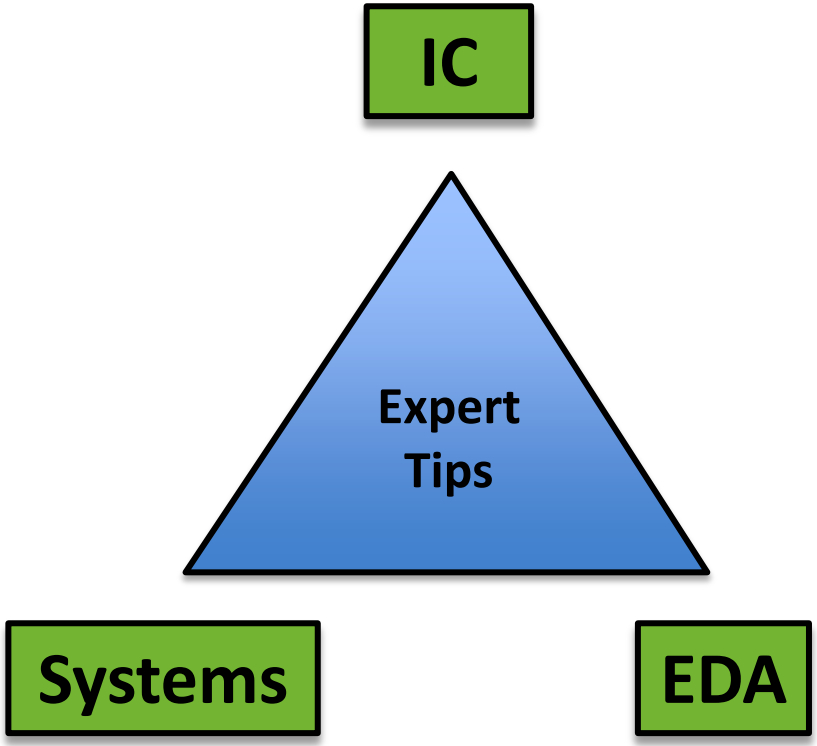
Moderator: Donald Telian, SiGuys

Welcome to the 2017 AMI Panel Discussion

- **Getting the Most from IBIS-AMI: Tips & Secrets from the Experts**
  - Donald Telian, Owner / Signal Integrity Consultant, SiGuys

- **Panel Format:**
  - 6 Panelists
  - 5 questions
  - Timed response
  - Interruptions - flags
  - Audience questions

Getting the Most from IBIS-AMI



PANEL:

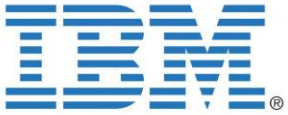
2 IC

2 Systems

2 EDA

Panelists

- Adge Hawes, IBM
- Todd Westerhoff, SiSoft
- Stephen Scearce, Cisco
- Bob Elsheimer, Broadcom
- Ken Willis, Cadence
- Shahriar Mokhtarzad, Brocade



Getting the Most from IBIS-AMI: Tips from Experts

- **AMI is a feature-rich spec – lots of possibilities**
- **It's time to make greater use of the capabilities**
  - For example, less than 50% of companies make use of Tx/Rx programmability
    - AMI models and simulators excel at the task of exploring/optimizing/resolving settings
    - 100%+ performance improvements possible, will become imperative at higher speeds
    - Partly a SerDes/organizational/process issue
- **This Panel is designed to help us all learn new ways to use AMI**
  - So let's hear from the experts…

Question 1

Introduce yourself and your role at your company.

Outline your company's and your personal involvement with AMI models.

1 min - Hawes

Adge Hawes

- Adge Hawes is a Development Architect for IBM at its Hursley Labs, United Kingdom.
- Worked for IBM for more than 40 years
- Currently develops simulators for High Speed Serial Links under contract to GlobalFoundries, Inc.
- Represented IBM in standards bodies such as IBIS, PCI, SSA, and Fibre Channel
- Worked on the development of storage virtualization, graphics displays, printing subsystems, and PCs.

Todd Westerhoff
VP/Semiconductor Relations
SiSoft

- We provide Quantum Channel Designer (QCD)
- We provide IBIS-AMI model development tools
- We develop IBIS-AMI models for customers
- We validate IBIS-AMI models developed by others
- We perform design work under contract using IBIS-AMI
- We actively drive changes to IBIS and IBIS-AMI

Stephen Scearce

Engineering Manager CHG-PDS- SI

SI/PI/EMC focused for 16 years

Introduction

- Bob Elsheimer – Broadcom Ltd
- Have worked in IC manufacturing and IC design, VCSEL Laser Models, SerDes Architecture and Modeling
- Have worked on opto-isolator, infrared transceiver, fiber optic and SerDes products
- Started writing model and simulator code for SerDes Links 8 years ago. Standardized model code to AMI a few years ago to separate model code from simulator code

Overview of Cadence involvement with IBIS-AMI

- Introduced the first commercial channel simulator in 2004
- Drove definition of the AMI extension to IBIS in 2007
- Helped customer develop and correlate the first AMI model
- Helped evangelize the IBIS-AMI modeling technique inside (IP group) and outside of Cadence

cadence

Shahriar Mokhtarzad

- **Group Manager, Signal Integrity & Component Engineering at Brocade Communications System Inc.**
- **Primary focus is in design and characterization of next generation high-speed systems, backplane, daughter card and ASIC packages for networking systems.**
- **Received his MS in Physics and MS in Mathematics from the University of California at Irvine.**

Question 2

What percentage of the AMI capabilities do you see engineers using today?

What important features are AMI users missing when they perform simulation?

1 min, Willis

What % of AMI capabilities are being used? What's missing?

- Too much % sometimes. Prefer AMI models that use AMI_Init or AMI_Getwave for equalization. "Dual" models generate confusion with most users about statistical vs. time domain channel simulation.
- Jitter/noise injection is often left out of the .ami file. These factors are big contributors to the end results.
- Back-channel support is still missing from the IBIS spec.

What % of AMI is being used? What's missing?

- **Current simulators allow the user to use all of the capabilities of current AMI models**
- **However, about 40% - 70% of are used by average users.**
- **What is usually missing is the limited sweep of parameter space for finding the optimal performance point.**
  - This can be accomplished by DOE tools integrated into some simulators to explore channel performance and its dependence on various SerDes parameters.
- **Users must ensure a reliable and accurate channel models used**
  - This can be accomplished by tools provided by many simulator vendors.

Question 2

What percentage of the AMI capabilities do you see engineers using today?

What important features are AMI users missing when they perform simulation?

Rx Model Capabilities

Capability	Frequency	Comments
Jitter modeling	80%	Mostly in .ami file
Report adapted settings	33%	Parameters_Out and text output
Broadband analog	30%	[External_Model] not used
Statistical simulation	25%	Control loop modeling is complex
Tx/Rx co-optimization	10%	Mixture of techniques

% of the AMI capability using today? What pieces are they missing?

- Documentation/Portability
- Receiver adaptation algorithms different from HW
- May overlook System optimization BC the newer serdes can compensate for so many impairments
- Jitter injection and correlation to Jitter specs,
- Setting may not easily map to real HW serdes, (Generic modules used to create models may not match specific HW.
- Serdes Complexity on latest serdes may not be covered by AMI

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How do I see AMI used today?

- **System Designers/ Signal Integrity**
  1. Architectural investigation
  2. Validate end product performance over process/temperature
- **SerDes Design**
  1. Architectural Investigation – AMI can be a wrapper for behavioral models
  2. IC design – Tie design changes (gain, BW, peaking) to channel equalization performance
  3. Validate designs over broad range of channels and data rate

Question 3

How can I get up to speed on IBIS-AMI?

What resources are available?

1 min, Mokhtarzad

How can I get up to speed on IBIS-AMI?

- **Start with general literature on the web.**
  - Some of the better martial is available on the web from Cadence, Sisoft, Ansys and etc.
- **Such material provided a good amount very useful, detail information about AMI model in general.**
- **AMI models are complex and I use the resources our simulator vendors provide.**
  - I have found them to be extremely helpful in resolving AMI related issues.
- **Some specific links:**
  - http://www.ibis.org/macromodel_wip/archive-date.html
  - http://www.sisoft.com/elearning/design-of-experiments.html
  - http://www.sisoft.com/elearning/webinars.html
  - www.ansys.com -> customer portal
  - www.cadence.com -> community -> elearning & support

Question 3

How can I get up to speed on IBIS-AMI?

What resources are available?

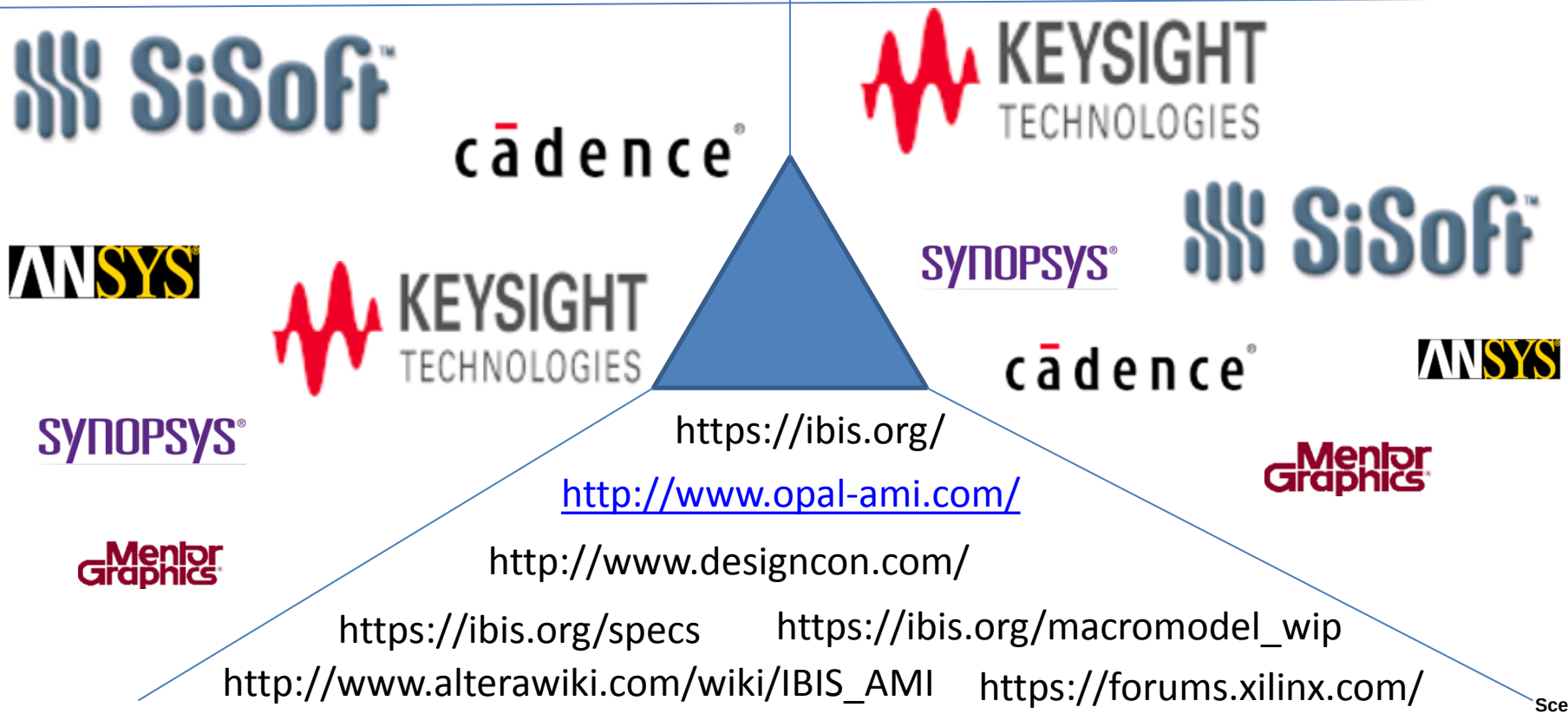
IBIS-AMI Resources

- IBIS-Specification and Summit presentations: www.ibis.org
- Conference papers (especially DesignCon)
- EDA vendor training, design kits, app notes
- Semiconductor vendor kits and app notes
- Colleagues, tool time and elbow grease

AMI Resources

Web Based Education

Video content



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Getting Started in IBIS-AMI….

- **Start using it through your EDA vendor**
- **If you are a SerDes customer, ask your SerDes vendor for models and assistance**

How can I get up to speed on IBIS-AMI?

- Read the IBIS spec
- Donald has some nice DesignCon papers on this
- We have CDNLive papers and Sigrity “Tech Tip” videos on some AMI capability that can help
- We often do “AMI 101” presentations to customers when we demo the tools, can schedule that if interested

- *Go build one and test drive! It is easy these days!*

Question 4

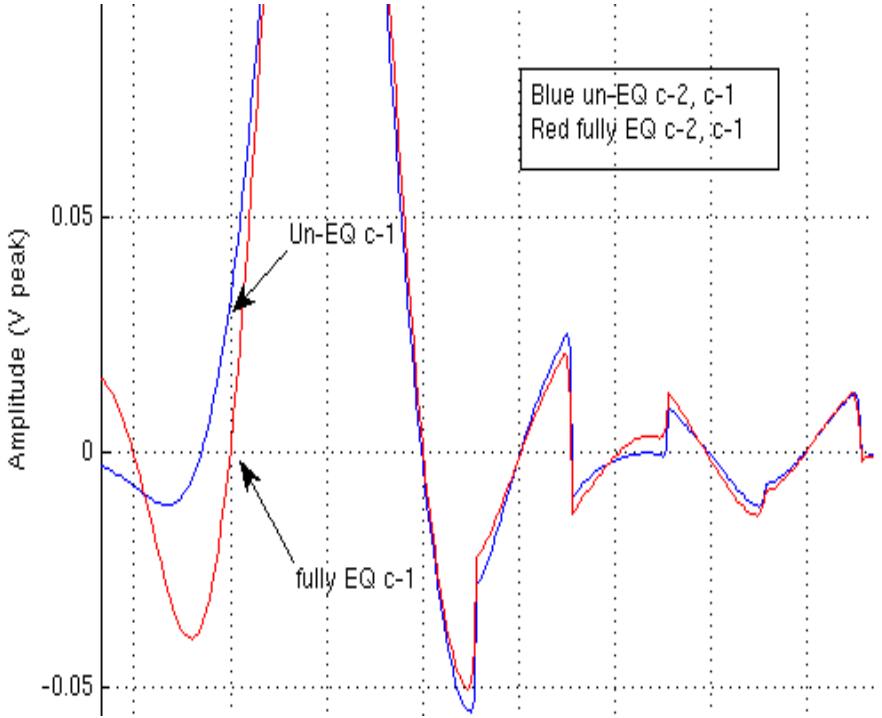
AMI Models allow us to explore SerDes equalization setting options. Are design teams making use of these programmable settings?

Tell us about how/when adapting settings saved the day, in your experience.

2 min - Elsheimer

AMI Settings….do they matter?

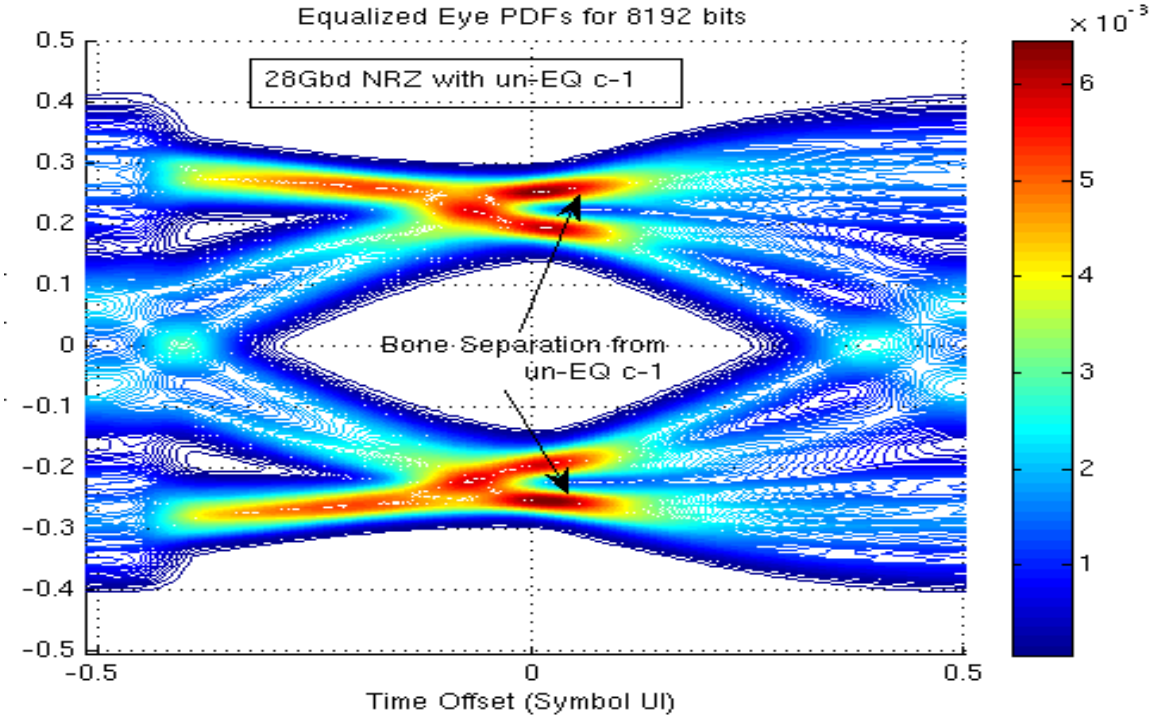
- **Can I leave un-EQ pre/post on the table?**
- **NRZ has a broad tuning range for open eyes even when pre/post not fully equalized.**
- **PAM4 has much smaller tuning range to open eyes. Need to fully EQ all pre/post cursors to avoid interference between eyes.**



Elsheimer

AMI Settings….do they matter?

- **For NRZ it depends on your margin requirements.**
- **Un-EQ pre1 (c-1) leaves margin on the table.**



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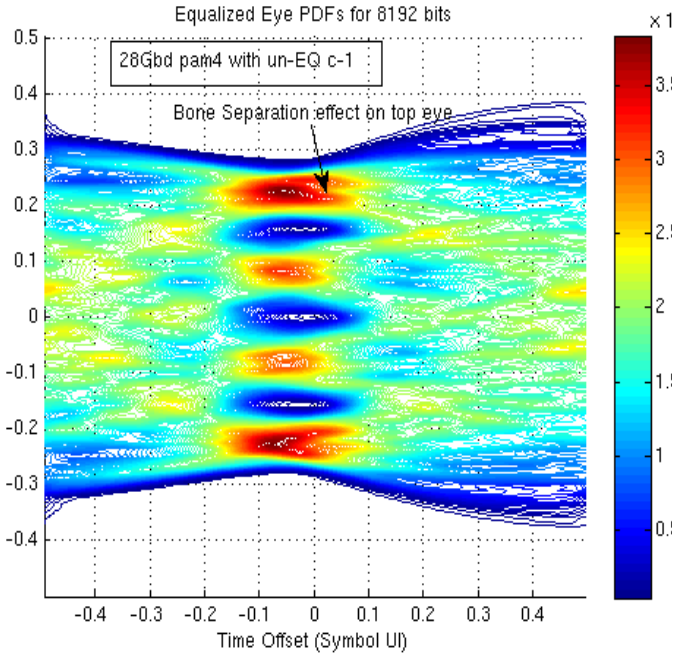
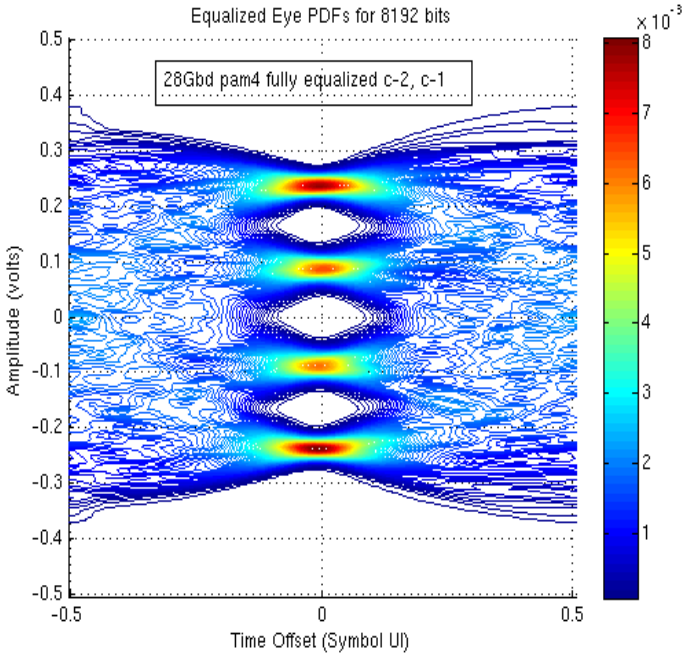
AMI Settings….do they matter?

- **For PAM4 all cursors must be equalized.**
- **Un-EQ ISI in each eye crosses into other eyes.**





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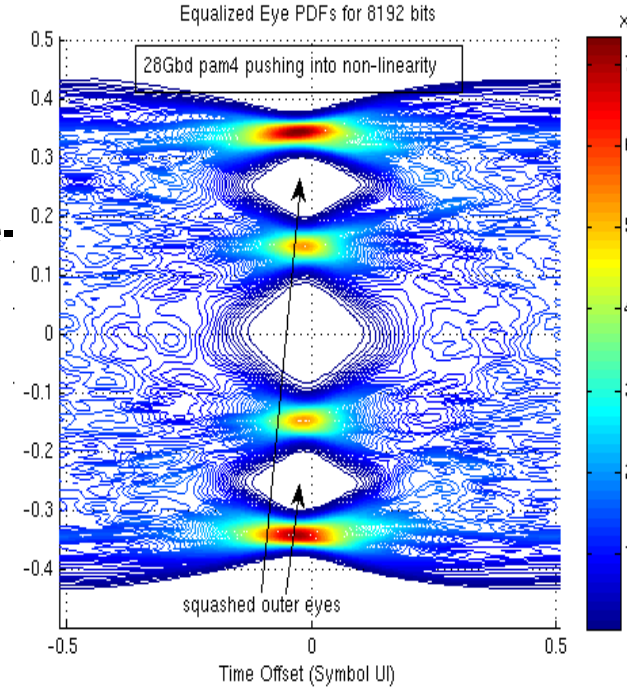
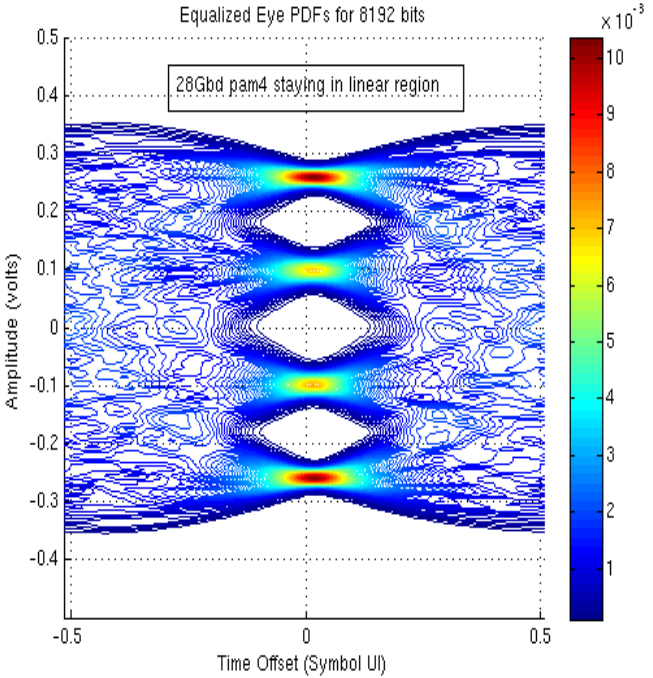
AMI Settings….do they matter?

- **Different EQ settings to get to the same Veye, Heye margins (pre-FEC BER).**
- **Linear eyes have lower post-FEC codeword error rate**





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Are design teams making use of programmable settings?

- Absolutely, we see design teams experimenting, sweeping, and trying to optimize settings for specific types of channels
- Even if the actual device doesn't adapt, you can still put some of that self-optimization capability into the model to save the user time
- Customers sometimes use automated adaptation in our template models to get a starting point as to what optimized settings may be

- You should only expose to the user the settings that they are able to adjust and control

Are design teams making use of programmable settings?

- **Most AMI models both SerDes & repeaters expose a good portion of the silicon capabilities such as TX taps, amplitude, external jitter control, RX blocks such as VGA, CTLE taps, DFE taps, etc.**
- **Users can change all SerDes parameters or disable functional blocks in the study of their systems.**
- **AMI provides a way to change settings of mentioned parameters to explore how different functional blocks affect the channel performance**
  - for example is a VGA block needed for a given channel or should it be disabled,
  - or how does increasing pre cursor affect the eye.

Question 4

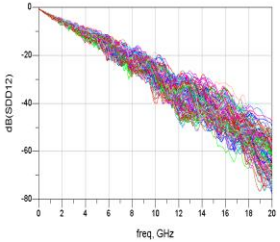
AMI Models allow us to explore SerDes equalization setting options. Are design teams making use of these programmable settings?

Tell us about how/when adapting settings saved the day, in your experience.

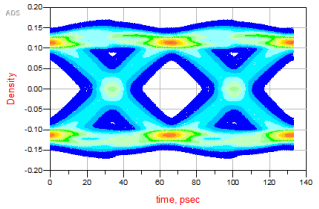
Adapting Equalization Settings

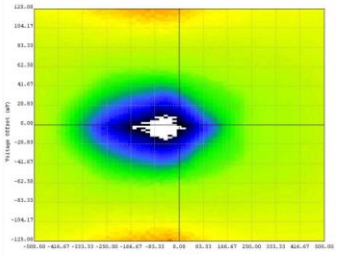
- **Our users explore combinations of EQ settings**
  - It probably helps that QCD is set up to facilitate that
- **Our customers use that information to drive system configuration**
  - Some can drive that information into system firmware automatically
- **The trick is maintaining the right perspective**
  - Are 50,000 simulations **really** better than 500?
  - How do you **know** you can trust the simulation results?

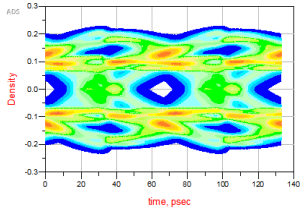
The Settings Conundrum



TX1:TX	RX1:peaking_filter.mode	npt75: Margin:Long_Channel_EyeMask (V)	HR02: Margin:Long_Channel_EyeMask (V)	Diff (%)	npt75: Margin:Long_Channel_EyeMask (UI)	HR02: Margin:Long_Channel_EyeMask (UI)	Diff (%)	CORNER
0	off	0.0852	0.0719	-16	0.224	0.209	-7	TTTE
1	off	0.0519	0.0422	-19	0.213	0.15	-30	TTTE
2	off	0.0287	0.0163	-43	0.209	0.185	-11	TTTE
0	fixed	0.13	0.129	-1	0.172	0.179	4	TTTE
1	fixed	0.039	0.0448	15	0.058	0.0619	7	TTTE
2	fixed	0.0142	0.0146	3	0.0169	0.0188	11	TTTE
0	off	0.0746	0.0574	-23	0.215	0.191	-11	SSSE
1	off	0.0393	0.0326	-17	0.134	0.154	15	SSSE
2	off	0.0127	0.00918	-28	0.16	0.175	9	SSSE
0	fixed	0.125	0.125	0	0.175	0.185	6	SSSE
1	fixed	0.0366	0.0364	-1	0.058	0.058	0	SSSE
2	fixed	0.0118	0.0132	12	0.0188	0.0169	-10	SSSE
0	off	0.088	0.0801	-18	0.224	0.215	-4	FFFE
1	off	0.0386	0.0545	-9	0.217	0.218	0	FFFE
2	off	0.0363	0.0297	-18	0.175	0.183	5	FFFE
0	fixed	0.142	0.136	-4	0.173	0.177	2	FFFE
1	fixed	0.0512	0.0467	-9	0.0658	0.0639	-3	FFFE
2	fixed	0.0138	0.0179	-10	0.0286	0.0247	-14	FFFE







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Question 5

What AMI tips and secrets do you want to share?

3 min, Westerhoff

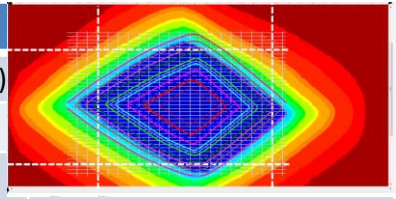
Effective AMI - Tips and Tricks

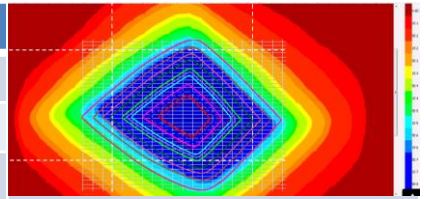
- **Start small and add complexity incrementally**
  - One small step at a time takes you a lot farther than you might think
- **Understand how your simulator is modeling your channel**
  - If the impulse response is off, everything else goes downhill with it
  - S-parameter files have portability issues, too
- **Learn how to test AMI models in your environment**
- **Learn how to “unwind” simulation results in your environment**
  - If the eye is closed – why, and what can you do about it?

AMI tips and secrets

- Focus on Lab to Simulation Correlation

	No Crosstalk		With Crosstalk /Phase Sweep	
	Eye Width (pS)	Eye Height (mV)	Eye Width (pS)	Eye Height (mV)
Lab Eye Scan	20.8	143	19.4	132
AMI Simulation	21.6	142	20.5-21.1	128-140

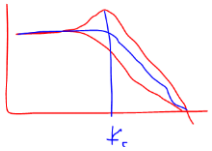


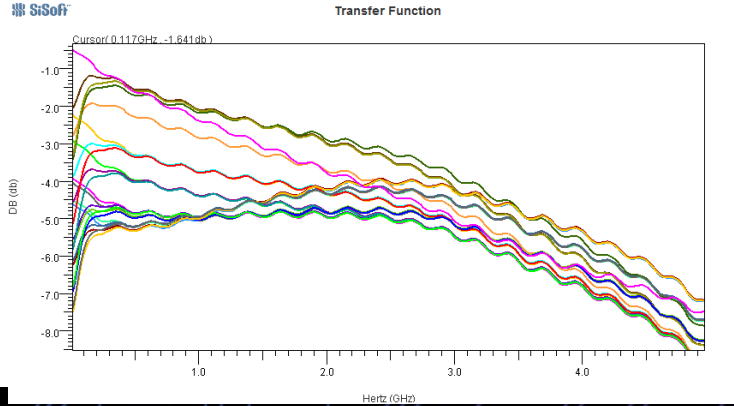


Courtesy of Brandon Jiao/Howard Ireland Xilinx

- AMI vs Lab algorithms don't always match,
  - Harvest Settings, Lab (RX Auto) - > Simulation, Vendor adaptation algorithms

- Match RX/TX CTLE to system Loss





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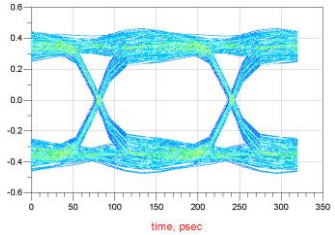
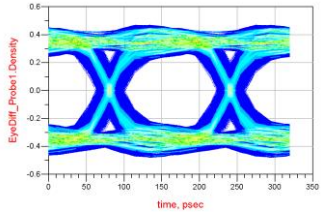
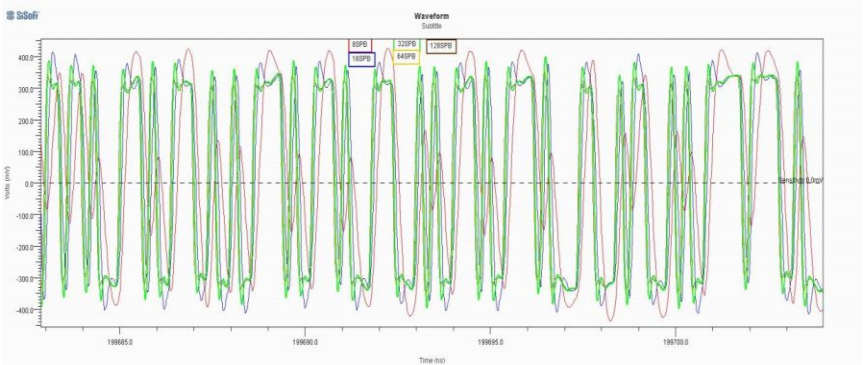
AMI tips and secrets

- Don’t forget the Jitter Tx_Dj, Tx_Rj, Rx_Dj and Rx_Rj, Rx_Noise?





- Sampling VS Simulation time and compatibility issues



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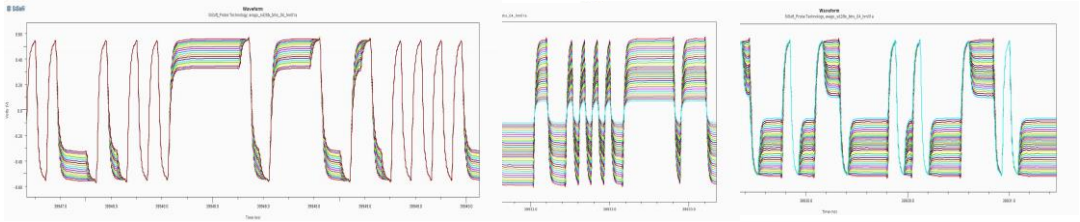
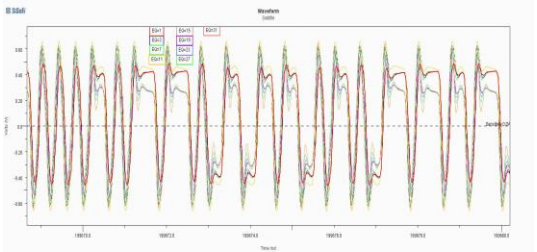
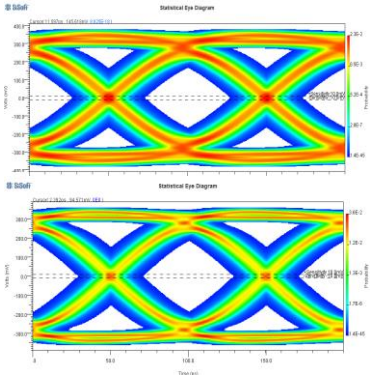
AMI tips and secrets

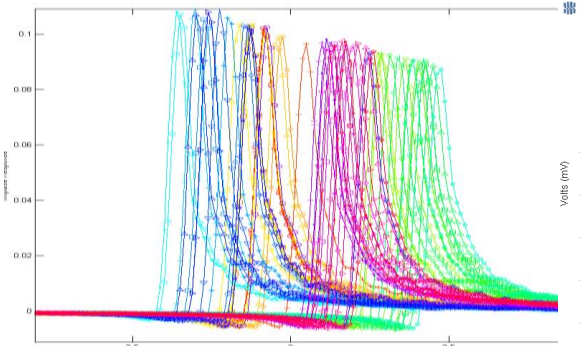
- Leverage the IBIS-AMI model to validate the analog model.

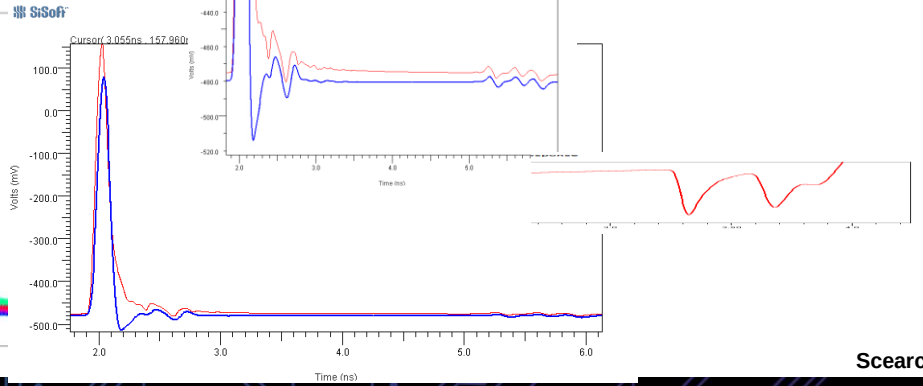




- Focus on the Pulse response







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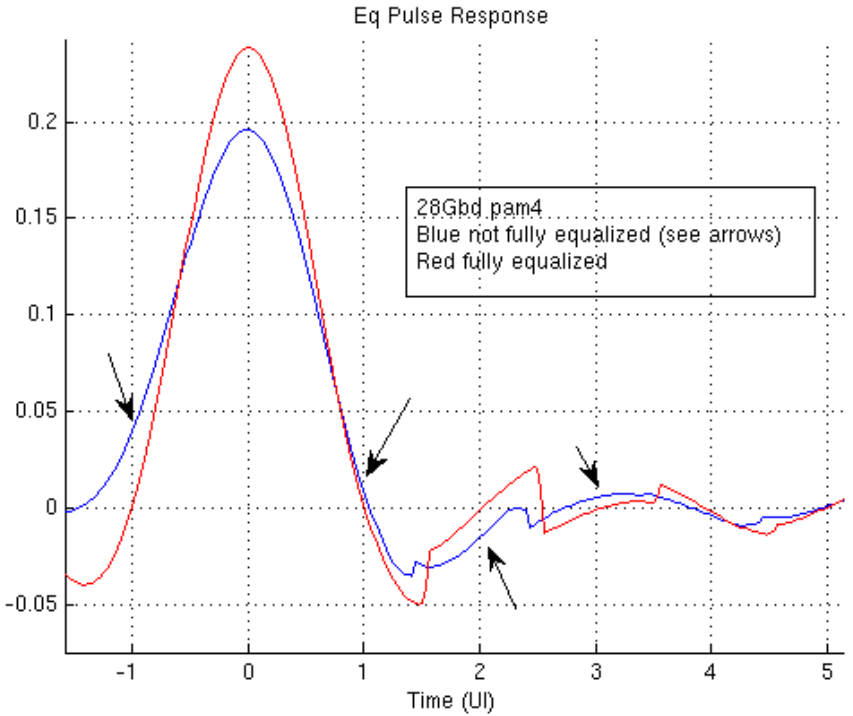
Tips for AMI Simulation

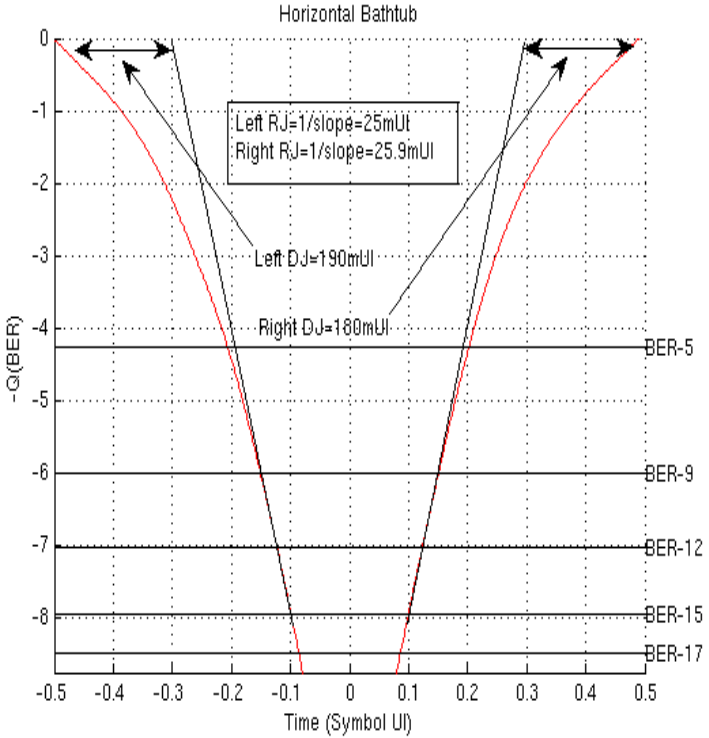
- **Use the pulse or impulse response**

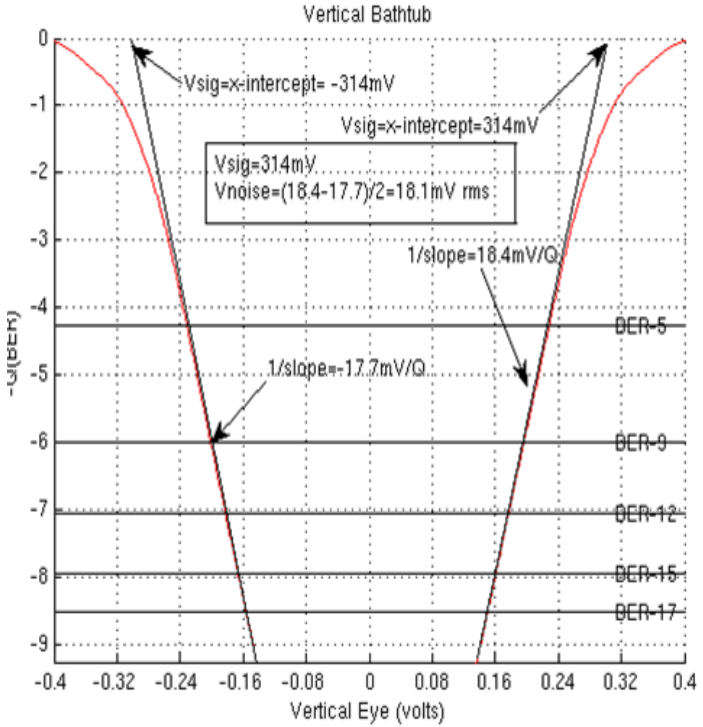


Elsheimer

Tips for AMI Simulation

- **Use the Hbath and Vbath to determine amounts of DJ, RJ, ISI, noise**
- **Use Vbath before and after Xtalk to determine ICN**





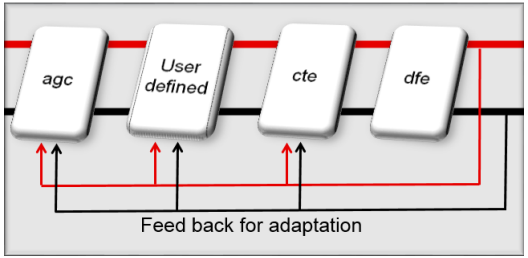
Elsheimer

What AMI tips and tricks can be shared?

For model users:

- **Examine ramp/impulse response for your channel before running channel simulations with AMI models**
- **Run IBIS golden parser on all incoming models**
- **Read the documentation before you start simulating**
- **Understand what platform your AMI models are compiled for**
  - Ex. 64 bit AMI model will not run on 32 bit channel simulator, and vice versa
- **Understand the difference between statistical and time domain channel simulation, and determine which capability (or capabilities) you have**
- **Run a test simulation on a simple channel to observe cause / effect (i.e. smoke test)**
- **Understand if the model contains corners**

What AMI tips and tricks can be shared?



For model developers:

- **Run IBIS golden parser on all outgoing models**
- **Provide documentation of the settings for the user**
- **Don't distribute models with external DLL dependencies**
- **Don't burden users with specific samples/bit settings**
- **Build in model adaptation that mimics hardware behavior**
  - Understand adaptation in the context of overall architecture
  - Ex. CTLE adjust 3 times, it triggers an AGC increment
- **Provide graphical output to let user visualize adaptation**
  - And adjust Ignore_Bits intelligently!
- **Output EQ settings that are convenient for lab use with hardware**

Willis

Tips for AMI Simulation

- **I do not have any AMI secrets, my secret is using all resources available to me to get better and more accurate results faster.**
- **Develop a close working relationship with your simulator and chip vendors and engage them regarding issues you face,**
  - they have the firsthand knowledge about inner workings of the simulator, model and how it correlates to silicon, it can have tremendous impact on the results.
- **For faster time to results during early simulations runs using statistical instead of time domain analysis will save time and allows more exploration.**
- **For more accurate results, it is important to set the samples per bit, max frequency input & output, time domain analysis.**
- **For lossy channels use larger post and pre cursors along with more emphasis.**
- **For channels with more return loss, use less TX equalization and allow for more RX side equalization.**

Mokhtarzad

Question 5

What AMI tips and secrets do you want to share?

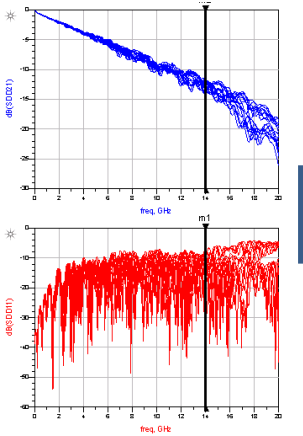
AUDIENCE QUESTIONS

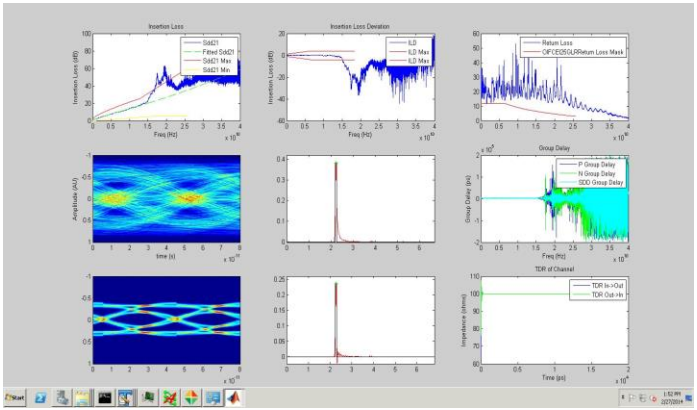
Question

How can AMI analysis be useful if/when models are not available?

Its all about the Serdes capability

- Generic model or similar that facilitate analysis against standard interfaces.
- Lab measurements should form the basis for all your efforts, leverage your engineering judgement when making decisions.
- Internal Matlab tools that leverage AMI and generic compensation





Netname	Frequency	Sdd21 @ Freq	Sdd11 @ Freq	Scc21 @ Freq	Scc11 @ Freq	ILD @ Freq	Max ILD	Max ILD Freq	Ave ILD	SD ILD	SNR
GRANDE_09092010_THRU_TP5_1	3.75	-7.082014	-20.285563	-11.382404	-9.699422	-1.312626	1.312626	3750000000	0.83723	1.0701	1.12
GRANDE_09092010_THRU_TP5_10	3.75	-7.656269	-35.548136	-32.4883	-11.996637	0.972723	0.972723	3750000000	0.92276	0.2866	1.093
GRANDE_09092010_THRU_TP5_100	3.75	-9.957296	-10.029956	-14.489998	-8.390563	0.122554	0.902685	3428000000	0.64775	0.3258	0.909
GRANDE_09092010_THRU_TP5_101	3.75	-8.660137	-10.300452	-12.364725	-8.984413	-0.186531	1.139537	6300000000	0.81243	0.9876	1.105
GRANDE_09092010_THRU_TP5_102	3.75	-8.734192	-12.332593	-13.262353	-10.839432	0.615439	0.865188	3354000000	0.84938	1.0968	0.958
GRANDE_09092010_THRU_TP5_103	3.75	-8.974707	-11.594945	-13.126685	-9.345485	-0.444431	1.189554	6360000000	0.77379	0.9859	1.066
GRANDE_09092010_THRU_TP5_104	3.75	-8.361187	-15.875173	-12.466514	-11.411758	0.934961	0.98036	3702000000	0.64944	0.8447	0.977
GRANDE_09092010_THRU_TP5_105	3.75	-10.55378	-10.566801	-15.089283	-8.254951	-0.187623	0.613504	3480000000	0.68647	0.9393	0.893
GRANDE_09092010_THRU_TP5_106	3.75	-8.777111	-24.128972	-13.77267	-10.872052	-1.342075	1.342075	3750000000	0.90321	1.1058	0.929
GRANDE_09092010_THRU_TP5_107	3.75	-8.7516	-13.912546	-12.860269	-10.224785	0.138054	0.845202	5400000000	0.71836	0.9081	0.958
GRANDE_09092010_THRU_TP5_108	3.75	-8.669196	-13.971253	-11.745257	-11.472485	0.480498	0.722926	5760000000	0.55023	0.6778	1.027
GRANDE_09092010_THRU_TP5_109	3.75	-8.67208	-11.655131	-12.073485	-8.375121	-0.425066	0.743264	3416000000	0.69436	0.979	1.102
GRANDE_09092010_THRU_TP5_11	3.75	-7.492703	-22.28545	-12.604185	-9.581621	1.329457	1.329457	3750000000	1.12553	1.5726	1.095
GRANDE_09092010_THRU_TP5_110	3.75	-8.249678	-15.430276	-13.070512	-10.866635	1.2644	1.2644	3750000000	0.93636	1.2992	0.973
GRANDE_09092010_THRU_TP5_111	3.75	-8.692852	-9.827532	-12.471568	-8.681946	-0.292215	1.063955	6360000000	0.84396	1.1311	1.009
GRANDE_09092010_THRU_TP5_112	3.75	-8.830253	-10.869679	-13.351415	-9.607619	0.444035	1.024995	3384000000	0.77465	1.0579	0.977
GRANDE_09092010_THRU_TP5_113	3.75	-10.562237	-9.394818	-14.955747	-8.931535	-0.565391	1.103353	5470000000	0.86579	1.08	0.899
GRANDE_09092010_THRU_TP5_114	3.75	-9.488819	-13.895272	-14.091602	-10.243788	0.535405	0.91124	5518000000	0.82363	1.0443	0.921
GRANDE_09092010_THRU_TP5_115	3.75	-10.995212	-10.912662	-16.254038	-9.611179	-0.486976	0.929491	1482000000	0.79869	1.0104	0.861
GRANDE_09092010_THRU_TP5_116	3.75	-9.217321	-14.278639	-13.175158	-10.077611	0.768077	0.886023	3666000000	0.7652	1.0107	0.929
GRANDE_09092010_THRU_TP5_117	3.75	-9.115599	-10.396504	-12.540889	-9.880857	-0.235802	1.036659	1296000000	0.84403	1.0348	1.065
GRANDE_09092010_THRU_TP5_118	3.75	-8.95733	-12.918155	-13.161972	-12.252537	0.701035	0.933585	3234000000	0.81403	1.0799	0.933
GRANDE_09092010_THRU_TP5_119	3.75	-9.00972	-10.396445	-13.243117	-10.207093	-0.180346	1.012537	4260000000	0.88367	1.1049	1.069
GRANDE_09092010_THRU_TP5_12	3.75	-8.032266	-17.890862	-11.658022	-9.891868	0.987473	0.987473	3750000000	1.09861	1.4307	1.052
GRANDE_09092010_THRU_TP5_120	3.75	-8.786414	-11.295394	-12.838324	-10.819023	0.559219	1.03408	3306000000	0.81868	1.0614	0.948
GRANDE_09092010_THRU_TP5_121	3.75	-10.762679	-12.398257	-14.365451	-9.540229	-0.512723	0.803842	3540000000	0.75121	1.0512	0.867

How can AMI Analysis be useful if/when models are not available?

Scearce

What do you do if AMI models aren't available?

- **In the absence of a particular model I try to find a similar device that I have model for, and use it instead.**
- **To improve the results, I spend some time in the lab and compare the two devices to have a feel for how similar they are and in particular find the major difference between them.**
  - Then use that to de-rate my results.

What do you do if AMI models aren't available?

- **Push back on your IP supplier!**
- **Use template models in the tools**
  - Most have built-in AMI models that can give you significant insight
- **Build your own!**
  - If you know something about the equalization (ex. how many FFE taps, how many pre-cursor taps), and have some time or frequency domain plots for CTLE, etc. you can build your own fairly detailed model in a couple of minutes
  - Probably will not exactly match your hardware in a couple minutes of effort, but can get close to the top-level behavior very quickly, including adaptation

Question

How can design teams succeed in getting AMI results to affect product design?

What barriers are there?

How can design teams leverage AMI results in product design?

- **System Engineers:**
  - Use for up-front feasibility and component selection; figure out what EQ you need
  - Can use template models or your own experimental models to figure out what types of EQ are needed to drive the types of interconnect channels you are proposing
  - Post-layout, determine compliance vs. standard, and margins
    - Do I need to go improve something, ex. diff pair matching or via array design
  - Post-layout, can figure out what settings to use for your hardware
- **IP Designers:**
  - Use for up-front feasibility, spec design, and algorithm experiments
  - ***Can sometimes find potential design problems before you commit to silicon***

How can design teams succeed in getting AMI results to affect product design? What barriers are there?

- Partner with the architects to leverage AMI for upfront analysis to set design targets, establish realistic budgets for the system design.
- Document and verify the Software implementation for settings!
- Leverage process to verify settings used on every channel for every SW platform
- Text output from AMI for register settings.

Scearce

How can design teams leverage AMI results in product design?

- **Design teams benefit by reducing possibility of a flaw in the design before fabrication and save time any money in the process.**
- **The main issue is model quality, and performance criteria from silicon vendor.**
  - Such data is available but not provided by default.

Thank you!