Best Practices for Developing IBIS-AMI Models

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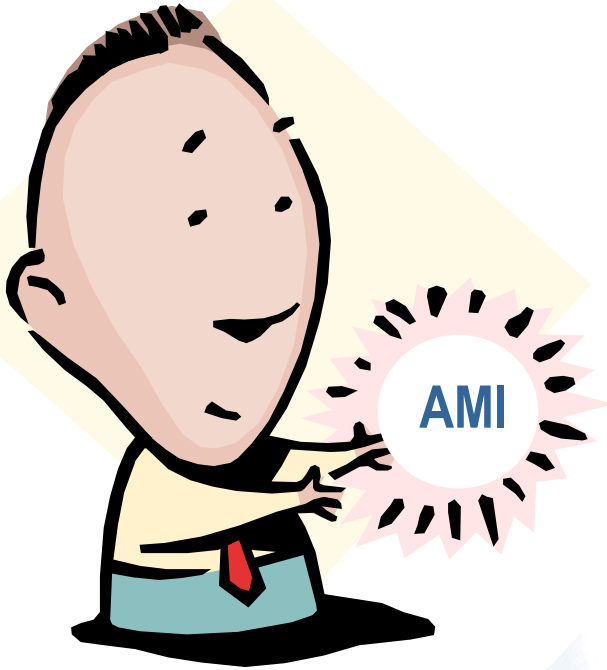
The Promise of IBIS-AMI

Goal: open modeling standard for SerDes PHYs

- **Interoperability:** different vendor models work together
- **Portability:** one model runs in multiple simulators
- **Flexibility:** support both Statistical and Time-Domain simulation
- **Performance:** comparable to semiconductor vendor simulators
- **Accuracy:** comparable to semiconductor vendor simulators
- **IP Protection:** accurate models without exposing device details



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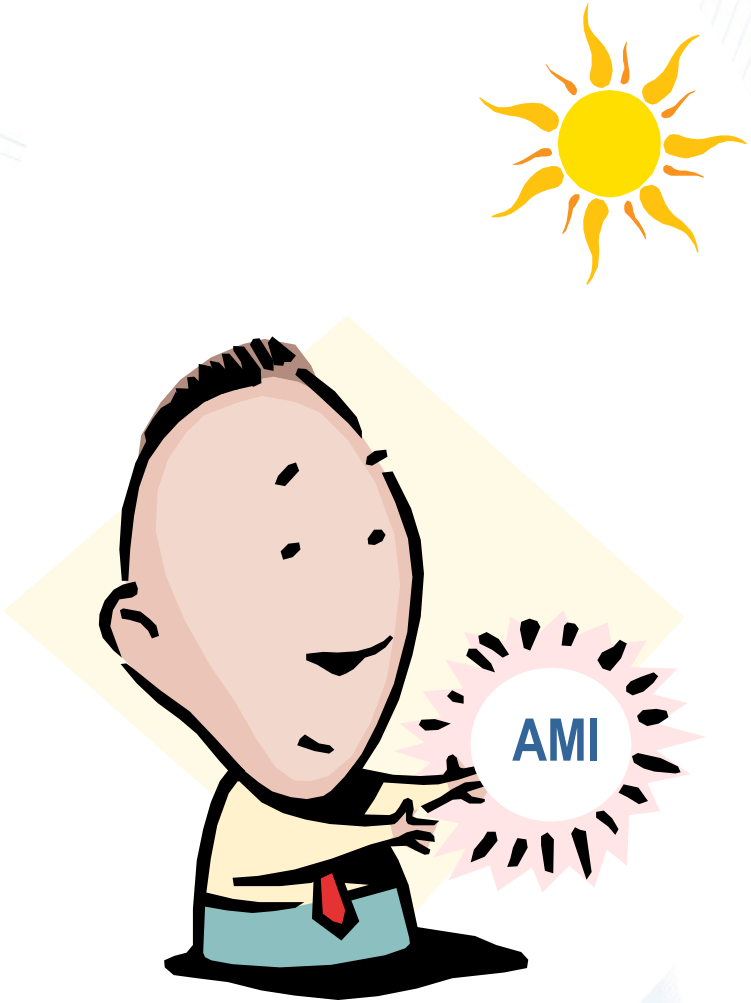
IBIS-AMI Successes

- Models delivered by multiple semiconductor vendors
- Model interoperability established
- Correlation demonstrated
- AMI support available from multiple EDA vendors
- High level of Algorithmic Model (.DLL) portability



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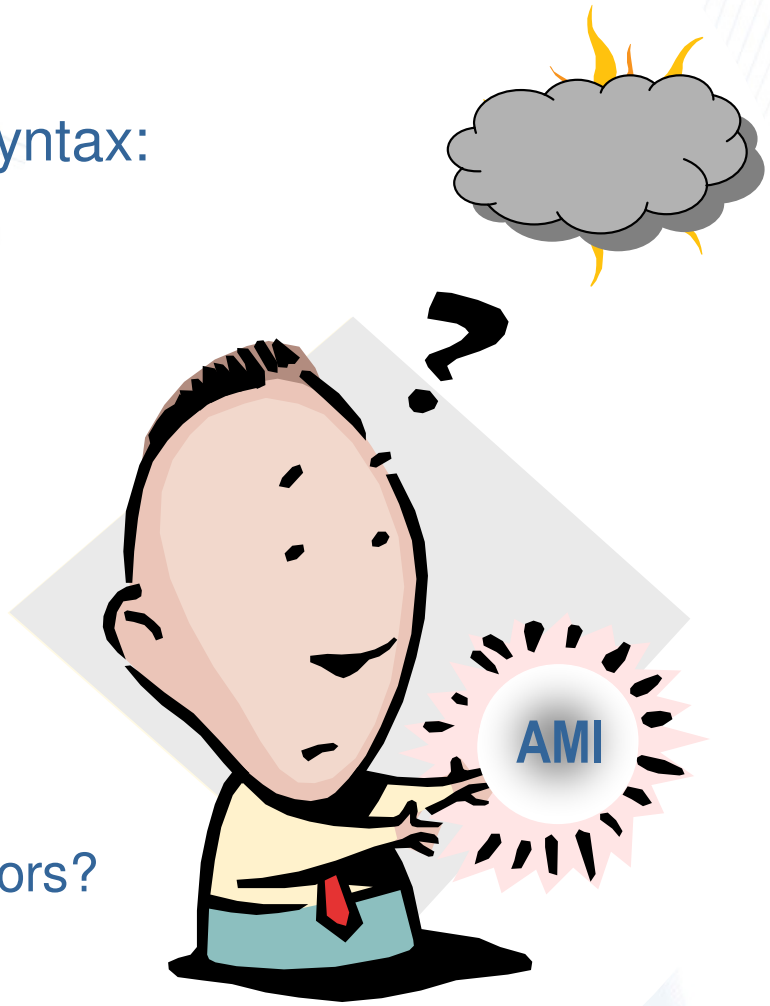
Challenges with IBIS-AMI

- Models released with non-standard syntax:
  - Missing / incomplete analog models
  - S-parameter analog models
  - Non-standard jitter syntax
- EDA-specific syntax
  - |SiSoft, Cadence DML, others
- Differing syntax causes confusion
  - Are models IBIS 5.0 compliant?
  - Are models portable between simulators?
  - Are models accurate?



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Was This Really Necessary?

YES

- Advanced features are needed NOW to ensure accurate simulation
- EDA vendors needed to support these capabilities **somehow**
- In the absence of a standardized approach, each vendor provided support as they saw fit

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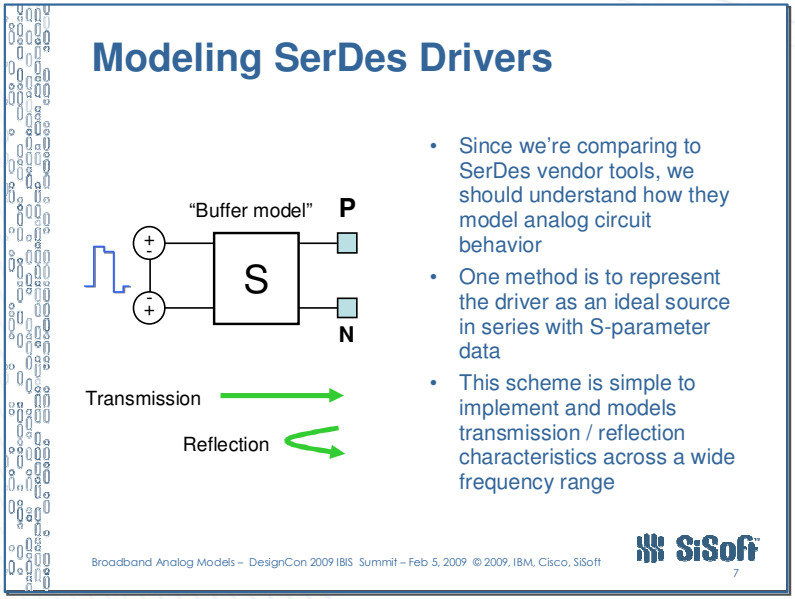
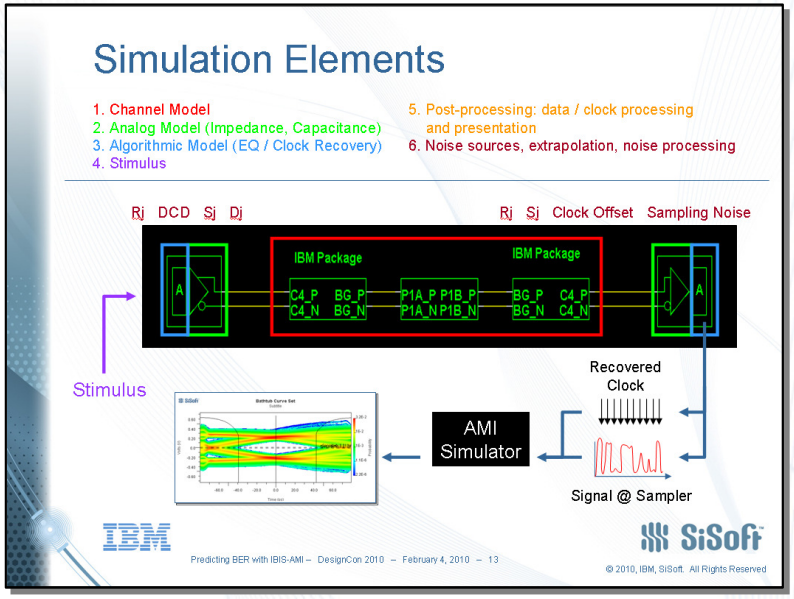
Advanced Feature Examples





- S-parameters for TX/RX analog models
- IBM / Cisco / SiSoft
- DesignCon 2009 IBIS Summit
- http://tinyurl.com/2bdxnj4

- Jitter budgets & correlation
- IBM / SiSoft
- DesignCon 2010
- DesignCon 2010 IBIS Summit
- http://tinyurl.com/2chg4ky

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Does It Have To Be This Way?

NO

EDA vendors NEED to be able to support advanced features quickly

… BUT …

There's no need for everyone to do it **differently**.

… wasn't "everyone is doing the same thing a little bit differently" one of the drivers behind IBIS-AMI in the first place?

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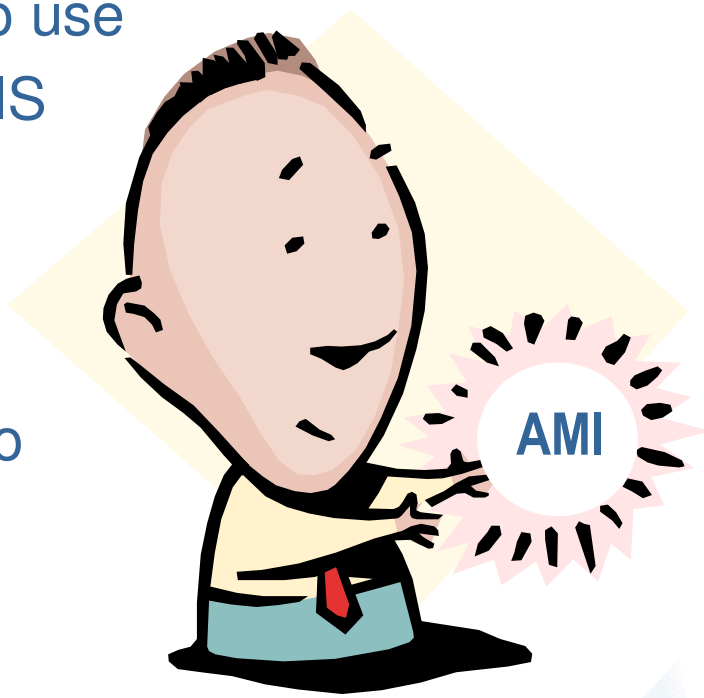
How Can We Reduce Confusion?

- It's simple:
  - Clearly document advanced features
  - Publish a document for everyone to use
  - Make the document available to IBIS for the standards process
- Bottom line:
  - If we have to use IBIS extensions to improve accuracy, at least we can all use the **SAME** IBIS extensions



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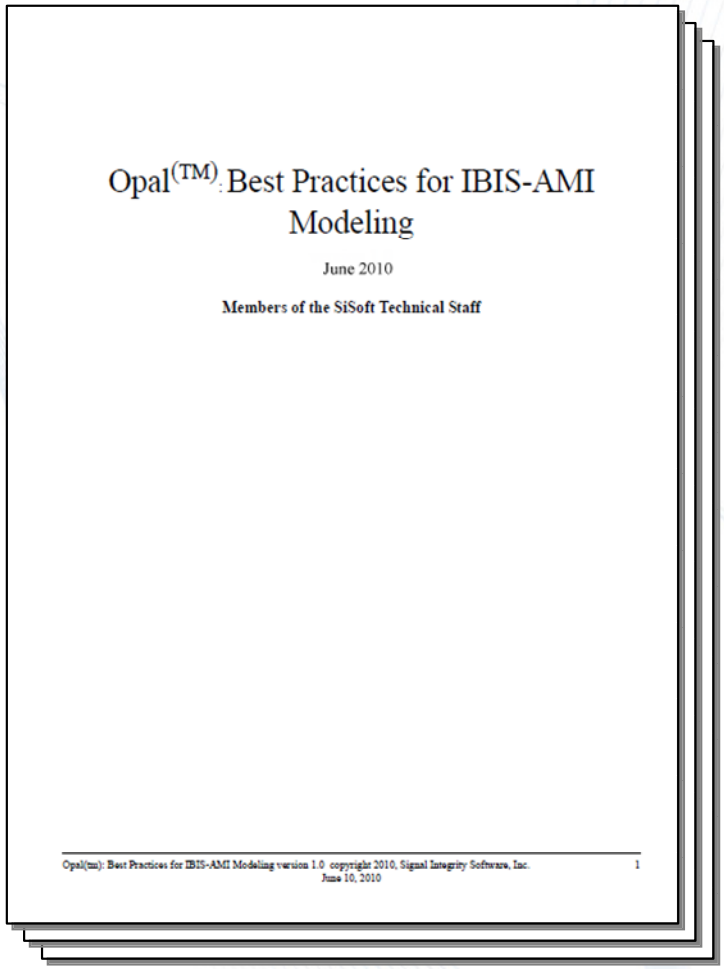
Introducing Opal™

- Resource guide for developing, debugging & validating IBIS-AMI models
- Best Practices
  - Determining AMI compliance
  - Simulation mode support
  - Parallel simulation support
  - …
- Opal AMI Parameters
  - Broadband analog models
  - Jitter budgeting
  - …
- Submitted to IBIS for consideration



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Best Practice Guidelines

Table of Requirements

☐ R2.1_A	All files distributed in a single archive
☐ R2.1_F	Model installation directory independent of execution directory
☐ R2.2.1_A	Support Windows and Linux
☐ R2.2.2_A	Multiple instances of one model in one simulation/analysis
☐ R2.2.2_B	Multiple instance of multiple models in one simulation/analysis
☐ R2.2.2_C	Multiple simultaneous simulations/analyses
☐ R2.4_A	Report model performance
☐ R2.5_A	Complete parameter declaration
☐ R2.5_B	Consistent parameter default value
☐ R2.5_C	Useful parameter description
☐ R2.5_D	Parameter names in model same as model names in .ami file
☐ R2.5_E	Unrecognized parameters do not cause failure
☐ R2.5_L	Comment Label declaration
☐ R2.5_M	Label array same length as List array
☐ R2.7_A	Model correlated to another behavior description
☐ R2.7_B	Correlation conditions defined
☐ R2.7_C	Correlation method defined
☐ R2.7_D	Correlation criteria defined
☐ R2.8_A	Minimum documentation requirements
☐ R3.0_A	All parameters in dependency table declared before table
☐ R3.0_E	Column header and all rows in dependency table have same length
☐ R3.0_F	Dependency row value type convertible to all column types
☐ R4.0_A	Fully IBIS compliant analog model available
☐ R4.2_B	S parameter file ports and organization
☐ R4.2_F	Node map consistent with S parameter file

Table of Recommendations

☐ r2.1_B	Files installed in same directory or in a subdirectory of same
☐ r2.1_C	Allowable characters in file name
☐ r2.1_E	Use Supporting_files when appropriate
☐ r2.1_G	Don't use environment variables
☐ r2.2.1_B	Support both 32 bit and 64 bit x86 architectures
☐ r2.2.3_A	Don't write to side files
☐ r2.2.3_B	Don't write to console
☐ r2.2.3_C	Don't generate graphic display
☐ r2.3_A	AMI_Init() produces impulse response for statistical analysis
☐ r2.3_B	AMI_GetWave() produces complete time domain response
☐ r2.3_C	Support any number of samples per bit >= 8
☐ r2.3_E	Support Samples_Per_Bit parameter if necessary
☐ r2.4_B	Model execution time ratio < 10
☐ r2.5_F	Acceptable characters in parameter names
☐ r2.5_G	Output parameters for all time varying state information
☐ r2.5_H	Put Opal™ parameters on Model_Specific branch
☐ r2.5_J	Use DllPath if appropriate
☐ r2.6_A	AMI_Init() msg states result of model configuration
☐ r2.6_B	Detect and report invalid parameter values
☐ r2.6_C	Standard format for Info, Warning and Error messages
☐ r2.6_D	AMI_Init() AMI_parameters_out echoes configuration
☐ r2.6_E	AMI_GetWave() AMI_parameters_out reports control loop outputs
☐ r2.6_F	AMI_GetWave() AMI_parameters_out only contains time varying parameters
☐ r2.8_B	List supporting files in documentation
☐ r2.8_C	Describe environmental dependencies
☐ r2.8_D	Opal™ compliance statement
☐ r2.8_E	Explain analog models
☐ r4.0_B	One model version makes best use of available data

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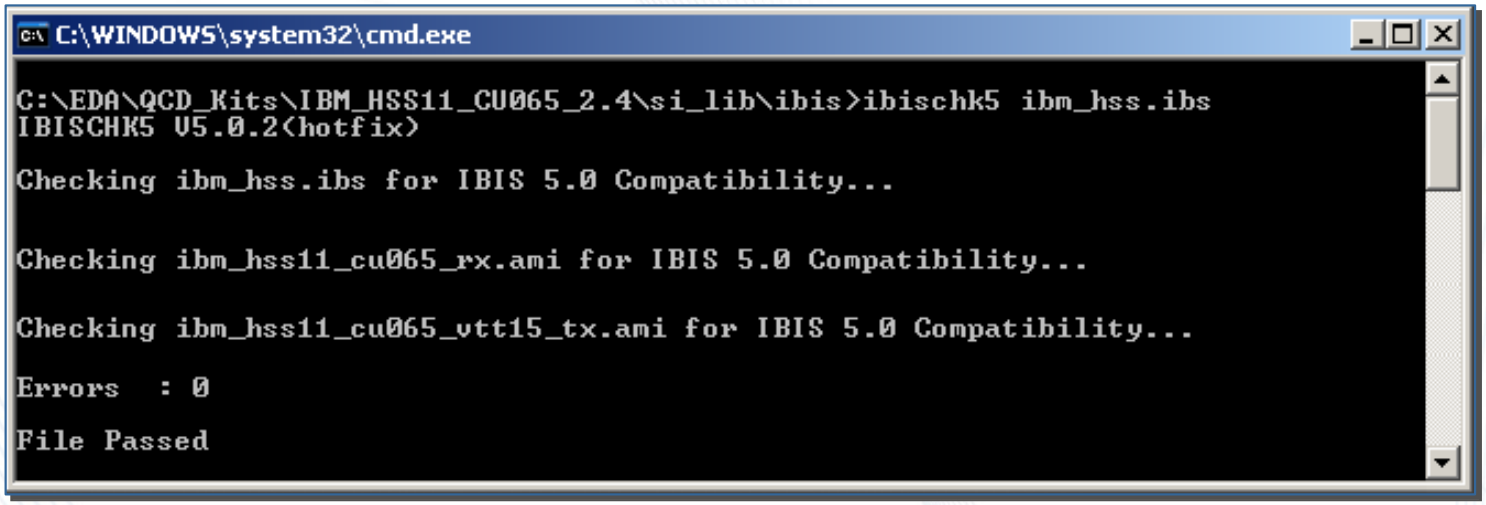
Opal Models are IBIS 5.0 Compliant



- Opal requires IBIS-AMI models conform to IBIS 5.0 syntax and make best use of IBIS 5.0 features
- Opal AMI Parameters use IBIS 5.0 syntax and pass the IBIS 5.0 parser without Errors or Warnings
- Opal models are **portable** between different EDA tools that support IBIS 5.0

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Opal AMI Parameters

- Extend IBIS 5.0 to improve accuracy / features while maintaining full IBIS 5.0 compliance:

```
(Rx_Rj (Usage Info)(Type UI)
       (Corner 0.006 0.007 0.005)
       (Description "RX Random Jitter in UI.")
)
```

- Openly published so that all semiconductor & EDA vendors can use the same syntax
- Can be promoted to IBIS “Reserved Parameters” & included in updates to the standard

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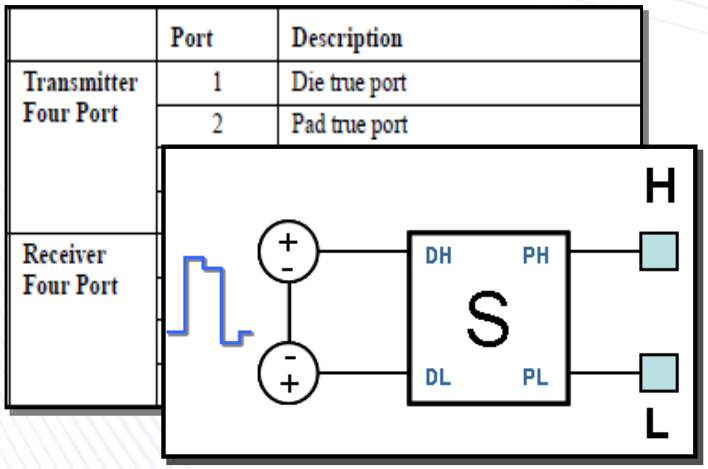
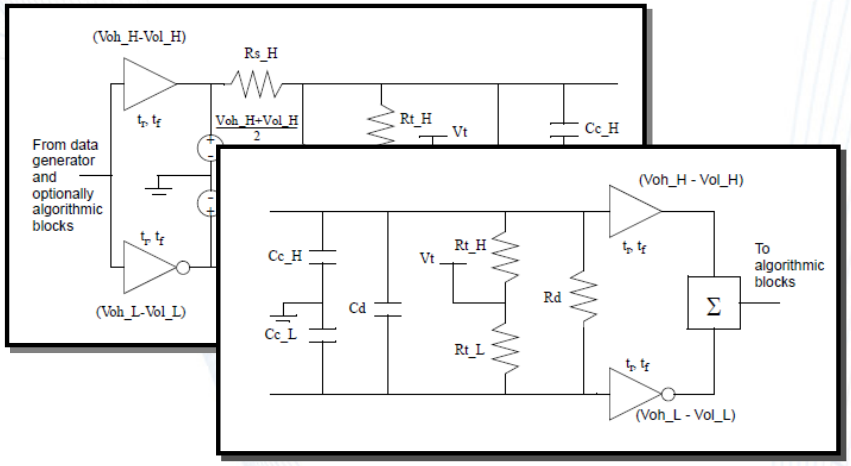
Opal AMI Parameters - Examples





Using S-parameters to model TX analog output, RX termination network

Specifying equivalent circuit models for TX analog output, RX termination network

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Opal AMI Parameters - Examples

```
(VolRsSelector (Dependency
   (Parameter (List "Corner In" "tx_swing In" "Voh PWL" "Rs PWL") (Usage Info)(Type String)
              (Description "Dependency Table for Voh and Rs vs Corner and Strength."))
   (Row (List Typ   .3 0.3 51)(Usage Info)(Type String) )
   (Row (List Typ   .8 0.8 50)(Usage Info)(Type String) )
   (Row (List Typ  1.1 1.1 49)(Usage Info)(Type String) )
   (Row (List Slow  .3 0.2 55)(Usage Info)(Type String) )
   (Row (List Slow  .8 0.7 54)(Usage Info)(Type String) )
   (Row (List Slow 1.1 1.0 53)(Usage Info)(Type String) )
   (Row (List Fast  .3 0.4 45)(Usage Info)(Type String) )
   (Row (List Fast  .8 0.9 44)(Usage Info)(Type String) )
   (Row (List Fast 1.1 1.2 43)(Usage Info)(Type String) )
) |Dependency
) |VohRsSelector
```

```
| TX Jitter budgets
      (Tx_Dj (Usage Info)(Corner 0.0 0.0 0.0)(Type Float)(Default 0.0)
         (Description "TX Deterministic Jitter, expressed in UI."))
      (Tx_DCD (Usage Info)(Corner 0.008 0.010 0.005)(Type Float)(Default 0.008)
         (Description "TX Duty Cycle Distortion, expressed in UI."))
      (Tx_Rj (Usage Info)(Corner 0.006 0.007 0.005)(Type Float)(Default 0.006)
         (Description "TX Random Jitter, expressed in UI."))
      (Tx_Sj (Usage Info)(Corner 0.030 0.030 0.020)(Type Float)(Default 0.030)
         (Description "TX Sinusoidal Jitter, expressed in UI."))
      (Tx_Sj_Frequency (Usage Info)(Corner 50E6 50E6 50E6)(Type Float)(Default 50E6)
         (Description "TX Sinusoidal Jitter Grequency, expressed in Hz."))
```

Dependency tables: using a single user control to adjust multiple model parameters

Specifying TX/RX jitter and noise budgets for Statistical and Time-Domain simulation

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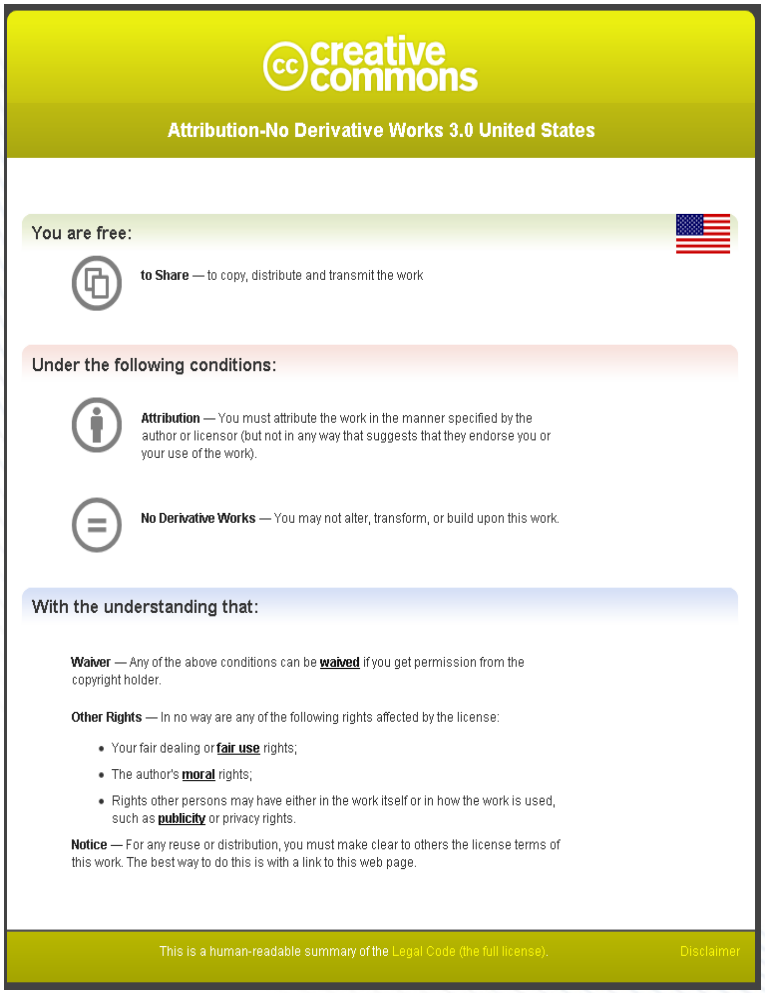
Opal Licensing



Without Permission

- Anyone may:
  - Redistribute the Opal document
  - Use Opal Best Practices to establish, assess and assert AMI model quality
  - Use Opal AMI Parameters in EDA tools and AMI models
- Anyone may not:
  - Modify the Opal document
  - Redefine Opal Best Practices and represent them as Opal
  - Create new Best Practices and represent them as Opal
  - Redefine Opal AMI Parameters and represent them as Opal
  - Create new AMI Parameters and represent them as Opal

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Opal FAQ's

- What is Opal?
  - Open, publicly available resource guide for IBIS-AMI
  - Best development practices & examples
  - Opal AMI Parameters to improve accuracy
- Why should I care?
  - Improves model quality & portability
  - Defines new features that improve accuracy
  - Document is available for **free**
- Does Opal supersede IBIS 5.0?
  - Absolutely **NOT**
  - Opal is **based** on IBIS 5.0
  - Opal **requires** best use of IBIS 5.0 syntax
  - Opal AMI Parameters improve accuracy where needed

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Opal FAQ's

- What does Opal stand for?
  - It isn't an acronym and doesn't stand for anything
  - Contributions to IBIS have used geological names (e.g. Touchstone®) & SiSoft is following that precedent
- Why does Opal need a Trademark / License policy?
  - Opal rigorously defines guidelines for IBIS-AMI model quality and functionality
  - Trademarking / Licensing Opal ensures that Opal models are consistent with user expectations
  - Creative Commons is an established licensing method (Wikipedia uses it)

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Opal FAQ's

- Will Opal models work with my EDA tool?
  - Opal models are IBIS 5.0 models; any EDA tool that supports IBIS 5.0 will run an Opal model
  - The Creative Commons license allows other EDA tools to support Opal AMI Parameters without requiring permission from SiSoft
- Does the IBIS Committee recommend Opal?
  - Opal is **based** on IBIS 5.0
  - Opal AMI Parameters are **compliant** with IBIS 5.0
  - Opal submitted to IBIS for consideration

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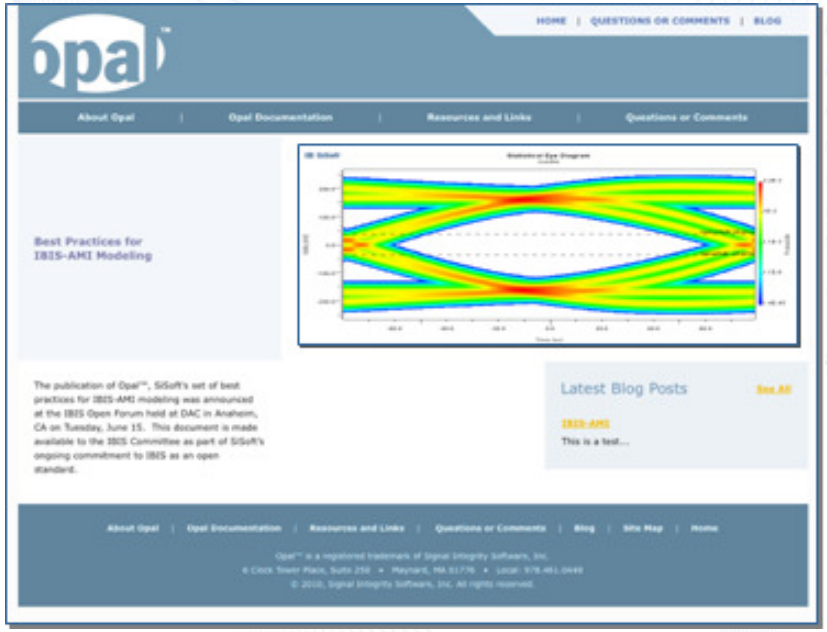
Opal FAQ's

- Where can I find more?
  - Opal website:
    opal-ami.com
    - Opal document
    - Opal Blog
    - Sample models
    - FAQ's



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Opal FAQ's

- Is Opal SiSoft proprietary?
  - **NO**
- Isn't this just a SiSoft ploy?
  - **NO:** Users need advanced features NOW, and each tool has been using different syntax. Something needed to be done.
  - **NO:** SiSoft is **committed** to open standards and IBIS. Opal has been submitted to IBIS for use as IBIS sees fit.
- Who controls Opal?
  - There's nothing to control. Opal is a set of guidelines that have been openly published & submitted to IBIS.

Opal FAQ's

- So …
  SiSoft does all this work and then publishes it for anyone to use, including other EDA companies?
  - **YES**

- Why?
  - Because proliferation of different EDA-specific syntax has caused confusion and slowed adoption of IBIS-AMI
  - Because SiSoft is **committed** to IBIS-AMI as an **open** standard, and Opal allows everyone to move forward **together**

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SiSoft Contributions to IBIS-AMI

- Terminology for Serial Link analysis
  - IBIS-ATM (Dec 2006), IBIS Summit @ DAC 2009
- Co-authored original specification
  - BIRD 104.1, Oct 2007
- First free IBIS-AMI toolkit
  - Test simulator / sample model & source code, Aug 2007
- Drove resolution of first portability issues
  - BIRD 107.2, April 2008
- Presented interoperability, performance, correlation results
  - DesignCon Conference & IBIS Summits 2007 – 2010
- Opal document
  - IBIS-ATM Working Archive, June 2010

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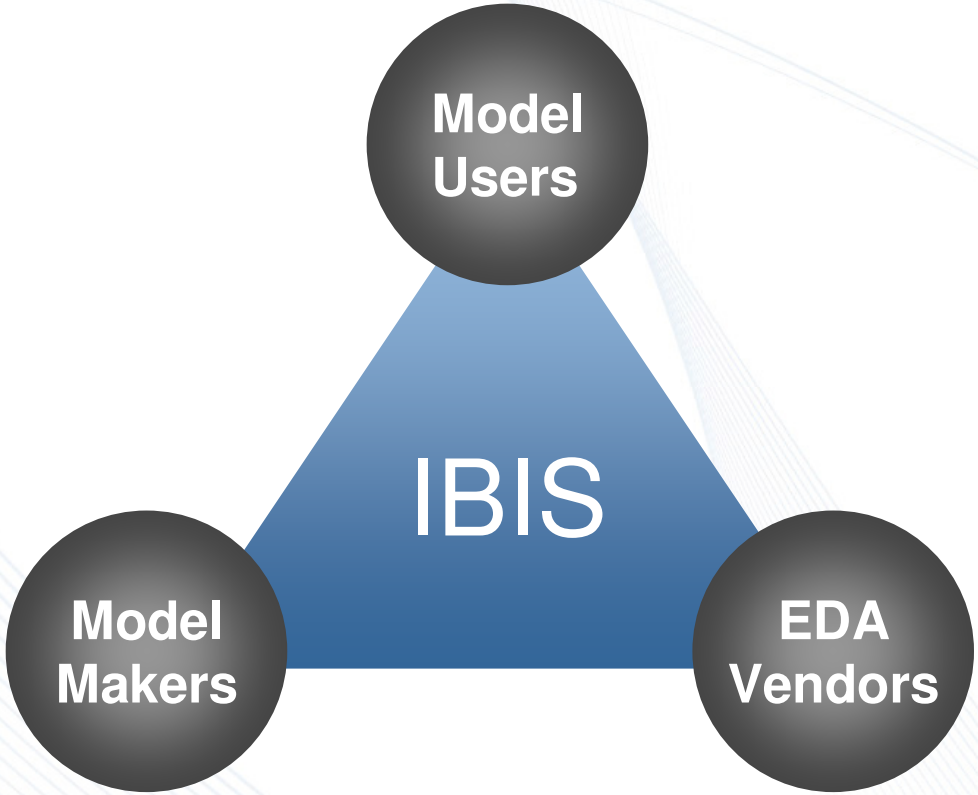
Opal Benefits

- Model Accuracy
- Model Availability



- Model Accuracy
- Single Model Support

- Simulation Accuracy
- Broad Model Support

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Next Steps

- Visit the Opal website and review the Opal document
- Check that models are IBIS 5.0 compliant and make use of Opal AMI Parameters
- Join the IBIS-ATM working group and the IBIS Open Forum
- Your feedback is welcome and appreciated!

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Thanks!

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