IBIS-AMI Flows

July 2010

SiSoft™
We Are Signal Integrity

Agenda

- Evolution of AMI flows
- AMI model capabilities and implications
- Current IBIS-AMI flow (SiSoft's view)
- The sticky bit
- Summary / next steps

* Note: Terminology used in the presentation is taken from Walter Katz's DAC 2009 IBIS Summit Presentation: http://www.eda.org/ibis/summits/jul09/katz1.pdf

How Did We Get Here?

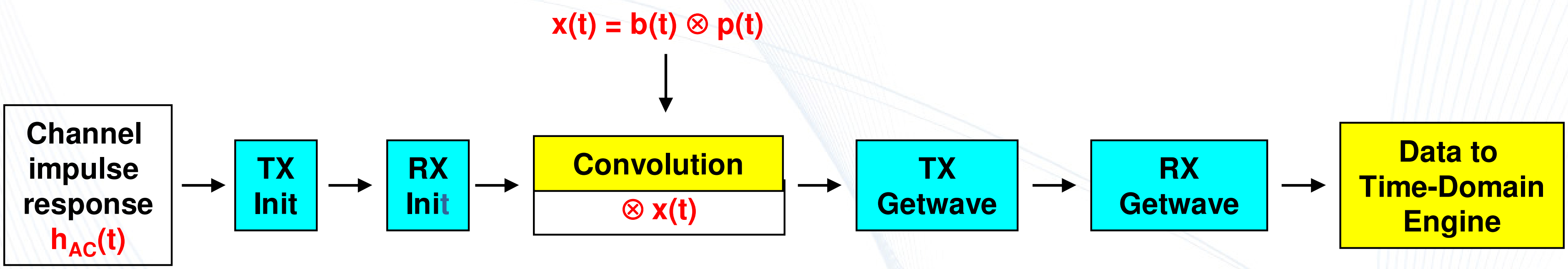
The common goal of all participants is to anticipate problems before they occur, take appropriate action to prevent those problems from occurring and act swiftly to correct existing problems.

… however …

when you are up to your waist in alligators, it is difficult to remember that the original objective was to drain the swamp.

SiSoft™
We Are Signal Integrity

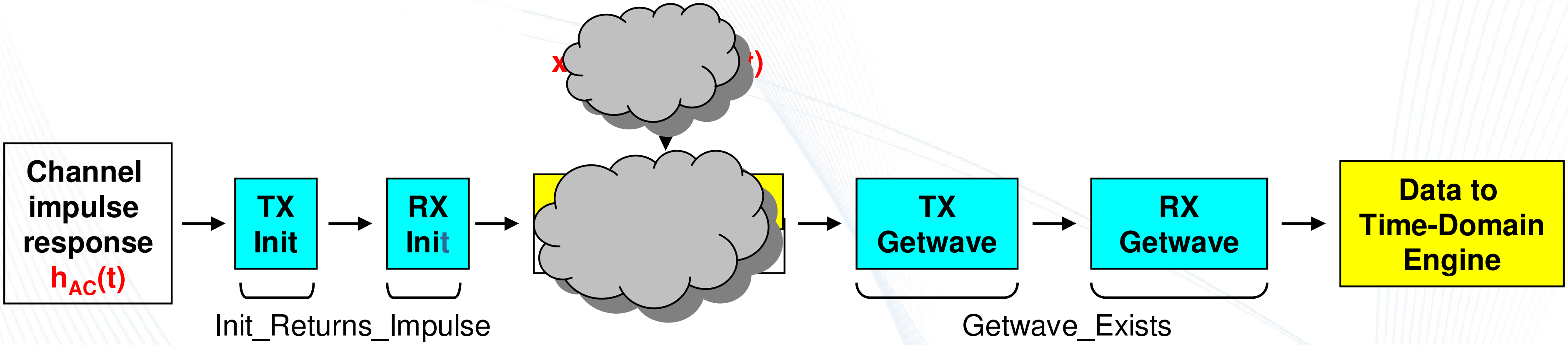
Algorithmic Model Flow (10/2006)



- Notes
  - Analysis flow is invariant
  - Time-Domain flow only, no discussion of Statistical analysis
  - Assumption of split Init/Getwave models is unstated
  - TX Getwave does not support non-LTI TX models
- Supports
  - Init-only models
  - Getwave-only models
  - Split Init/Getwave models
- Does not support
  - Dual Init/Getwave models (EQ is double counted)

We Are Signal Integrity

BIRD 104 (10/2007)

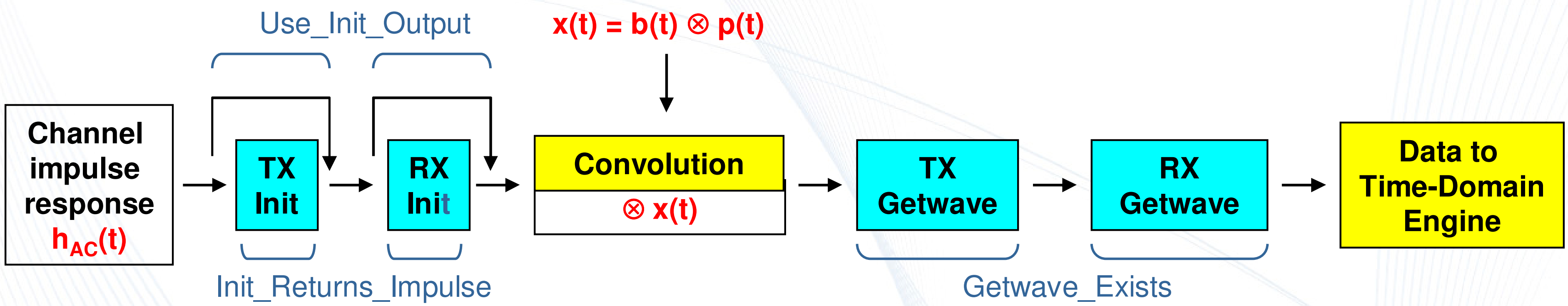


- Notes
  - .AMI file introduced with Model_Specific and Reserved_Parameters
  - Init_Returns_Impulse and Getwave_Exists declare the model's processing capabilities
  - Relationship between Init and Getwave was ambiguous
  - Input to TX_Getwave was ambiguous

- Supports / Does not support
  - As it turned out, poorly defined without BIRD 107

SiSoft We Are Signal Integrity

BIRD 107 (5/2008) / IBIS 5.0 (8/2008)



- Notes
  - Relationship between Init and Getwave clarified
    - Use_Init_Output allows both Split & Dual Init/Getwave models
  - Input to TX Getwave clarified (“analog” input)
    - Does not support non-LTI TX models
  - Reference flow introduced
    - Statistical simulation enabled, but not explicitly defined

- Supports
    - Init-only models
    - Getwave-only models
    - Split Init/Getwave models
    - Dual Init/Getwave models

We Are Signal Integrity

IBIS 5.0 AMI Model Capabilities

Getwave_Exists	Init_Returns_Impulse	Use_Init_Output	Model Type
False	False	False	Illegal
False	False	True	Illegal
False	True	False	Illegal
False	True	True	Init only
True	False	False	Getwave only
True	False	True	Illegal
True	True	False	Dual Init/Getwave
True	True	True	Split Init/Getwave

- TX & RX can each be one of 4 different types
- 4 TX * 4 RX = 16 different combinations

SiSoft
We Are Signal Integrity

Simplifying the Problem

Redundant if T/ T/ T
case is removed

Getwave_Exists	Init_Returns_Impulse	Use_Init_Output	Model Type
False	True	True	Init only
True	False	False	Getwave only
True	True	False	Dual Init/Getwave
True	True	True	Split Init/Getwave

No known models

True / True / True case doesn't exist in practice
and creates complication & confusion

SiSoft
We Are Signal Integrity

Simplified Model Logic

Getwave_Exists	Init_Returns_Impulse	Model Type
False	True	Init only
True	False	Getwave only
True	True	Dual Init/Getwave

Deprecating Use_Init_Output provides
3 model types and 9 TX/RX combinations

- If Init_Returns_Impulse = False, Getwave_Exists MUST BE True
- If Getwave_Exists = False, Init_Returns_Impulse MUST BE True

SiSoft We Are Signal Integrity

AMI Equations for 9 TX/RX Cases

Case #	Tx Type*	Rx Type*	Statistical	Time Domain
1	FT	FT	hAC(t)⊗hTEI(t)⊗hREI(t)	hAC(t)⊗hTEI(t)⊗hREI(t)⊗x(t)
2	FT	TF	hAC(t)⊗hTEI(t)	gREG[hAC(t)⊗hTEI(t)⊗x(t)]
3	FT	TT	hAC(t)⊗hTEI(t)⊗hREI(t)	gREG[hAC(t)⊗hTEI(t)⊗x(t)]
4	TF	FT	hAC(t)⊗hREI(t)	hAC(t)⊗hREI(t)⊗gTEG[x(t)]
5	TF	TF	hAC(t)	gREG[hAC(t)⊗gTEG[x(t)]]
6	TF	TT	hAC(t)⊗hREI(t)	gREG[hAC(t)⊗gTEG[x(t)]]
7	TT	FT	hAC(t)⊗hTEI(t)⊗hREI(t)	hAC(t)⊗hREI(t)⊗gTEG[x(t)]
8	TT	TF	hAC(t)⊗hTEI(t)	gREG[hAC(t)⊗gTEG[x(t)]]
9	TT	TT	hAC(t)⊗hTEI(t)⊗hREI(t)	gREG[hAC(t)⊗gTEG[x(t)]]

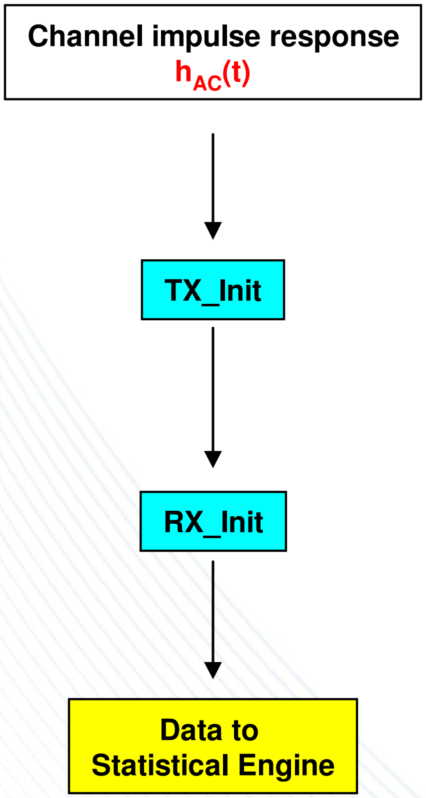
* = Getwave_Exists, Init_Returns_Impulse

- These 9 cases are a subset of 16 cases previously reviewed and agreed upon
- The challenge is – how does the simulator load & run the models to produce these results?

IBIS-AMI Reference Flow

- The Reference Flow shows one way a simulator can load & run IBIS-AMI models to produce the results shown on the previous slide
  - Other flows are allowed as long as they produce the same results
- Since each model can have different capabilities, the Reference Flow must accommodate all possible TX/RX combinations

IBIS-AMI Reference Flow - Init

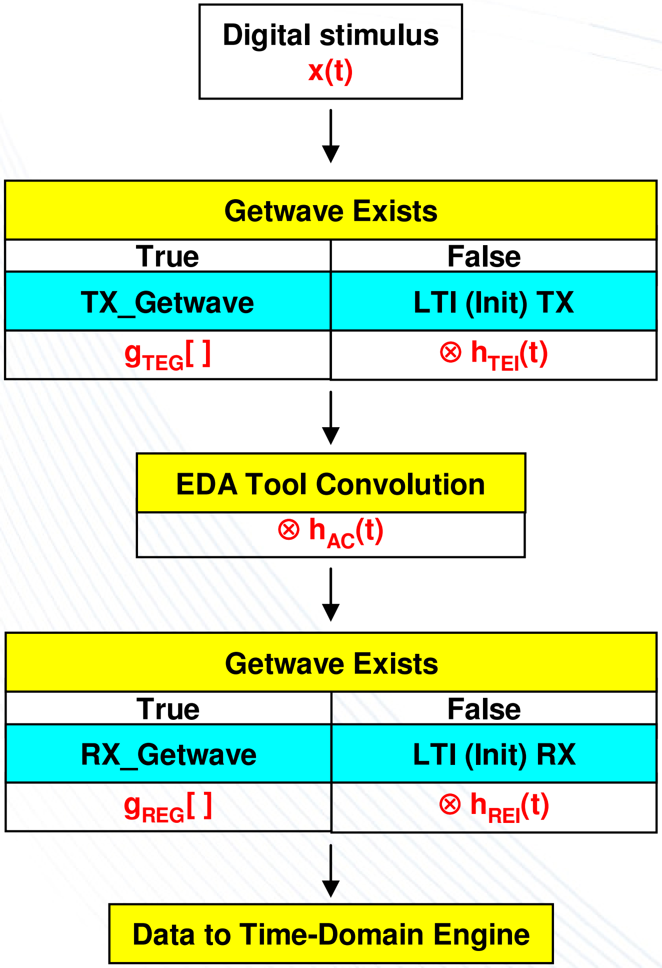


- Init flow depends only on Init_Returns_Impulse
- Flow never changes (models modify impulse response in place) - only the result changes
- Results from Init suitable for Statistical simulations

# Cases	Tx Type*	Rx Type*	Statistical	Comments
4	(X)T	(X)T	hAC(t)⊗hTEI(t)⊗hREI(t)	Full statistical flow
2	(X)T	TF	hAC(t)⊗hTEI(t)	Analog channel & TX EQ only (signal at RX input)
2	TF	(X)T	hAC(t)⊗hREI(t)	Analog channel & RX EQ only
1	TF	TF	hAC(t)	Analog channel only
* = Getwave_Exists, Init_Returns_Impulse				

SiSoft We Are Signal Integrity

IBIS-AMI Reference Flow - Getwave



- Digital stimulus allows non-LTI TX models to work properly
- Note that:
  - When Getwave_Exists = False, Init_Returns_Impulse = True
  - When Getwave_Exists = True, Init must be processed but is not used in the TD waveform
- Therefore:
  - There are only 4 flows, based on the value of Getwave_Exists

# Cases	Tx Type*	Rx Type*	Time Domain	Comments
4	T(X)	T(X)	gREG[hAC(t)⊗gTEG[x(t)]]	Full non-LTI flow
2	FT	T(X)	gREG[hAC(t)⊗hTEI(t)⊗x(t)]	LTI TX, hAC(t)⊗hTEI(t) comes from TX_Init
2	T(X)	FT	hAC(t)⊗hREI(t)⊗gTEG[x(t)]	LTI RX, hREI(t) requires deconvolution with IBIS 5.0 flow
1	FT	FT	hAC(t)⊗hTEI(t)⊗hREI(t)⊗x(t)	LTI TX & RX, hAC(t)⊗hTEI(t)⊗hREI(t) comes from RX_Init
* = Getwave_Exists, Init_Returns_Impulse				

We Are Signal Integrity

What's This Getwave LTI Stuff?

Getwave Exists	
True	False
TX_Getwave	LTI (Init) TX
$g_{TEG}[\ ]$	$\otimes\ h_{TEI}(t)$

Getwave Exists	
True	False
RX_Getwave	LTI (Init) RX
$g_{REG}[\ ]$	$\otimes\ h_{REI}(t)$

- When the AMI model doesn't support Getwave, the simulator creates a "LTI Getwave" function by convolving the model's input waveform with the impulse response from the model's Init call
  - e.g. **⊗ hTEI(t), ⊗ hREI(t)**

SiSoft™ We Are Signal Integrity

… Where Does The Simulator Get $h_{XEI}(t)$?

… actually, it usually doesn't need it:

No impulse response needed
Output from TX_Init
Output from RX_Init

Let's look closer at this one

# Cases	Tx Type*	Rx Type*	Time Domain
4	T(X)	T(X)	gREG[hAC(t) ⊗ gTEG[x(t)]]
2	FT	T(X)	gREG[hAC(t) ⊗ hTEI(t) ⊗ x(t)]
2	T(X)	FT	hAC(t) ⊗ hREI(t) ⊗ gTEG[x(t)]
1	FT	FT	hAC(t) ⊗ hTEI(t) ⊗ hREI(t) ⊗ x(t)

* = Getwave_Exists, Init_Returns_Impulse

SiSoft
We Are Signal Integrity

The Sticky Bit

Output from RX_Init

This one's the challenge

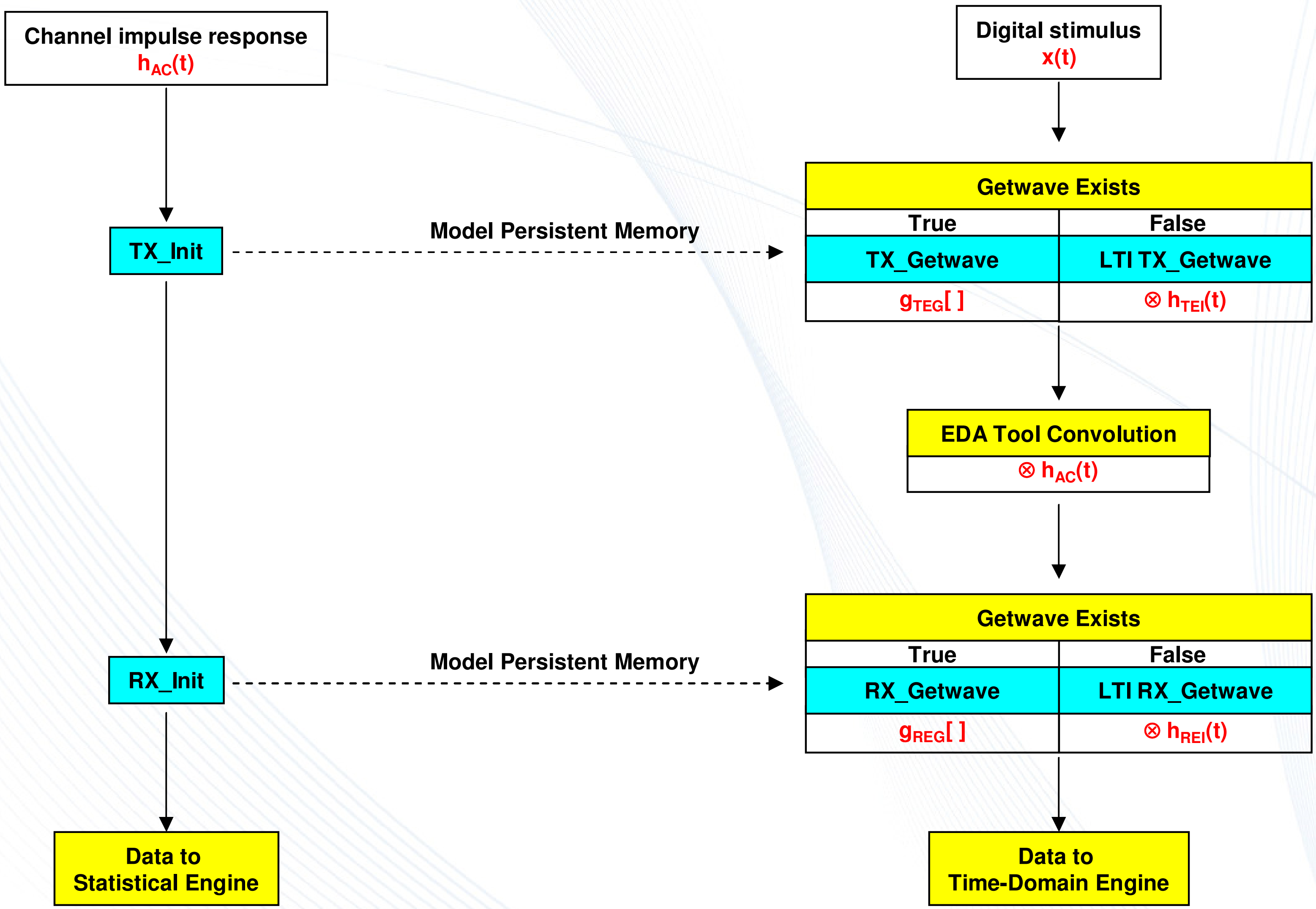
Case #	Tx Type*	Rx Type*	Statistical	Time Domain
4	TF	FT	hAC(t)⊗hREI(t)	hAC(t)⊗hREI(t)⊗gTEG[x(t)]
7	TT	FT	hAC(t)⊗hTEI(t)⊗hREI(t)	hAC(t)⊗hREI(t)⊗gTEG[x(t)]
* = Getwave_Exists, Init_Returns_Impulse				

- How Do We Get hREI(t)?
- Three different possibilities
  1. De-convolution
  2. Init_Returns_Filter
  3. Modified Impulse Matrix

We Are Signal Integrity

Proposed AMI Reference Flow

Init Flow … followed by … Getwave Flow



# Cases	Tx Type*	Rx Type*	Statistical	Comments
4	(X)T	(X)T	hAC(t)⊗hTEI(t)⊗hREI(t)	Full statistical flow
2	(X)T	TF	hAC(t)⊗hTEI(t)	Analog channel & TX EQ only (signal at RX input)
2	TF	(X)T	hAC(t)⊗hREI(t)	Analog channel & RX EQ only
1	TF	TF	hAC(t)	Analog channel only
* = Getwave_Exists, Init_Returns_Impulse				

# Cases	Tx Type*	Rx Type*	Time Domain	Comments
4	T(X)	T(X)	gREG[hAC(t)⊗gTEG[x(t)]]	Full non-LTI flow
2	FT	T(X)	gREG[hAC(t)⊗hTEI(t)⊗x(t)]	LTI TX, hAC(t)⊗hTEI(t) comes from TX_Init
2	T(X)	FT	hAC(t)⊗hREI(t)⊗gTEG[x(t)]	LTI RX, hREI(t) requires deconvolution with IBIS 5.0 flow
1	FT	FT	hAC(t)⊗hTEI(t)⊗hREI(t)⊗x(t)	LTI TX & RX, hAC(t)⊗hTEI(t)⊗hREI(t) comes from RX_Init
* = Getwave_Exists, Init_Returns_Impulse				

SiSoft™ We Are Signal Integrity

SiSoft's Recommendation

- Reference flow defined in BIRD that goes with this presentation
- Define new Reserved Parameter, Init_Returns_Filter, in additional BIRD
- Review and discuss in IBIS-ATM
- Bring BIRDs and recommendations to IBIS Open Forum

SiSoft™
We Are Signal Integrity

Presentation Goals

- How we got here (flows through the ages)
- Highlight advantages of simplified model logic (deprecating Use_Init_Output)
- Present SiSoft's view of IBIS-AMI flow
  - Highlight the problem area
  - Present alternative solutions
  - Present SiSoft recommendations
- Provide basis for subsequent discussion

Thanks!

We Are Signal Integrity