IBIS AMI Model
(Algorithmic Model Interface)

~Theory & Structure~

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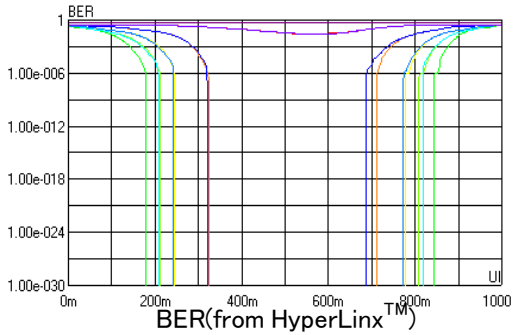
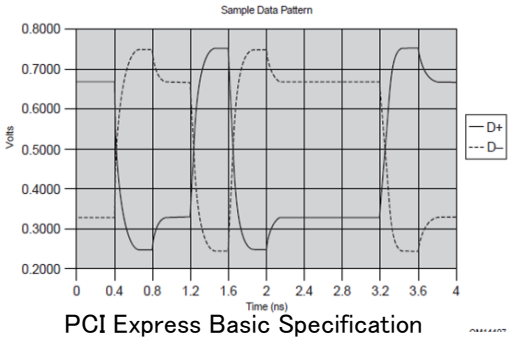
KEI Systems

Why IBIS AMI

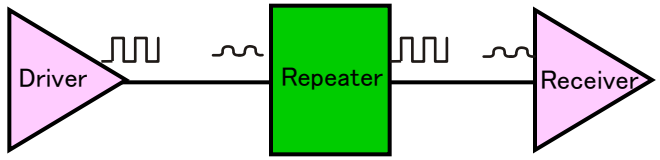
- G b/s Serial Link
  - PCI Express (Gen1, Gen2, Gen3)
  - USB 3.0
  - SATA (Serial ATA) Express
  - HDMI 2.0
- Serial Link Standard
  - BER (Bit Error Rate)
    - BER < $1/10^{-12}$
  - Analog Filter
    - Equalization (De-Emphasis)
  - Repeater



BER(from HyperLinx™)



PCI Express Basic Specification



Simulation Model for Serial Link

IBIS AMI for Serial Link Simulation

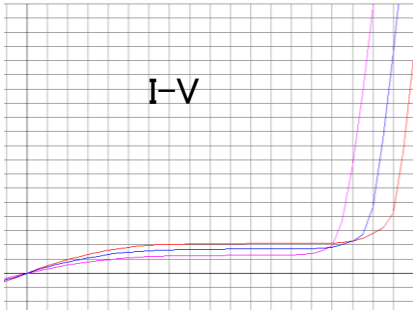
- BER Simulation (Very Fast Simulation)
  - 10^{12} bit Simulation
  - Jitter Simulation
- Analog Filter (Dynamic Model Control by Previous Data)
  - Dynamic Characteristics
- Repeater (Both Receiver and Driver Model)
  - IBIS is either Driver or Receiver

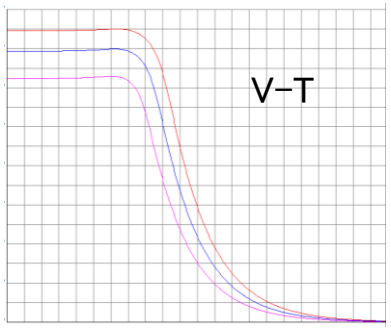
	IBIS	IBIS AMS	Spice	IBIS AMI
Simulation Speed	△	×	×	○
Model Control	×	○	○	○
In & Out Model	×	○	○	○
Easy to Use	○	×	×	○

Overview of IBIS AMI

- Since IBIS Version 5
- New Simulation Algorithm Good by I-V, V-T Based Sim.
  - IBIS Traditional Model
    - Model for Circuit Simulation (Spice)

    (I-V, V-T Curve)

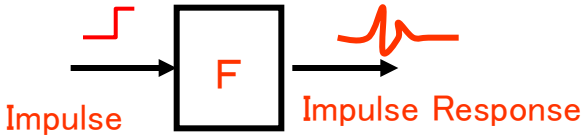




- No more Compatibility
  - No Compatible with Traditional IBIS Model
  - AMI model Depends on Simulator
  - Depends on OS (H/W)

IBIS AMI

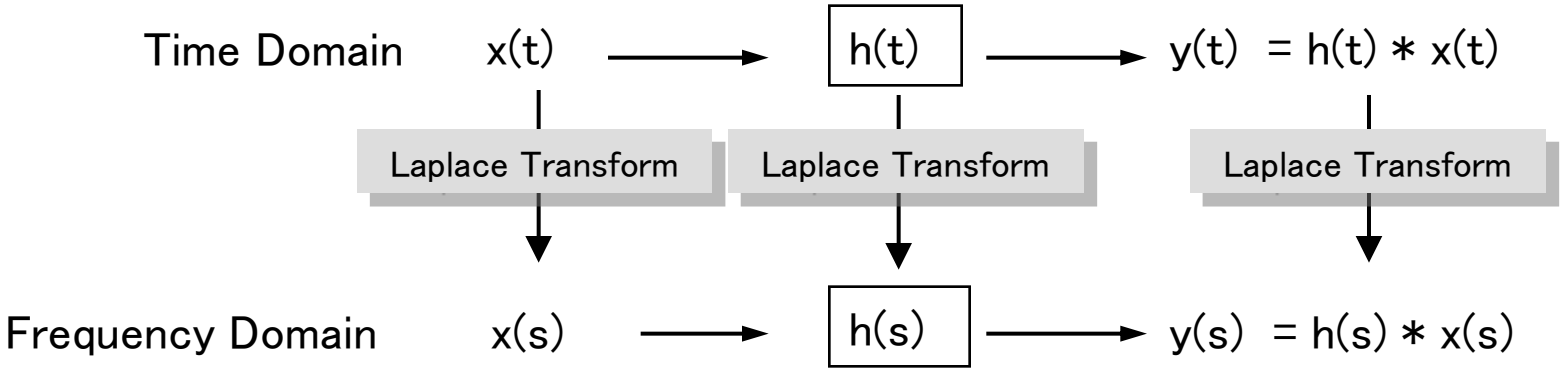
- Binary Programming
  - Strong
    - IP Protection
    - Flexible
  - Weak
    - Depend on Execute Environments (OS, Version, H/W)
    - Customer cannot Estimate the Model before Sim.
- New Simulation Algorithm
  - Model for Transfer Function Algorithm
- Simulation Time is Incredibly Fast
- Call the Program from IBIS Model
- Flexible Simulation
  - Multi-Level Logic
  - Equalizer, Repeater, S-parameter



Impulse Response

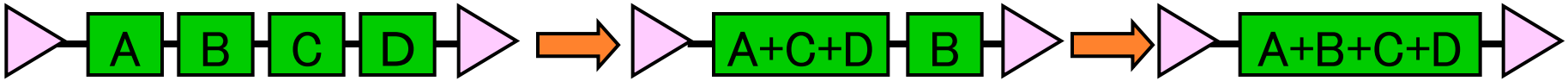
- Impulse Response
  - Output when Input the Impulse (Function)

- "Transfer Function" is Laplace Transformed "Impulse Response"



Transfer Function Based Simulation

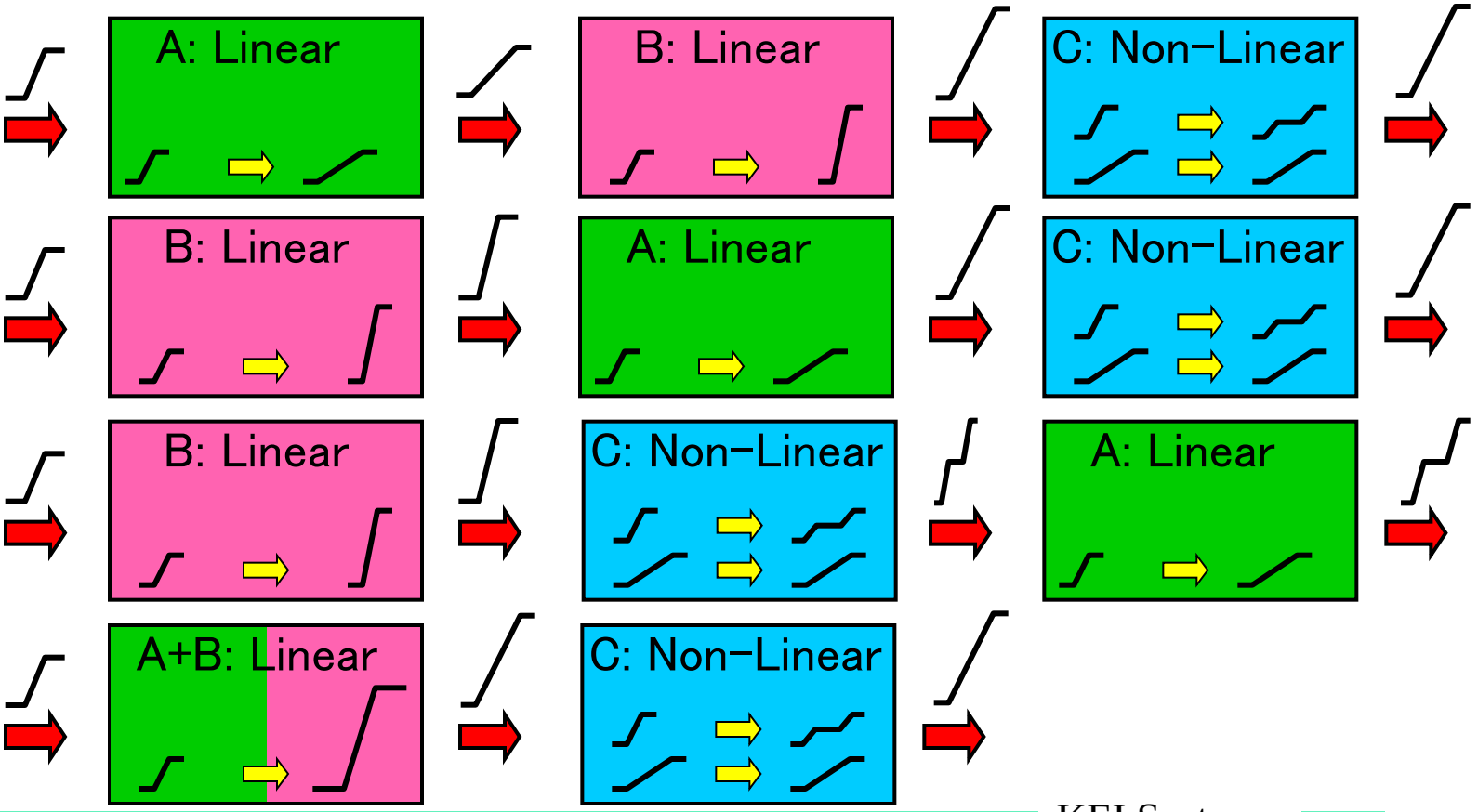
- Precondition: LTI (Linear and Time Invariant)
  - Complex Circuit can be Simplified
    - Synthesize the Series connected Elements into One
    - Exchange the Element Sequence



- Easy to use S-parameter
  - S is Transfer Function
  - Circuit Simulator is Hard with S-Parameter
    - S-Parameter is NOT Circuit
  - Convert to Circuit Model (Broadband Spice)

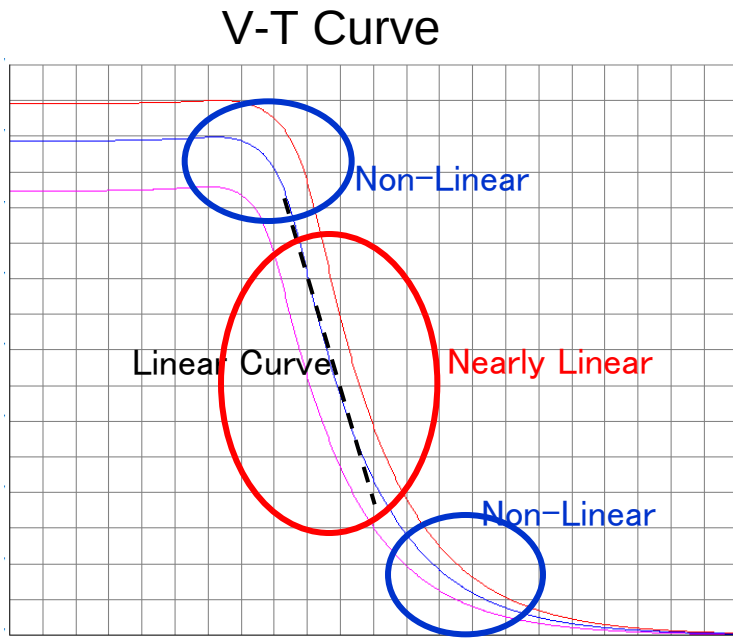
LTI (Linear Time-Invariant)

LTI Model Can Get the Same Waveform
If Elements Sequence Changed/Elements Synthesized



Characteristics Is Not Linear

- Approximation to Linear
- Can Apply LTI Condition?

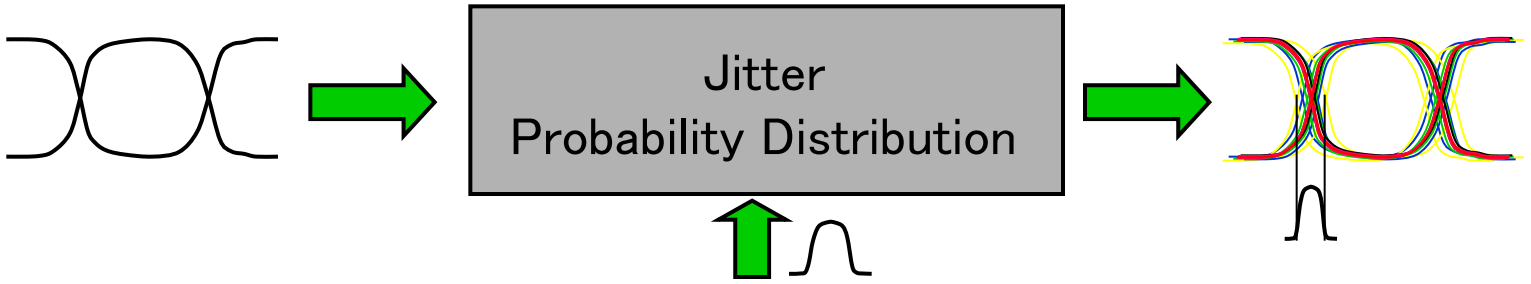


Simulation Accuracy using AMI Model?

➡Checking Simulation Accuracy by IBIS Open Forum, Venders and Users

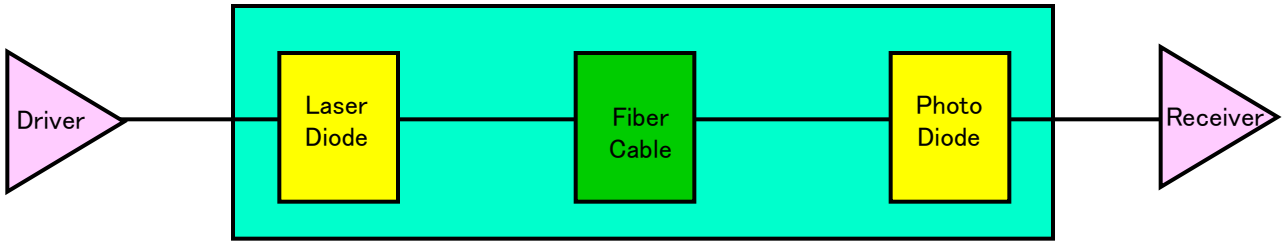
Statistical Simulation

- Random Jitter Simulation
  - Jitter Probability Distribution
- Statistical Eye Diagram

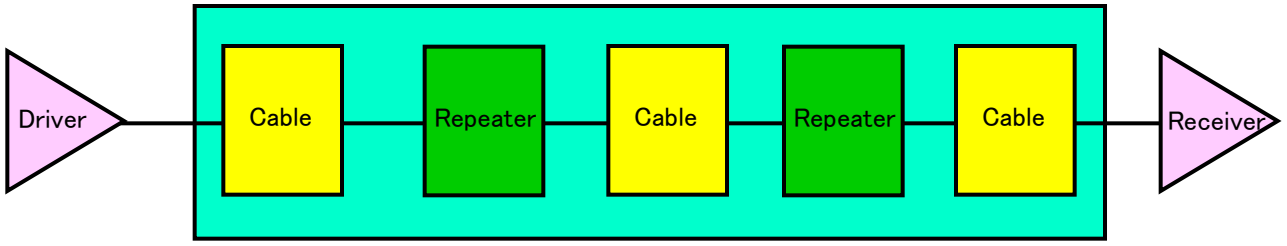


Transfer Function Can Use Widely

- Transmission System Include Optical System

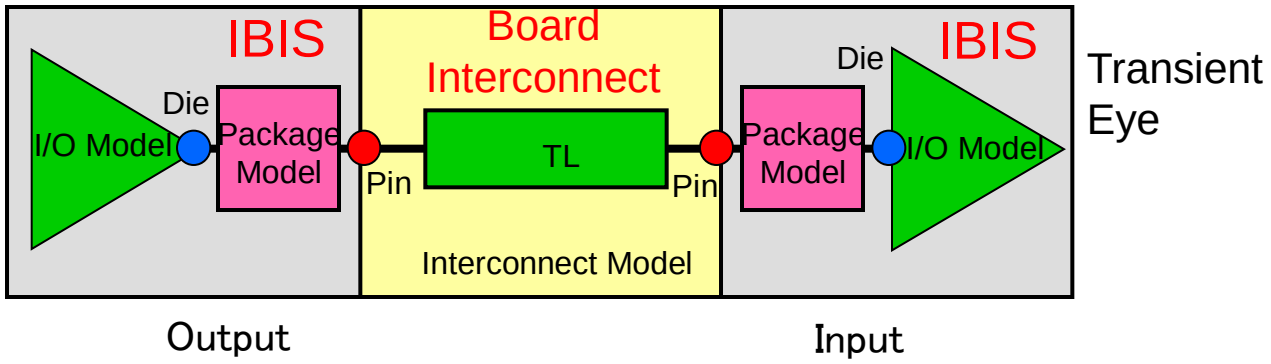


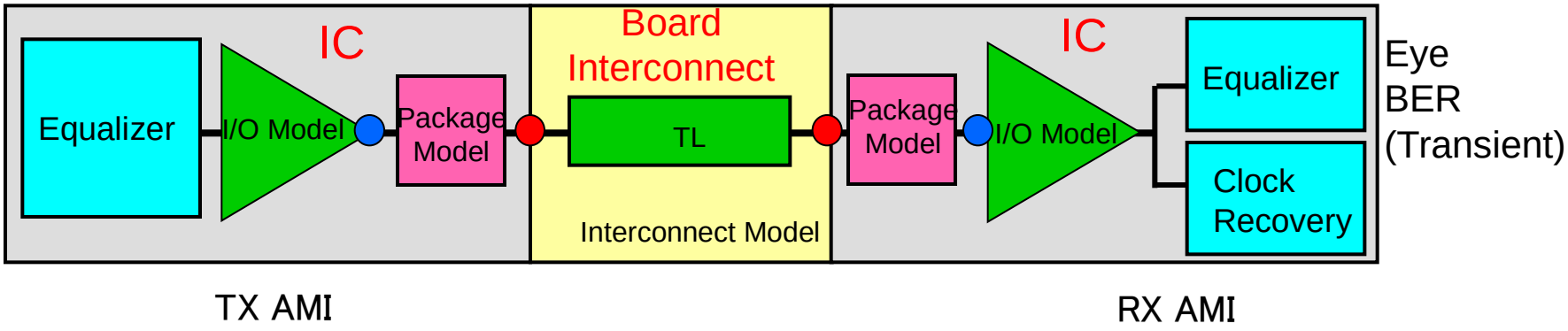
- Long Distance Transmission System



Structure of IBIS Model

- IBIS (Traditional) vs. IBIS AMI

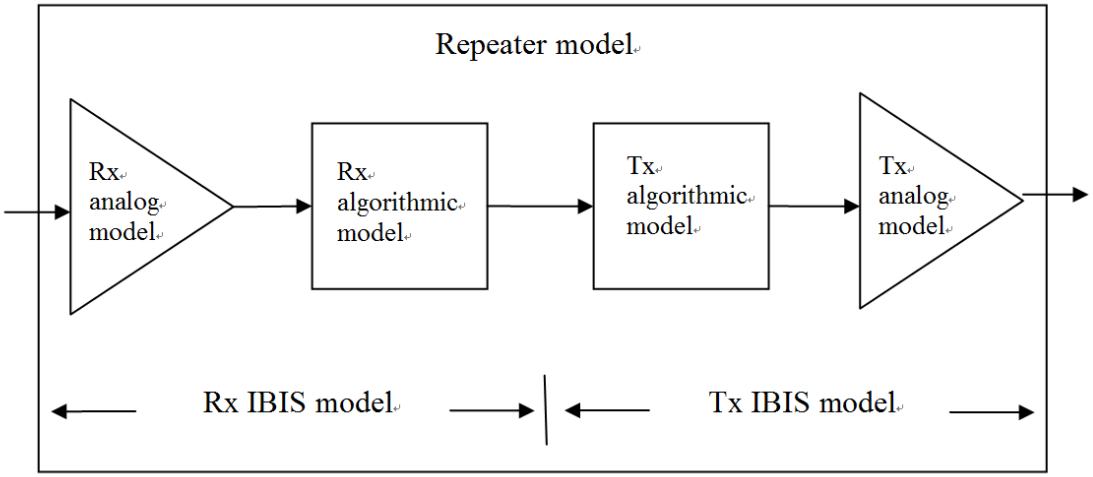




AMI Model

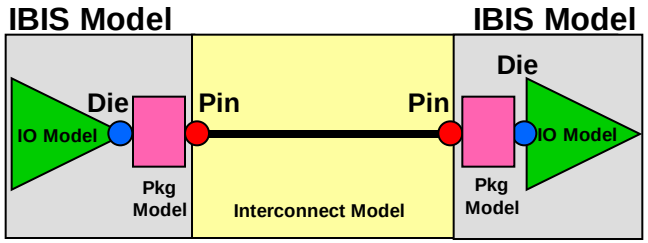
IBIS vs. IBIS AMI

- AMI Model is a part of IBIS Model
  - Instead of detailed I-V, V-T, IBIS AMI Calls the Program which Define Impulse Response
  - AMI Can Define the Repeater Model
    - IBIS Can Define One Port (Driver or Receiver)



Structure of IBIS Model

- Define the Model by 3 Blocks
  - Header/Components/Model
- Model Description Block
  - IO Model
    - I-V, V-T
  - Optional Package Model Definition



[IBIS Ver] [File Name] [File Rev] [Date] [Source] [Notes] [Discraimer] [Copyright]	Header
[Component] [manufacturer] [Package] [Diff Pin] [Model Select]	Components
[Model] [**Range] [I-V] [Slew Rate] [V-T]	Model

Structure of IBIS AMI Model

- Model Description
  - IO Model
    - AMI Model

[Model] Model
[**Range]
[Algorithmic Model]
Executable
[End Algorithmic Model]
[I-V]
[Slew Rate]

```
[Model] xxxx
Model_type Output
C_comp 800f 750f 850f
Cref = 0
[Model Spec]
Vmeas .157 .15 .165
Vref .157 .15 .165
[Temperature Range]  25 100 0
[Voltage Range] .314 .299 .329
[Algorithmic Model]
Executable Windows_VisualStudio7.1.3088_32 xx_gtp_ami_tx.dll xx_gtp_ami_tx_1.ami
Executable Linux_gcc3.2.3_32 xx_gtp_ami_tx.linux.so xx_gtp_ami_tx_1.ami
[End Algorithmic Model]
[Pulldown]
-2.500 -4.95638E-02 -5.02816E-02 -4.88759E-02
0.000 +0.00000E+00 +0.00000E+00 +0.00000E+00
2.500 +4.95638E-02 +5.02816E-02 +4.88759E-02
[Pullup]
-2.500 +4.95638E-02 +5.02816E-02 +4.88759E-02
0.000 +0.00000E+00 +0.00000E+00 +0.00000E+00
2.500 -4.95638E-02 -5.02816E-02 -4.88759E-02
[Ramp]
dV/dt_r .094/60f .09/60f .098/60f
dV/dt_f .094/60f .09/60f .098/60f
|
```

IBIS AMI (Algorithmic Model Interface)

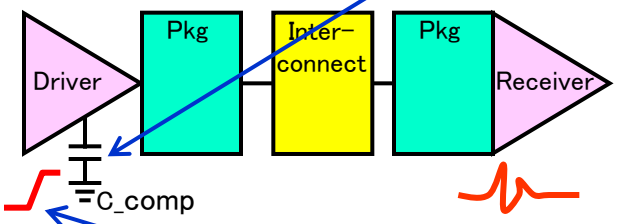
- AIM: 3 Arguments
  - Executable Environment
  - .dll: Binary Executable Program Name
  - .aim: ASCII Parameter File Name

Example of Receiver Model in [Algorithmic Model]:

```
[Algorithmic Model]
                    Executable              Executable File     Parameter File
Executable Windows_VisualStudio_32 example_rx.dll example_rx_params.ami
[End Algorithmic Model]
```

Simulator Makes Impulse Signal

- Use Linear Model



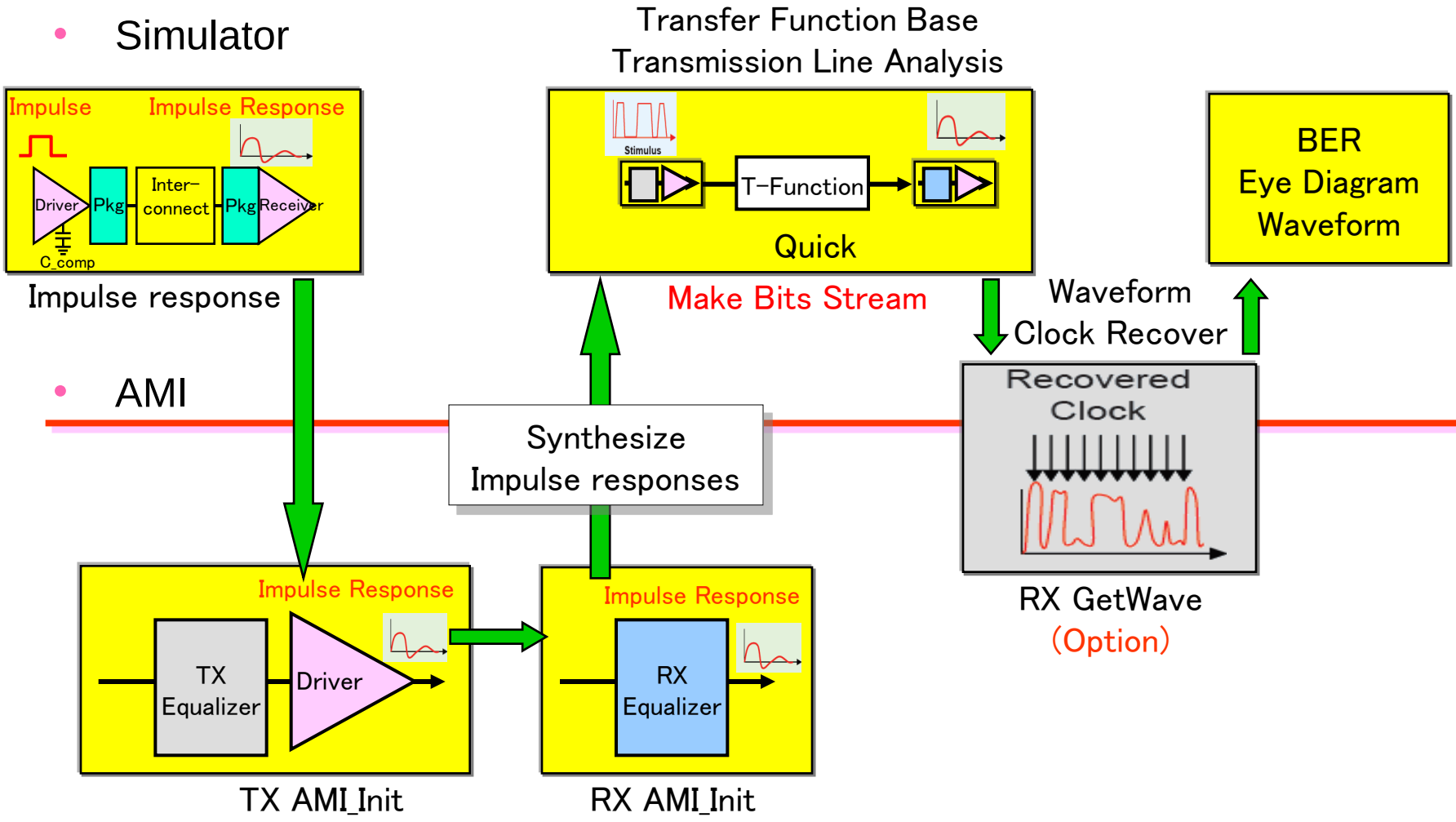

```
[Model] xxxx
Model_type Output
C_comp 800f 750f 850f
Cref = 0
[Model Spec]
Vmeas .157 .15 .165
Vref .157 .15 .165
[Temperature Range]  25 100 0
[Voltage Range] .314 .299 .329
[Algorithmic Model]
Executable Windows_VisualStudio7.1.3088_32 xx_gtp_ami_tx.dll xx_gtp_ami_tx_1.ami
Executable Linux_gcc3.2.3_32 xx_gtp_ami_tx.linux.so xx_gtp_ami_tx_1.ami
[End Algorithmic Model]
[Pulldown]
-2.500 -4.95638E-02 -5.02816E-02 -4.88759E-02
0.000 +0.00000E+00 +0.00000E+00 +0.00000E+00
2.500 +4.95638E-02 +5.02816E-02 +4.88759E-02
[Pullup]
-2.500 +4.95638E-02 +5.02816E-02 +4.88759E-02
0.000 +0.00000E+00 +0.00000E+00 +0.00000E+00
2.500 -4.95638E-02 -5.02816E-02 -4.88759E-02
[Ramp]
dV/dt_r .094/60f .09/60f .098/60f
dV/dt_f .094/60f .09/60f .098/60f
```

Linear I-V

Linear V-T

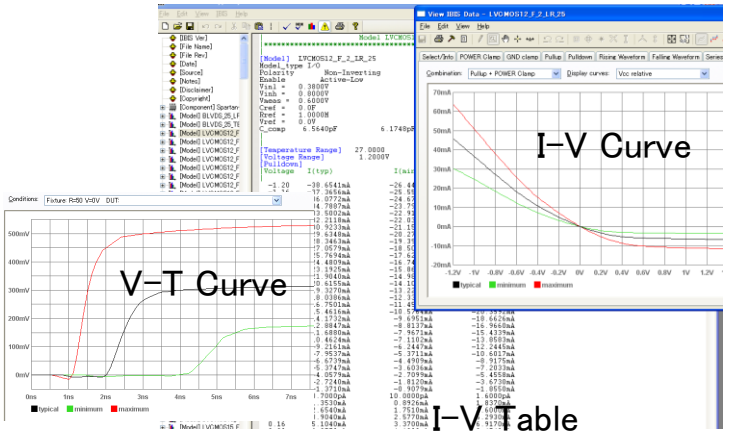
IBIS AMI Reference Flow

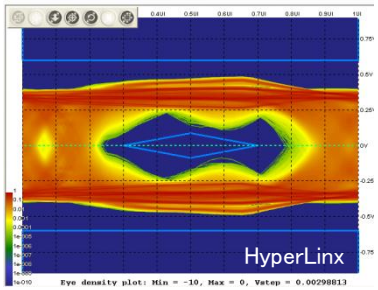
- Simulator



Concerns for IBIS AMI

- Can not Check the Model
  - Binary Program
  - No Model Viewer/Editor
- Simulator Dependent Model
  - Design Kit for xxx Simulator
- System Dependent Model
- Minimal Documentation, Evaluation Tool
  - IBIS Specification
  - Design Kit
    - How to Use Documentation
    - Simulation Sample & Results
    - Measurement Results





References

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