Automated AMI Model Generation & Validation

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Agenda

- AMI Model Generation Barriers
- Automated AMI Model-generation flow

  Example-1: 6.25 Gb/s

  Example-2: 10.3125 Gb/s
- TX Model Correlation Study

  -with Transistor Simulations

  -with Measurements
- Benefits of Automated AMI flow

#1 AMI modeling barrier

Model Generation Time

AMI Modeling suppose to Speed-up System Design Cycle,
BUT, Model-generation takes Significant Time & Resources

….System Vendors have to wait a LONG time before accurate AMI models become available

Note: Vendors with NO experience in AMI modeling are spending 6-12+ months to come up with first-generation models

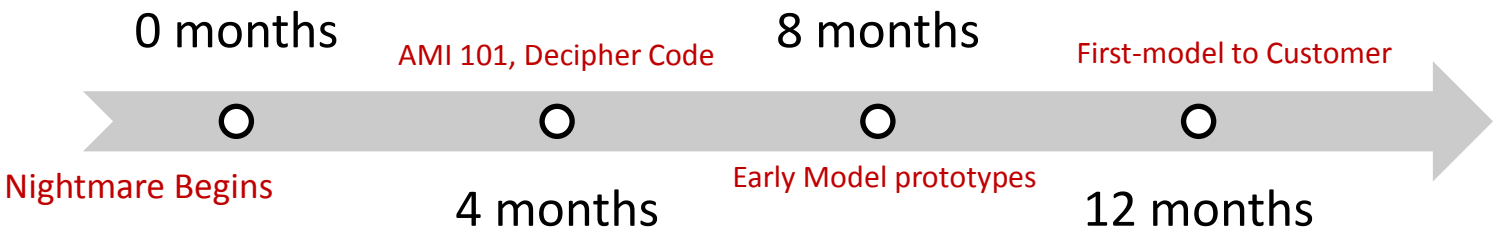
Models come very late in Design Cycle → used only for Validation, NOT Design

Why AMI-model generation takes so long?

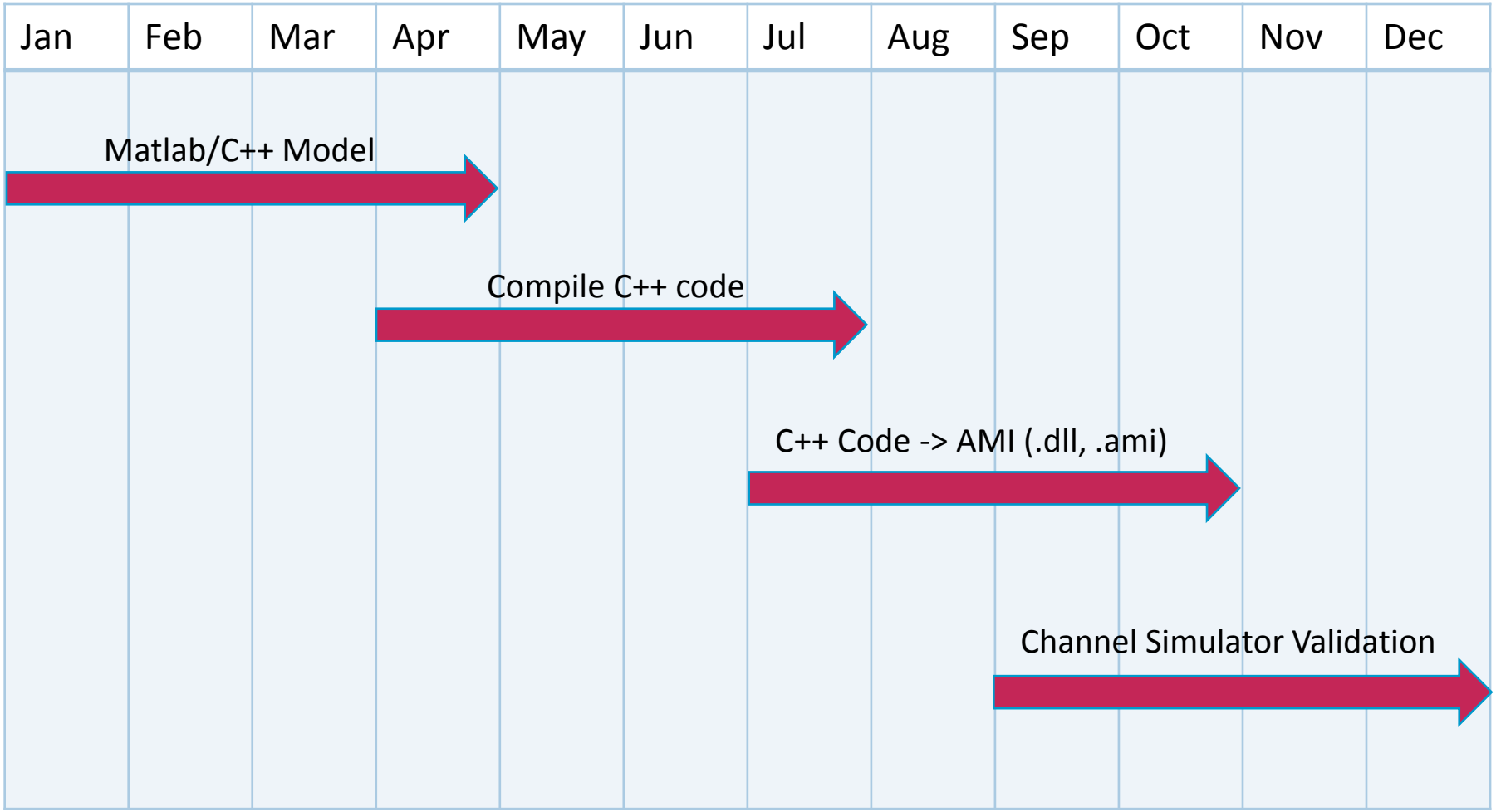
Typical Signal Integrity Engineers are NOT programmers

….they are having “Nightmares” in trying to develop AMI models

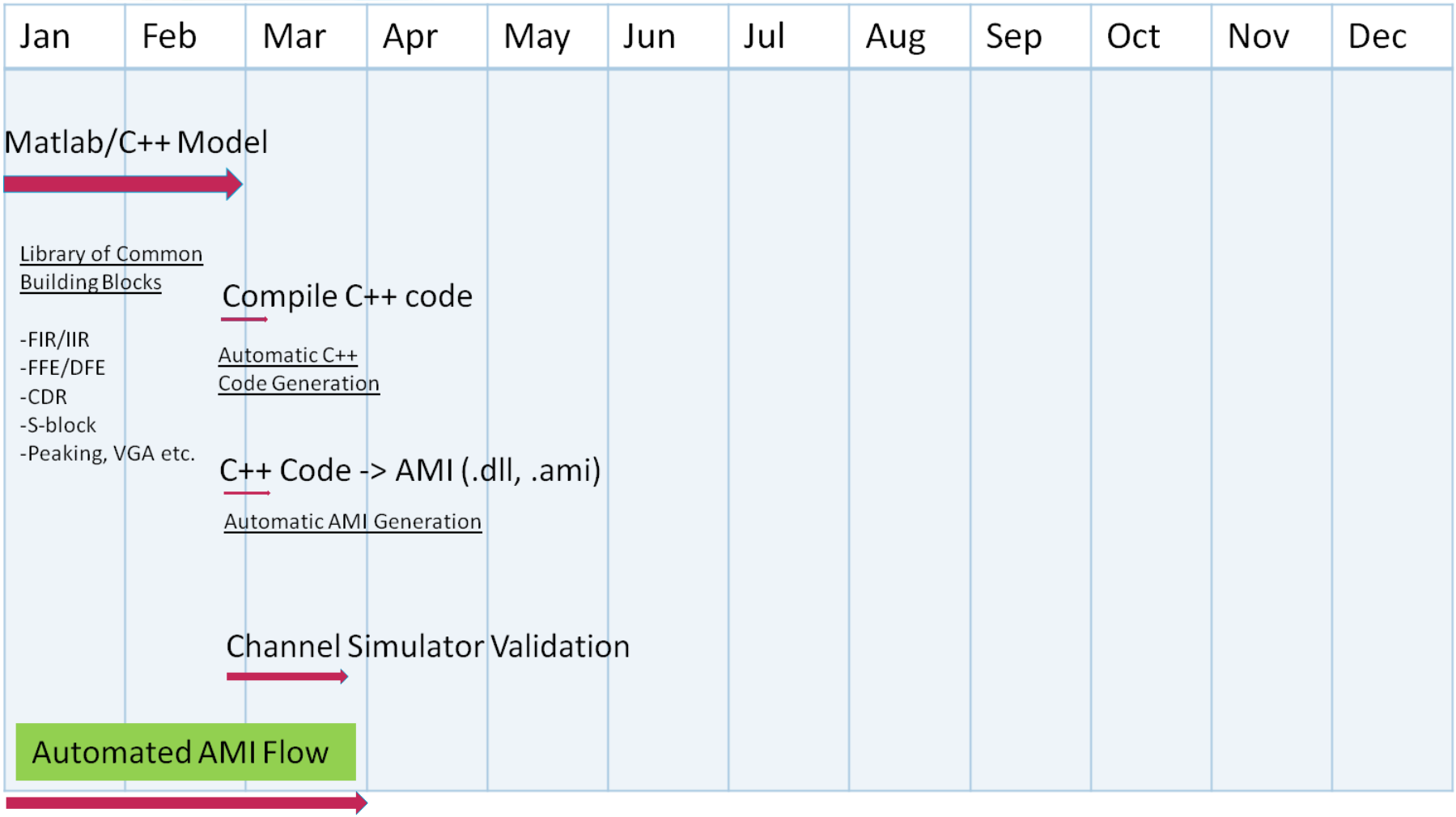
- Cryptic Matlab/C++ code passed from System-Architectures → AMI Modeler (if lucky)
- Challenge to Convert Algorithm design Code → AMI format



Typical AMI model generation flow…



Automated AMI model generation flow…

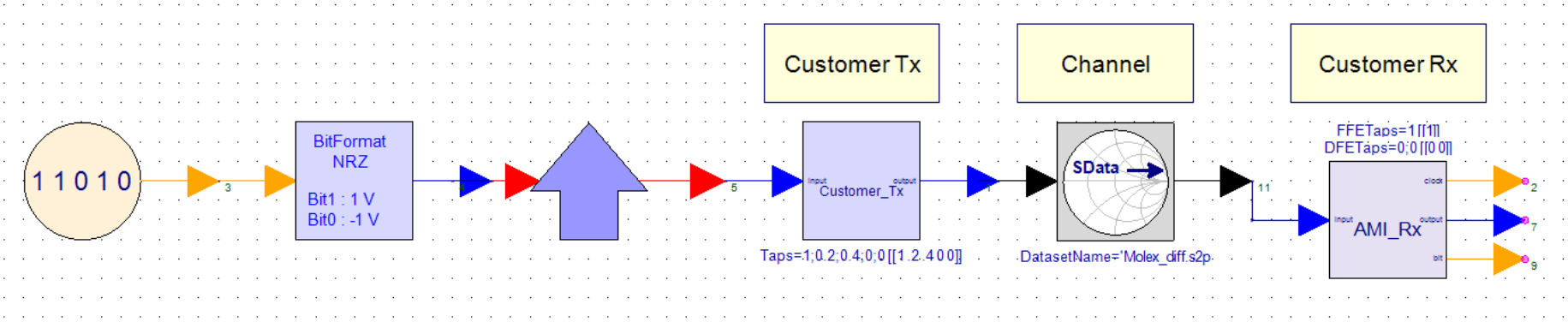


ESL flow for Automated AMI Modeling

Electronic System Level (**ESL**) design and verification is an emerging electronic design methodology that focuses on the *higher abstraction* level concerns first and foremost.

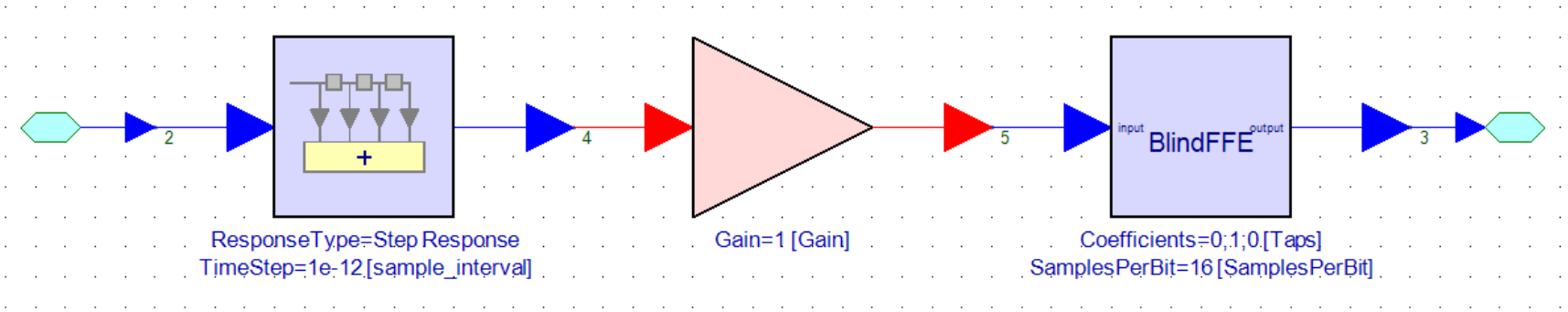
ESL flow facilitates utilization of appropriate abstractions in order to *increase comprehension about a system*, and to enhance the probability of a successful implementation of functionality in a *cost-effective* manner

Here is an Example of SerDes modeling using ESL flow-



ESL flow: TX Modeling Example (1)

Step-1: Starting Architecture Design with Generic Model



FIR/IIR filter

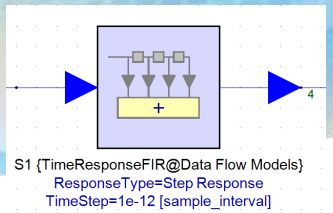
Gain

n-tap FFE

Different blocks represent high-level TX architecture

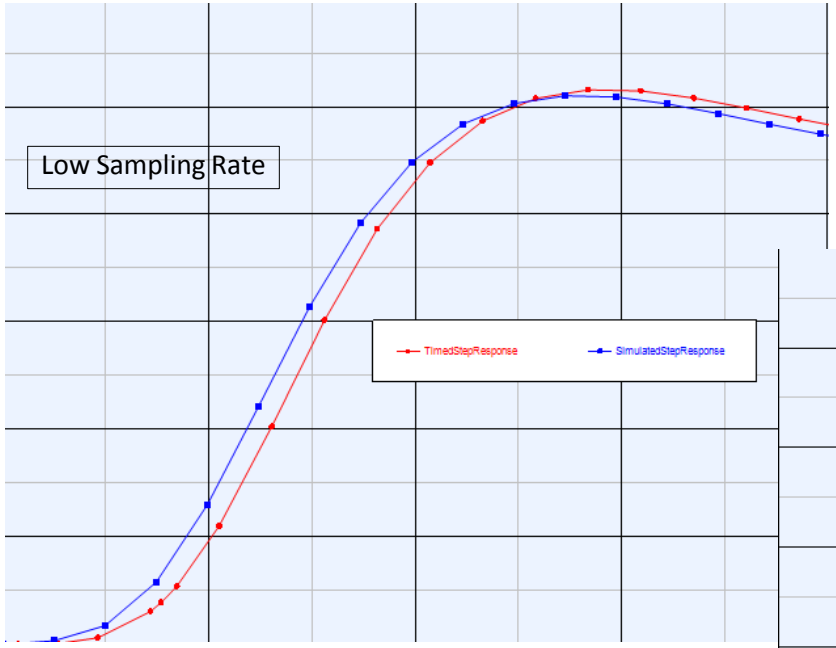
More on FIR Filter…

How to bring in Spice or Measured data?

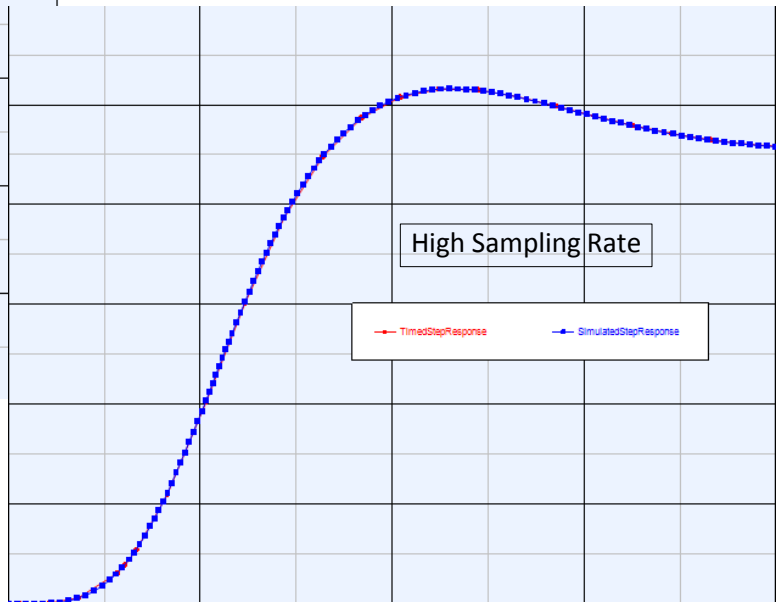


Challenges:

1. Typical Simulation and Measured Data is not equally time-stepped



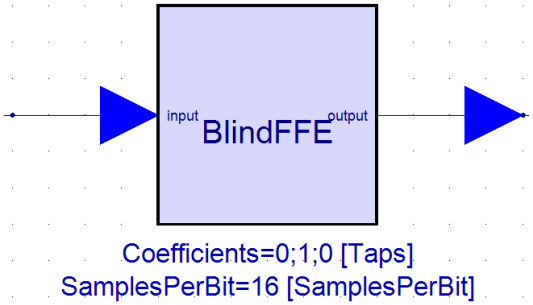
Sampling Rate determines Simulation Accuracy



FIR model should support "Arbitrary" Sampling Rate

ESL flow: TX Modeling Example (2)

Step-2: Customize IP -> Bring in Math Lang or C++ Code



Fine-tune and Customize models with Math Lang and/or C++ code

Designator: B2 — Show Designator

Description: Blind Feed-Forward Equalizer

Model: MathLang@Data Flow Models — Show Model

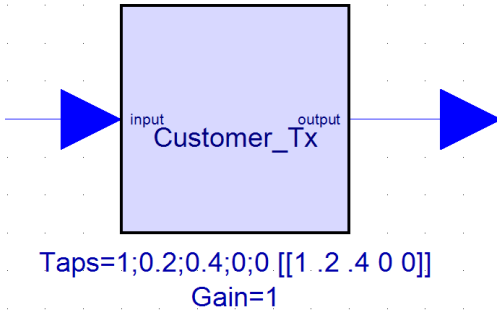
Manage Models... | Model Help | Use Model

Equations | I/O | Custom Parameters

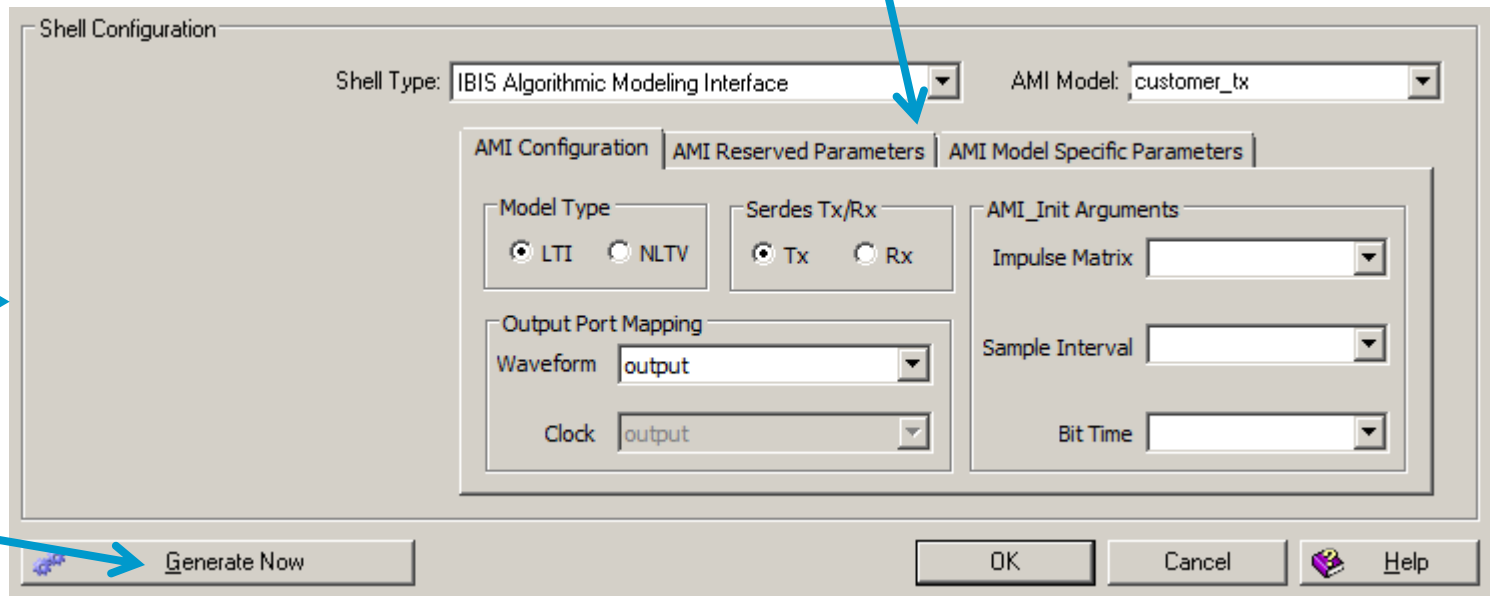
```
1   persistent dSamples;
2   persistent numSamples;
3   persistent taps;
4
5   if isempty(dSamples)
6      % first time we hit this routine
7      numSamples = length(Coefficients) * SamplesPerBit;
8      dSamples = zeros( 1, numSamples);
9      dSamples(1) = input;
10     taps = Coefficients';
11  else
12     dSamples = [input,dSamples(1:numSamples-1)];
13  end
14
15  output = dSamples(1:SamplesPerBit:numSamples) * taps;
```

ESL flow: TX Modeling Example (3)

Step-3: One-click AMI Code-Generation



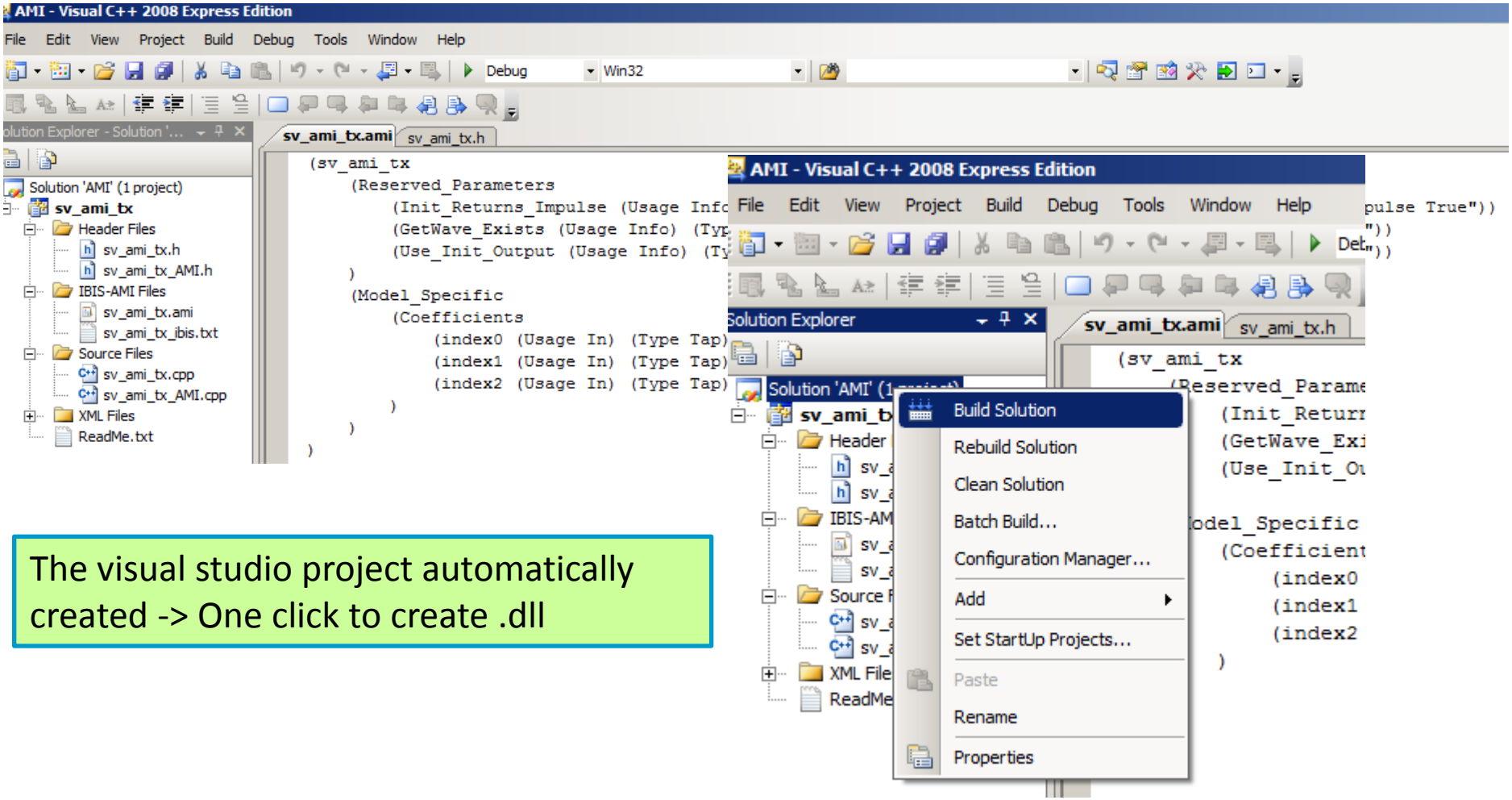
Define Reserved and Model Specific Parameters -> Automatically configure appropriate AMI wrapper



One-click AMI Code-generation

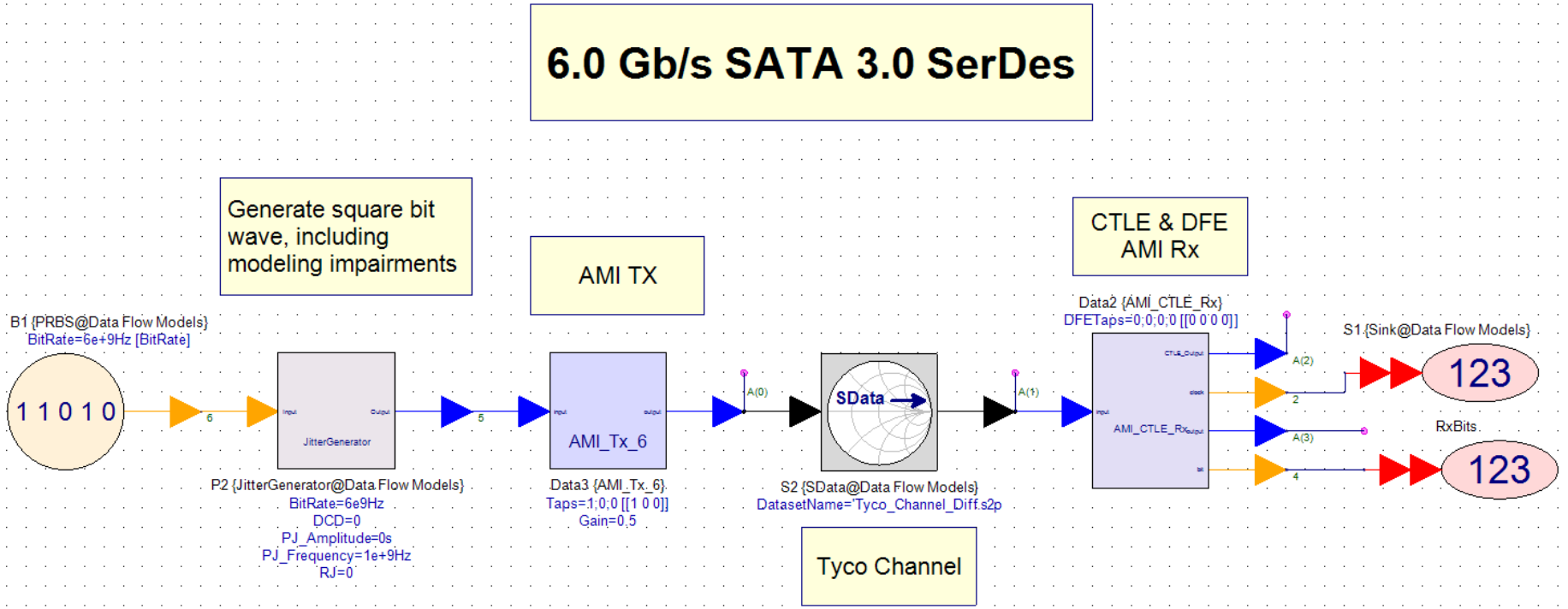
ESL flow: TX Modeling Example (4)

Step-4: Automatically Generated .ami and Visual-Studio project



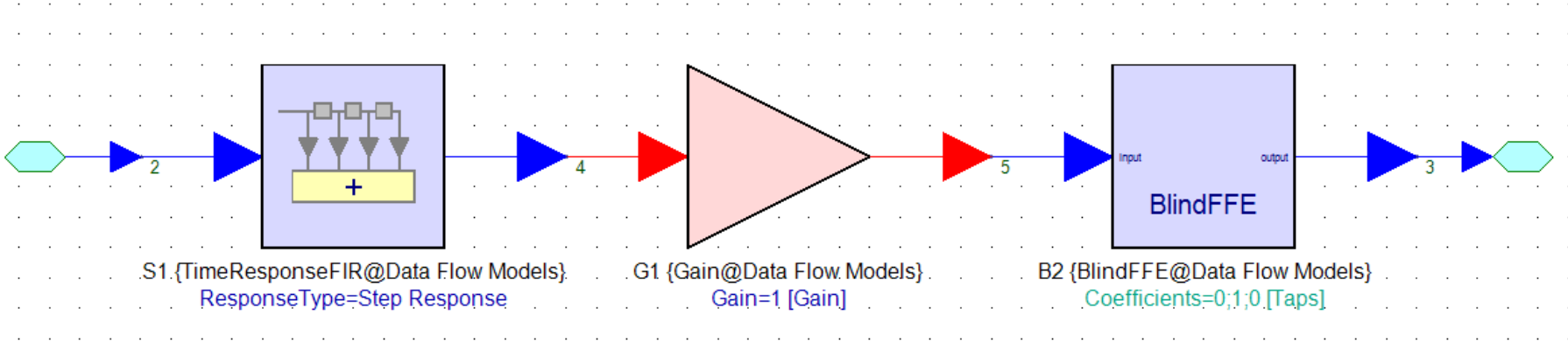
The visual studio project automatically created -> One click to create .dll

Example #1
6.0 Gb/s (SATA 3.0)



TX Modeling
6.0 Gb/s (SATA 3.0)

TX Architecture



FIR filter

3-tap FFE

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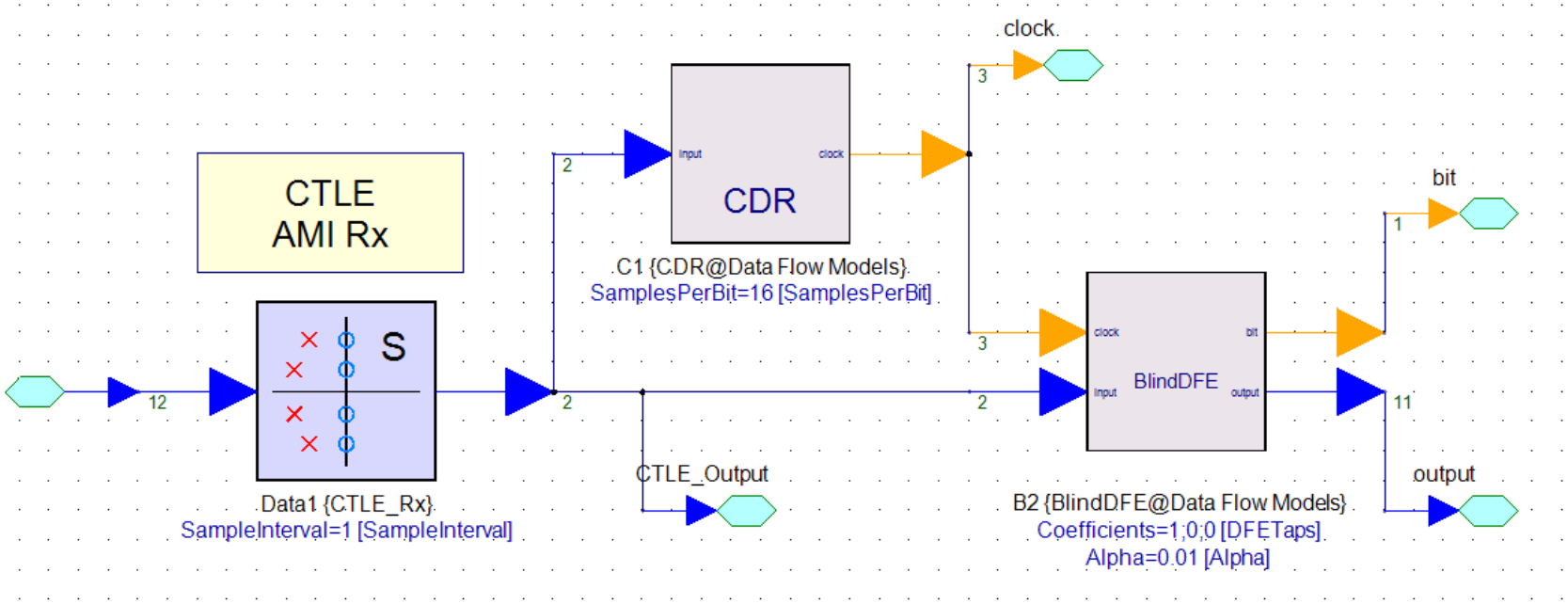
RX Modeling
6.0 Gb/s (SATA 3.0)

RX Architecture



S-domain filter

3-tap DFE

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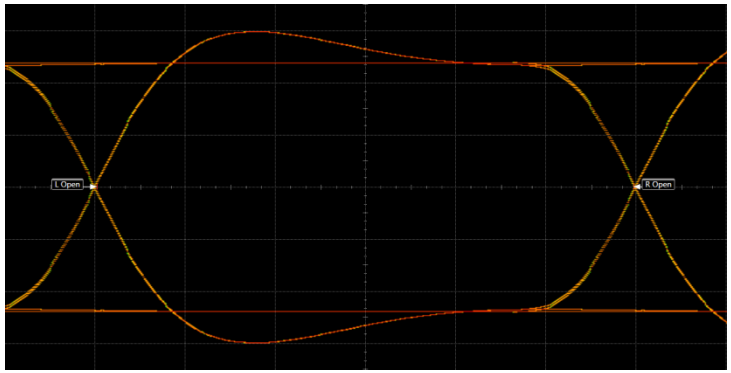
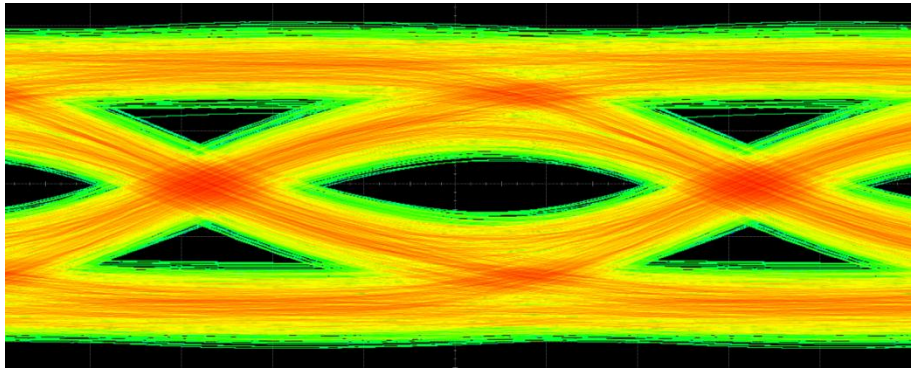
Results

6.0 Gb/s (SATA 3.0)

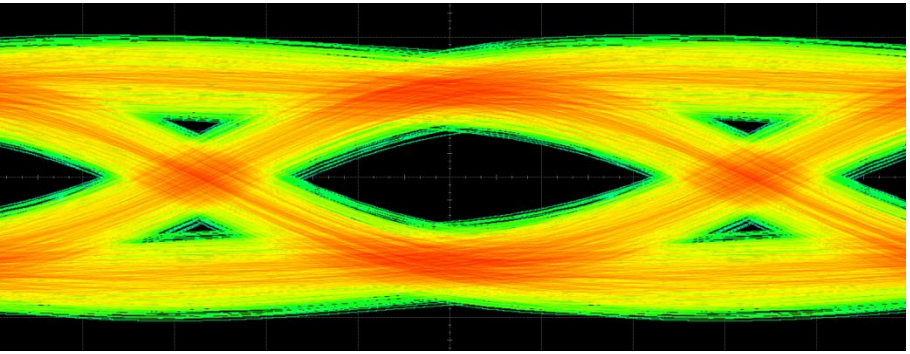
TX Output



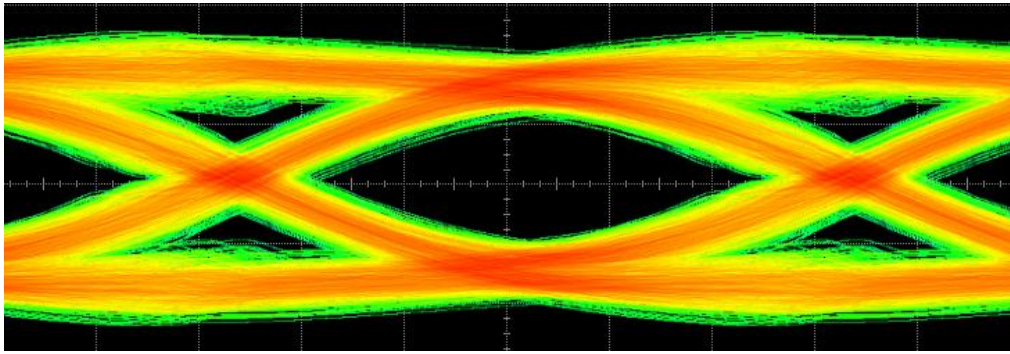
After Channel



After CTLE EQ



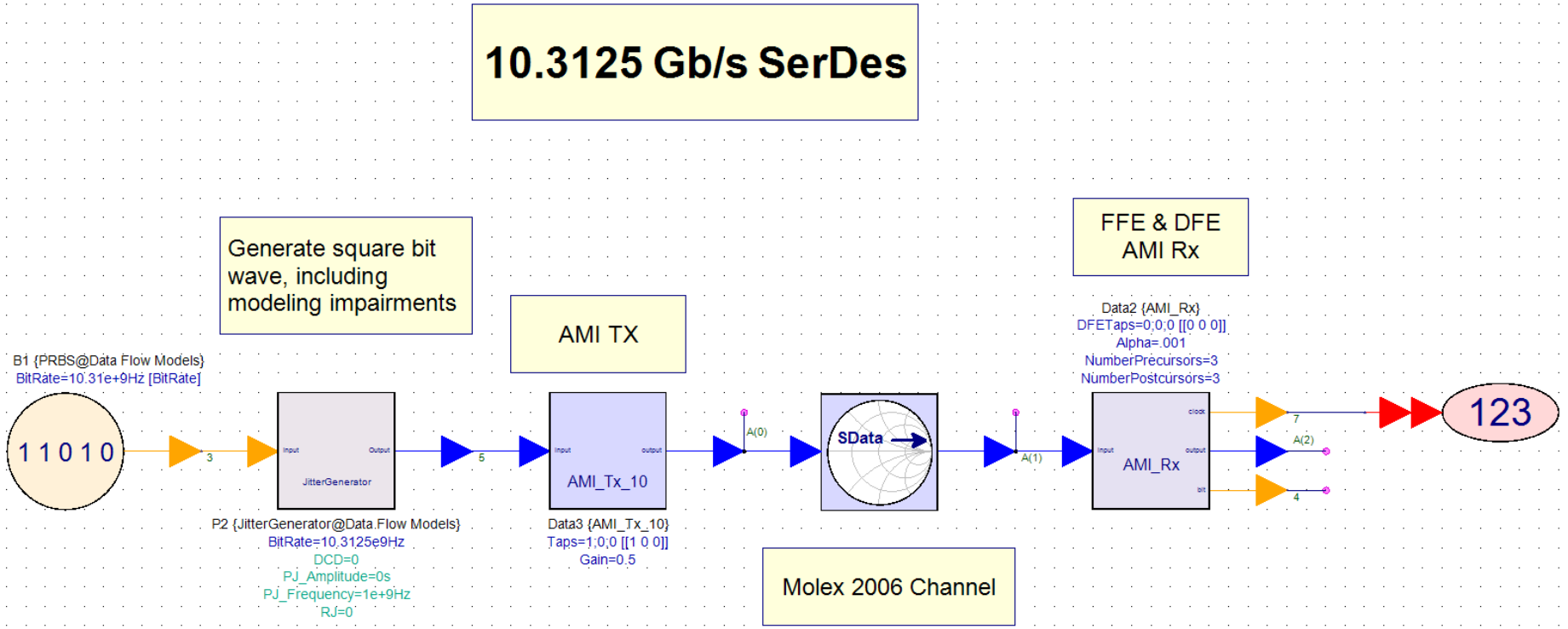
After CTLE+DFE EQ



*Note: EQ taps not optimized for maximum eye

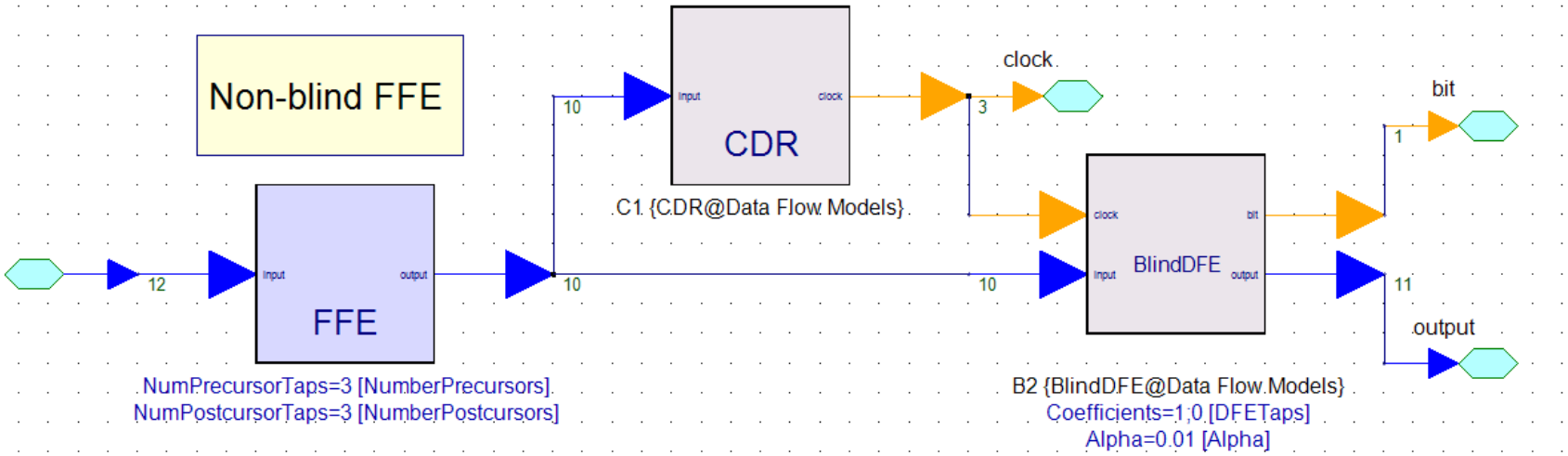
Example #2

10.3125 Gb/s (10-GB Ethernet)



RX Modeling

10.3125 Gb/s (10-GB Ethernet)



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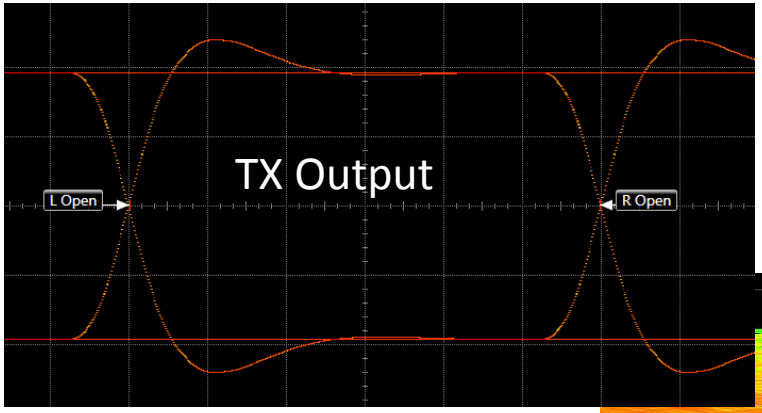
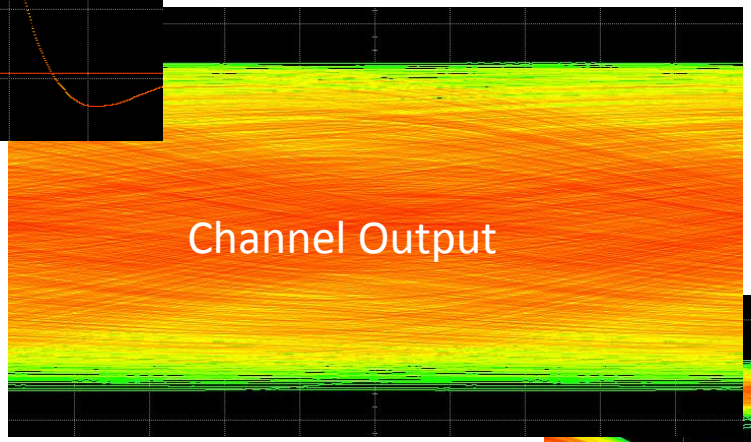
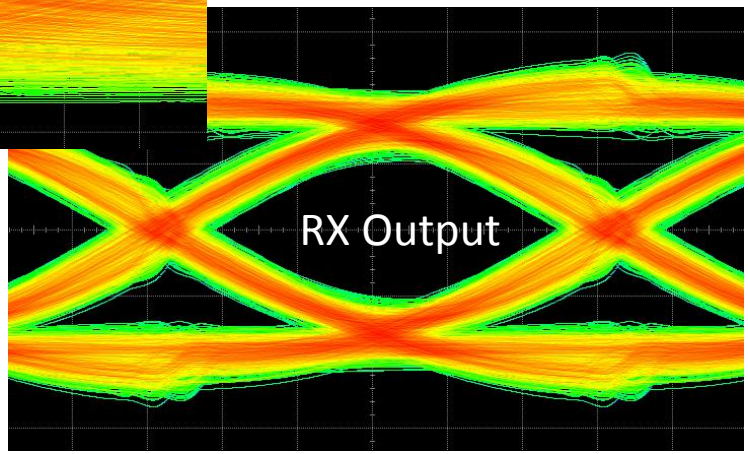
Example #2

10.3125 Gb/s (10-GB Ethernet)







TX 10.3125 Gb/s
AMI model correlation study

Strategy

1. Correlate Transistor Simulation vs. AMI model
2. Correlate Measured vs. AMI model

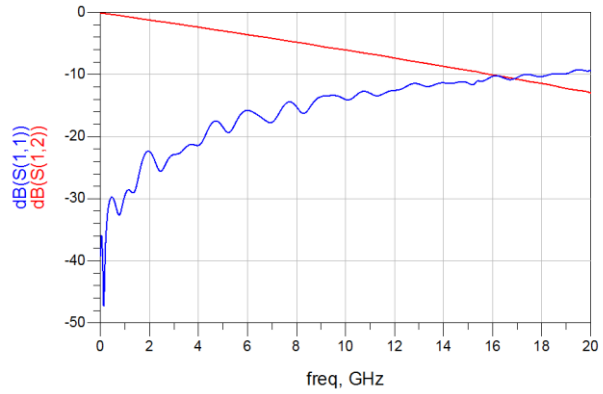
Transistor Simulation vs. AMI Model

Steps-

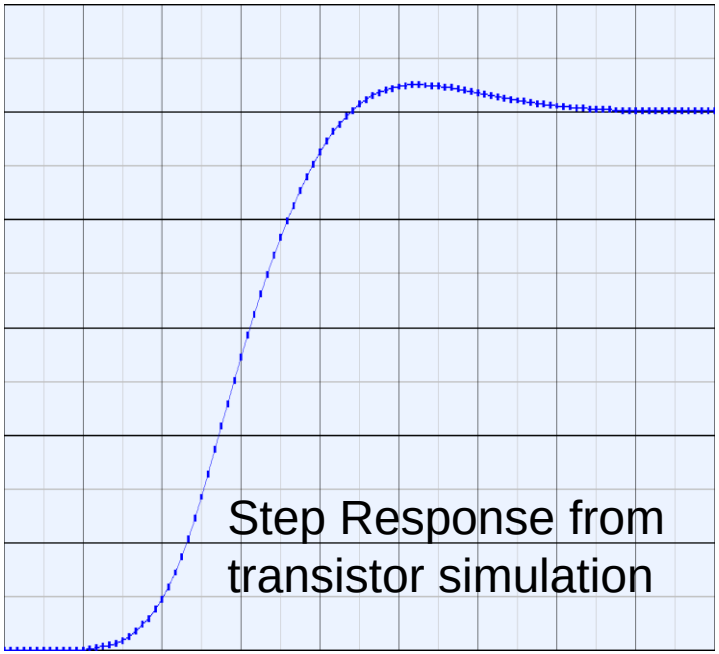
1.Generate Step Response from transistor simulation

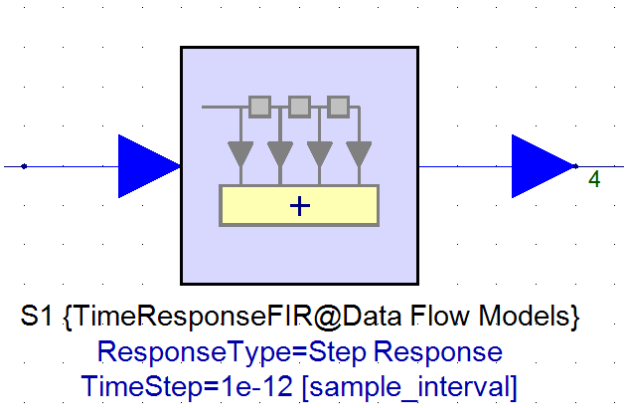
2.Generate AMI model using EDA tool

3.Compare



Step Response Model

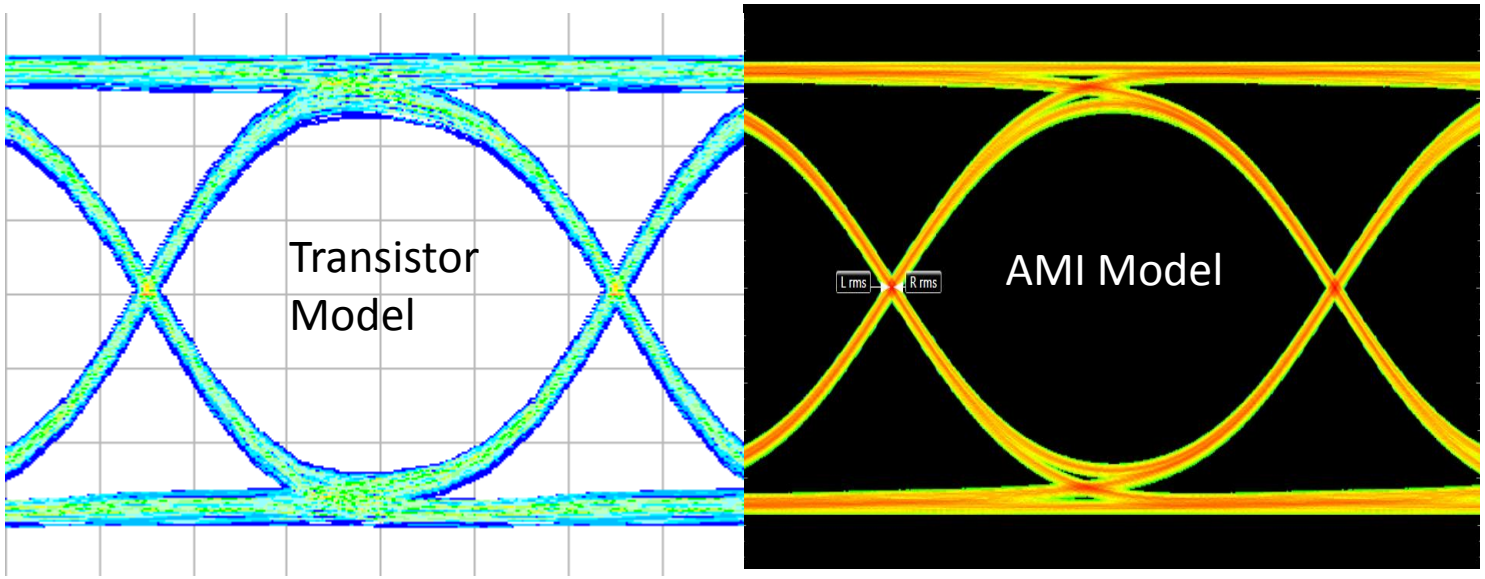




FIR filter with Step Response Input

Correlation

transistor model vs. AMI model



Excellent match between transistor simulation and AMI model

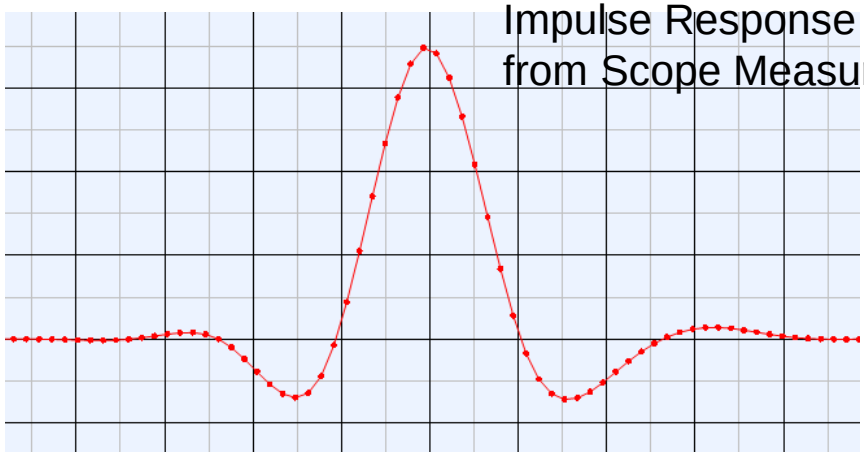
Good faith in model-generation methodology!

Measurement vs. AMI Model

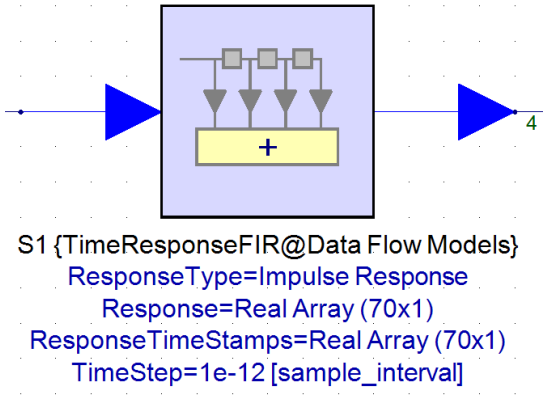
Steps-

1. Measure waveform
2. De-embed Channel
3. Output Impulse response

Impulse Response Model



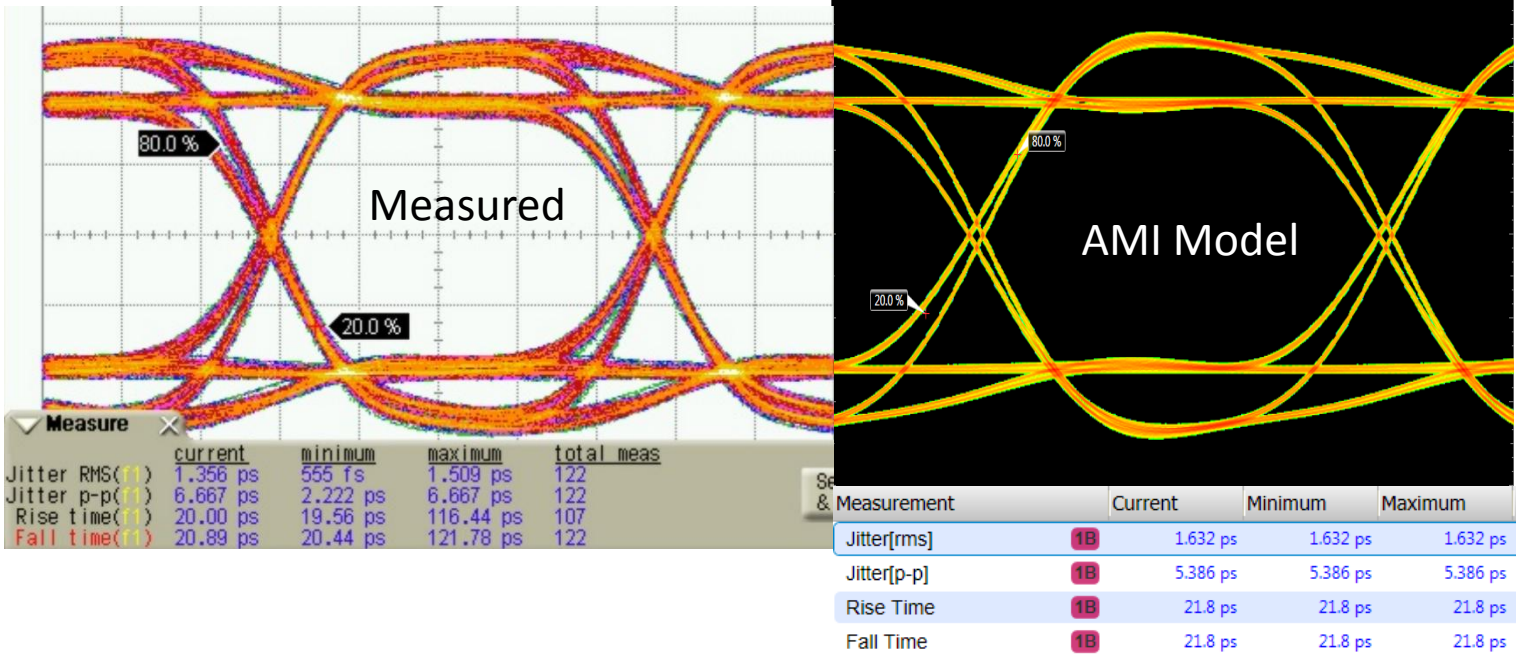
Impulse Response derived from Scope Measurement



FIR filter with Impulse Response Input

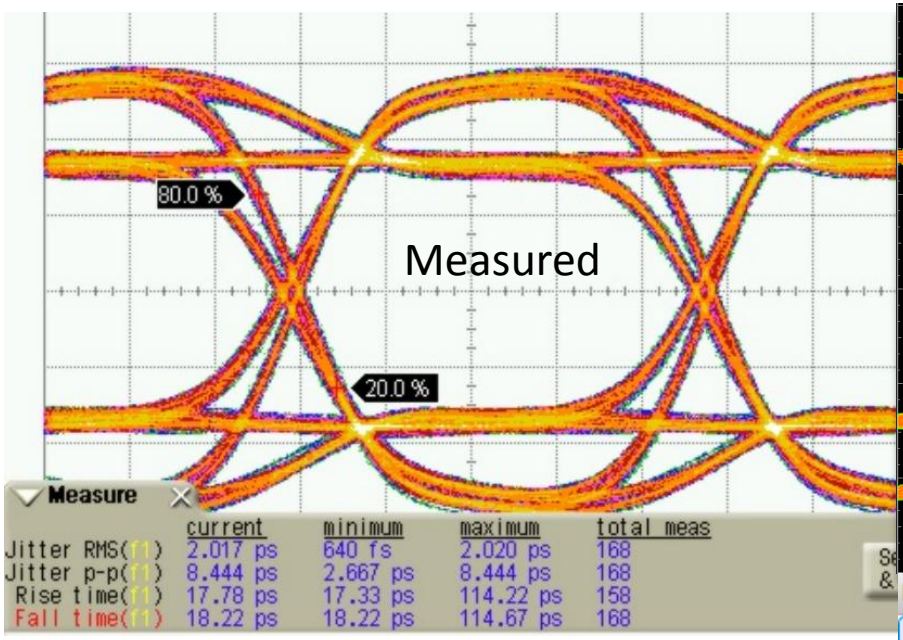
TX Correlation Measured

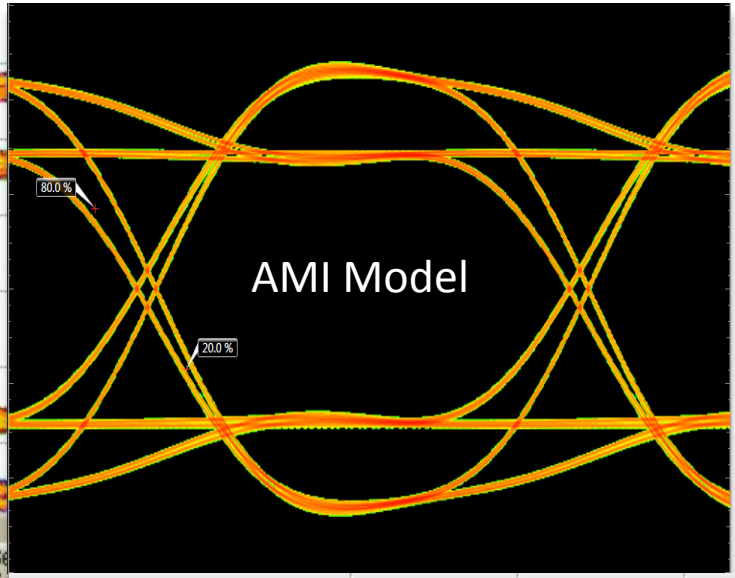
emphasis #1: tap 0, 1, -0.2



TX Correlation Measured

emphasis #2: tap 0, 1, -0.25





Measurement		Current	Minimum	Maximum
Jitter[rms]	1B	2.160 ps	2.154 ps	2.162 ps
Jitter[p-p]	1B	6.464 ps	6.248 ps	6.464 ps
Rise Time	1B	20.4 ps	20.4 ps	20.4 ps
Fall Time	1B	20.4 ps	20.4 ps	20.4 ps

Benefits of ESL Design Flow

Automated AMI-Model Generation

1. Complete “Automation” of Code-generation and Model Compilation
   a task that routinely takes months because of its complexity

2. Basic building blocks that can used to start model development
   FIR/IIR filters, FFE, DFE, CDR etc.

3. Easily customize models to include custom IP
   Custom C++ and Math-Lang