FIRST-PASS SYSTEM SUCCESS

APPLICATION WORKSHOPS FOR HIGH-PERFORMANCE ELECTRONIC DESIGN

A Modular Platform for Accurate Multi-Gigabit Serial Channel Validation

Presenter: **Andrew Byers**

Ansoft Corporation

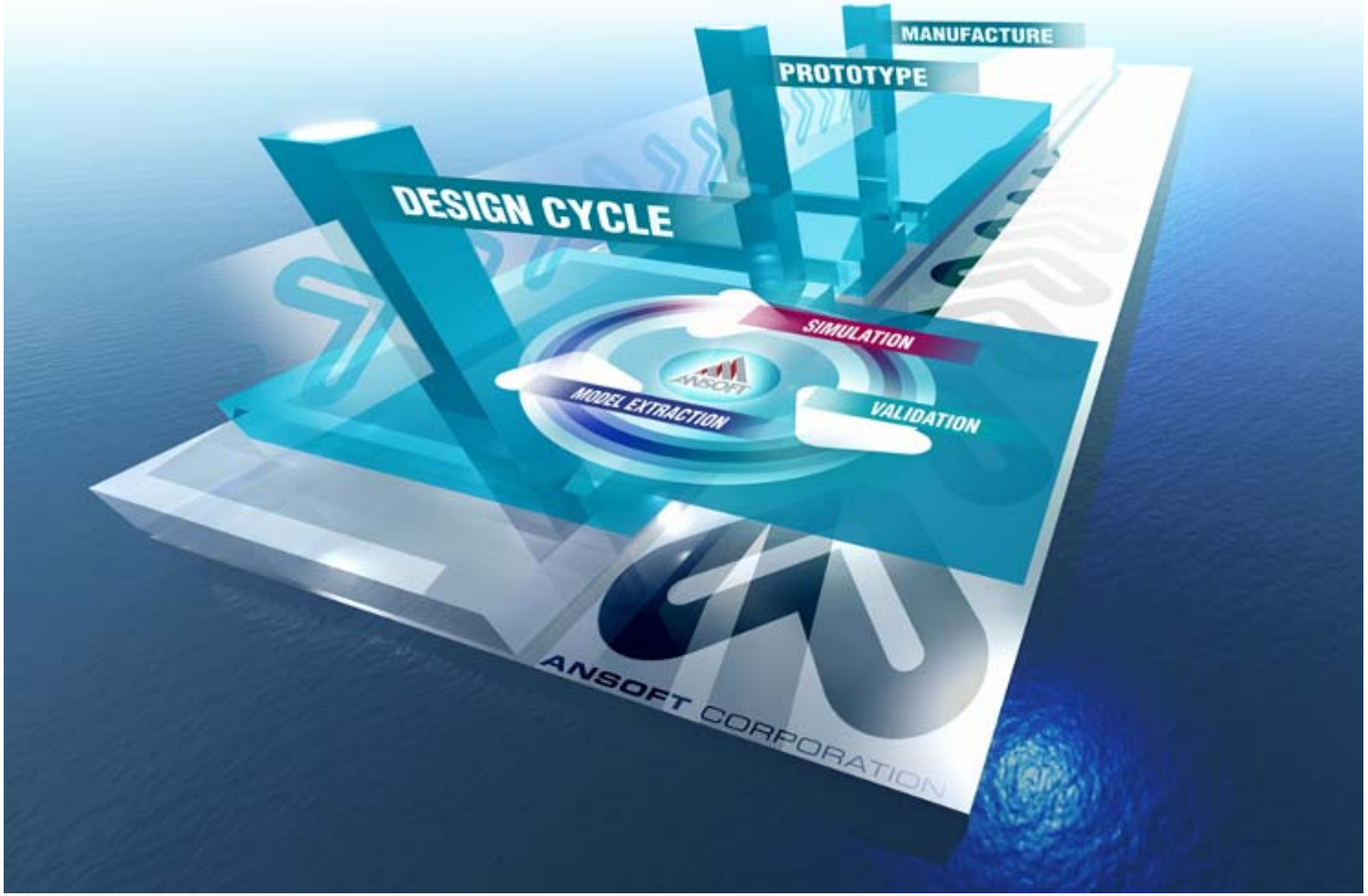
Tektronix®

Enabling Innovation

High Performance Electronics: Technical Challenges

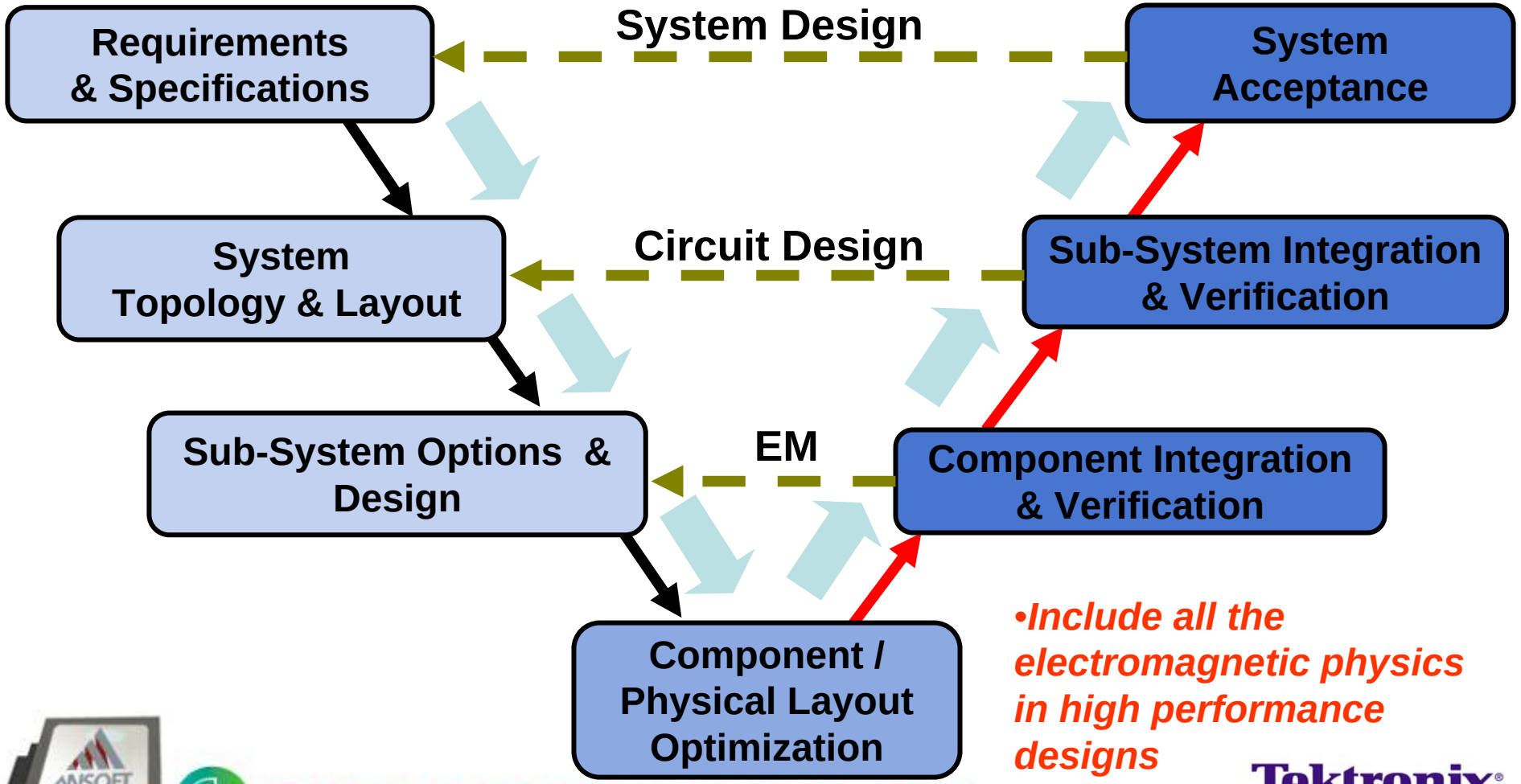
- Faster data rates in increasingly complex systems
  - ***Accuracy:*** capture all high-frequency phenomena
  - ***Capacity:*** handle large problems that were previously difficult to consider
- System-level consideration
  - Significant interactions between sub-systems need to be considered
  - System-aware design considerations lead to improved performance, reduced cost, and faster time-to-market
- Embracing powerful methodologies
  - ***Design Management:*** develop ability to quickly optimize component-level design while assessing system-level impact
  - Simulation and measurement interact at several key points in a modern design cycle – at component, channel, and system-levels

The Traditional Ansoft Methodology



The Traditional Ansoft Methodology

Converged EDA

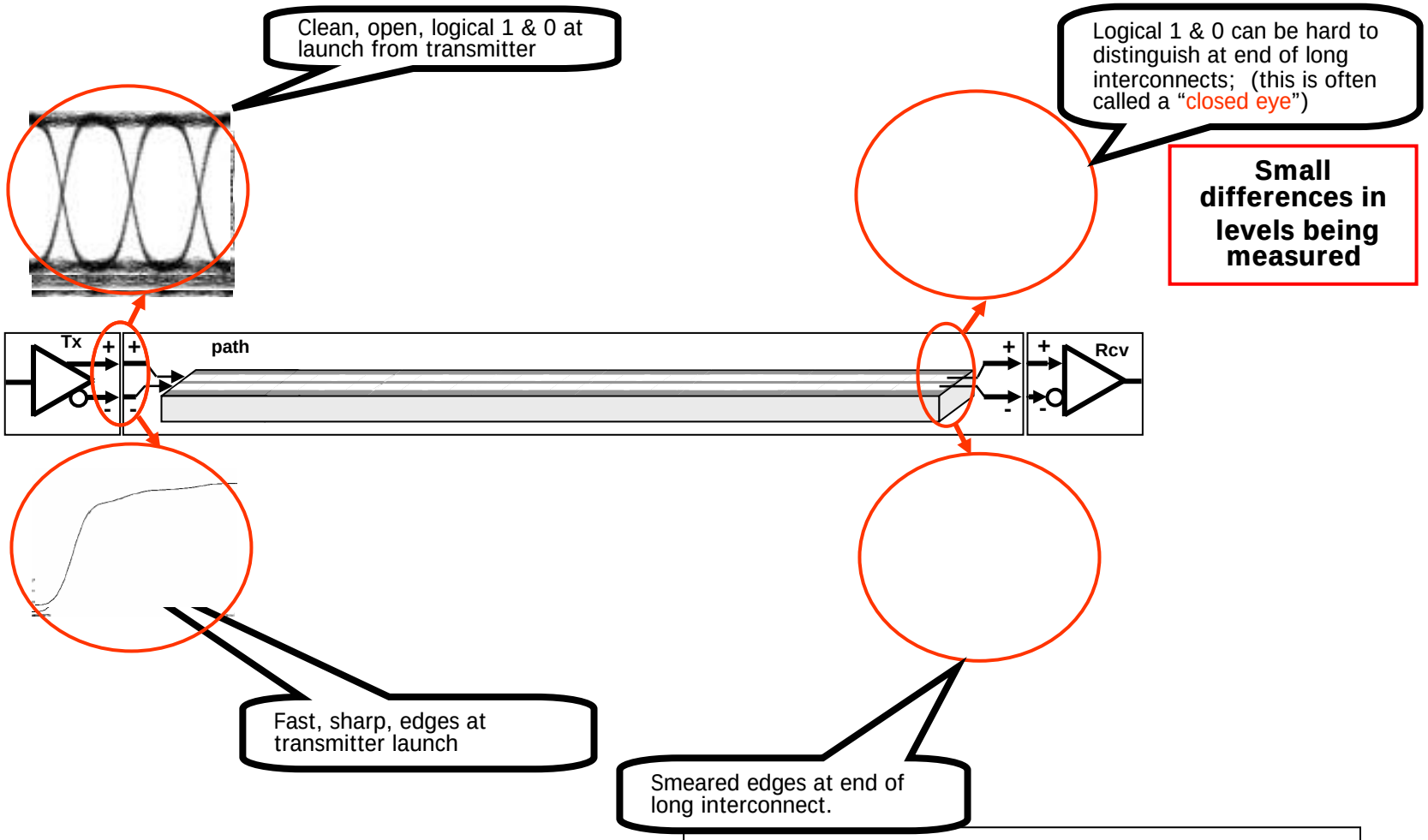


•Include all the electromagnetic physics in high performance designs

Agenda

- Traditional simulation example at the system-level
- Traditional validation of EM simulations at the component-level
  - Microstrip impedance-step
  - Chebyshev filter on PCB
- *Extension* of the simulation methodology with TDR-based models
  - Description of hybrid-methodology approach
  - HDMI test assembly example
- Revisit the 10GB/s PCB Equalizer System
  - Apply the hybrid methodology
  - Validate against measured results
- Conclusions

Fast Data Rates, More Loss, Smaller Signal Levels

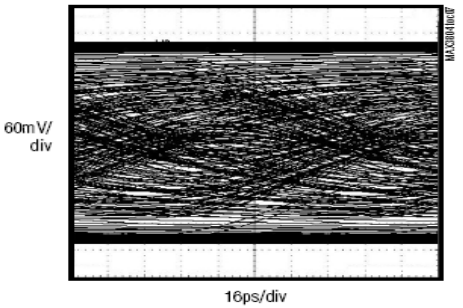


Reference Maxim Note HFDN-27.0 (Rev. 0, 09/03)

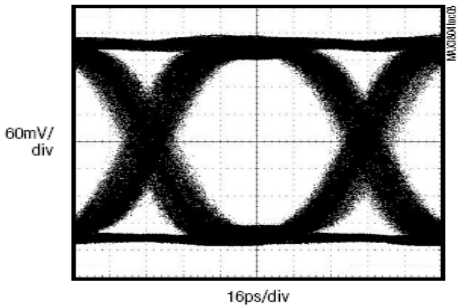
System-level case study:
Equalization to Improve the Signal Integrity of a 10 GB/s Channel

- Equalization at the receiver is quickly becoming necessary to resolve ("open") eye diagrams at multi-GB/s data rates.
  - >2-3 GB/s: for long backplanes and cable assemblies
  - > 5GB/s: in specs (PCIe 3.0, Gigabit Ethernet, etc.)

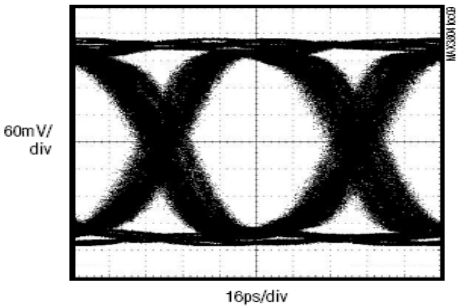
EQUALIZER INPUT EYE AFTER 30in OF FR-4
(2^7PRBS WITH 100 CIDs AT 10.7Gbps)



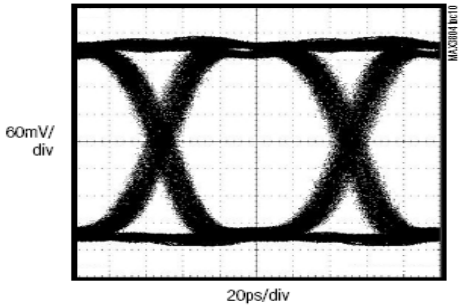
EQUALIZER OUTPUT EYE AFTER 30in OF FR-4
(2^7PRBS WITH 100 CIDs AT 10.7Gbps)



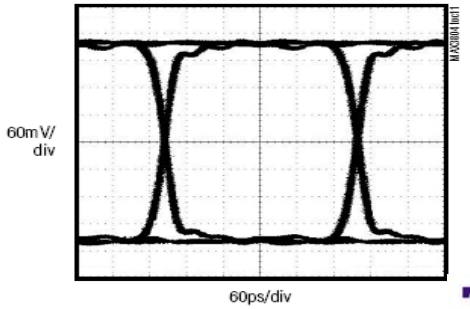
EQUALIZER OUTPUT EYE AFTER 30in OF FR-4
(K28.5 AT 12.5Gbps)



EQUALIZER OUTPUT EYE AFTER 24ft
OF RG-188/U COAXIAL CABLE, SINGLE ENDED
(2^7PRBS WITH 100 CIDs, 9.953Gbps)



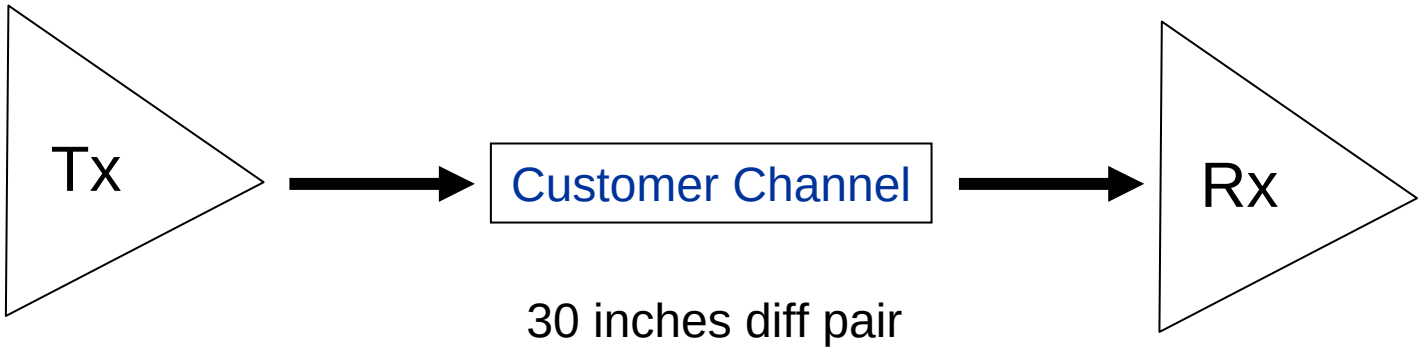
EQUALIZER OUTPUT EYE AFTER 30in OF FR-4
(2^7PRBS WITH 100 CIDs AT 3.2Gbps)



Maxim:
MAX 3804
equalizer

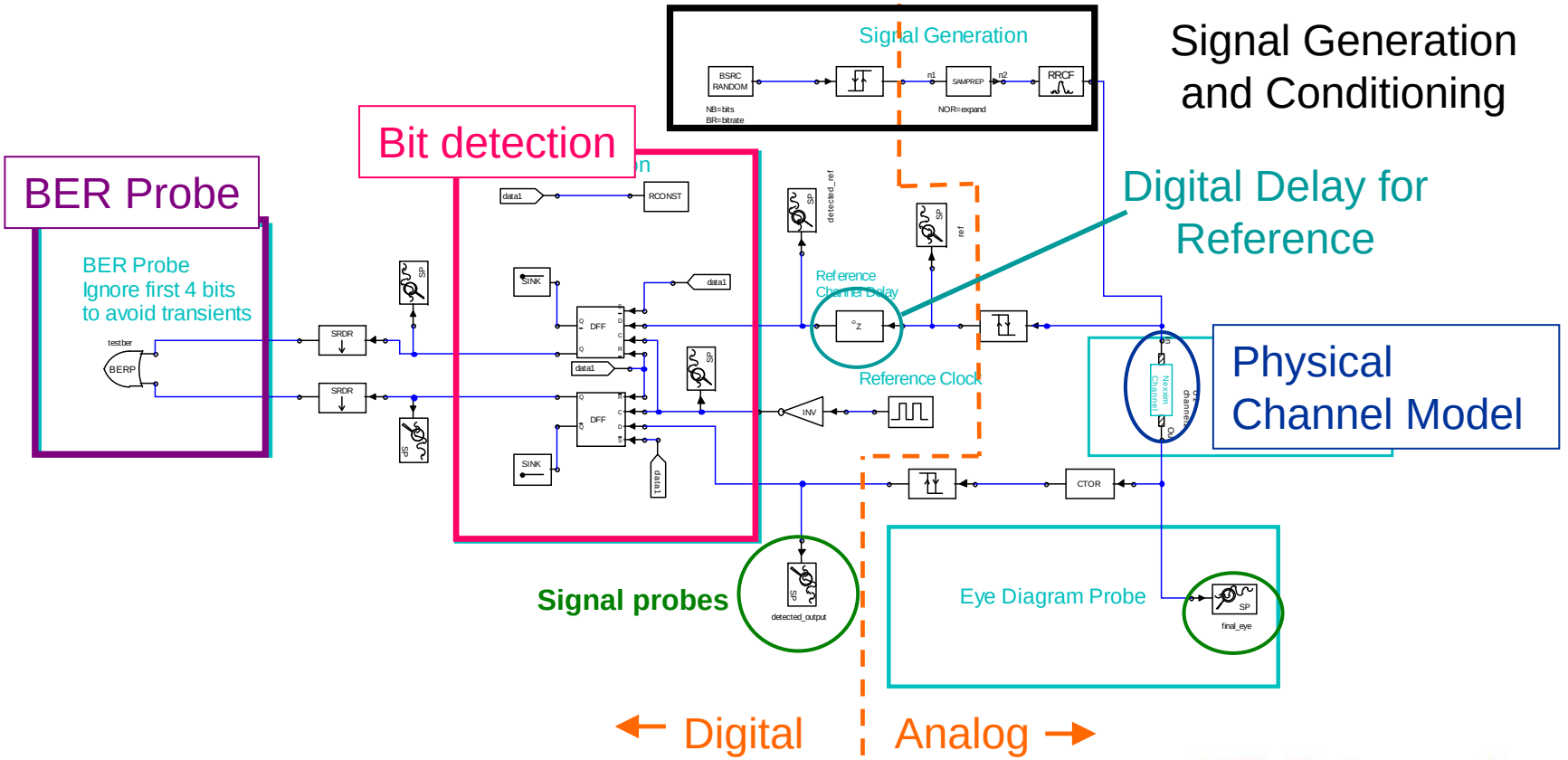
System-level simulation

- Goal: Create a reusable (modular), channel "test" framework for evaluating the performance of selected components.

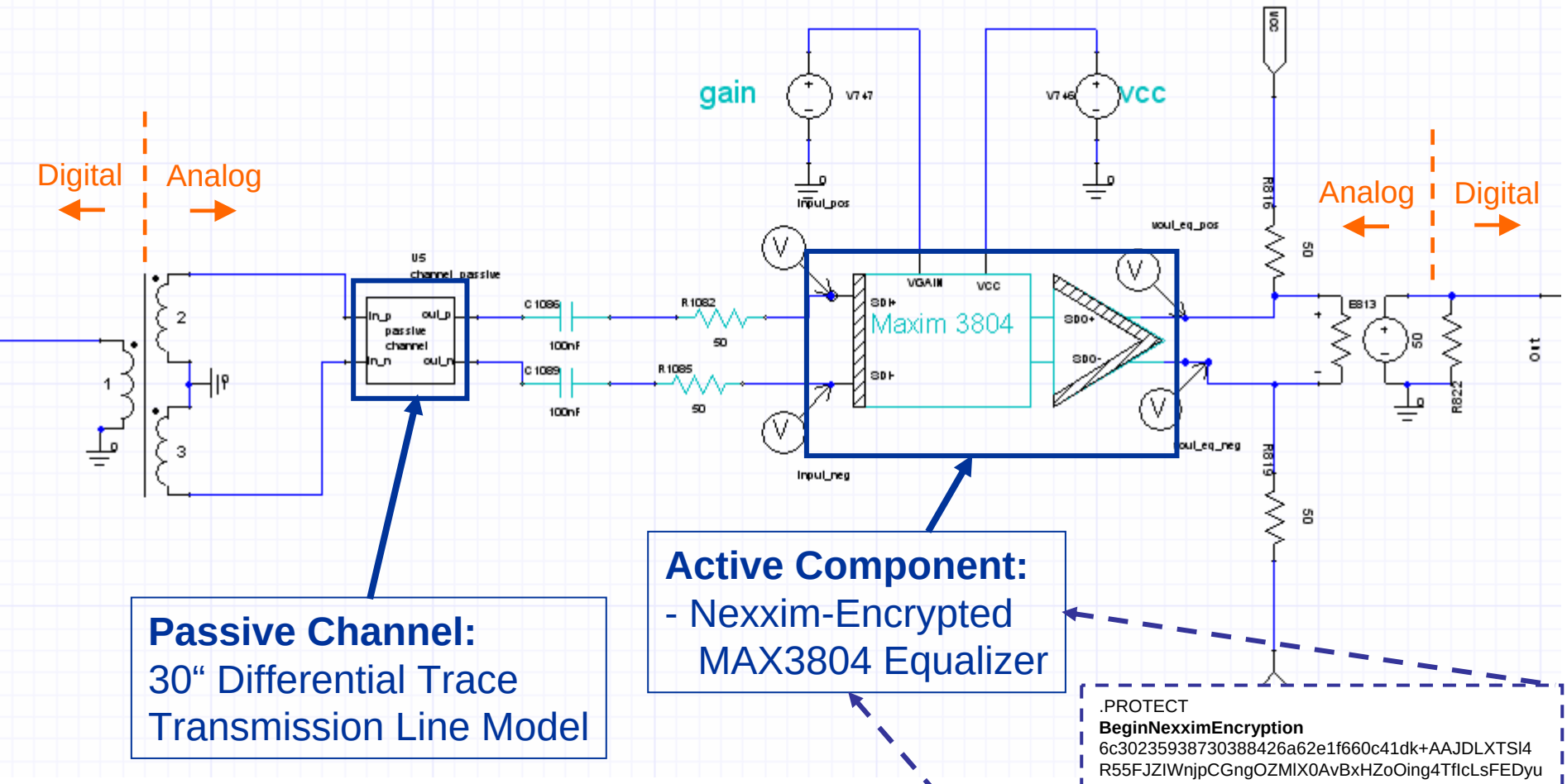


Provide the Framework

- Provides a way to test Maxim component (3804) that “opens the eye” at receiver end of the high-speed differential channel.
- Emulates a ***test bench environment*** to rapidly change channel lengths and components to test the equalizer under different conditions.



Sub-system:
Passive Channel + Equalizer

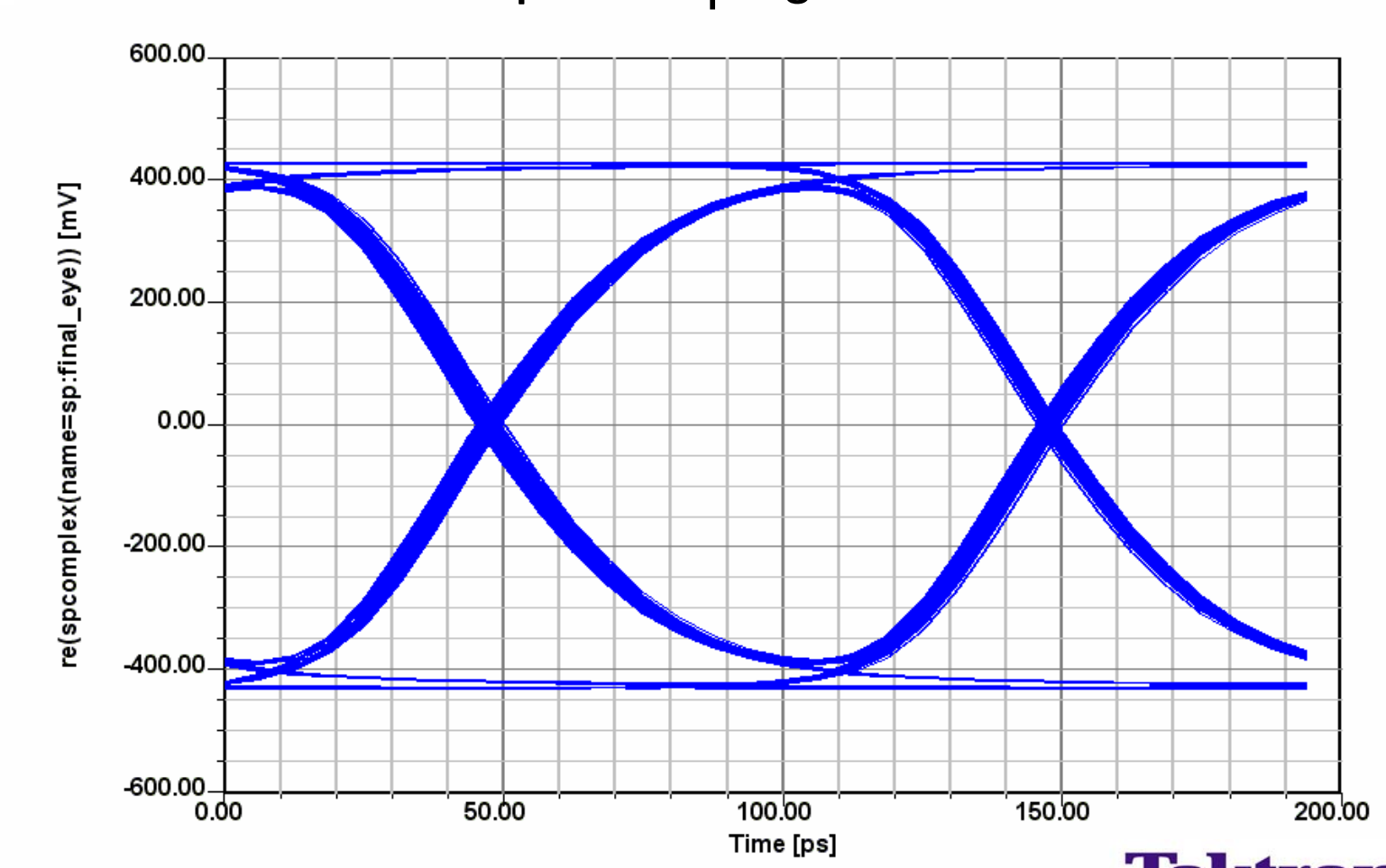


Passive Channel:
30“ Differential Trace
Transmission Line Model

Active Component:
- Nexxim-Encrypted
MAX3804 Equalizer

.PROTECT
BeginNexximEncryption
6c302359387303884 26a62e1f660c41dk+AAJDLXTSl4
R55FJZIWnjpCGngOZMlX0AvBxHZoOing4TfIcLsFEDyu
2jMAgUAVXdZmJ7ZV6F7Nn2L
ArrWRTFAF3zrWMORM6pWd83l21o6l9Bb7vcH2YxpTH
walueD5t/FCRjw2ZwYEC/1C4PAmkYr36zmUAa
6POVn7wt1PFl6XiDT4kaWyDQ9PLDWyJEfJnyOUuGsl
uc5T1962PdM8tG4khbbmbUghpXs/7nzMvK/i3
0L5oF9MR6m48krSOuN9TFXXOPI3tduBeICbh7WqDtM
2VlcNP8FY3t5X4Ji7dCOfI5S4ayW5zlPX3rY9
.UNPROTECT

System Simulation Test:
30“ FR4 transmission line model



Validation and *Extension* of the Ansoft Methodology

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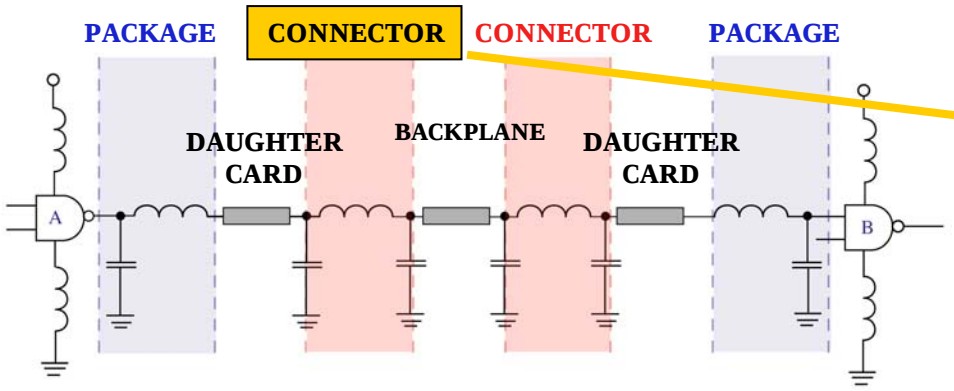
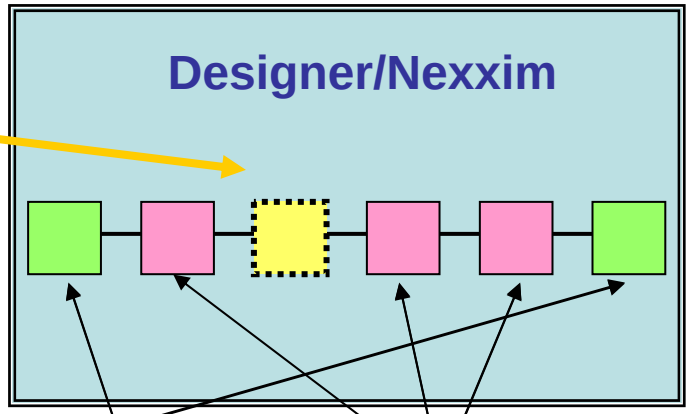
Tektronix-Ansoft Partnership

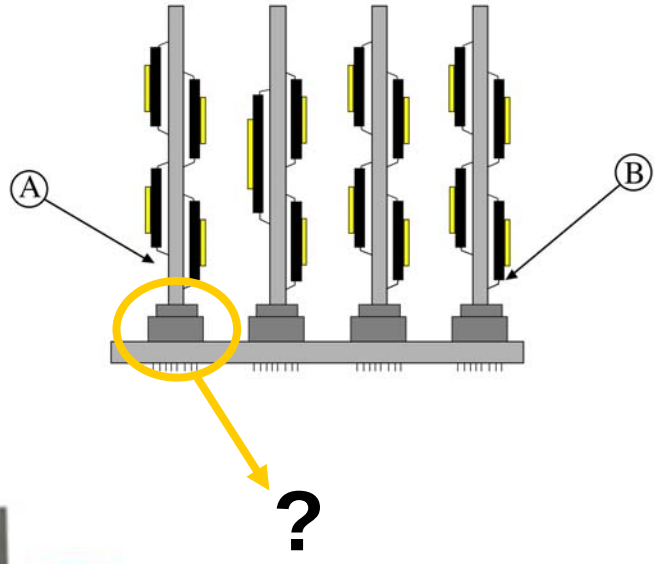
- Both companies recognize the importance of a practical design methodology that adequately supports emerging standards
- Engineers trust that both measurements and simulations give correct answers in a timely manner
- Therefore, we have defined a modular design platform comprised of both simulation and measurement components to address these demanding market needs

Modular Platform Conceptual Example

Connector model not available!

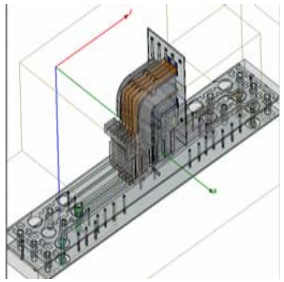


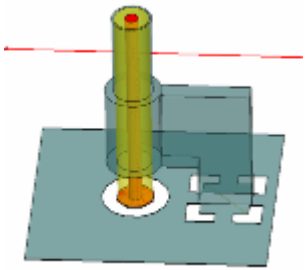




Active Devices

Passive components





Solution:
Simulation and Measurement Together

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Hybrid approach

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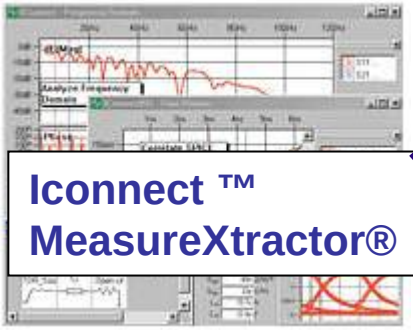

Iconnect ™
MeasureXtractor®

TDR-based model

frequency-domain

time-domain

Designer/Nexxim

DSA8200

Validation:
Compare measurements and simulations at important milestones.

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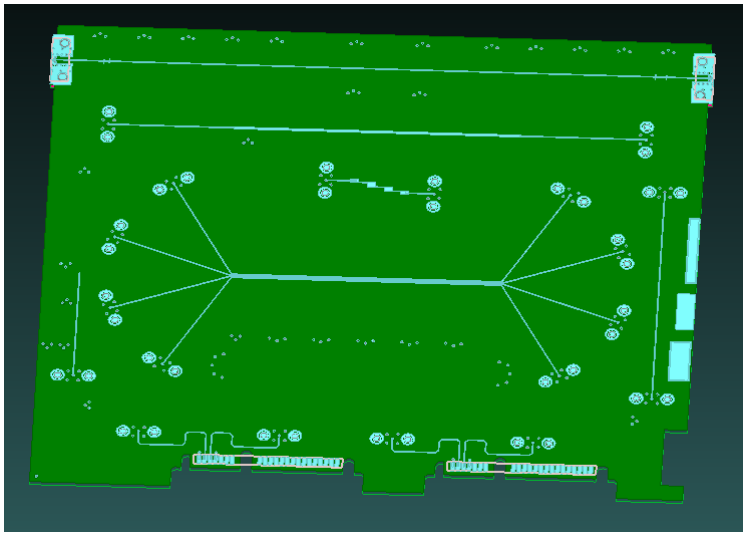
Component-level: Model Validation
TDR Test Board

Two structures are tested:

1. Microstrip Impedance Step
2. 10GHz Chebyshev Filter



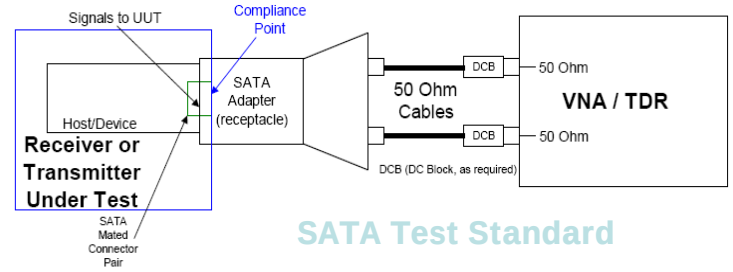
Tektronix Serial Data Network Analysis

TDR-based industry accepted solution for S-Parameter Analysis

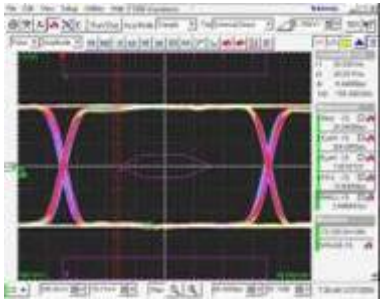
Highly accurate impedance measurements

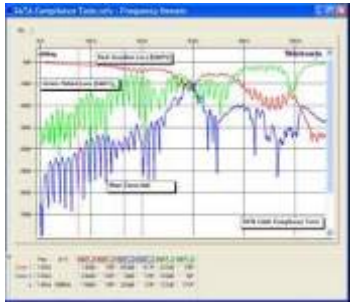
1M record length enables measurements of long interconnects at higher frequency

Complete technical support for high-speed serial data technologies



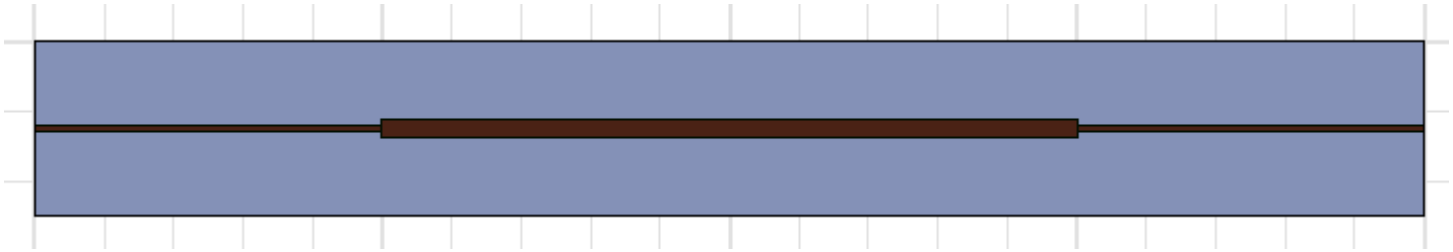
SATA Test Standard





Standard	Data Rate	Differential Return Loss	Differential Insertion Loss	Differential Crosstalk
SATA II	3 Gb/s	*	*	*
PCI Express 1.0	2.5 Gb/s	*	*	-
PCI Express II	5 Gb/s	*	*	*
HDMI 1.3	.75 Gb/s to 2.25 Gb/s	-	*	*
FC 1, 2, 4 Gb/s	1 Gb/s to 4.25 Gb/s	*	*	-
FB-DIMM II	4.25 Gb/s	*	-	-
Infiniband	2.5			
XAUI	3.125			

Component 1: Microstrip Impedance Step



Many Ansoft Simulation Options!

HFSS full solution -> S-parameter models

HFSS port solve -> W-element models

Designer PlanarEM

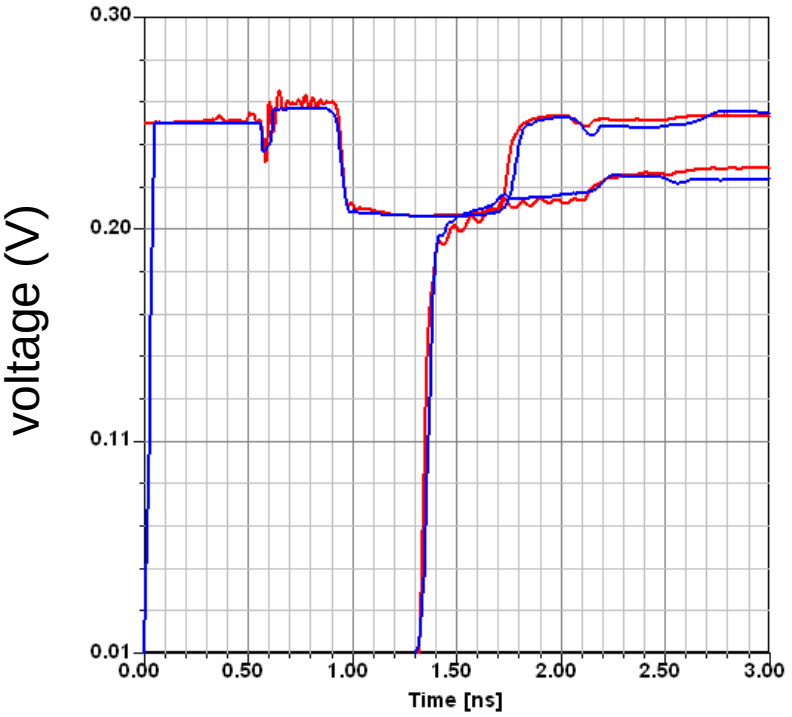
SIwave

Nexxim Built-in Transmission Line Models

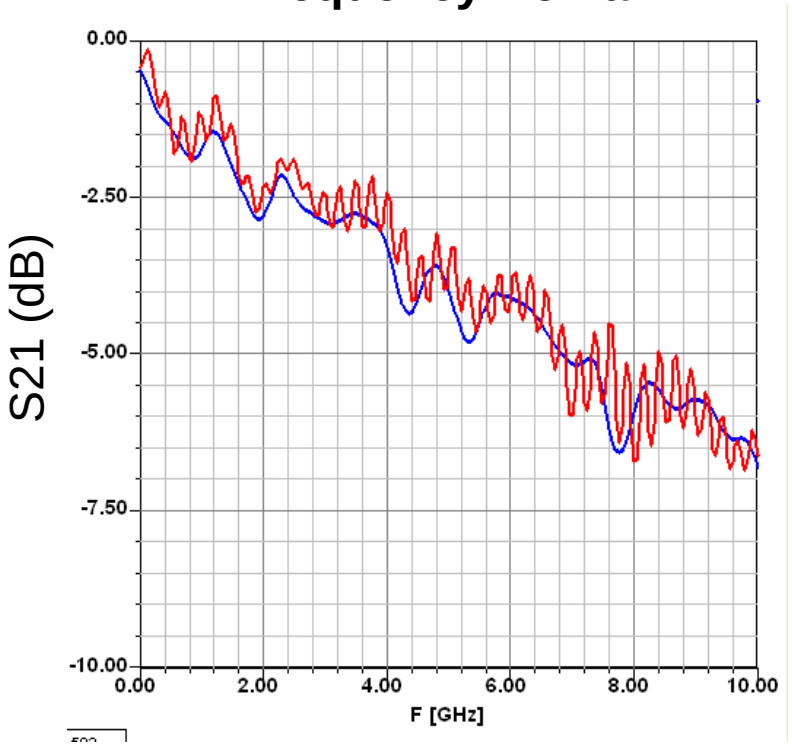
Q2D Extractor

Component 1: Microstrip Impedance Step

Time Domain



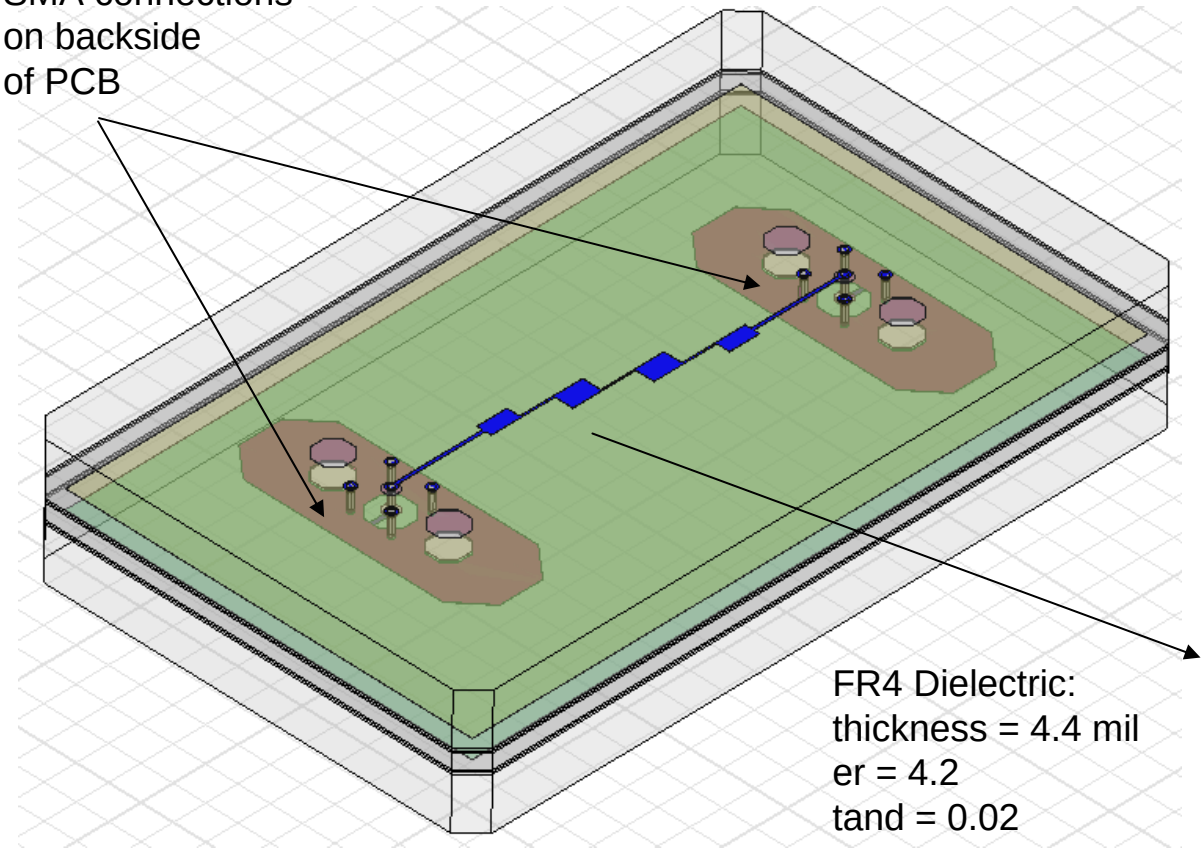
Frequency Domain



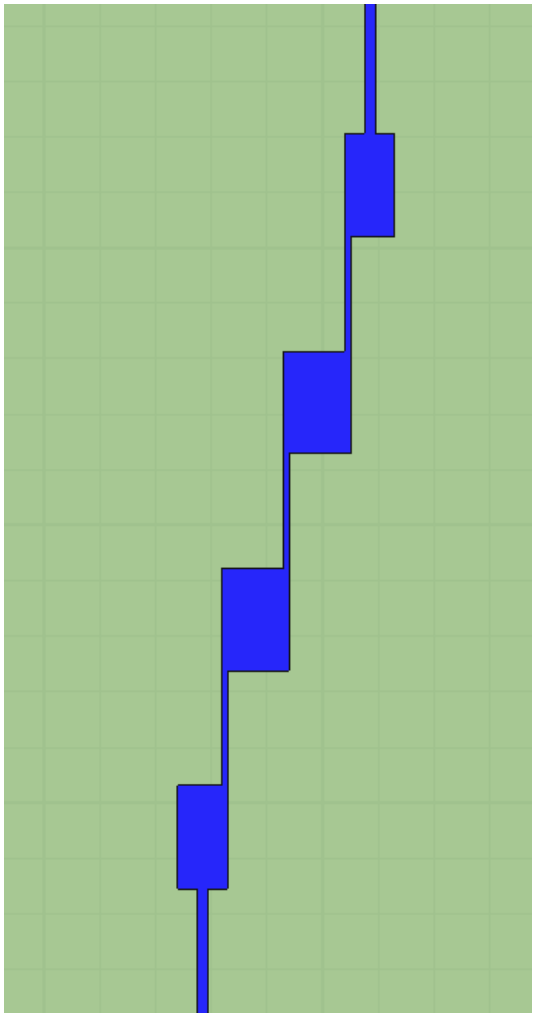
Built-in Tline Simulation
TDR-based Measurement

Component 2: 10 GHz Chebyshev Filter

SMA connections
on backside
of PCB

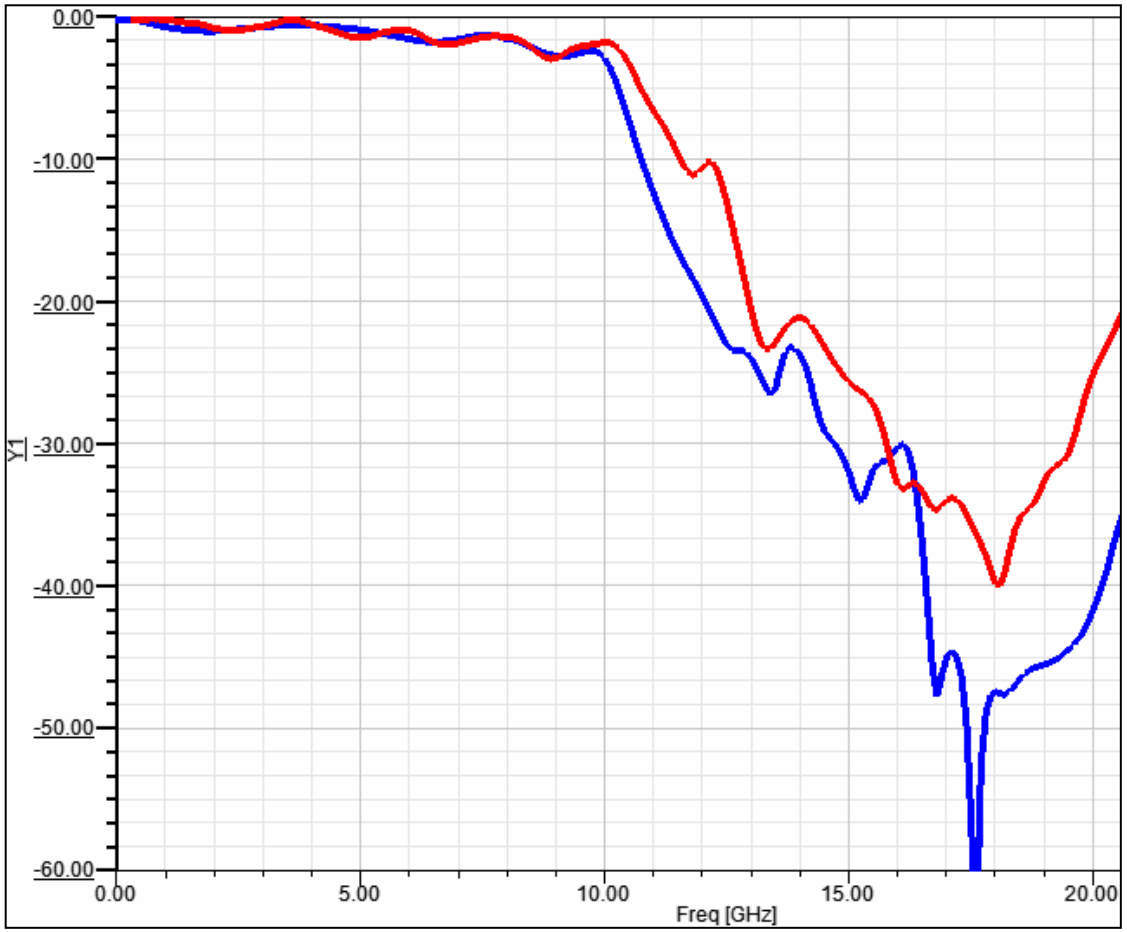


FR4 Dielectric:
thickness = 4.4 mil
er = 4.2
tand = 0.02



Component 2: Chebyshev Results

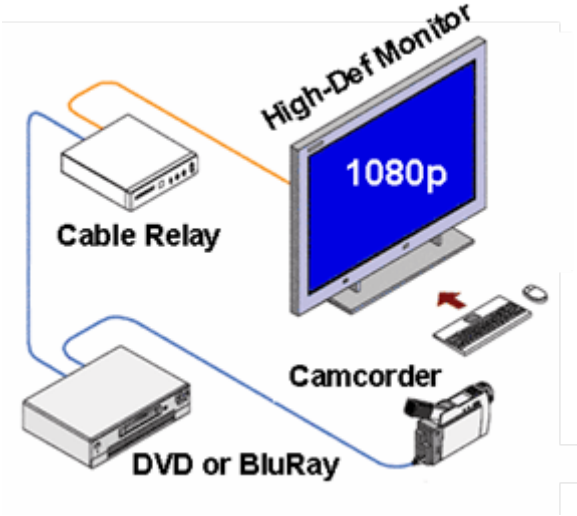
HFSS Simulation
TDR-based Measurement



Channel-level: Hybrid Method HDMI Assembly

- This case highlights the benefits of the modular, hybrid platform.
- TMDS (transition minimized differential signaling) is the serial-link spec used to transmit the data – SPEEDS.
- A HDMI Type-A Test Adapter (provided by Efficere*) is used to interface HDMI assemblies to measurement equipment.

Where HDMI May Be Used:



HDMI
HIGH DEFINITION MULTIMEDIA INTERFACE

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*Efficere Technologies - http://www.efficere.com/

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HDMI Full Channel

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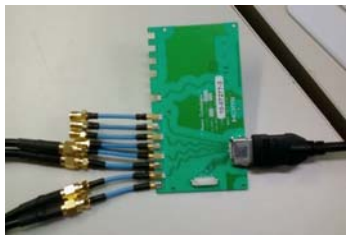


test adapter

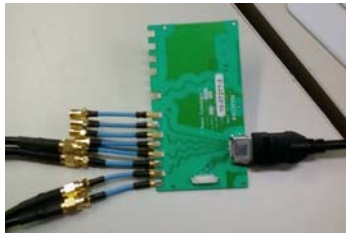
Instrumentation

DSA8200
w/ Iconnect

HDMI Assembly
(connectors + cable)

2.5m and 10m

test adapter



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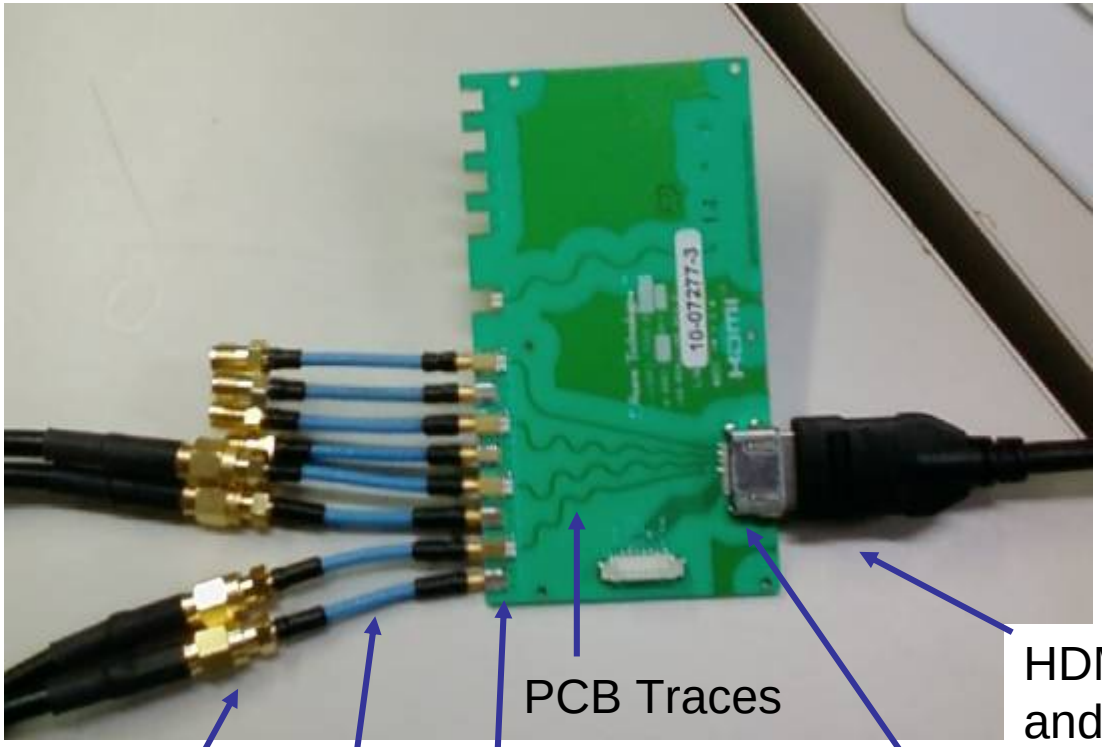
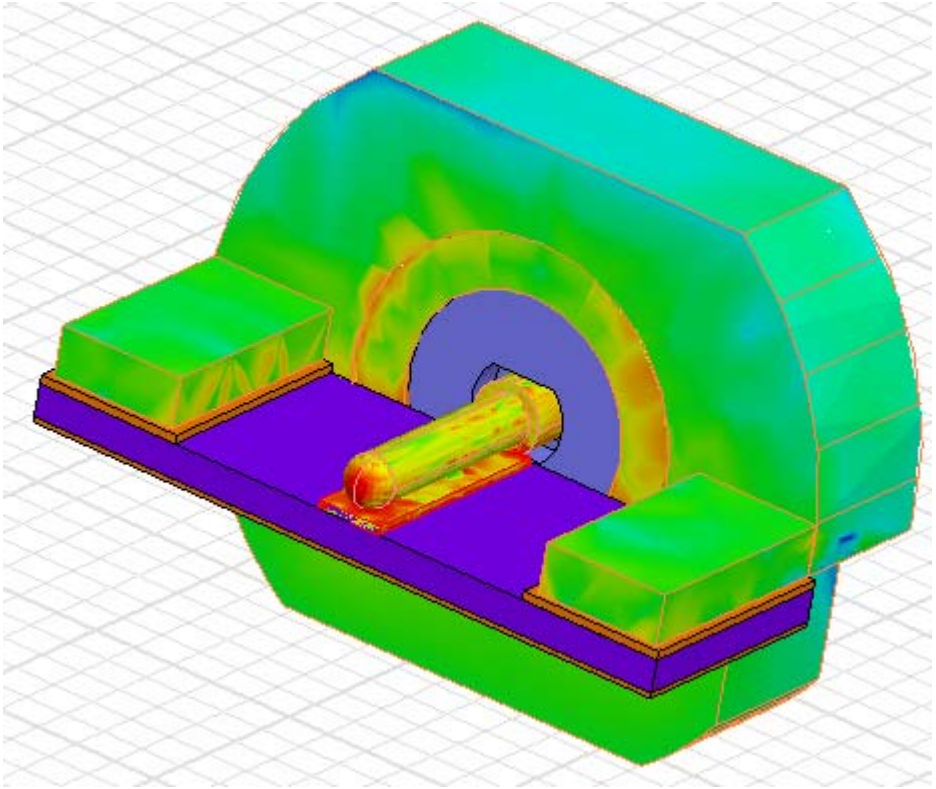
Test Adapter Details

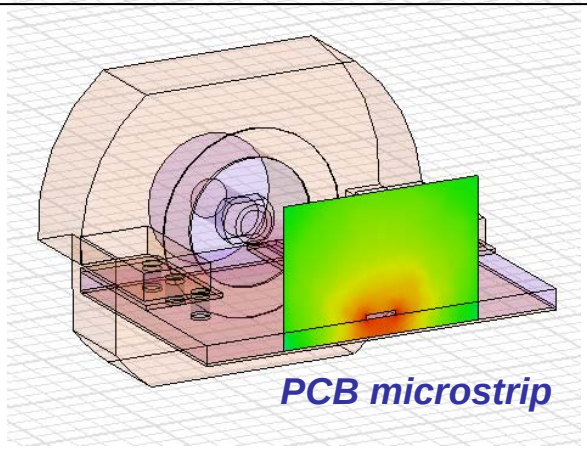
cable to Sampling Scope and TDR



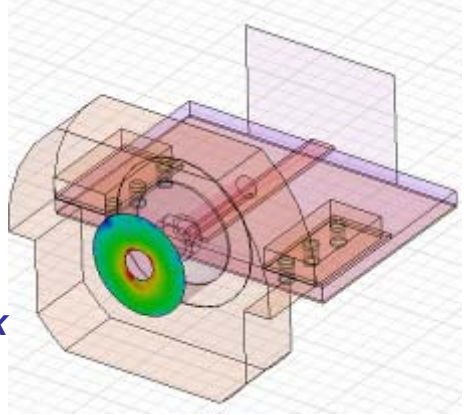
Test Adapter Design - HFSS

HFSS used to design and model the GPPO connector launch – virtual prototyping leads to industry-leading performance for adapter.



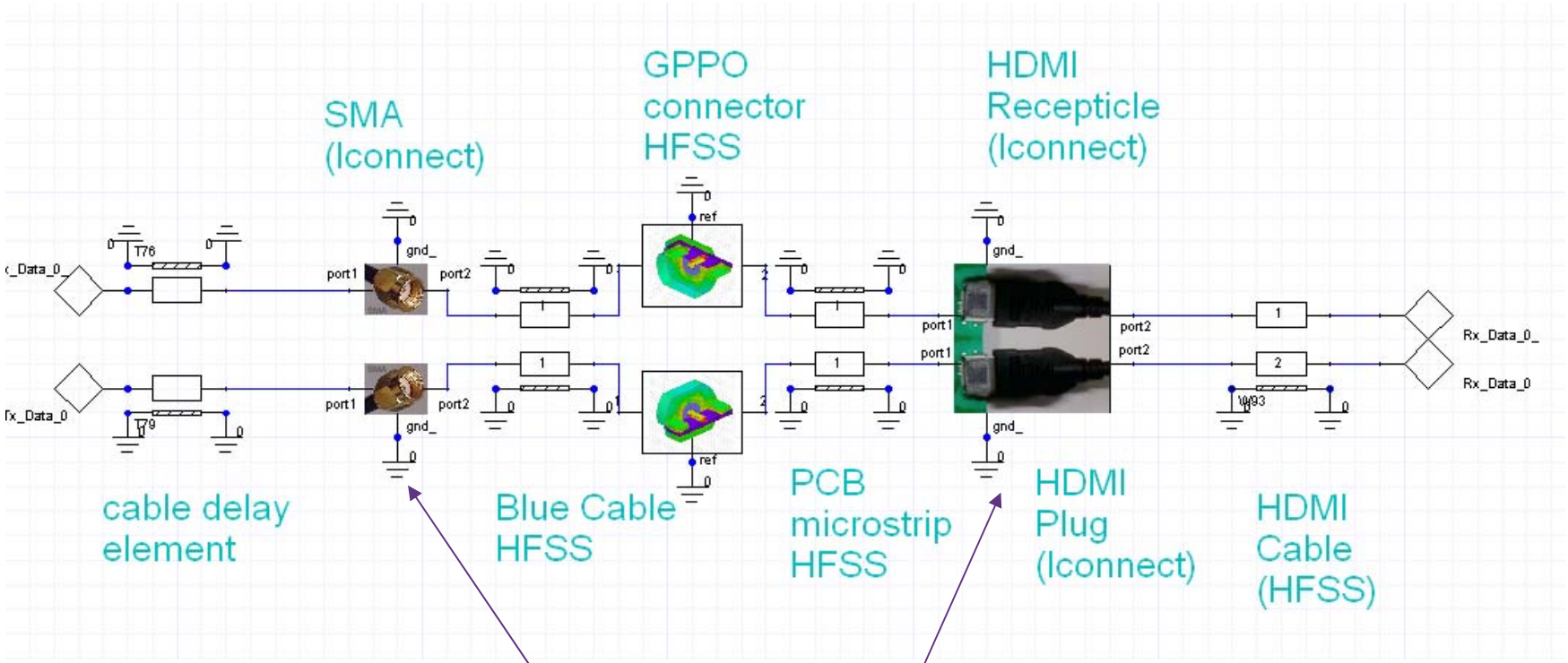


Transmission line (W-element) models were output from the HFSS waveport data.



So … three models with one simulation!

Channel-level Simulation: Two models are missing



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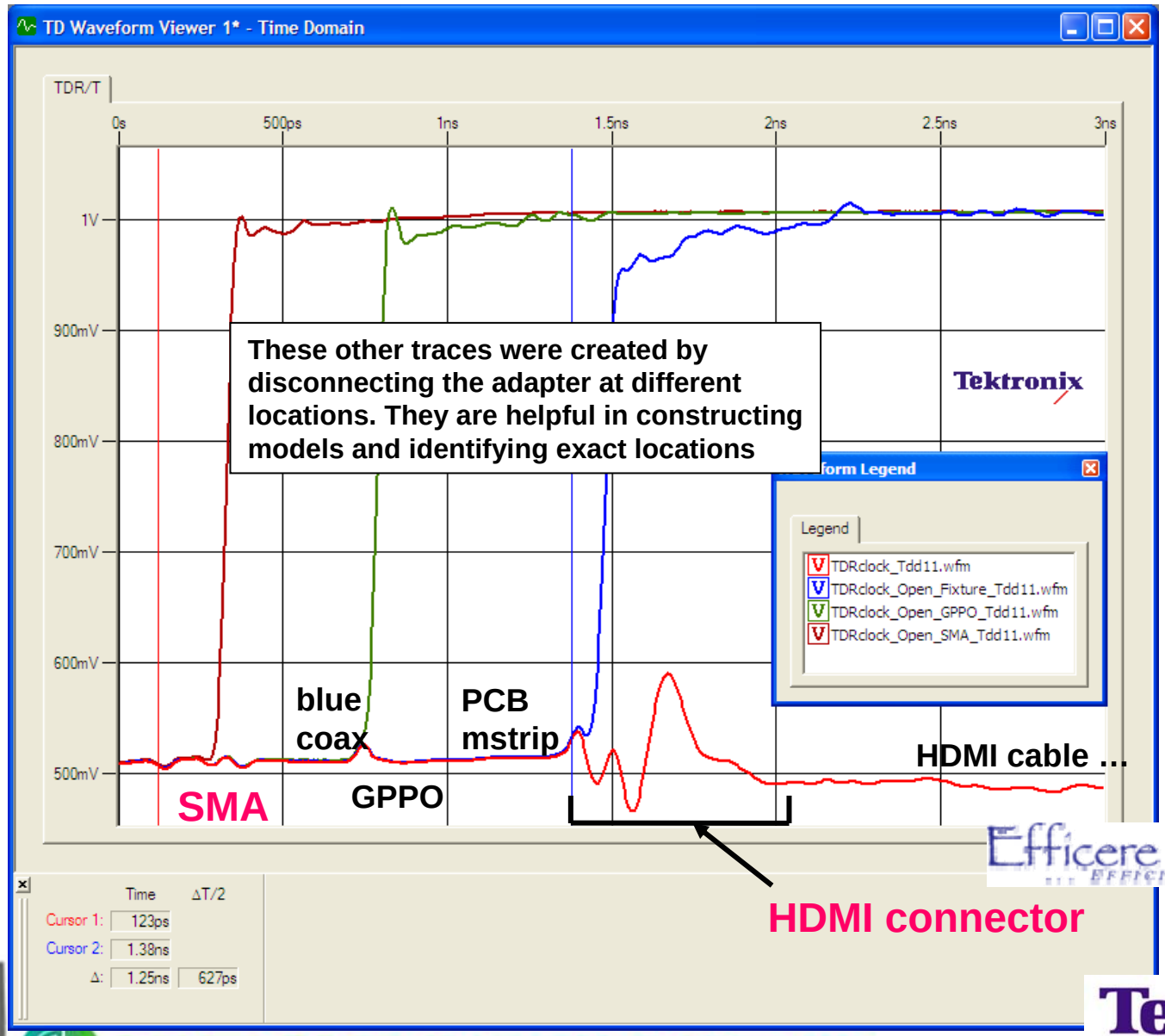
TDR Measurement Detail: Adapter



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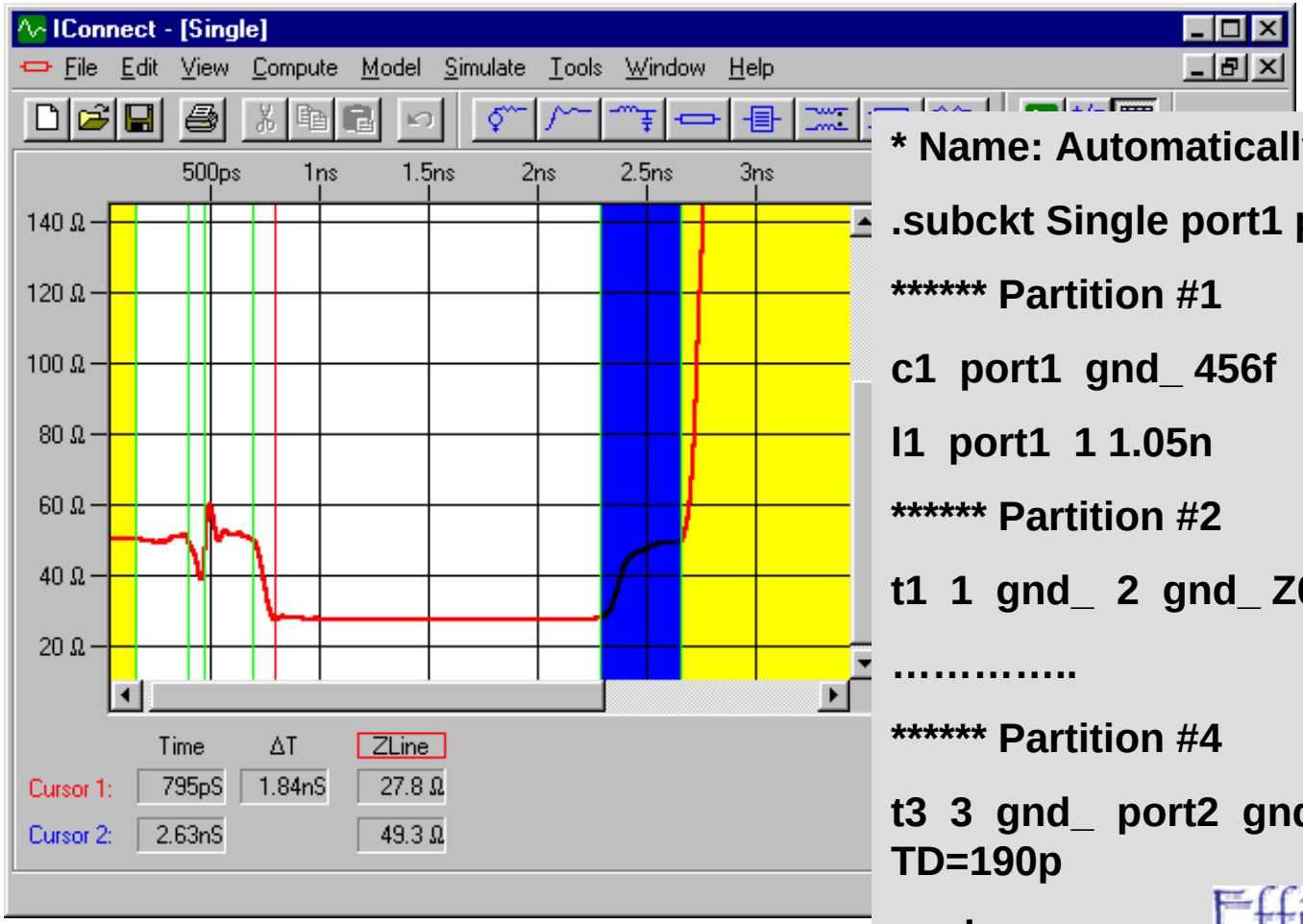
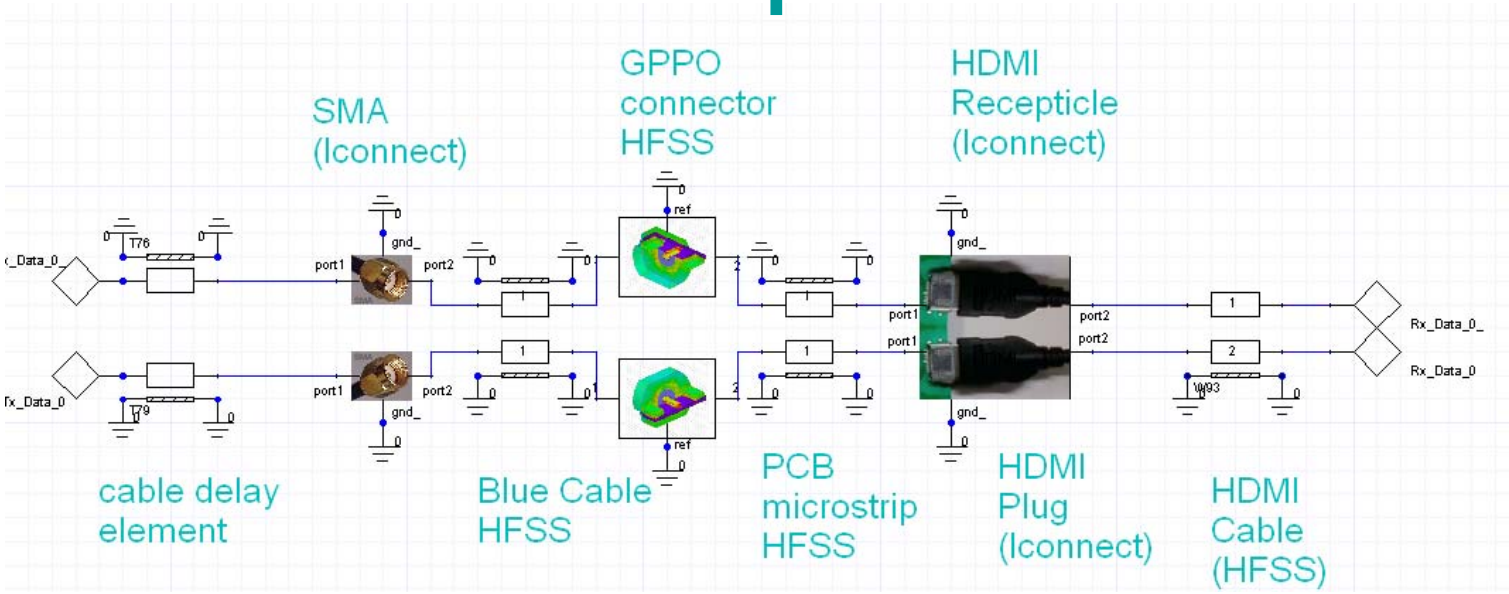
Extracting a model with Iconnect

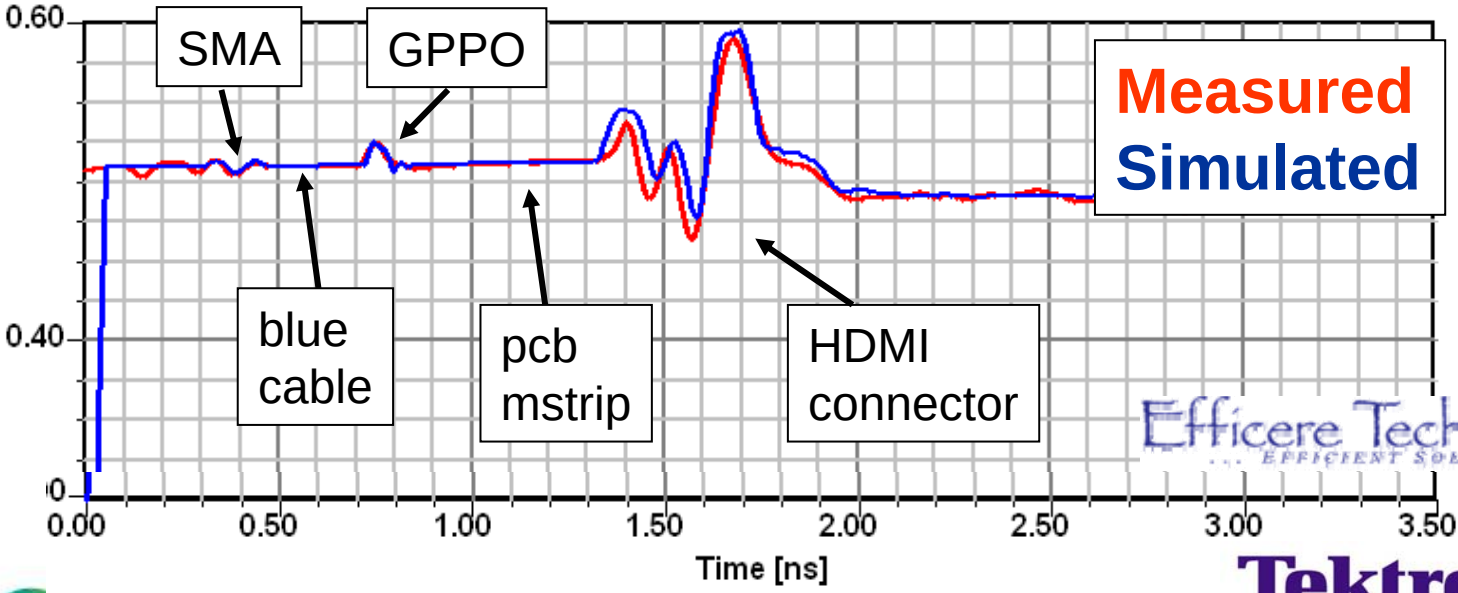



```
* Name: Automatically Generated
.subckt Single port1 port2 gnd_
****** Partition #1
c1  port1  gnd_ 456f
l1  port1  1 1.05n
****** Partition #2
t1  1  gnd_  2  gnd_ Z0=50.8 TD=125p
……..
****** Partition #4
t3  3  gnd_  port2  gnd_ Z0=48.2
TD=190p
.ends
```

Efficere Technologies™ … Efficient Solutions

HDMI Test Adapter TDR Results





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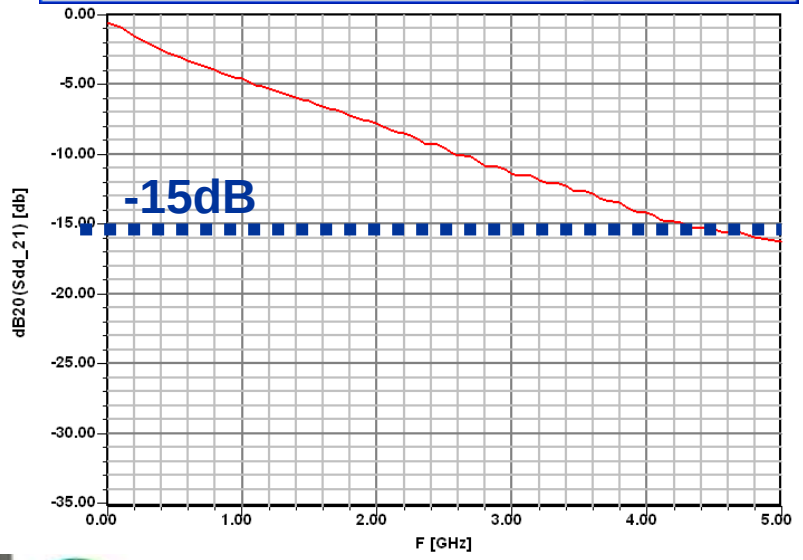
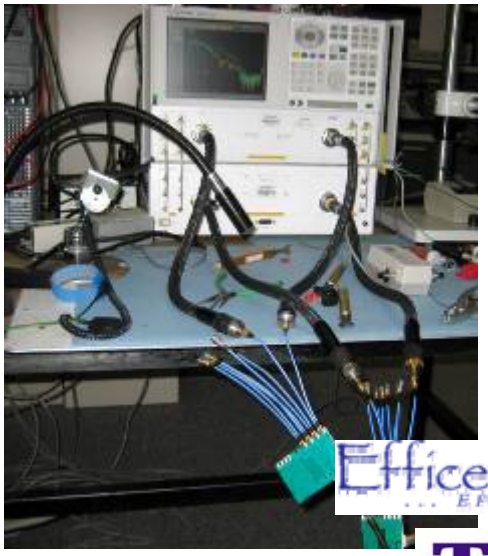
Full channel including 2.5m cable: TDR-based, VNA, and Ansoft Results





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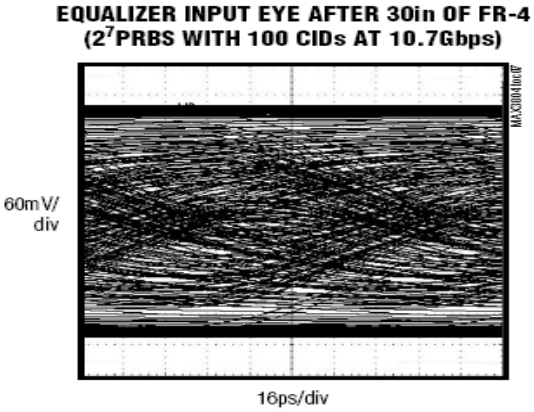
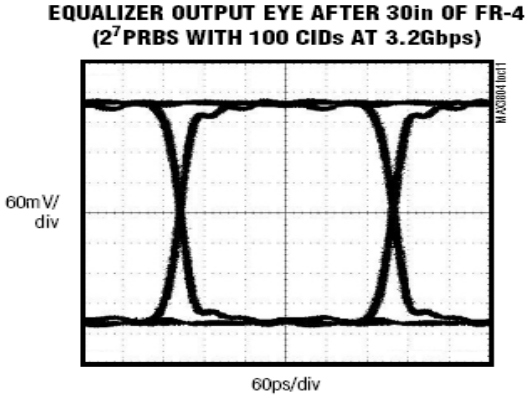
Revisit the System Simulation

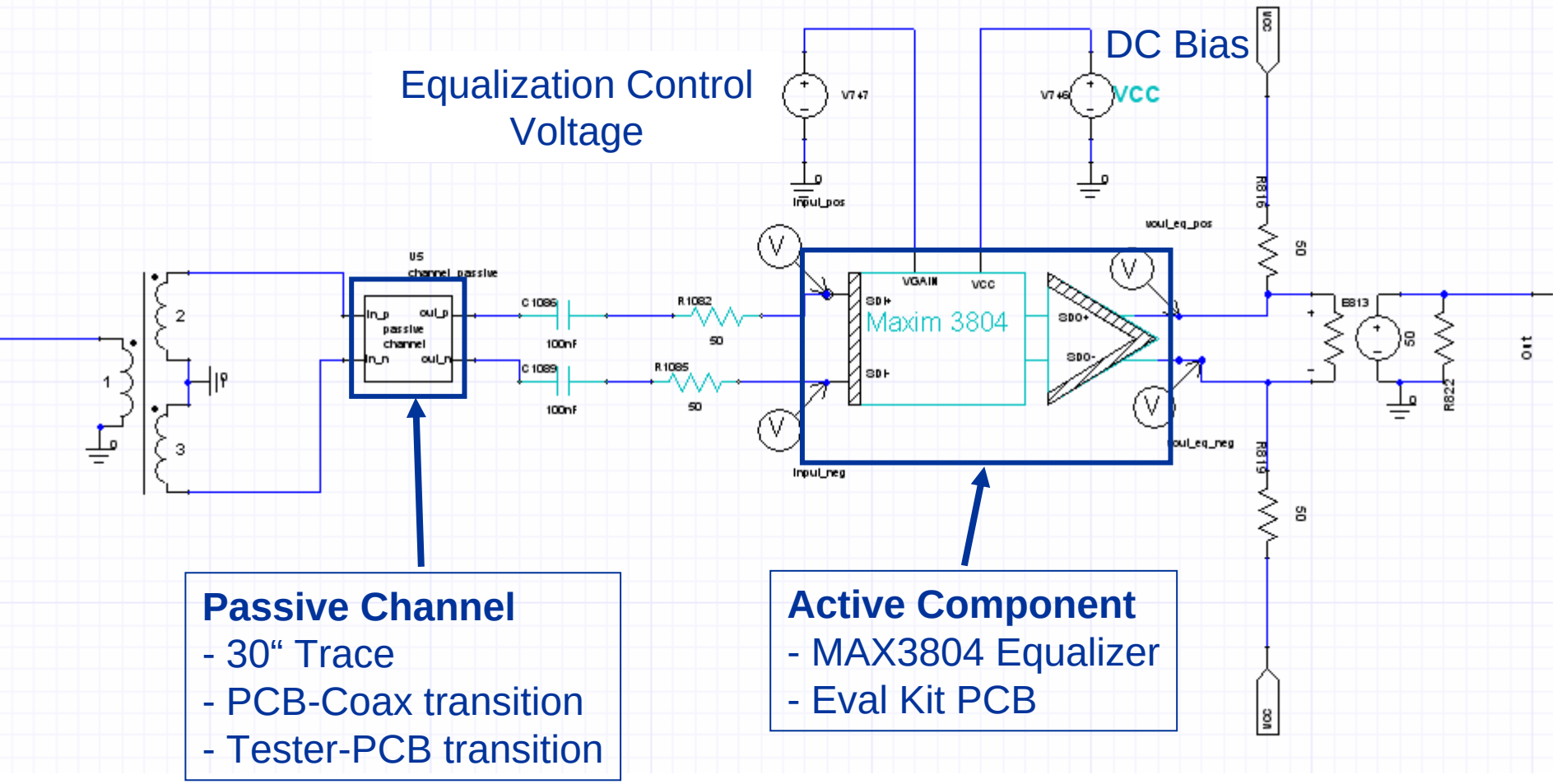
- Exercise the modular nature of the platform
  - Add Full-wave EM models
  - Verify against TDR models
  - Simulate entire channel – eye diagram





Actual Measured Channel:

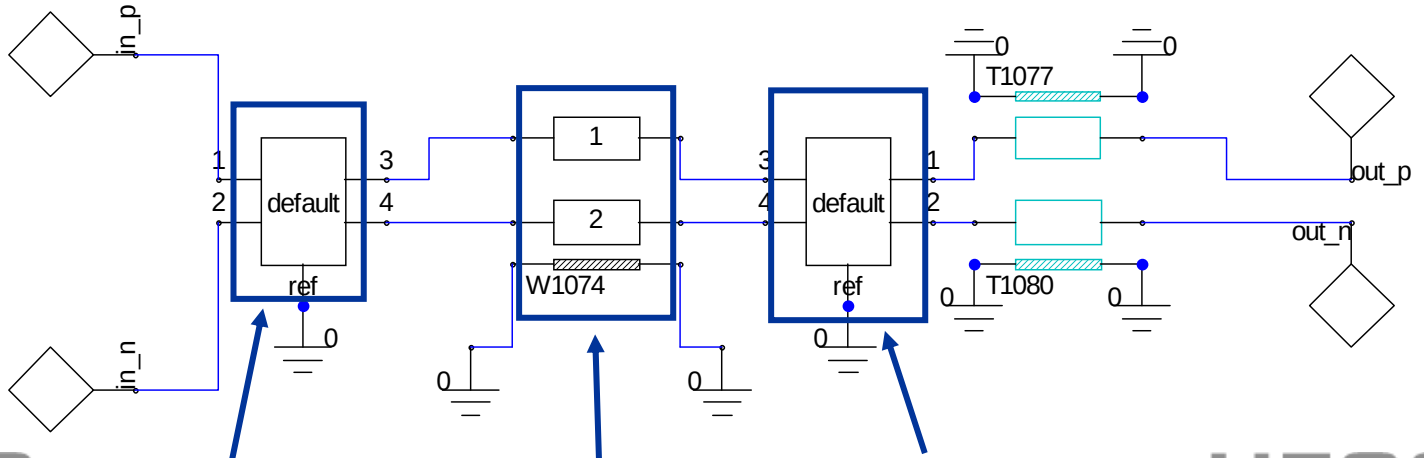
Includes *30“ traces*, *connectors* and *eval testboard*



Passive Channel
- 30“ Trace
- PCB-Coax transition
- Tester-PCB transition

Active Component
- MAX3804 Equalizer
- Eval Kit PCB

Measured Channel includes SMA launches



SMA launch onto PCB

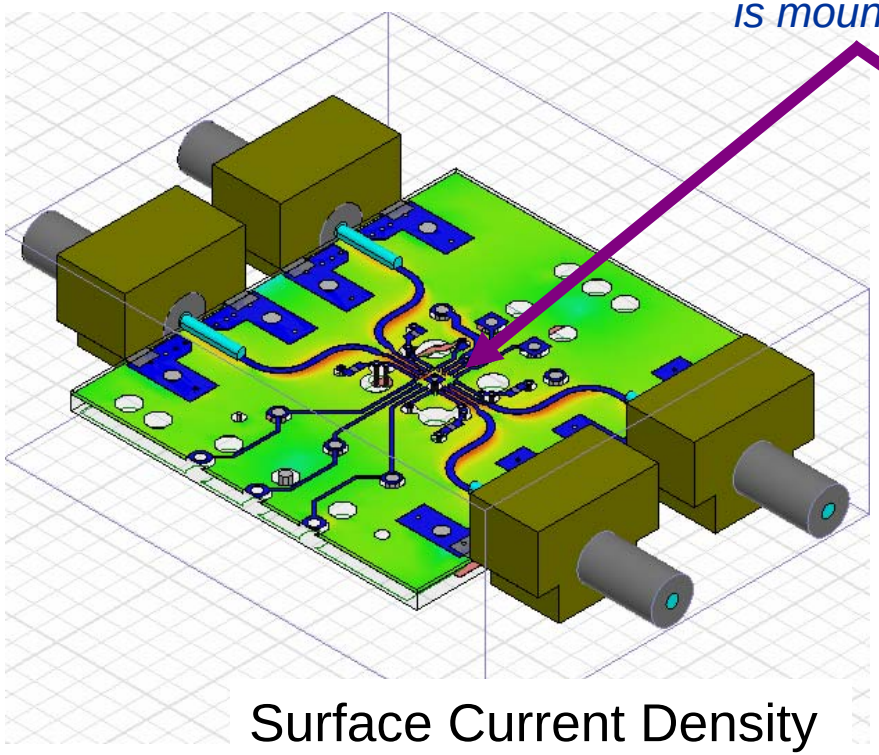
differential microstrip cross section

SMA launch off PCB

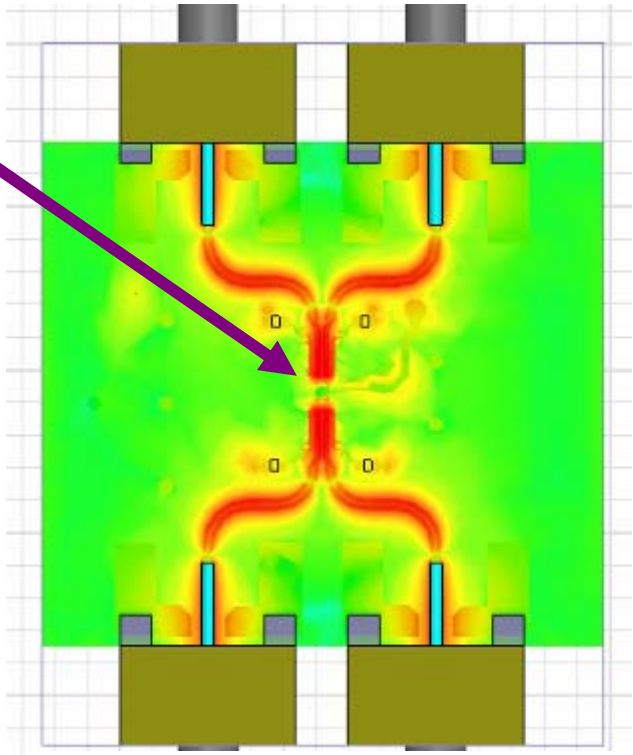
Measured Channel also includes MAX3804 Evaluation Kit

HFSS

MAX3804 component is mounted here

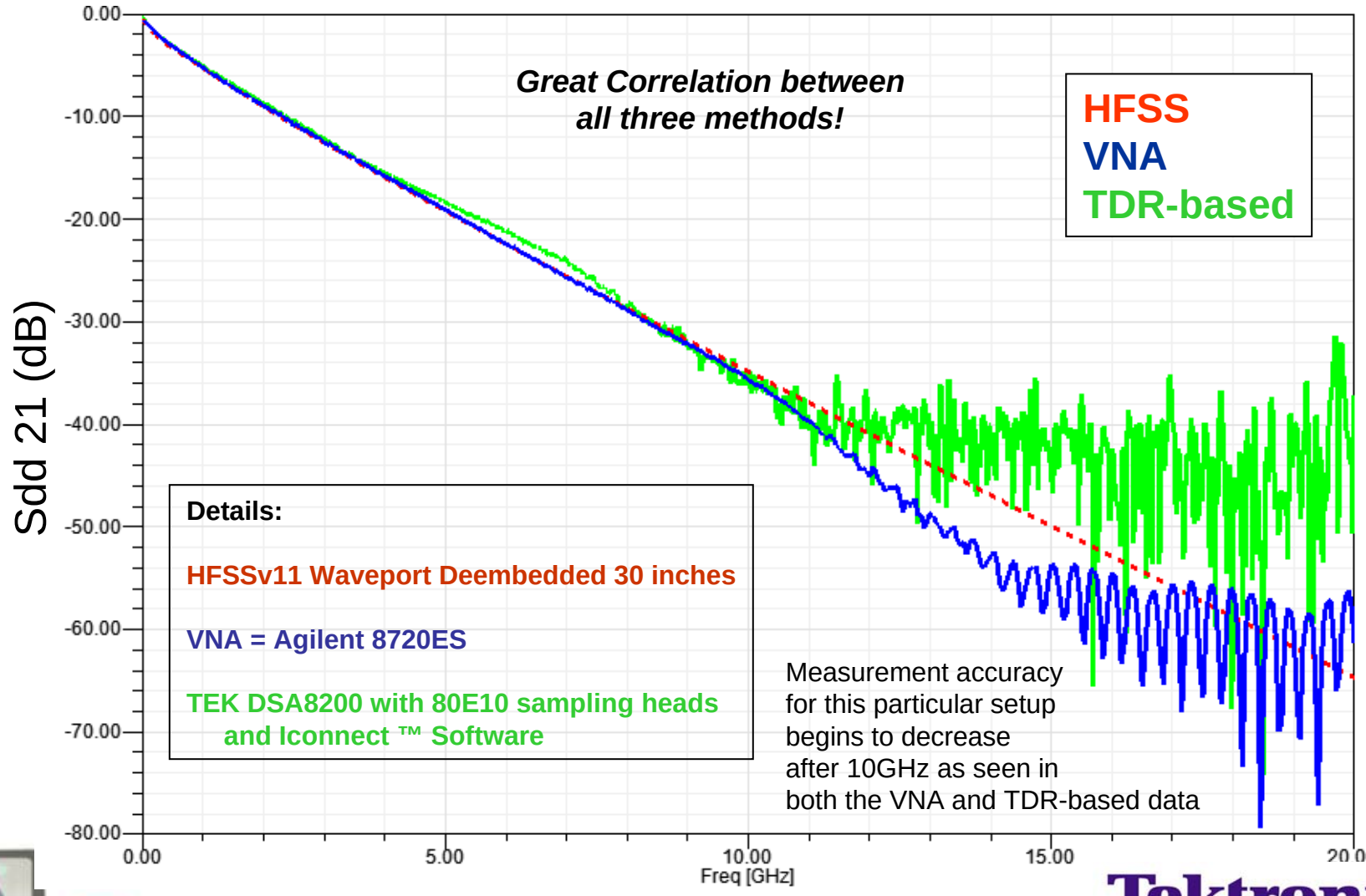


Surface Current Density in Ground Plane



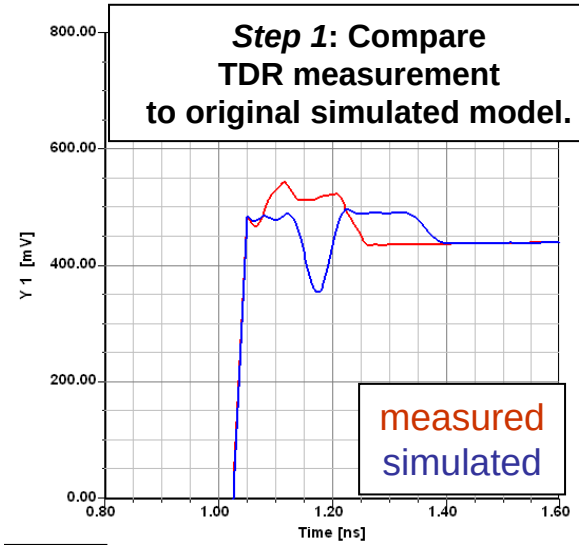
E-field intensity in dielectric

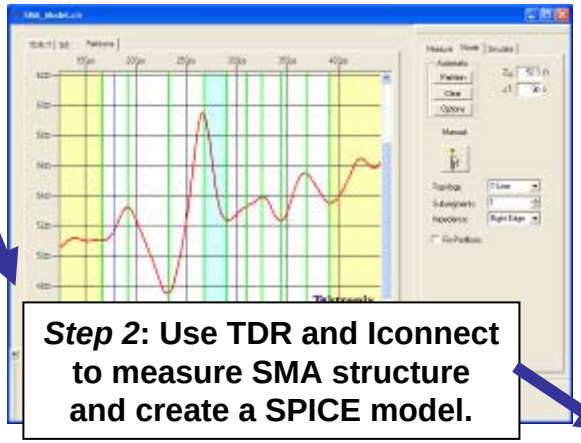
Component-level *validation*
30 inch differential microstrip



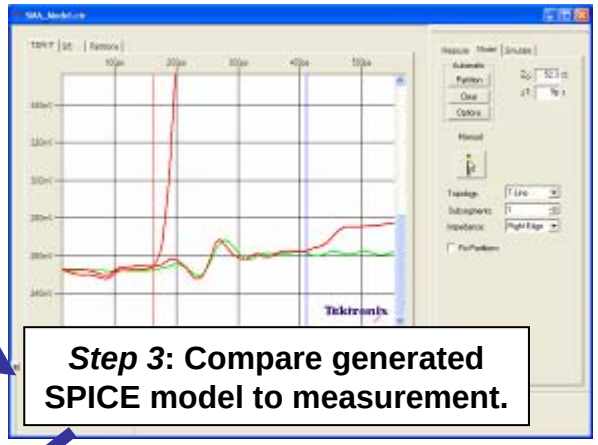
PCB SMA Launch Model Development

***Step 1*: Compare TDR measurement to original simulated model.**



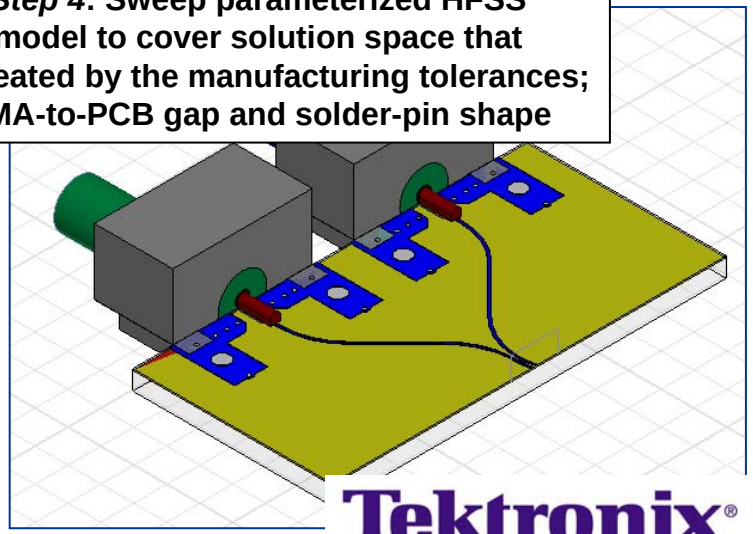


***Step 2*: Use TDR and Iconnect to measure SMA structure and create a SPICE model.**

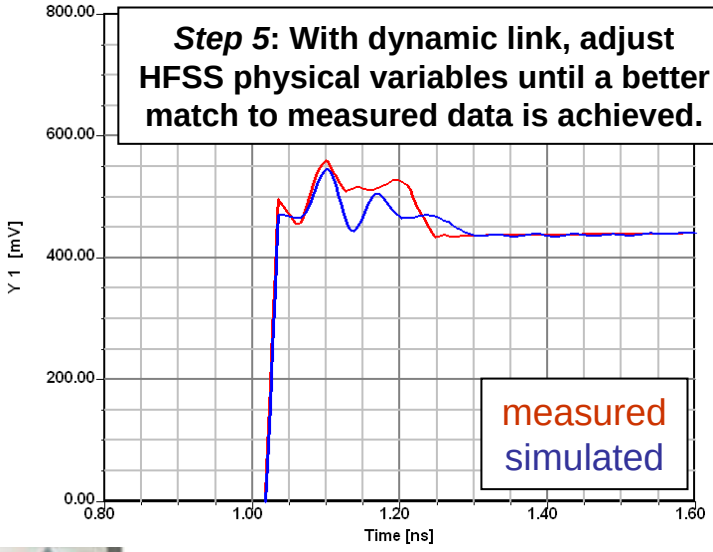


***Step 3*: Compare generated SPICE model to measurement.**

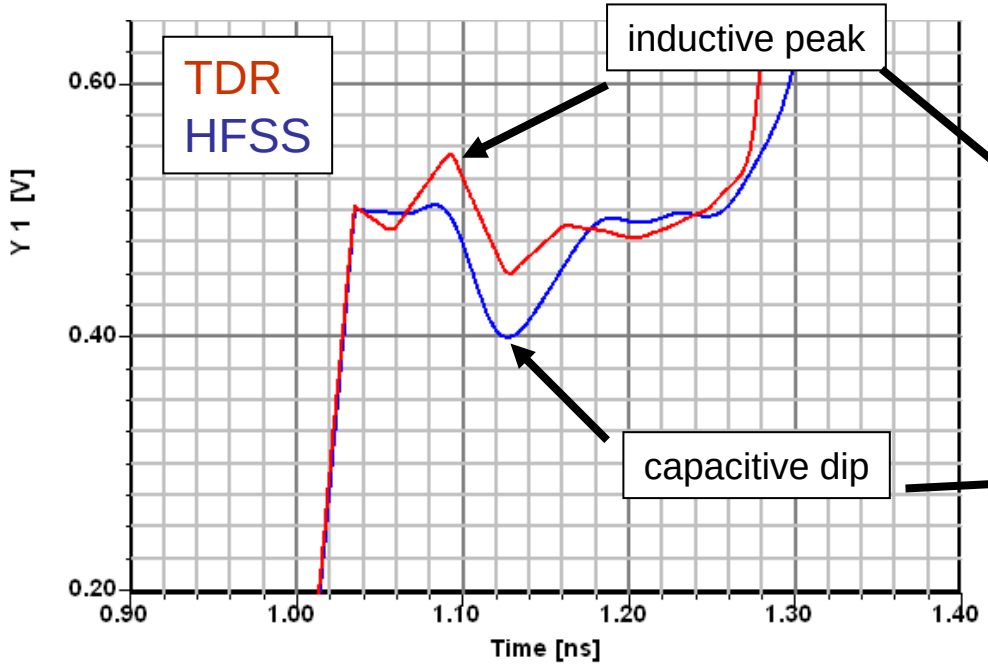
***Step 4*: Sweep parameterized HFSS model to cover solution space that is created by the manufacturing tolerances; SMA-to-PCB gap and solder-pin shape**

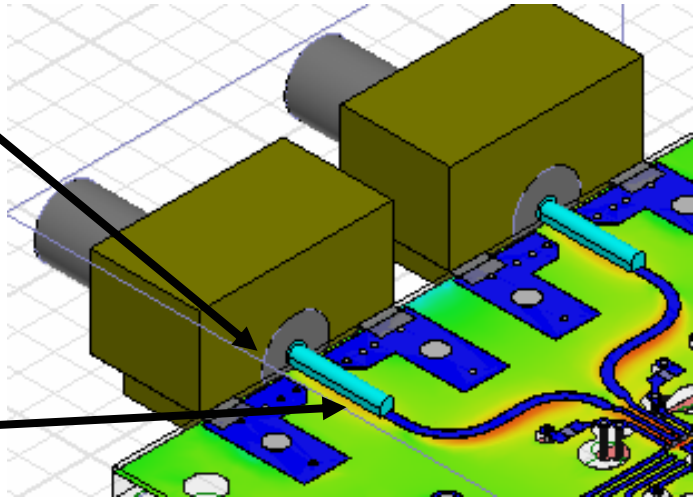


***Step 5*: With dynamic link, adjust HFSS physical variables until a better match to measured data is achieved.**



Eval Kit Model Validation: TDR Measured Data vs. HFSS Simulation





Manufacturing Tolerances:

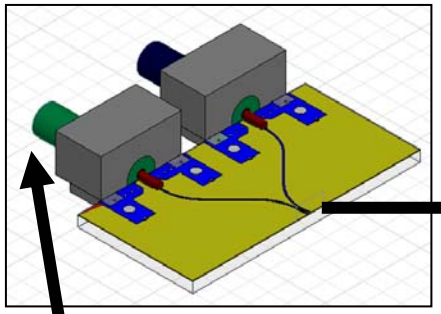
Inductive peak: related to SMA-to-PCB gap in HFSS

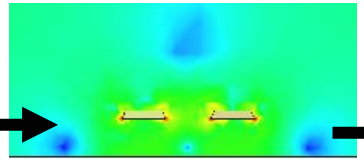
Capacitive dip: related to inner-pin solder size in HFSS

Using TDR helps engineer focus on area to improve in model and gain insight into manufacturing-related physical variations and how they affect signal integrity.

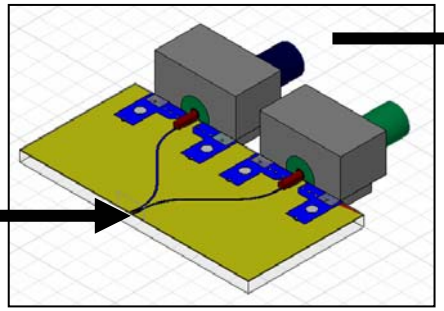
Final system-level simulation and measurement setup

SMA launch onto PCB

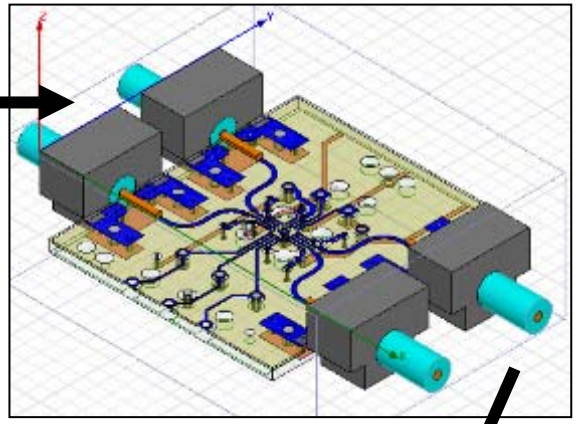




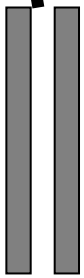
differential microstrip W-element model from HFSS



SMA launch off PCB



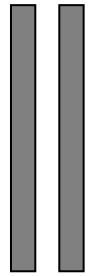
MAX3804 EV KIT



matched 3' Hubner Suhner coax cables

Agilent 70543B pattern generator

HFSS DESIGNER NEXXIM



matched 3' Hubner Suhner coax cables

Tektronix CSA8000 with FrameScan

ANSOFT

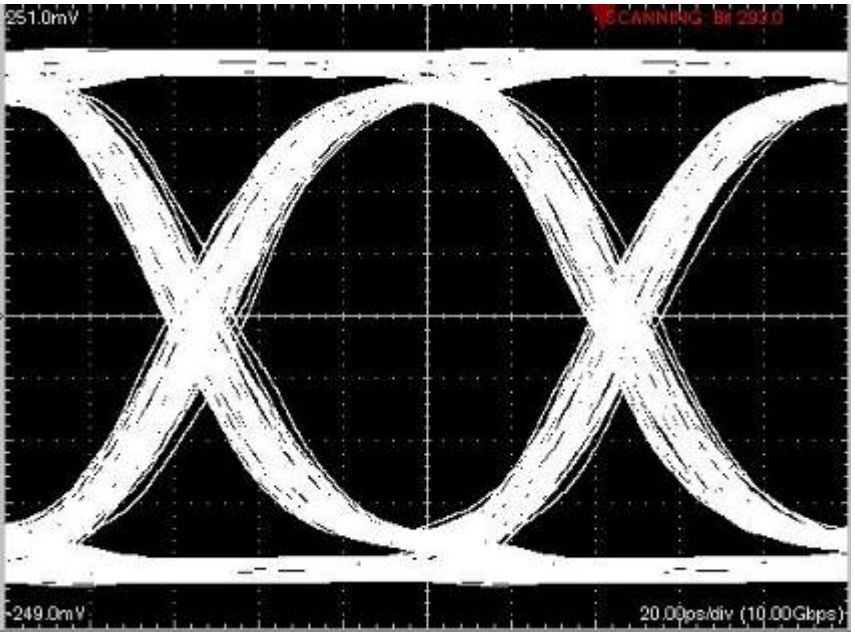
FIRST-PASS SYSTEM SUCCESS
APPLICATION WORKSHOPS FOR HIGH-PERFORMANCE ELECTRONIC DESIGN

Tektronix®
Enabling Innovation

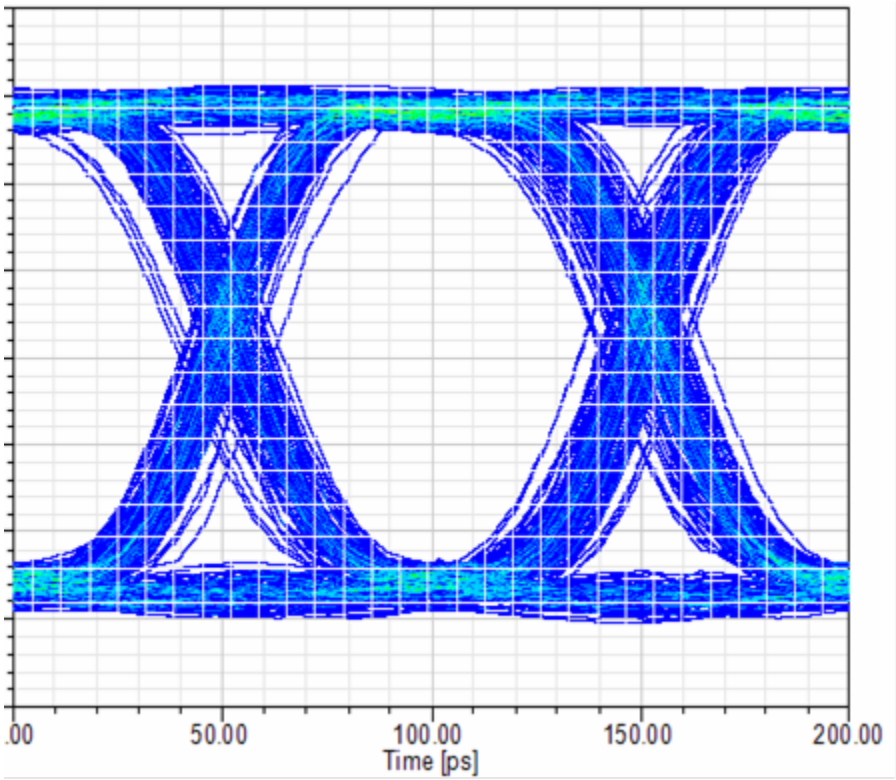
Eye Diagrams:

10GB/s equalization with 2^7 PRBS pattern

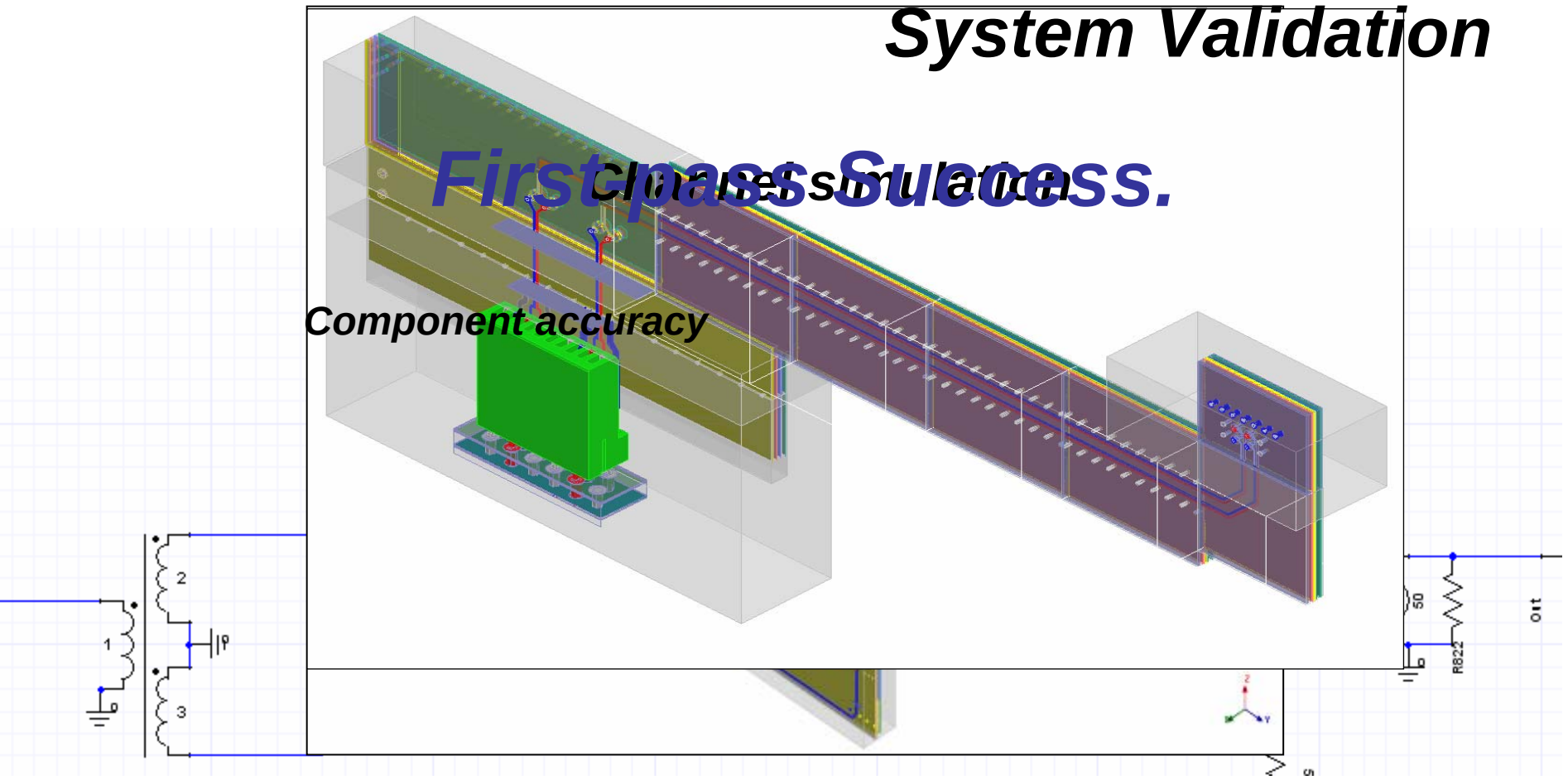
Measurement



Simulation



The Power of Simulation:
Validation … Optimize … Invent …



Concluding Remarks

- Simulation and measurement can be used together to build a modular, “hybrid” system-design platform.

- Validation is an important step:
  - ***Learn to trust simulation models***
  - ***Learn how to vary physical dimensions to accurately represent real electrical performance with electromagnetic and circuit models***

- Utilize Platform to “push the limits” and come up with innovative, award-winning designs as fast as possible.

Acknowledgements

- Tektronix Inc.
- Efficere Technologies
- Maxim Integrated Circuits

FIRST-PASS SYSTEM SUCCESS
APPLICATION WORKSHOPS FOR HIGH-PERFORMANCE ELECTRONIC DESIGN

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