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The Touchstone 2.0 Format for Interconnect Modeling

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Purpose / goal

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House

- Importance of the channel description for **SI+PI**
- Touchstone format 2.0 is a good choice

Outline

-
- Motivation
 - Transmission channel description
 - Conglomerate of different models
 - Impulse response
 - Touchstone description
 - Touchstone format
 - Short historical survey
 - TS 2.0
 - Highlights
 - Application
 - Insufficiency of TS 1.0
 - Summary

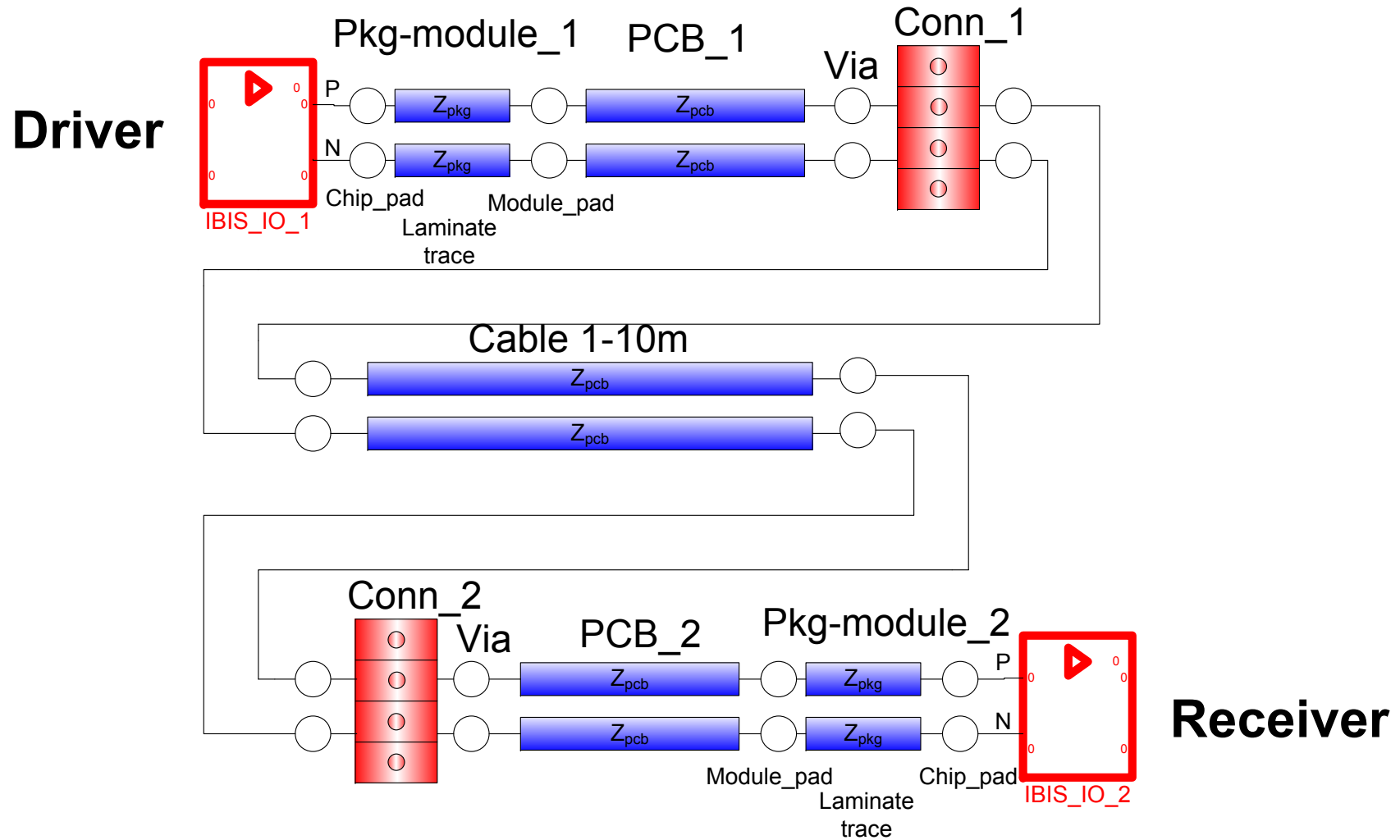
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Transmission Path

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Motivation

-
- Channel = { PCB/via/connector/cable/PKG ... }
 - Channel = „electrical device“
 - Channel = determining system performance
 - Channel has to be modeled as good as
necessary
 - The channel modeling effort should be
reasonable vs. the design cost

Channel description 1/3

- **Classical way**
each electrical element = one model
- **Pro** → multiple use
- **Con** → different degree of accuracy
→ different boundary conditions
→ poor fitting → incompatibility
→ substantial simulation time

Channel description 2/3

- **Impulse response**
AMI (Algorithmic Modeling Interface) approach
- **Pro** → easy to use
 - very good concordance
 - short simulation time
- **Con** → Dynamic Link Library (DLL)
 - application specific
 - proprietary approach

Channel description 3/3

- **Touchstone** → a general approach
 - # complex description of the channel behavior
 - # network data as function of frequency
- **Pro** → most of the simulators can use it
 - easy to measure
 - short simulation time
 - very good accuracy in a wide frequency range
- **Con** → additional description required

References to Touchstone 2.0 (1.0)

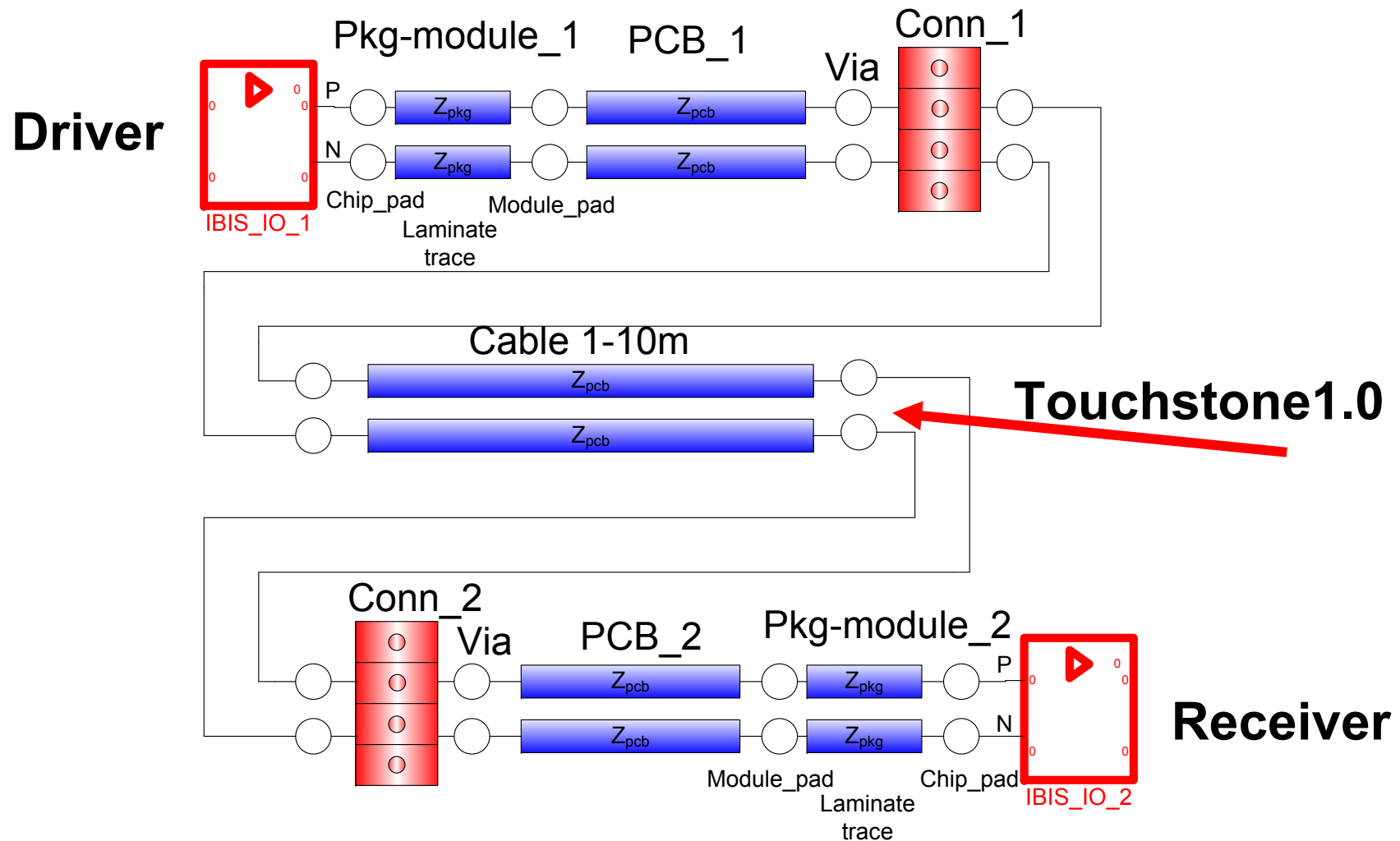
- **Touchstone® File Format Specification / Version 2.0**
(http://www.eda.org/ibis/touchstone_ver2.0_wip/touchstone2_wip.pdf)
- **Bob Ross – Touchstone Syntax for Versions 1.0 and 2.0**
(IBIS Summit / Feb. 7, 2008 / Santa Clara)
- **Michael Mirmak – (Re-) Re-Introducing Touchstone® 2.0**
(Feb. 20, 2009)
- **IBIS Summit Meeting** - Mentor Graphics / Simberian
(Feb. 5, 2009 / Santa Clara)

-
- **Touchstone® registered trademark by EEsof (now part of Agilent Technologies)**
from January 7, 1984 to October 10, 2007 → **OPEN**
 - **Advantages:**
 - defacto standard supported by nearly all simulators
 - broadband frequency dependent coupling
 - reference for the ICM reference
 - **Limitations:**
 - additional port information required (s#p / #=1..99)
 - no mixed-mode (e.g. differential)
 - same resistive reference for all ports (no PDS+signal)
 - # of ports limited to 99

Touchstone[®] 2.0 (Highlights 1/2)

-
- **Fully backward compatible to Version 1.0**
 - **IBIS-like specification by 12 additional [Keywords]**
 - ➔ **no ambiguity inside the file**
 - ➔ **header with all relevant information**
 - **Mixed-mode support (single ended + diff. signals)**
 - **Reference impedance (resistive) per port**
 - **Unlimited number of ports**
 - **Network-data as Matrix, with reduced format, if symmetry**

High Speed Serdes (HSS)



Questions from the Designer

- **Is it possible to connect the driver and receiver through a cable?**
if yes → **what is the maximum length,**
to guarantee the specified parameters
under all PVT-conditions?
- **Which cable of the two vendors is the better one?**
- **What improvements can/should we make on our design?**

Format of the 1m cable model

• Touchstone 1.0 Filename → xxx_onemeterCable.s8p

! Model Node Map:

!

! Input port (pin) Output port (pin)

!

! 1 (B5) 5 (A5)

! 2 (B6) 6 (A6)

! 3 (B8) 7 (A8)

! 4 (B9) 8 (A9)

!

hz S ma R 50

! 8 Port Network Data from SPx.SP block

50000000 0.070418 -31.994015 0.063284 -18.313799 0.000321 -112.727222 0.000341 163.66853
0.943215 -98.080275 0.047345 154.586143 0.001156 141.464354 0.000621 116.167497

. . .

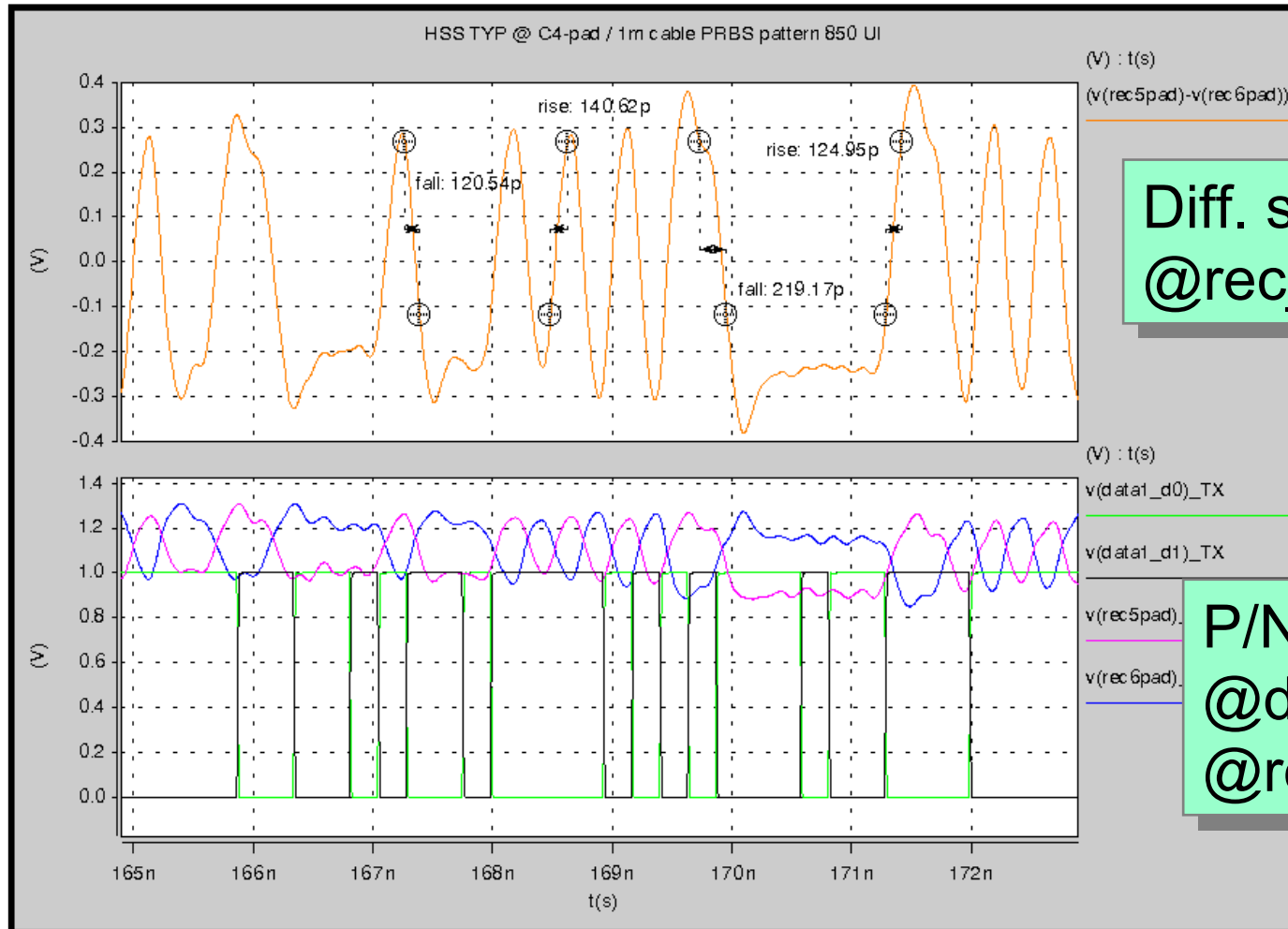
2e+010 0.239653 0.006759 0.426902 -155.791533 0.040966 -50.297325 0.041196 -90.422866
0.00811 -41.879136 0.00731 152.510564 0.001145 -176.026914 0.001592 118.514298

- Cable +

- 2 attached connectors
with RLC-network inside

- only the signal path
is modeled

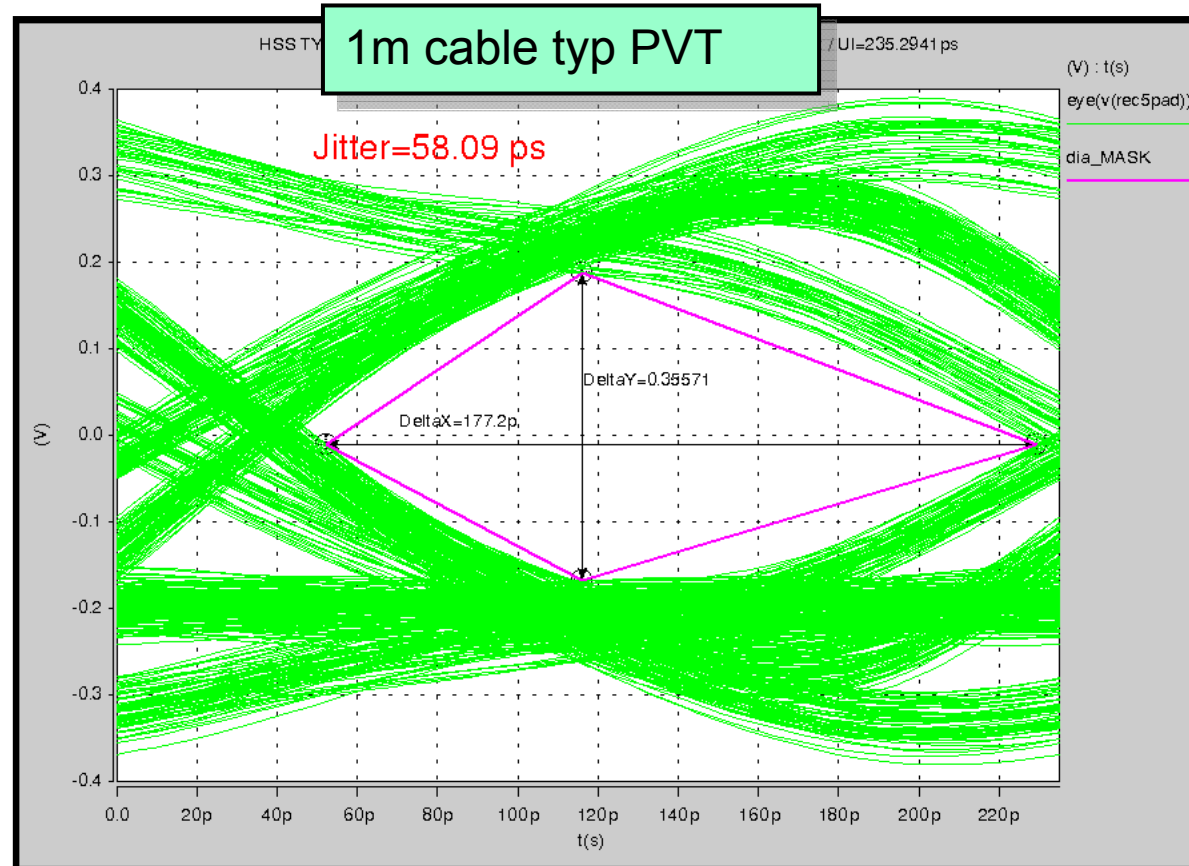
HSS Signal @ the receiver pad



Diff. signal
@rec_pad

P/N-signal
@dri_pad+
@rec_pad

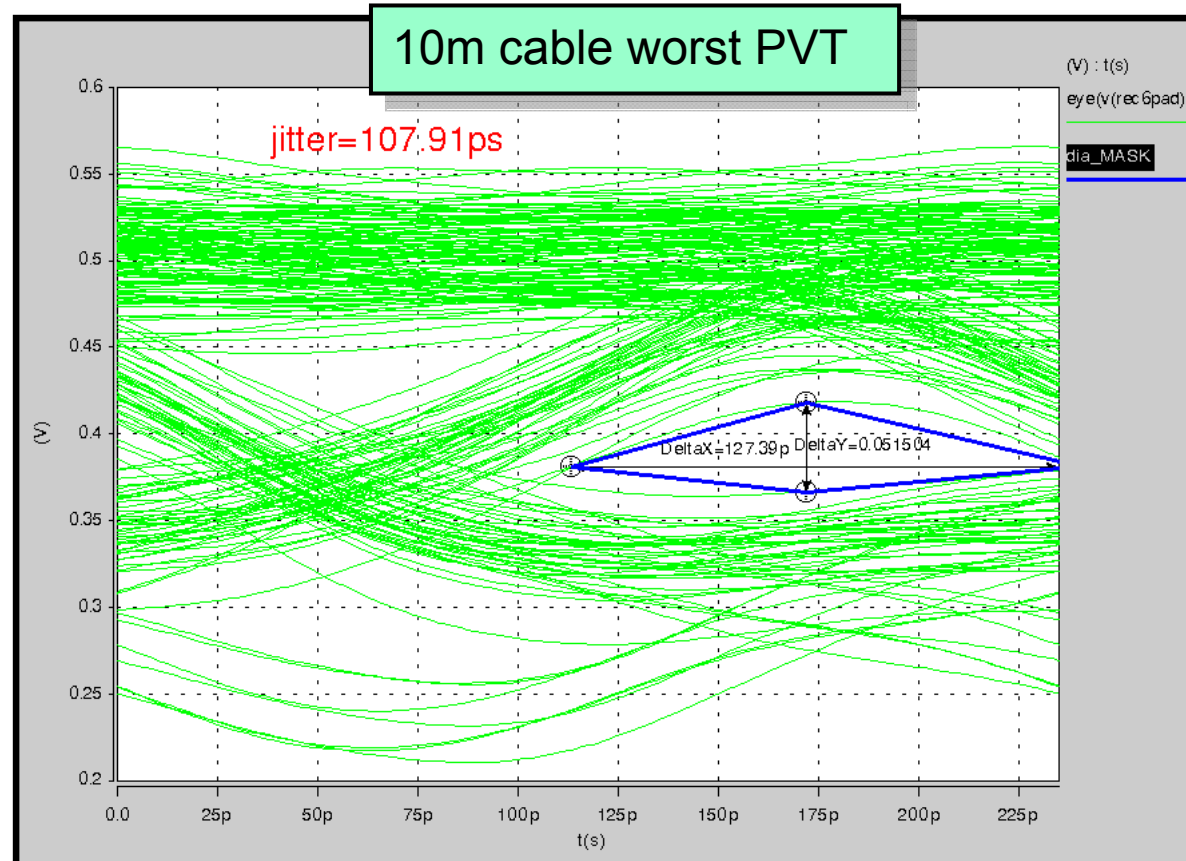
Eyediagram of the diff. signal @ receiver_pad



OK

Jitter max. : 71ps U_amplitude min.: 200mV

Eyediagram of the diff. signal @ receiver_pad



NOK

NO PDS information included in the TS 1.0 model
→ only „restricted“ SSO-investigation possible

Summary to Touchstone[®] 2.0

- The whole transmission path can be described with the same high **quality** and **accuracy**
- The Touchstone[®] Specification 2.0 defines a **mixed-mode** description, which enables **SI** analysis with the impact of the **PDS**, too
 - Hope, that simulation tool vendors will include it ASAP
- Touchstone[®] is the **best IBIS-like behavioral** description of the channel
 - ➔ **unified “picture” of the whole transmission path**

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Q/A ?

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