As presented at Euro DesignCon 2004 Channel Compliance Testing Utilizing Novel Statistical Eye Methodology

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A Simple System Perspective

Receiver

Current Methods



The Real Problem



How to Measure The Channel



Measuring the whole Channel



Differential Measurements

| | | | Differen | Differential Signal | | Common Signal | |
|----------|-------------------|----------|-------------------|---------------------|-------------------|-------------------|--|
| | <mark>a</mark> | - | Port 1 | Port 2 | Port 1 | Port 2 | |
| Response | Differential Sign | Port | S _{DD11} | S_{DD12} | S _{DC11} | S_{DC12} | |
| | | Port 2 | S _{DD21} | S_{DD22} | S_{DC21} | S_{DC22} | |
| | Common Signal | Port 1 | S _{CD11} | S _{CD12} | S _{CC11} | S _{CC12} | |
| | | ort 2 | S _{CD21} | S_{CD22} | S_{CC21} | S _{CC22} | |
| | | – | | | | | |

Frequency Response



Analysing Channels

Must include all channel effects

- Mode conversions
- Channel and device return loss
- Crosstalk
- Magnitude and phase
- Return Loss
- Influence of the pattern/coding
- Must include all jitter and statistical effects

What is the real problem?



- Correlated and uncorrelated transmitters
- Various Channels incl. FEXT and NEXT
- Various jittered signalling types with common mode noise and return loss

Introducing Stateye

- Following slides introduce the basic theory of stateye based on alpha c++ code and gnuplot running under Linux
- I would suggest that if there are questions, ask while I am presenting. It is important to understand each step

Simple Transfer Function



Impulse Response



Pulse Response



Symbols



ISI



Worst case patterns



Worst Case Sampling Jitter



Worst Case Eye Opening



Cursor Extraction



Conditional pdf



Conditional pdf



Conditional pdf



Sampling Jitter



Average pdf over transmit jitter



Pdf -> cdf



Conditional Average cdfs



Stateye



Taking more cursors



Taking more cursors



Simple Crosstalk



Pulse Response of Crosstalk



Effect of crosstalk on pdf





time (UI)

Effect of crosstalk on stateye



Multiple Crosstalk Aggressors



Multiple Crosstalk Aggressors



Real Probability



Pause for Breathe (mine)

A Channel Example

| | Market I | _ |
|---------------------------------------|---|-----|
| | Description | • |
| | | |
| | Πψψγγλ_JEFE βμαβατοπο | |
| | MLSUBSTRATE/ | |
| | · · Subst4· · · · · · · · · · · · · · · · · · · | • |
| | • Er[1]=4.5 • Er[4]=4.5 • T[7]=1.4 mil • • • • • • • • • • • • • • • • • • • | • |
| | | |
| | TanD[1]=0.018TanD[4]=0.018LayerType[1]=signal | |
| | TI11=1.4 mil TI41=1.4 mil LaverTvpeI21=ground | |
| | Cond(1)=6e7 Cond(4)=6e7 LaverType[3]=signal | • |
| | Pri21=4.5 Fri21=4.5 LayerTynel4 l=ground | |
| | HD = 6 mil HD = 6 mil LayerType [] = ground | |
| P 11one | | |
| | Tip_1 / mil Tip_1 / mil LoverType/7 around | • |
| · · · · · · · · · · · · · · · · · · · | 1/21-1/4 min 1/21-1/4 min cayer/yhe/r -ground | • |
| | | |
| | | |
| i P_1Tone i i i i i i i i | - H[3]=6 mil: - H[6]=6 mil: P_1Tohe | |
| · · · PORT2· · · · · · · · · | - IanD[3]=0.0181anD[6]=0.018 PORT8 PORT8 | • |
| | . I [3]=1.4 mil . I [6]=1.4 mil | |
| | Cond[3]=6e7 . Cond[6]=6e7 | |
| P 1Tone C2 | | |
| рартз 📥 С=400 fF | | |
| · · · · · · · · · · · · · · · · · · · | | • |
| | | |
| | | |
| D 1Topo | | |
| | | • |
| POR14 | | • |
| | | |
| | | |
| P_1Tone Control to | | |
| | | • |
| | | • |
| | | |
| | | |
| i P_1Tone | ML6CTL V P_1Tone | |
| PORT6 · · · · · · · · · · · | Cling | • |
| | Subst="Subst41 aver[3]=3 | |
| | bength=15 in dayer[4]=3 · · · · bength=5 in · dayer[4]=3 · · · · · · | |
| 🛓 | Will-6 mil Laver/51-3 Will-6 mil Laver/51-3 | |
| | Still-6 mil Laver/61-3 | • • |
| 1 1 1 🖓 1 SIPARAMETERS 1 | | • |
| | WIZES MIL REGUINES WIZES MIL REGUINES | |
| · · · S.Param · · · · · · · | | |
| SP1 | | |
| Start=10 MHz | | |
| Ston=20.0 GHz | · vv(4)=5 mil. · · · · · · · · · · · · · · · · · · · | • |
| Step=20.0 OT12 | 3[4]=15 mil. | |
| | | |
| | S[5]=6 mil S[5]=6 mil | |
| | VV[6]=5 mil | |
| | Layer[1]=3 Layer[1]=3 Layer[1]=3 | • |
| | · Layer[2]=3 · · · · · · · · · · Layer[2]=3 · · · · · · · · · · · · · · · · · · · | |
| | | |

Short Channel no via



Short Channel no via

Amplitude



Short Channel no via



Short Channel with via



Short Channel with via

Amplitude



Short Channel with via



Longer Channel



Longer Channel

Amplitude



-Frequency (CHz)-

Longer Channel



Longer Channel + deemphasis



Longer Channel + deemphasis



Long Channel with close rx via



Long Channel with close rx via

Amplitude



Frequency (GHz) --

Long Channel with close rx via



Longer Channel + DFE



Longer Channel + DFE



Dealing with Correlated Data



DCD or Pulse Shrinkage

Amplitude



Frequency (CHz)

PAM



Return Loss, Boosting and FIRs

Transmitter n port s-parameter

Channel n port s-parameter

Linear Equaliser Receiver n port s-parameter

Convert to T-matrix, multiply and convert back to S-matrix

Calculate pulse response

Push pulse response through any FIR

Dealing with common mode



- Calculate common mode transfer function
- Create the pulse response seen at the receiver
- Extract the cursors
- Additional use the cursors in the calculation of the conditional pdf, as for crosstalk

Stateye

- Stateye is a non-profit, open source, developers forum under <u>www.stateye.org</u>
- Currently stateye is being re-developed
- Stateye is being rewritten currently under c++ to allow easier contribution and exploration of differing technical opinions
 - The initial c++ class structure and initial functions will be made available at the above website.



Stateye

- Lab results concerning validation of this technique are also available from the website
- Stateye is under continuous development and improvement and encourages contribution
- This presentation is available from the T10 website. T10/05-198r0