Proposal for CUI Package and reference Receiver Considerations

Richard Mellitz, Intel Corporation

Adee Ran, Intel Corporation

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Given:

- A channel that passes a channel compliance specification must work for all compliant chips.
- A device that passes a receiver compliance test will work for all compliant channels.

We will illustrate:

- Looking at the eye opening in mV is not enough
- Looking at the results with an ideal termination is not enough

Proposal:

- Evaluation with and without a reference package
- Reference DFE
- Look at normalized metric such as COM
  - Clause 83E.4.2.1 is essentially COM

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COM, EYE Diagram, and Clause 83E are similar

- Figure of merit used to determine equalization.
  - Best ratio of signal at sample point to rms of all appropriate cursors.
- Comparable to clause 83e
  - AV is like the available signal, A_s
  - EH15 is like "A_s – N"
  - COM is an opening and VEC is the closure
    - Essentially measuring they are same thing
    - COM noise uses an exact statistical calculation not an extrapolation

83E.4.2.1 Vertical eye closure

Vertical eye closure is calculated using Equation (83E–9)

$$VEC = 20\log\left(\frac{AV}{EH15}\right)$$
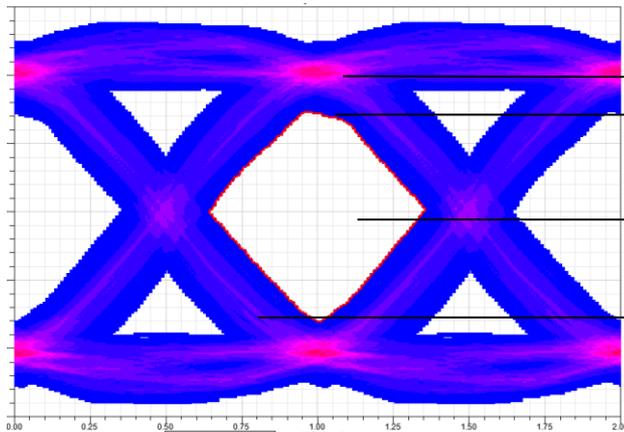
Available Signal, A_s, $\propto AV$

Total_noise, N, $\propto$ A_s-$EH15$

VEO $\propto EH15$

$$COM = 20 * log10\left(\frac{A\_S}{N}\right)$$

We will look at COM and Vertical Eye Opening (VEO)

Two channels considered

- Two channels considered
  - 15dB ~ one board: fairly clean channel
  - 13.39dB ~ two boards with good connector: somewhat reflective channel

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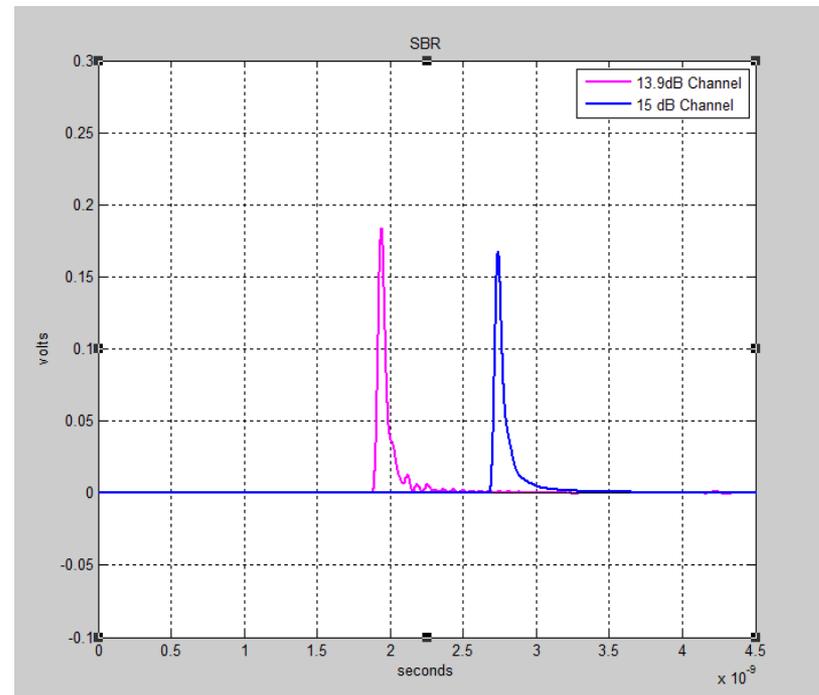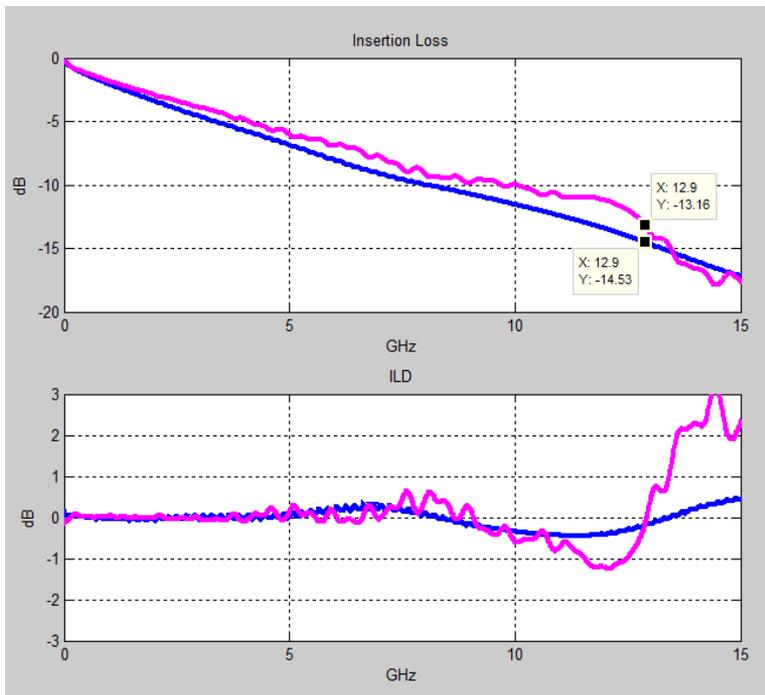
Terminations

- Two realistic Rx package models (clause 93a)
  - See: 12mm and 30 mm PKG
  - Die pad capacitance 250fF
  - Termination 55 ohms single ended
  - Board to package capacitance = 180fF
  - mellitz_3bj_01b_0113a, benartsi_3bj_01_0113, benartsi_3bj_01_0912, benartsi_3bj_01a_0113, benartsi_3bj_01a_0513, and benartsi_3bj_02_0912
- Ideal Rx termination
- 12 mm package is used for the transmitter in both cases

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COM and Vertical Eye Opening (VEO)

- Clause 93a COM parameters used for this comparison.

- Considerations with and without DFE

- Both channels have the same vertical eye opening (VEO) with an ideal Rx and tuned CTLE, but have different COM values.
  - Crosstalk has been omitted for clarity in understanding results.

loss	VEO (mV)	COM (dB)	DFE	Rx Pkg len	Tx Pkg len
13.39dB reflective	46.5928	3.8130	0	Ideal termination	12mm
15dB clean	46.6407	4.5356	0	Ideal termination	12mm

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What does it take to work without a DFE?

- Die pad capacitance of 150 fF
- Package to board capacitance to 100 fF
- Package length of 6mm

loss	VEO (mV)	COM (dB)	DFE	Rx Pkg len	Tx Pkg len
13.39dB reflective	39.7072	3.9099	0	6mm	12mm
15dB clean	36.9416	3.0265	0	6mm	12mm

- This may not be consistent with a wide range of products. Some would consider unrealistic.

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This (or something similar) is currently suggested as a reference receiver for RX interference compliance… I.e. Ideal Rx termination

- Very minor ISI effect – seems to have lots of margin
- Unrealistic – no package is transparent
- Those of us who don't have a good package may use other means to compensate… (e.g. DFE?)

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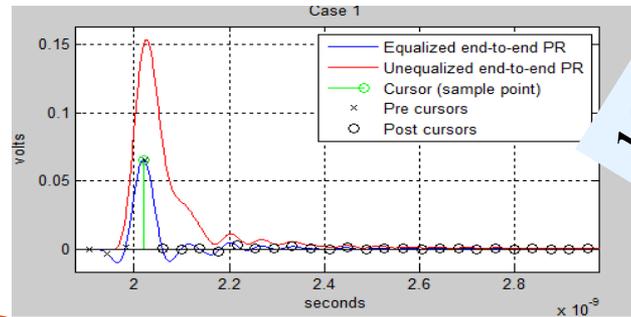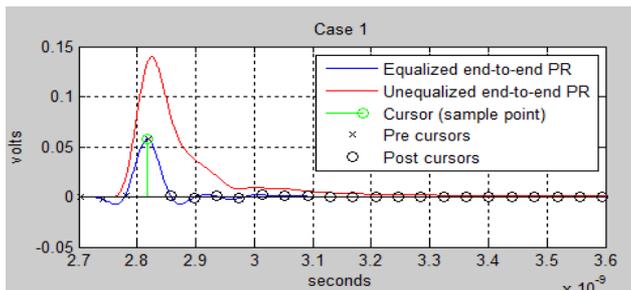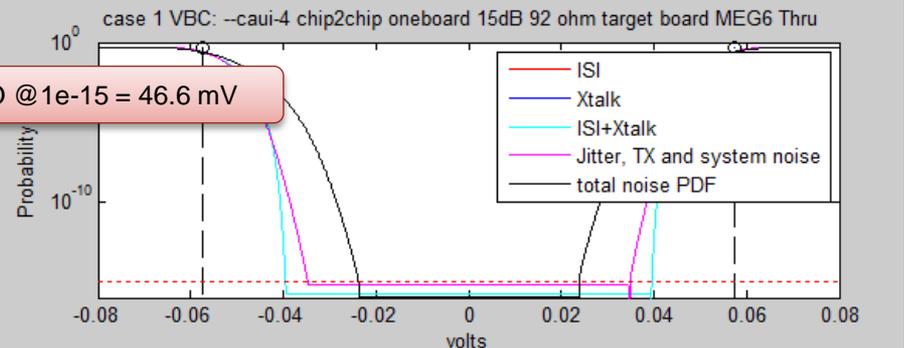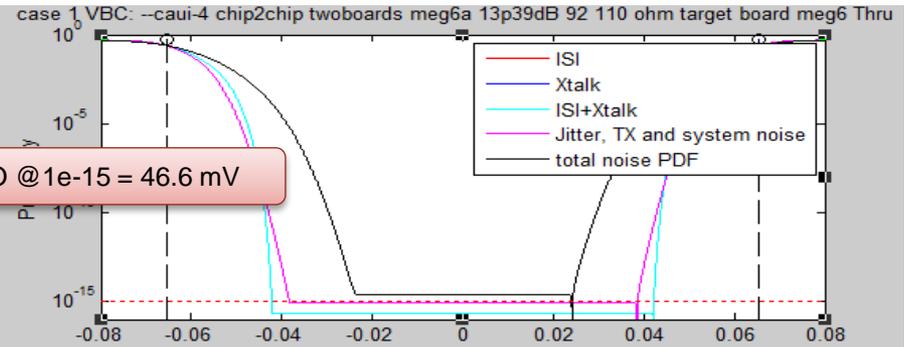
Both Receiver Packages Seem to Make the Channel Fail

- Both channels have unacceptable eye opening or COM without a DFE with either package (CTLE only)

loss	VEO (mV)	COM (dB)	DFE	Rx Pkg len	Tx Pkg len
13.39dB reflective	5.2617	0.4684	0	12mm	12mm
15dB clean	10.3430	1.0445	0	12mm	12mm
13.39dB reflective	3.0993	0.3409	0	30mm	12mm
15dB clean	9.5027	1.2711	0	30mm	12mm

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Each channel Rx package combination requires a different amount of minimum equalization to work acceptably

loss	VEO (mV)	COM (dB)	DFE	Rx Pkg len	Tx Pkg len
13.39dB reflective	18.1989	1.3130	1	12mm	12mm
15dB clean	32.0166	2.7336	1	12mm	12mm
13.39dB reflective	41.8348	3.5827	5	12mm	12mm
15dB clean	48.9645	5.3094	4	12mm	12mm
13.39dB reflective	21.0881	1.9521	1	30mm	12mm
15dB clean	30.5439	3.4005	1	30mm	12mm
13.39dB reflective	30.1332	3.1405	4	30mm	12mm

DFE1 is not enough

Conclusion

- Vertical eye opening into a reference load is not a sufficient receiver design requirement.
- DFE or equivalent is required for many cases

Proposal

- Use COM to evaluate channels
  - Utilize a DFE5 in COM
- Include 2 packages to evaluate channels with

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