Compliance Contour – Bridging the Gap between BER and Mask Testing for XFI, PCI-Express, OIF-CEI

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It's an age old problem – systems are expected to operate to better than $1x10^{-12}$ BER, but measurement to such levels takes too long. A straight BER measurement also doesn't indicate the margin available in the design. A solution to the speed problem has been to characterize a transmitter in terms of an eye diagram mask test, which is fast and lends itself to sampling scope-style measurement. Mask tests are usually shallow – an assessment of device performance will be made on a few hundred or thousand samples. The challenge is to use these shallow measurements to assess whether a device will exhibit problems that may be one in a billion. This is often achieved by extrapolation or de-rating – making the size of the mask sufficiently large or difficult, that a device that passes it must also be operating satisfactorily down at $1x10^{-12}$. There are several problems with this, including the obvious risks of an extrapolation of nine orders of magnitude in any situation; there is also the danger that too stringent a de-rating has been specified in order to catch corner case problems, and consequently good devices are being failed needlessly.

A new twist has been added by standards such as XFP/XFI[i], OIF CEI[ii] and PCI-Express[iii]. These specify a mask dimension that *must be achieved at $1x10^{-12}$ BER level* – for example, an eye width assuring a maximum amount of allowable jitter at this BER level. This is a sensible thing to require from a system viewpoint, but an almost impossible thing to measure – a typical mask measurement using the normal methodology would need to be run for years to acquire a big enough sample population for this.

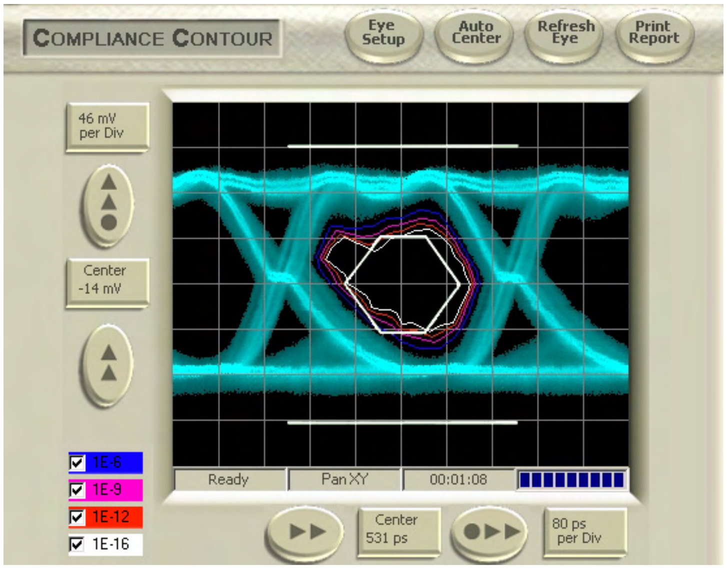

Figure 1: Compliance Contour overlays a mask on a measured BER contour to indicate the margin (or lack of) of the device compared to the standard.

BER Contour is a measurement methodology ideally suited to looking for infrequently occurring problems, and for assessing parametric performance at low BER levels. It is able to show in minutes the eye width and all the way around the inside of the eye. New **Compliance Contour** takes this a step further by overlaying the compliance mask for particular standards on top of a measured BER Contour, effortlessly showing whether a device passes, and also the margin by which it does or does not. For example, it is instantly obvious that while the example in Figure 1 might pass a shallow mask test, it is a long way from passing at low BER levels.

Notes

[i] XFP MSA, Annex E.1 Eye Mask Compliance: "Testing may include guard banding, extrapolation, or other methods, but must ensure that mask violations do not occur at a rate above 1E-12."

[ii] OIF CEI, 2.D.11Eye Mask Adjustment for Sampling Oscilloscopes: "In all Interoperability Agreement the data mask is defined for the bit error rate of the link. Given that this bit error rate is very small, typical oscilloscope measurement will not sample enough points to be able to verify compliance to these mask."

[iii] PCI-Express Base, 28th March 2005: Mask is specified in Figure 4.24, giving maximum jitter of 0.25 UI. Note 3 of Table 4-5 (Differential Transmitter Output Specifications) includes the following: "The $T_{TX\text{-}EYE}$ measurement is to be met at the target bit error rate." Section 4.3.2.2 "Jitter and BER" says: "The UI allocation is given as the allowable Tj at the target BER. The UI allocation must meet a maximum BER of 10^{-12} for the Tj. The allocation to Rj and Dj is not specified." In other words, the eye opening due to jitter on the mask must be met at a BER level of $1x10^{-12}$.