PAM4 overshoot and undershoot eye-mask concepts

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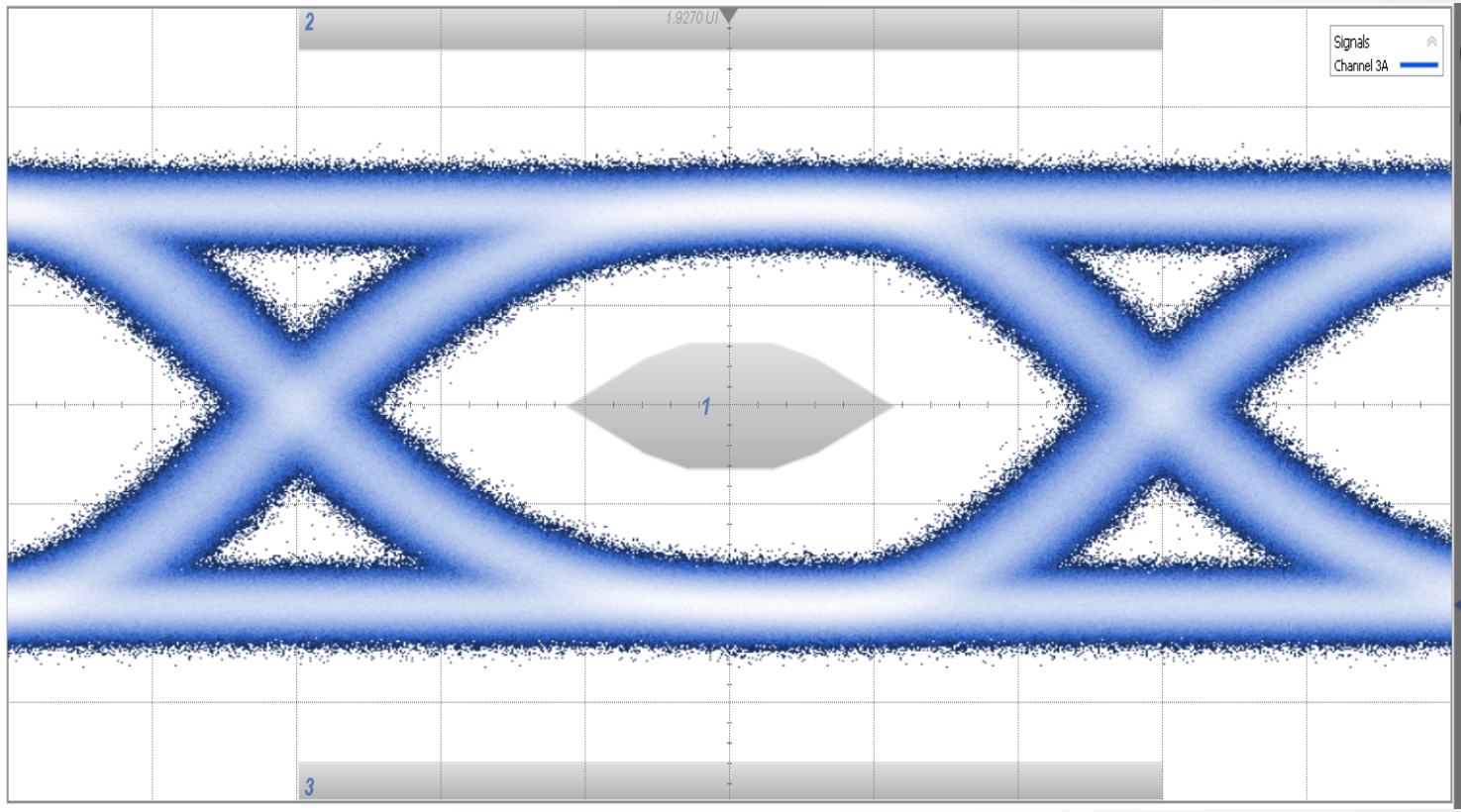
KEYSIGHT TECHNOLOGIES

Eye mask basics

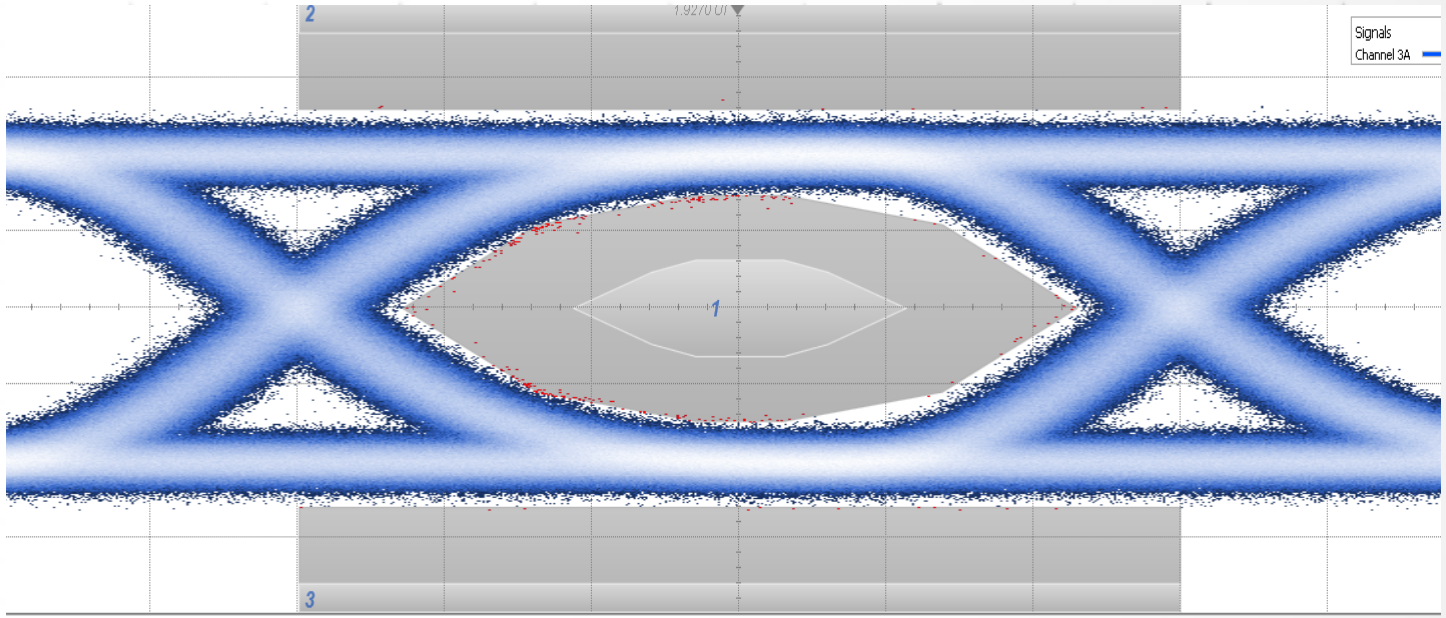
- The eye mask defines regions where the eye diagram waveform may not exist
- For NRZ, the three mask regions are inside, above, and below the eye diagram
- For a consistent analysis that is not dominated by one or two outlying samples, a small ratio (typically a “hit ratio” of 1:20000) of waveform samples are allowed to ‘violate’ the mask. (This eye has 0 violations)



The mask margin concept

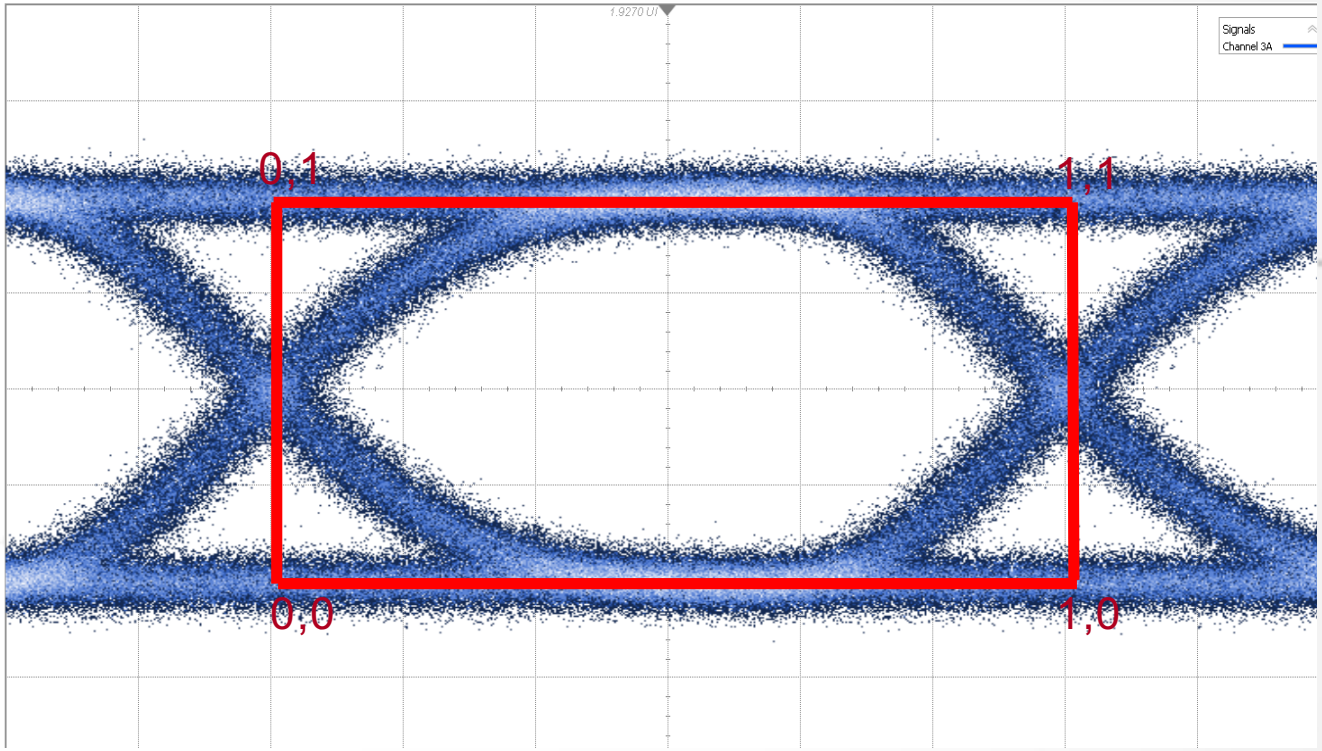
(MARGINS ARE GENERALLY NOT A CONCEPT INCLUDED IN A STANDARD)

- In addition to knowing that the mask test has been successful (simple pass or fail) it is common to determine a margin
- The mask dimensions are expanded until the hit ratio is achieved
  - “The eye mask passes with a 63% margin”
  - 100% margin is when the mask dimensions are expanded to the crossing points and mean 1 and 0 levels



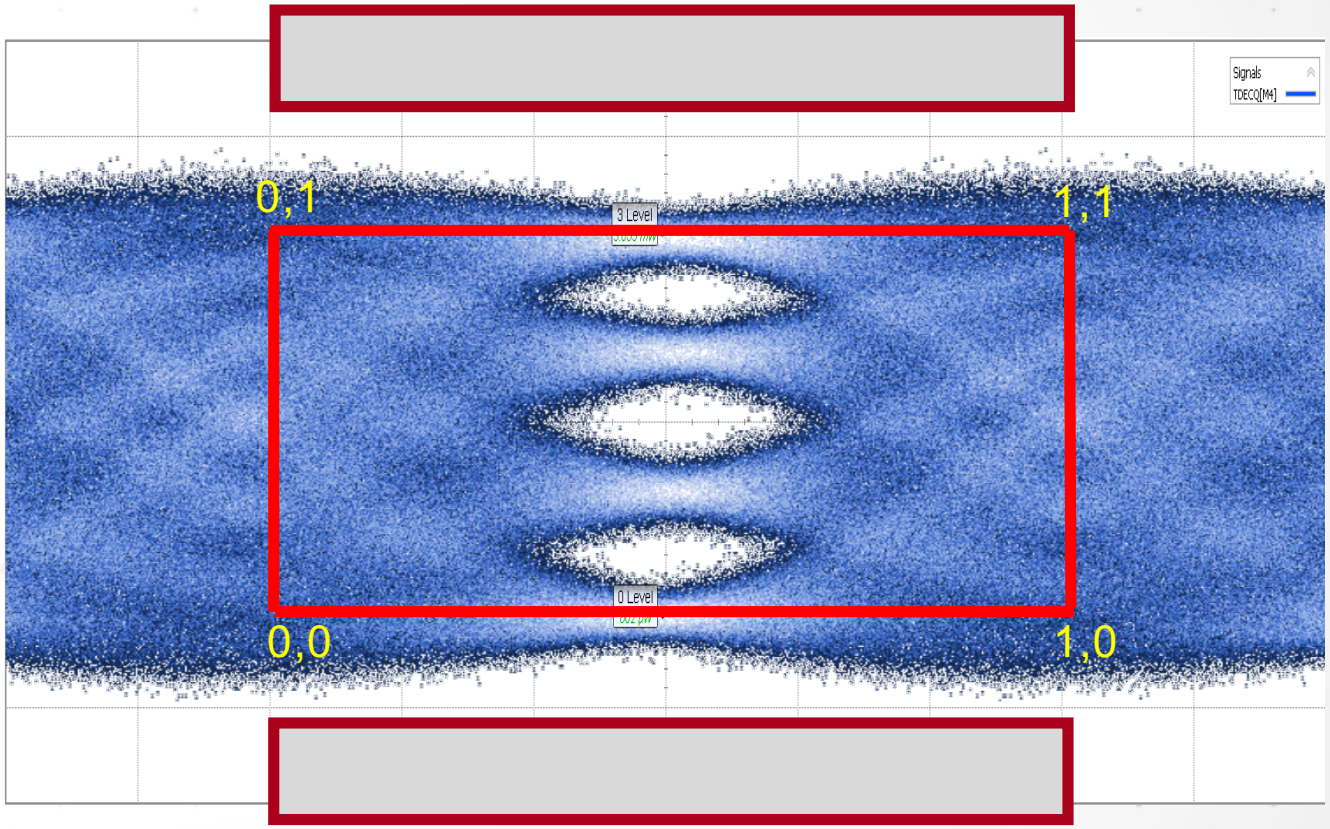
Mask test definitions

- Define a coordinate system for time and amplitude dimensions
- Time: 0 at the first crossing point, 1 at the second crossing point
- Amplitude: 0 at the mean zero level and 1 at the mean 1 level (determined between 0.4 and 0.6 UI)



An overshoot-undershoot mask for PAM4

- The basic coordinate system could be similar to NRZ
- In time, 0 and 1 based on crossing points, amplitude 0 and 1 based on the mean 0 and mean 3 amplitudes
  - Alternatively, average power and/or OMA could be used for amplitude coordinates
- The simplest mask is a rectangle, 1 UI wide, above and below the eye
- Careful consideration is required to define the mask shape and position to screen what you want to screen and pass what you want to pass



Issues to consider

- **Mask shape:** Is a simple rectangle sufficient to screen overshoot and undershoot without screening out good transmitters?
- **What signal?:**
  - Assume the output of the TX (prior to the TDECQ equalizer) is being screened
  - This signal is already available from the TDECQ acquisition
- **Reference receiver bandwidth?**
  - Assume the same signal as acquired for TDECQ, therefore the half-baud BW would be used
- **Noise:** As the signals get smaller, at some point scope noise will impact the results.
- **What 'Hit Ratio'?:** Since the allowed SER is much higher than for historical NRZ masks, should a higher hit ratio be considered (likely not much impact on results if 1:20000 is maintained)
- **Time alignment:** PAM4 crossing points may not yield precise alignment. If we have a simple 1 UI rectangle mask, not an issue, but could be problematic for a complex mask shape

Thank you!