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T10/00-225r1

Transmitter Precompensation used with Receiver Equalization

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Introduction

- Questions following the presentation of the previous revision of this document (00-225r0) at the SPI-4 working group meeting at the end of April in Colorado Springs focused on the nature of the conflict between transmitter precompensation and receiver equalization.
- We have performed additional work on adapter boost levels which provides more insight into the limitations of combining transmitter precompensation with receiver equalization.
- The receiver adaption circuitry has been overridden in several of the following plots to demonstrate the effects of the frequency dependent amplification of the receiver equalization circuit.

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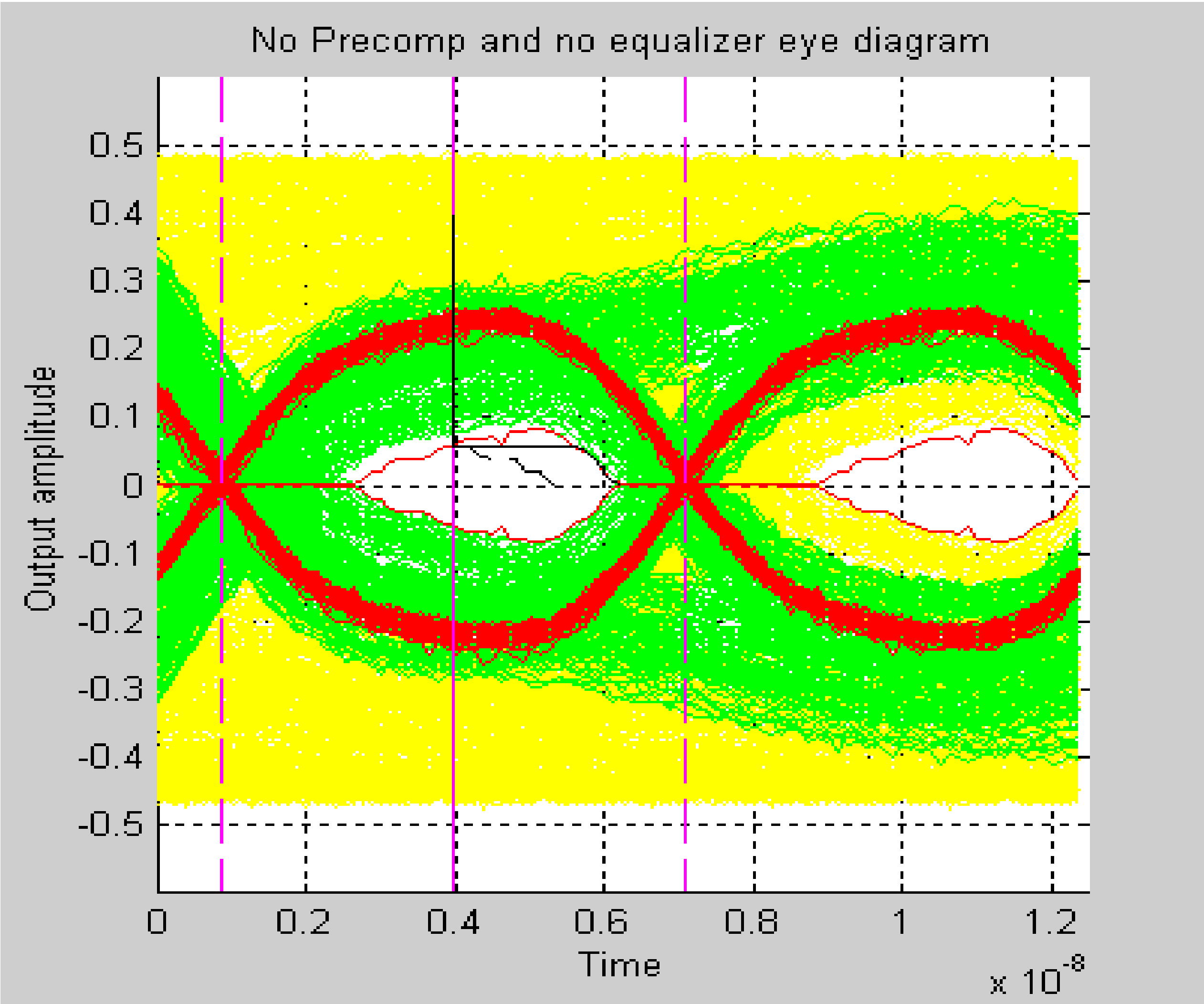
Test Procedure and Data Description

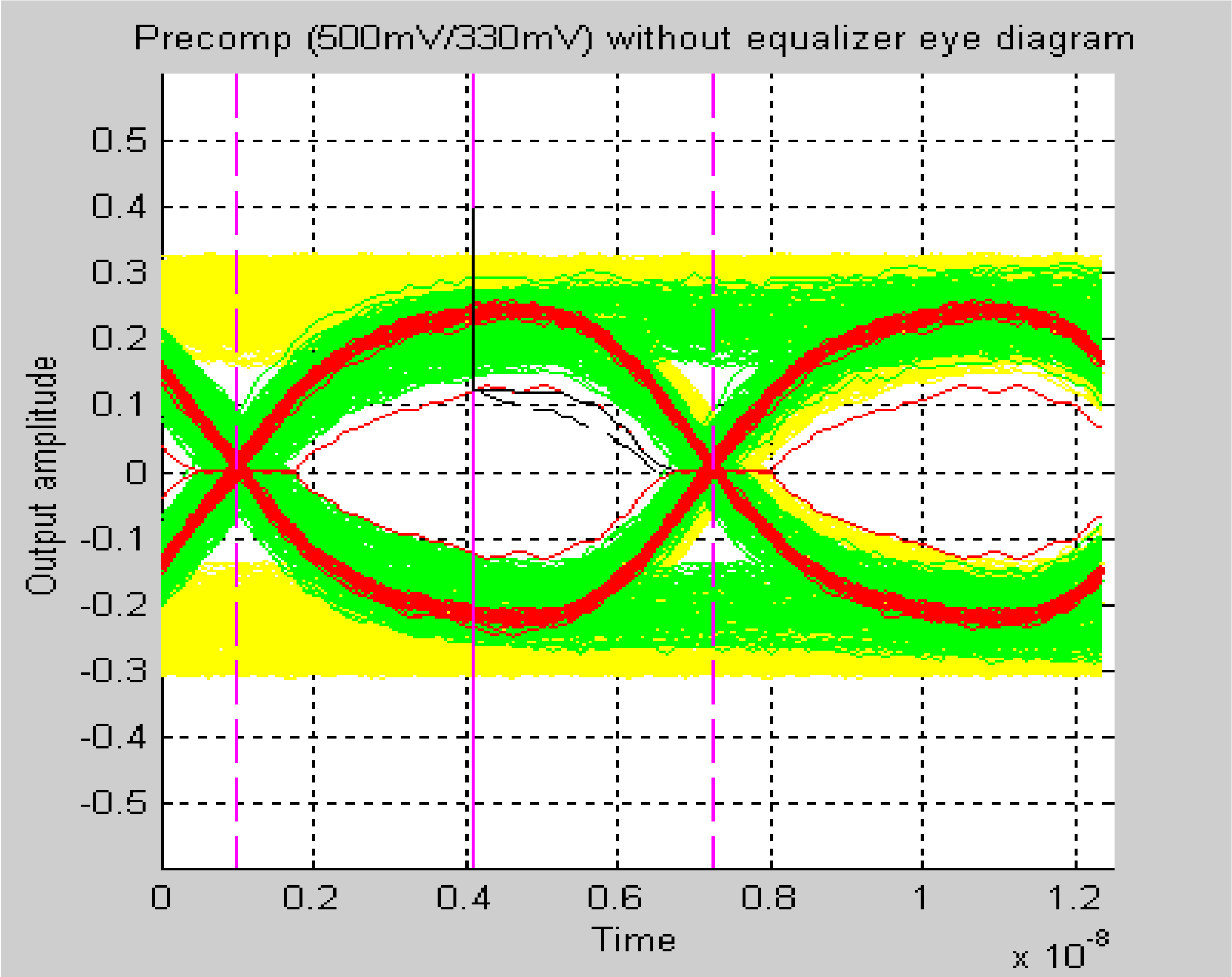
- The following procedure was used for gathering the data:
  - The system configuration is the same as the one used in revision 0 of this presentation (also see T10/00-215):
    - 10 meter, twisted flat cable, 32 AWG
    - 6 slot backplane, fully loaded.
    - Transmitter precomp was at 33% cutback (“50% boost”).
  - The data was gathered as described in T10/00-214.
    - No crosstalk was injected into the system.
- For the data in the following eye diagrams:
  - Green traces (darker gray traces in the black and white version of this presentation) switch early in the display screen
  - Red traces (black traces in the black and white version) represent a 101010 max rate toggle pattern
  - Yellow traces (lighter gray traces in the black and white version) are sweeps which do not switch early in the display screen.

No Tx PC, No Receiver Filter or Eq



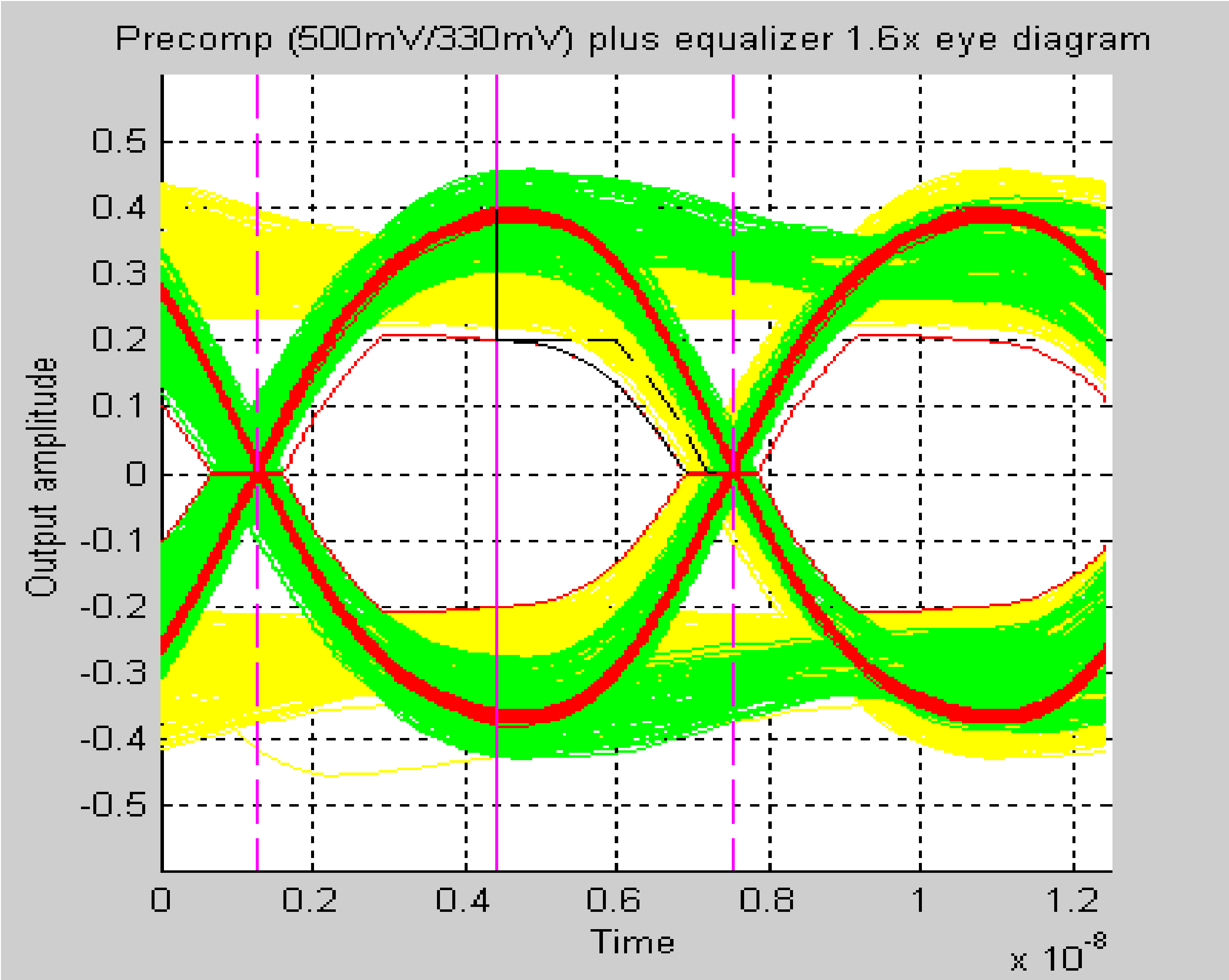
500mv signal without precomp or receiver equalization

Quantum™ Tx PC, Rcvr Boost adapted to1.0x



- Boost adapted to data; measured at 1.0
- Eye dominated by setup time
- Need more boost for this cable length

Tx PC, Rcvr boost forced to 1.6x



- Boost forced to 1.6
- Eye dominated by hold time
- Edge signals fell back too early

Tx PC, Rcvr boost forced to 2.0x

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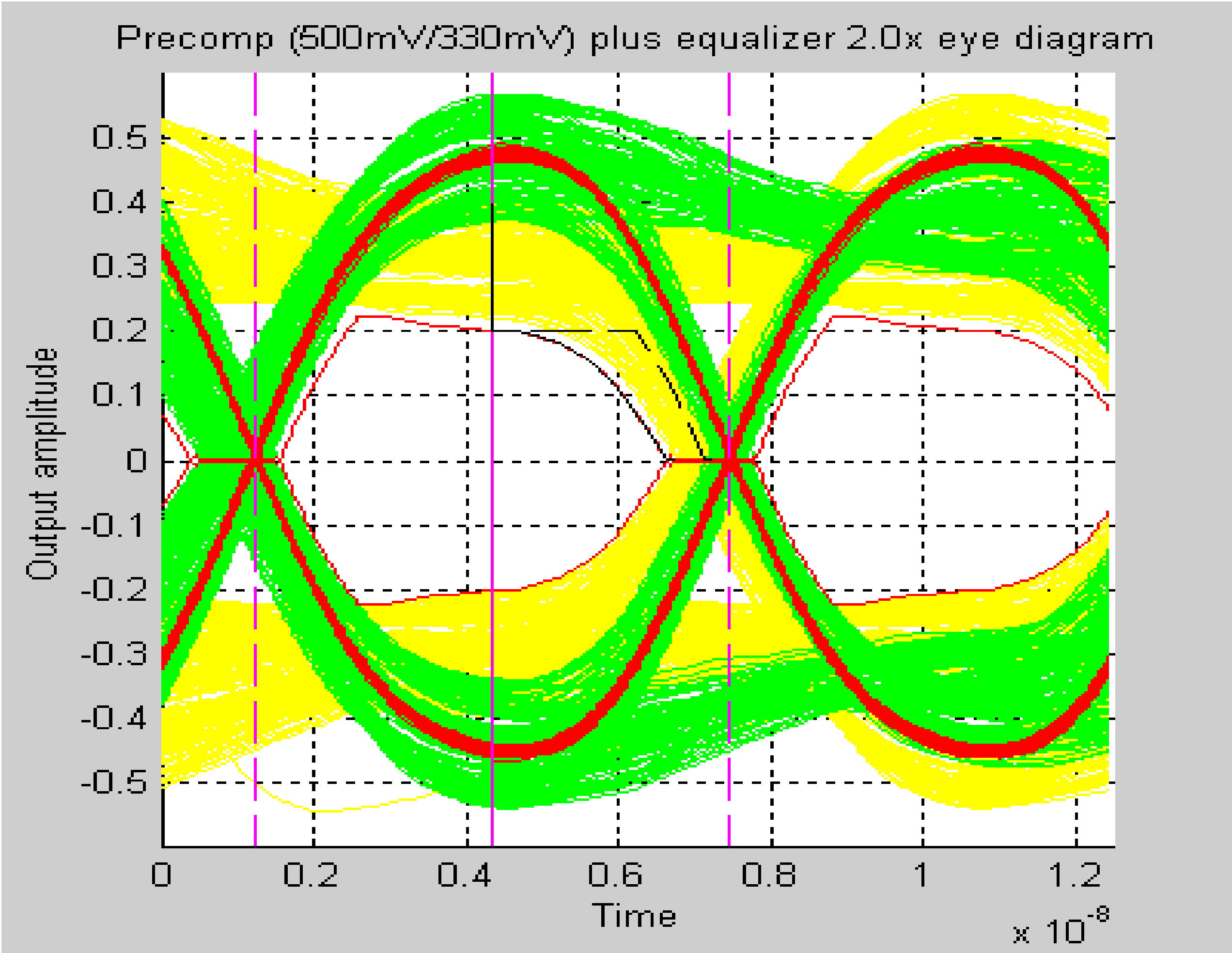
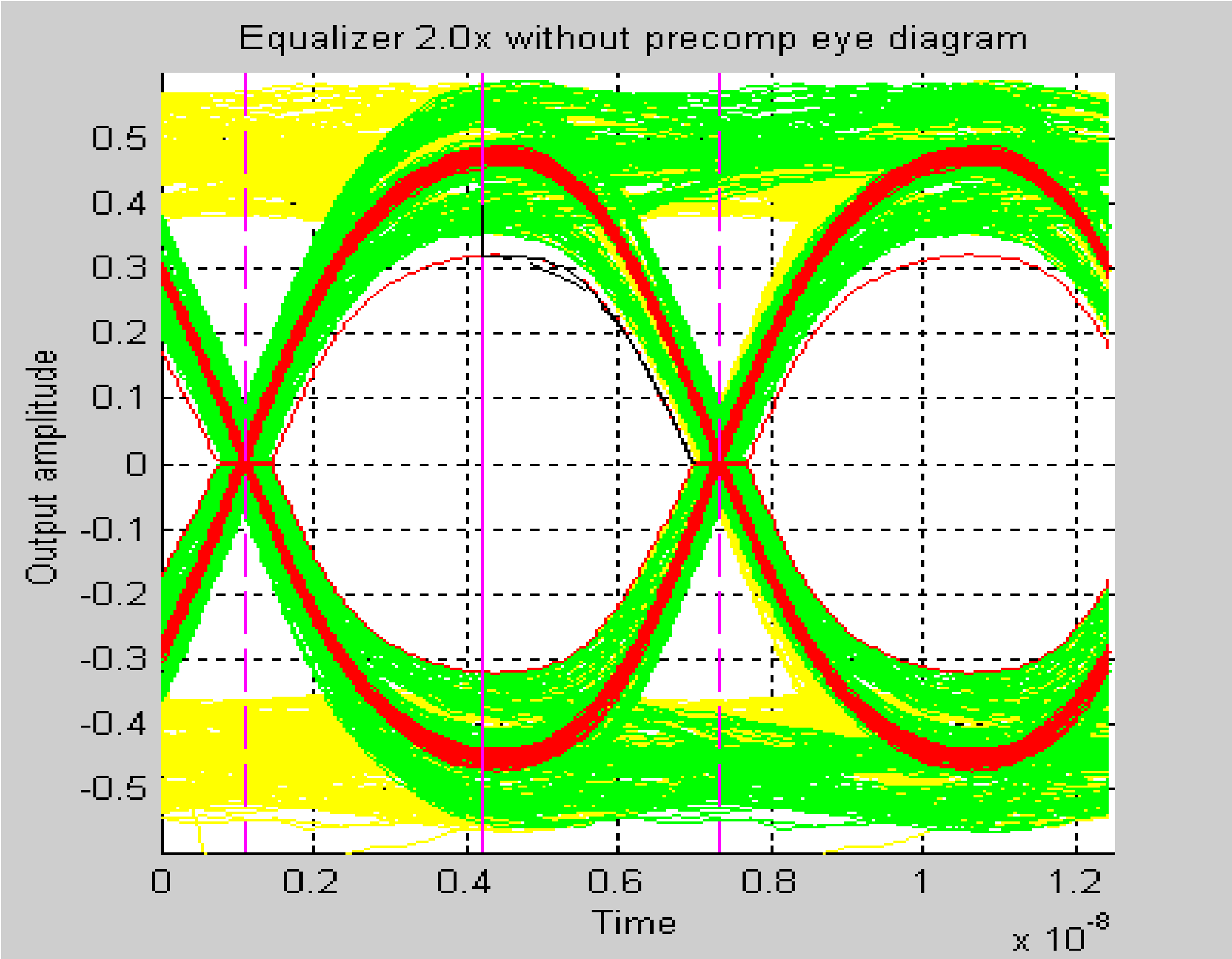


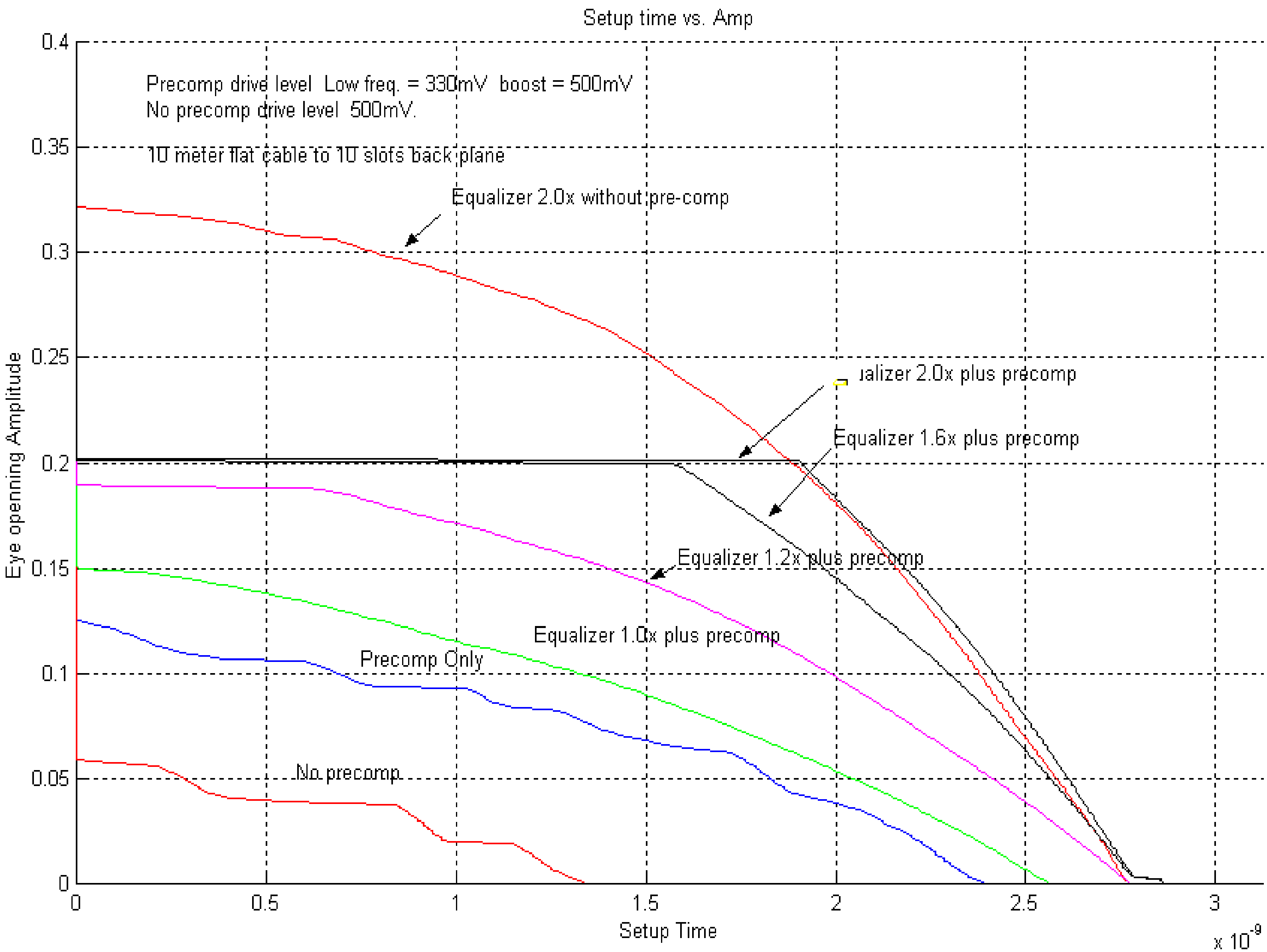
- Boost forced to 2.0
- Eye dominated by hold time
- Edge signals fell back too early

No Tx PC, Rcvr boost forced to 2.0x



- Boost forced to 2.0
- No precompensation
- Large, symmetrical eye

Composite eye diagram



Discussion

- On a long (high loss) cable plant such as this, the eye is dominated by signals which had inadequate precomp:
  - Not enough boost on the transition (T_{setup})
  - Too early a fall-back (T_{hold})
- On a short (low loss) cable plant, the eye is dominated by signals which had too much precomp energy added, resulting in harmful reflections. For an example of such a cable plant, refer to T10/00-194r1, slide 30 (Bruce Manildi / Seagate).
- The hold time transitions which define the eye in these plots are likely to be the second edge of 00000110 patterns. (boosted bits underlined)
- Extending the boost interval to 2 cells (000011000) would fix those specific edges, but would not alter the eye shape.
- A 2 cell boost scheme would lead to similar hold time problems on a 0000011100 pattern (the worst-case hold time now occurs on this pattern).

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Summary

- We have demonstrated that higher receiver equalizer gain will improve the eye diagrams when the received signal has been precompensated by the transmitter.
- The gain level of the equalizer in revision 0 of this presentation was adapted to the fallback level of the precomp driver and did not provide adequate gain to compensate for the lossy cable plant.
- There is currently no means for intelligently forcing the equalizer boost to a higher value to help such cable plants (such a scheme will be proposed in T10/00-231, but a receiver with equalization will disable Tx PC for Ultra320).
- A fixed length of boost will inevitably be marginal at some loss level (length) of cable plant. The lack of adaption (closed loop adjustment) is a fundamental limitation of transmitter precompensation.

Conclusions

- Adapting to the current training pattern prevents equalization from fully restoring the transmitted waveforms.
- If the adaption is based on matching the level of the boosted driver instead of the fallback driver, the net eye opening will improve on lossy cable plants.
- Open loop compensation (transmitter or receiver) cannot provide suitable eye diagrams over a wide range of cable plants.
- Equalization alone is still substantially better than transmitter precompensation with any forced setting of equalizer gain.