SIGNAL INTEGRITY ANALYSIS

NRZ AND PAM SIGNALS

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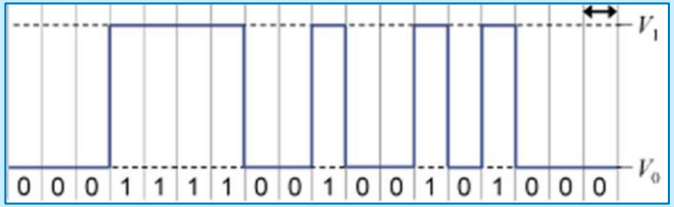
ROHDE&SCHWARZ

Make ideas real

MOTIVATION

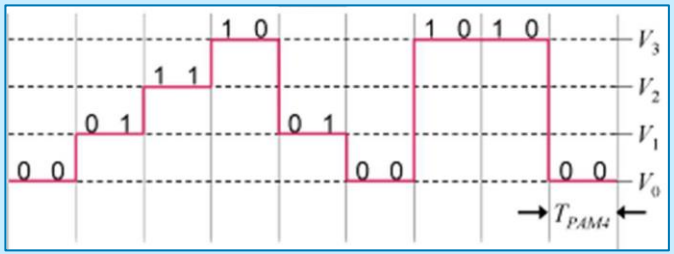
- Increasing data rates necessitate the evolution from **NRZ** (Non-Return-to-Zero) to **PAM** (Pulse Amplitude Modulation)
- **PAM** introduces challenges like reduced Signal-to-Noise Ratio (SNR) and increased complexity in signal integrity.
- Oscilloscopes need to be able to accurately measure products of signal integrity for both signal types

NRZ: Simple binary signaling, but limited bandwidth efficiency as data rates increase



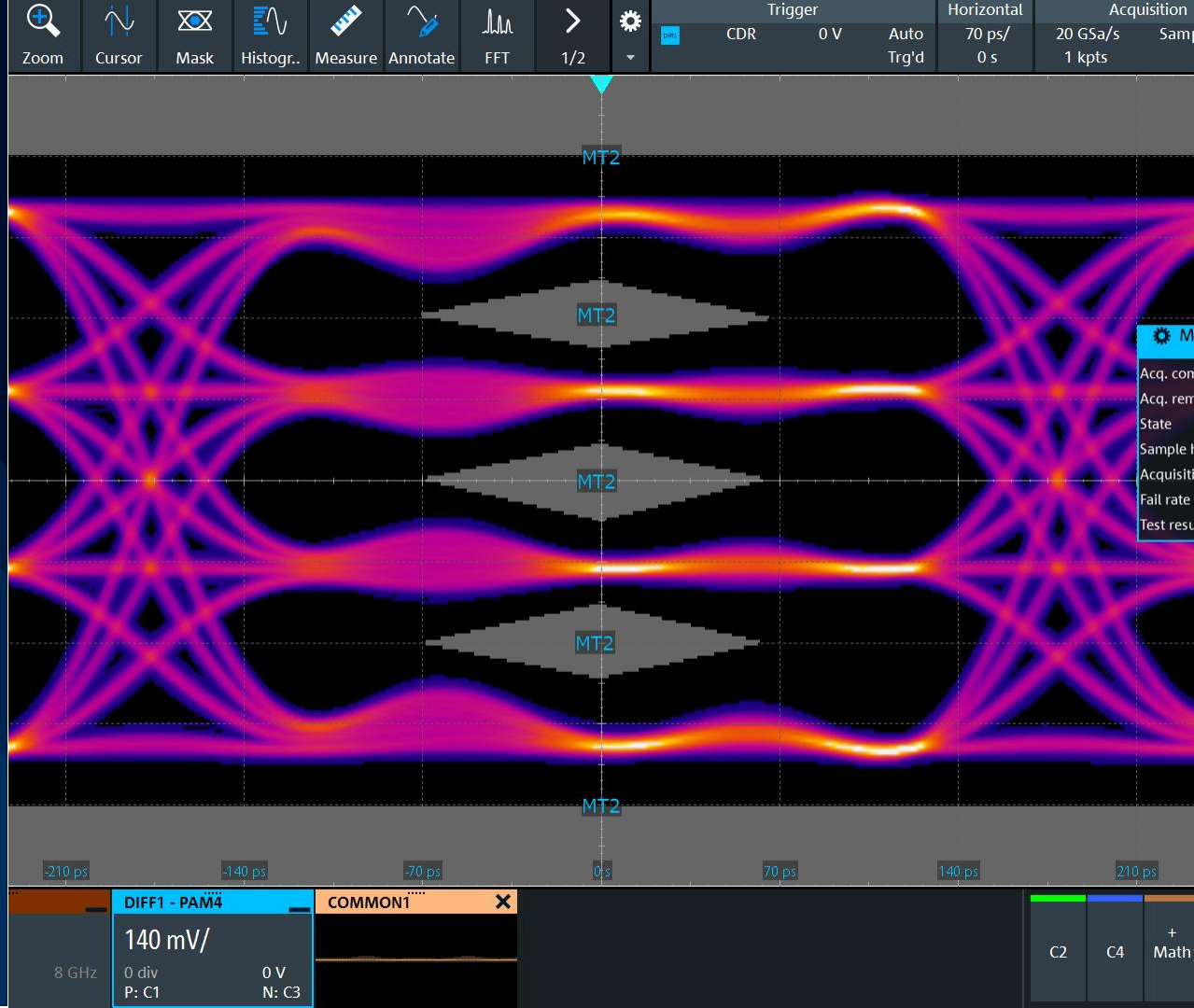
PAM: Encodes multiple bits per symbol, improving data throughput without increasing bandwidth.

Example PAM4:



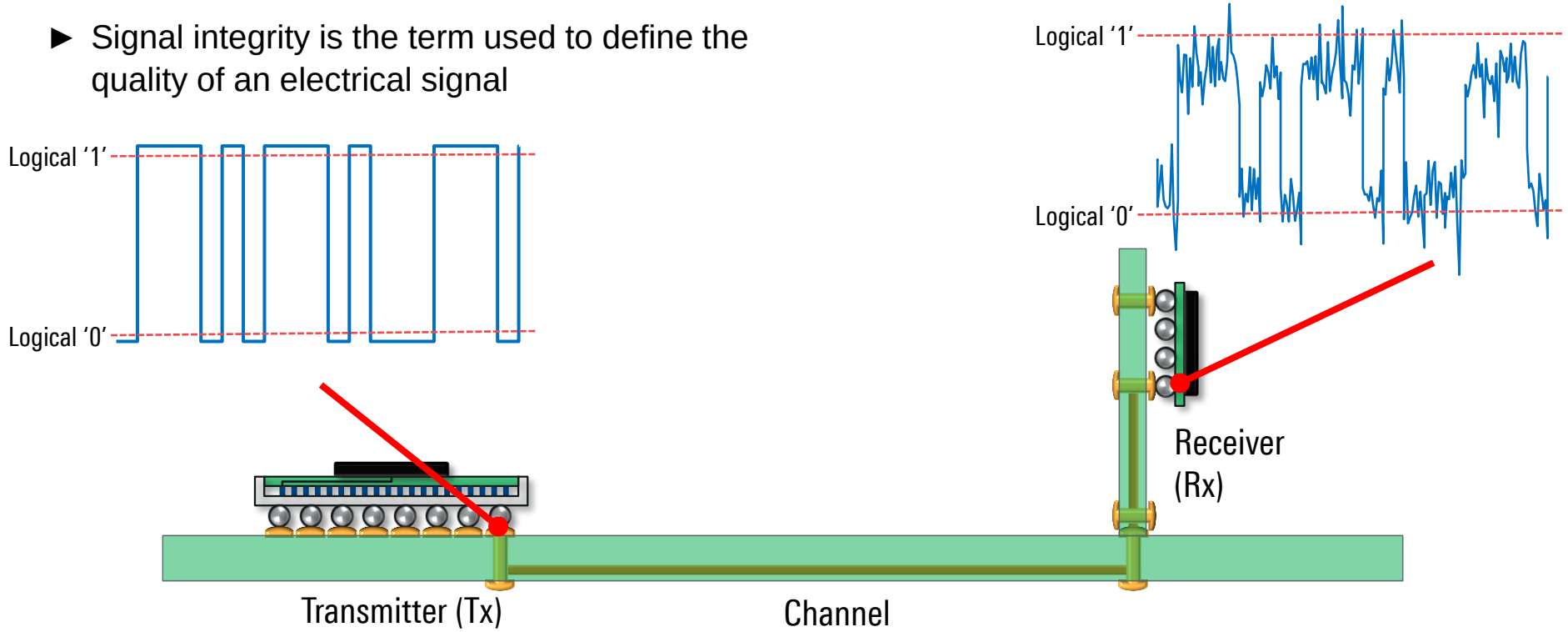
AGENDA

- Introduction to Signal Integrity (SI)
- Eye diagrams *(Demo)*
- Equalization and Embedding *(Demo)*
- PAM Analysis *(Demo)*

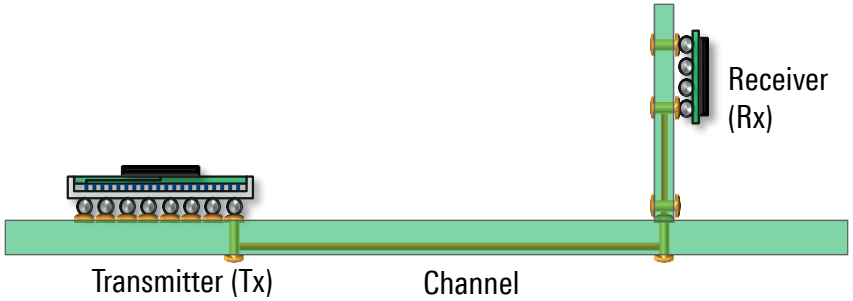


INTRODUCTION TO SIGNAL INTEGRITY

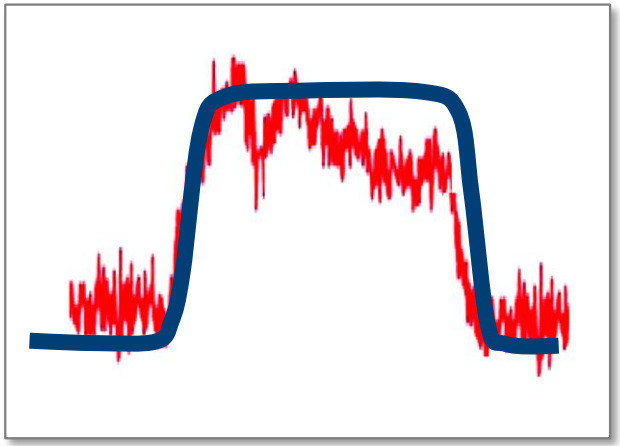
- Signal integrity is the term used to define the quality of an electrical signal



COMMON PROBLEMS



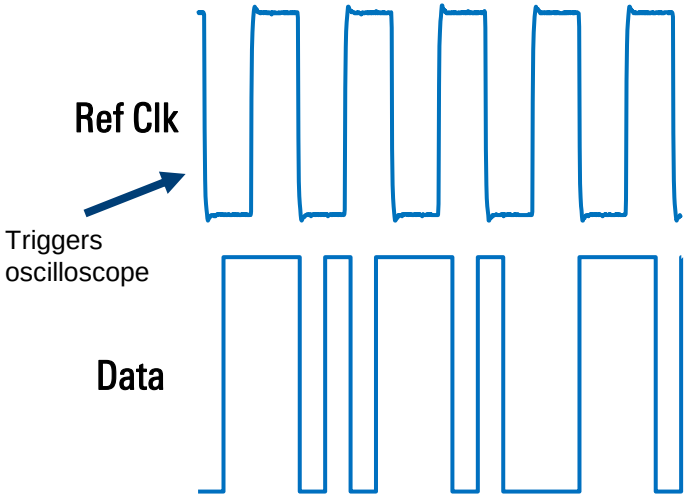
- **Transmitter effects**
  - Rise/fall imbalance
  - Timing jitter
- **Channel-related effects**
  - Ringing (overshoot/undershoot)
  - Signal loss/attenuation
  - Crosstalk
  - Reflections due to impedance mismatches
- **External sources** (can be intermittent)
  - EMI within or from outside the components in the system
  - Noise from power and distribution networks
  - Interferer from other functional cores

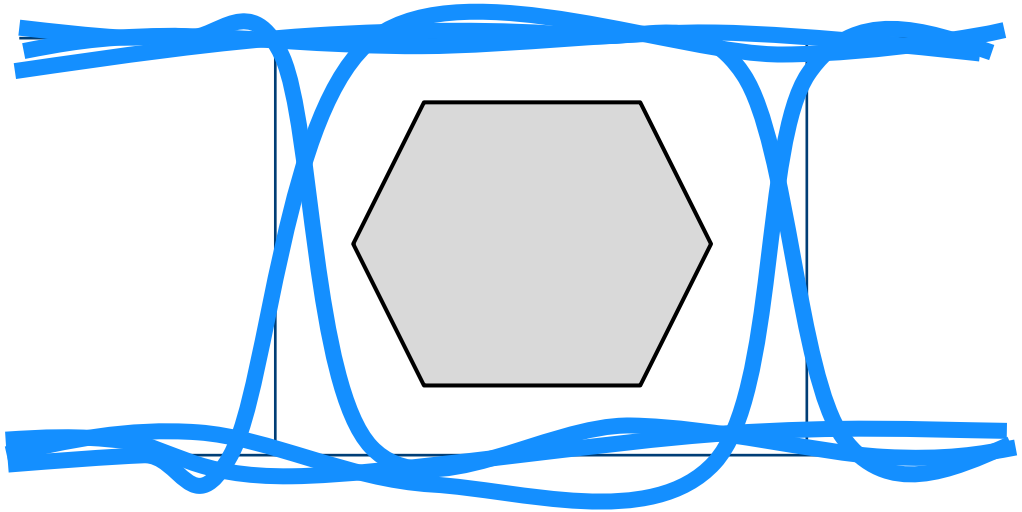


How to measure such parameters and what fault traps do exist?

EYE DIAGRAM

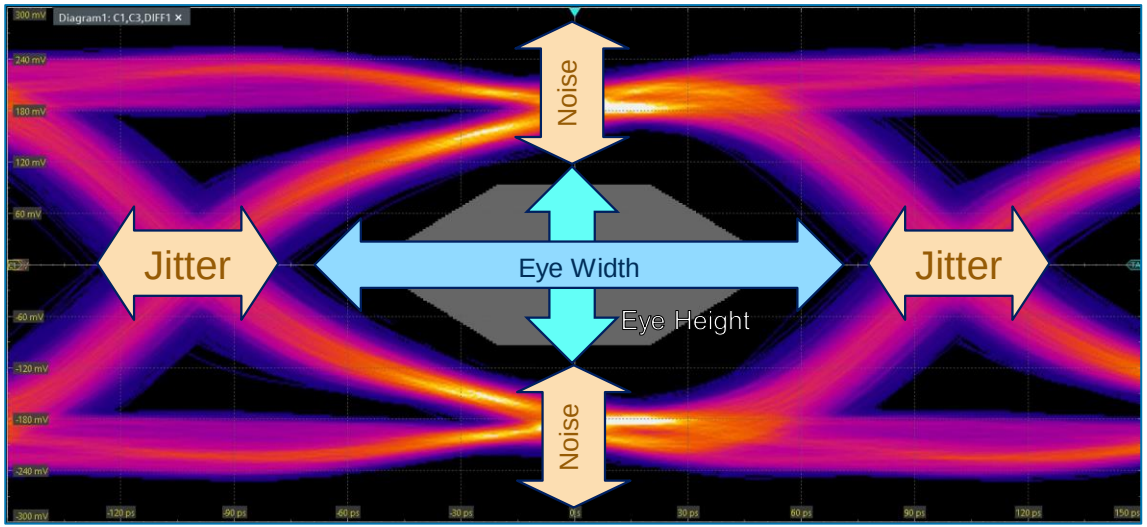
- Intuitive graphical tool for the evaluation of the quality and integrity of data signals
- Generated by superposition of multiple signal waveform segments aligned to well-defined reference time instants
  - Waveform segments commonly correspond to a data symbol
  - Reference clock provides timing information for alignment (e.g. symbol start instant)





INTERPRETING AN EYE DIAGRAM

- **Timing jitter:**
  - Peak to peak
  - Standard deviation
- **Noise:**
  - Peak to peak
  - Standard deviation
- **Eye width:** the minimum time interval over which no signal transition will occur
- **Eye height:** the minimum amplitude over which the signal level occur

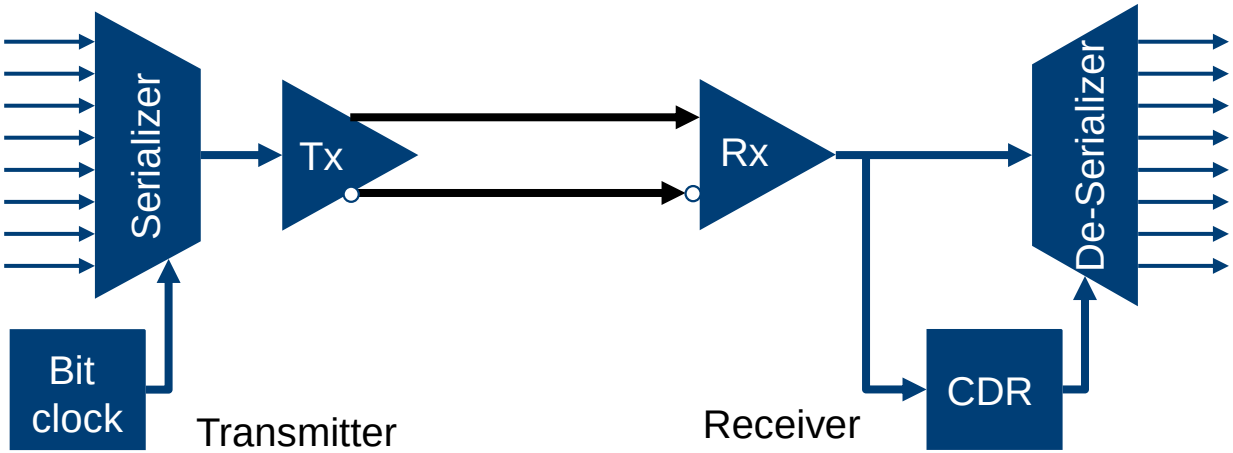


Eye parameters are based on statistics and require large sample size for repeatable measurements

REFERENCE CLOCKS FOR EYE DIAGRAMS

- Timing Reference can be from a reference clock (parallel clock signal) or from the data signal itself (embedded clock signal)

- Clock data recovery (CDR) typically uses a Phase Locked Loop (PLL) or Delay Looked Loop (DLL)

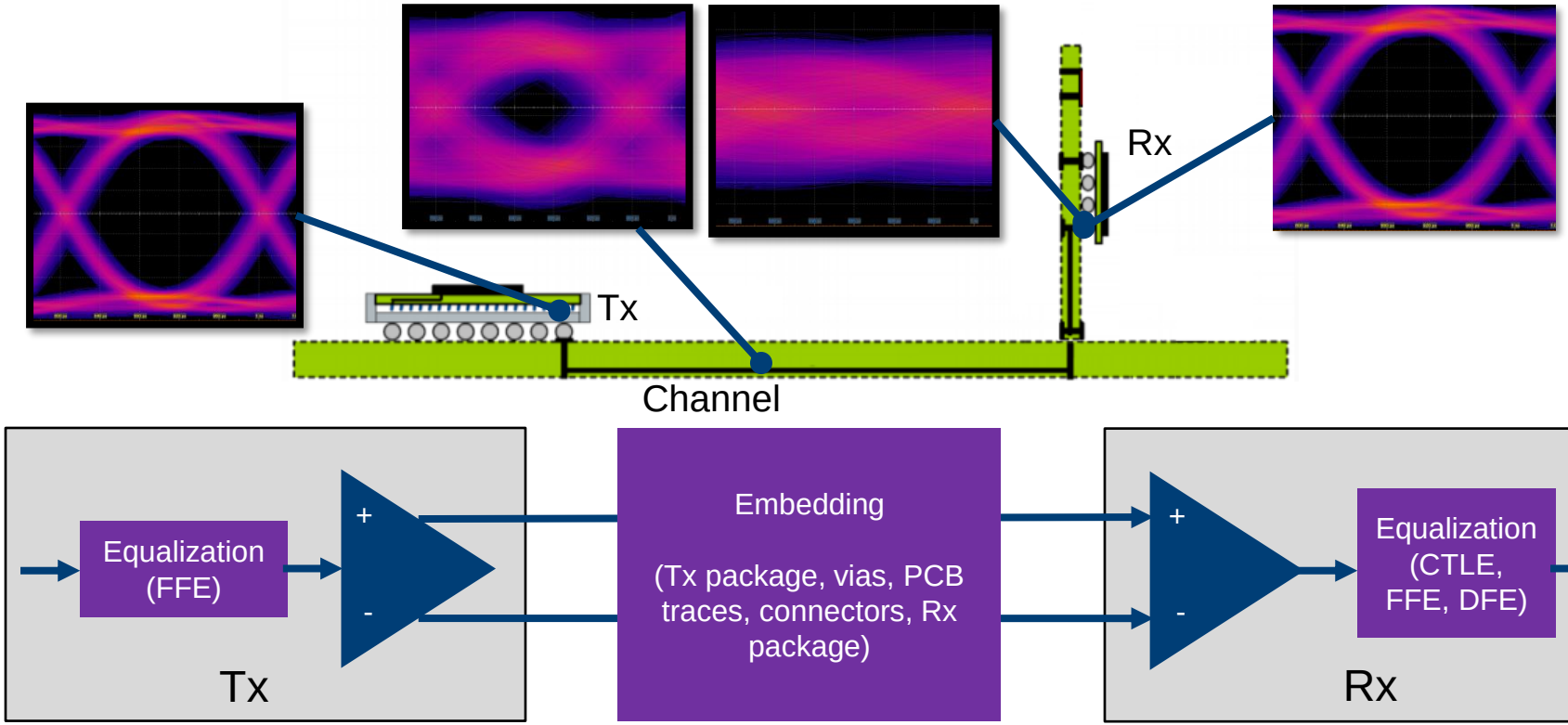


DEMO OF 2 EYE DIAGRAMS (LIVE EYE AND ADVANCED)

REQUIREMENTS: RTP164B, RT-ZB2, RTP-B7 (ACCESSORIES KIT)

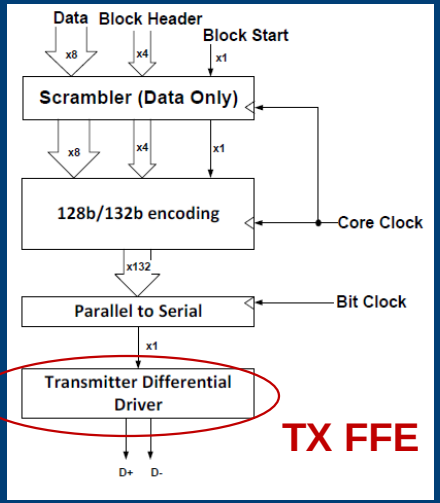
EMBEDDING AND EQUALIZATION

TRANSMISSION CHANNEL AND SIGNAL IMPAIRMENTS

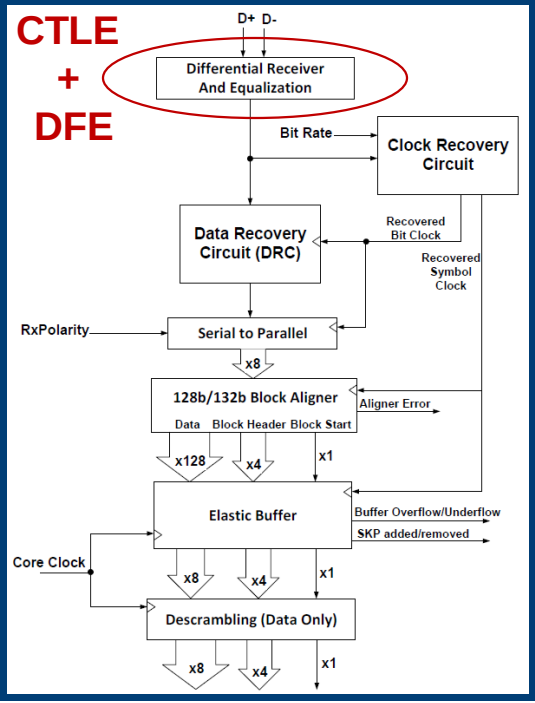


USB 3 GEN 1/2 - PHYSICAL LAYER EQUALIZATION

Transmitter



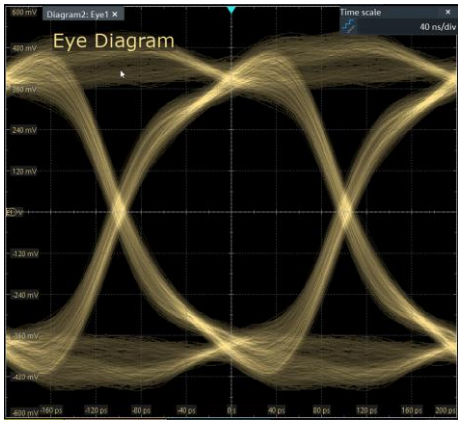
Receiver

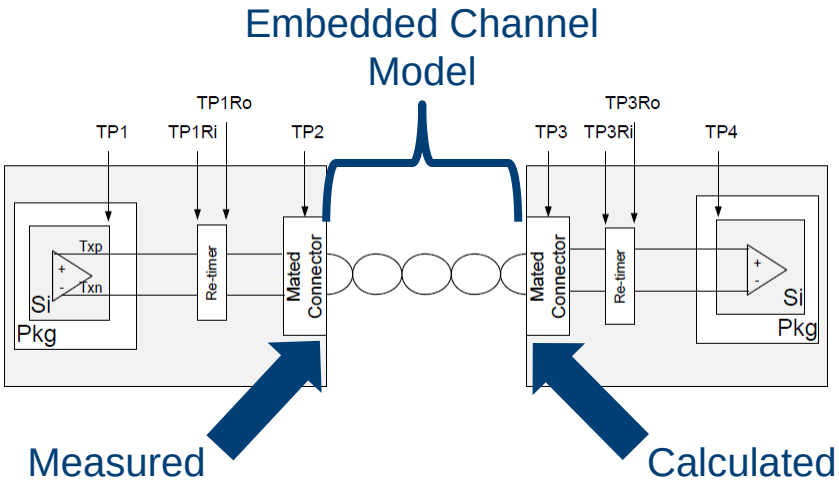


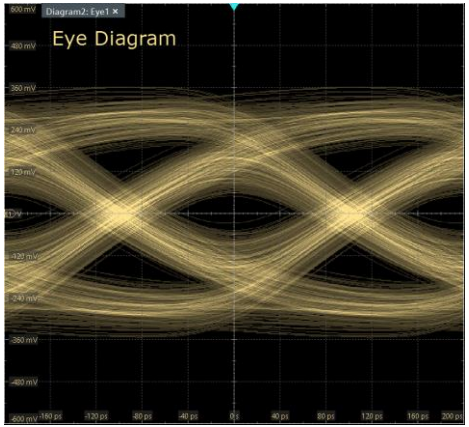
Source: USB 3.2 specification

EMBEDDING

- Emulates additional signal distortion by adding mathematically “lossy” components (e.g. cable)
- Components are expressed by S-parameters (typically 2-port or 4-port)
- Several components can be cascaded
- FIR filter gets designed to simulate respective frequency response

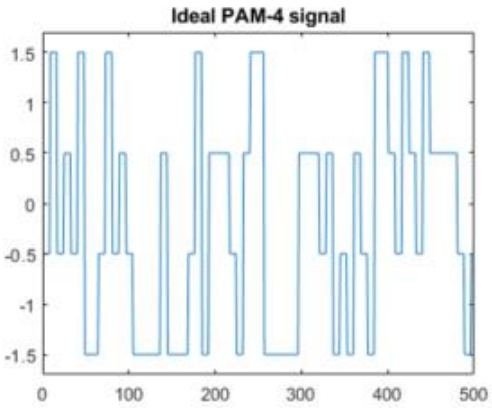


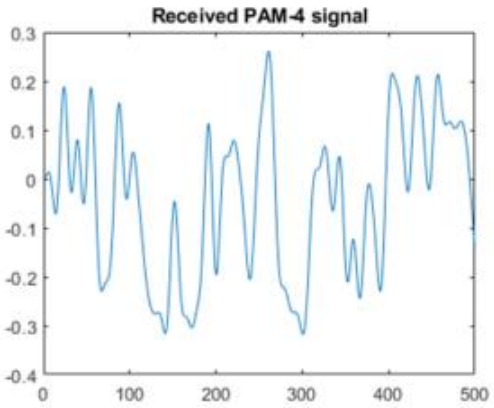


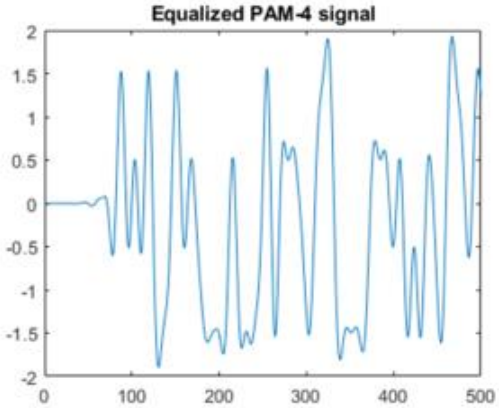


WHAT IS EQUALIZATION

- Operation that is applied to a signal that has been distorted by a channel (such as a cable).
- Equalizer compensate for some of the distortions introduced by the channel and can recover the transmitted symbols:
  - \+ can compensate inter-symbol interferences
  - − can not remove noise or delays







DEMO EQ + EMBEDDING, THEN PAM EXAMPLE

Find out more

www.rohde-schwarz.com/oscilloscopes

Thank you for listening!

Nick Le Bas – Oscilloscope Product Specialist

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REFERENCES

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