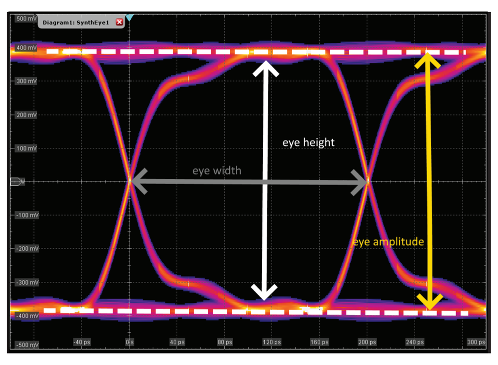
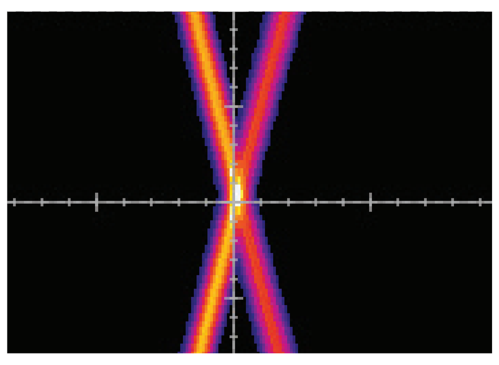
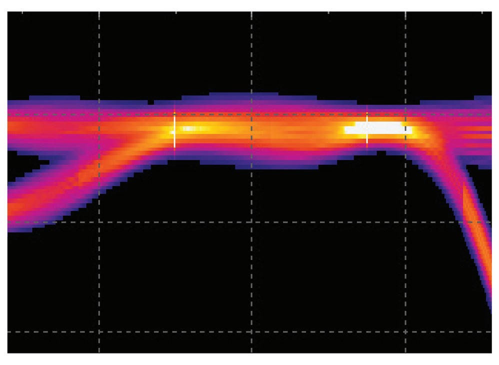
SIGNAL INTEGRITY EYE TEST

MEASURING AT THE TRANSMITTER

View the transmitter's influence on the eye diagram







PARAMETRIC

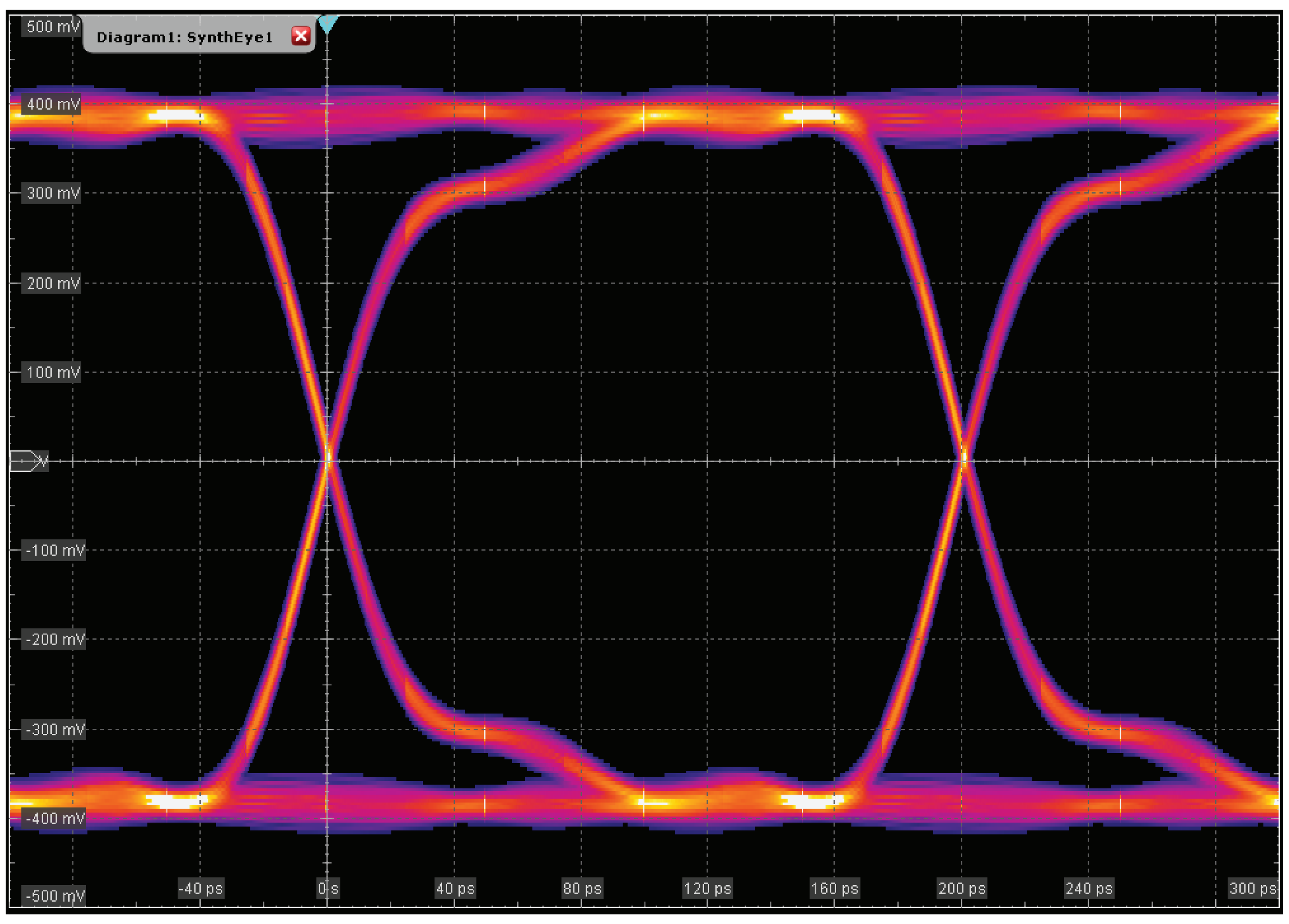
- Transmitter eye opening controlled by amplitude & rise time
- Slew-rate, driver imbalance, intra-pair skew contribute to EMI
- Typical measurements: eye height, eye width, amplitude, rise time, slew rate, mask testing

JITTER

- Transmitter jitter components include random jitter (RJ) & periodic jitter (PJ)
- RJ is mostly influenced by clock
- PJ mostly influenced by power rail and clock
- Typical measurements: total jitter, random jitter, and deterministic jitter

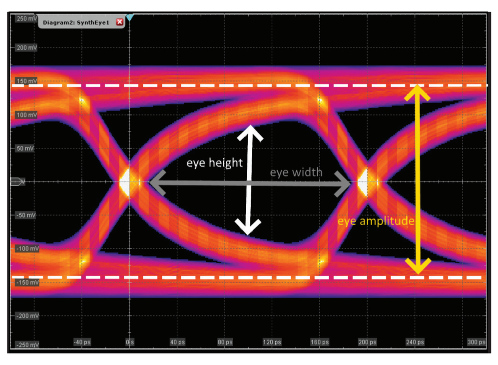
NOISE

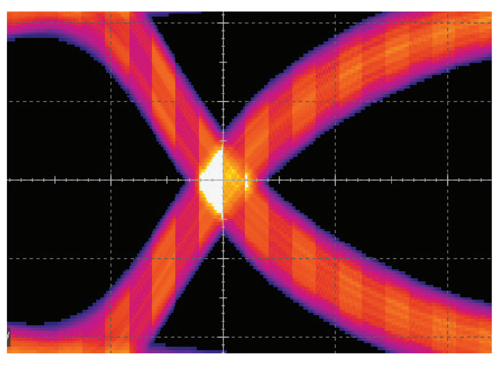
- Observed at the top and bottom of the eye diagram
- Noise at the transmitter is fundamentally power rail noise
- Typical measurements: total noise, random noise, deterministic noise

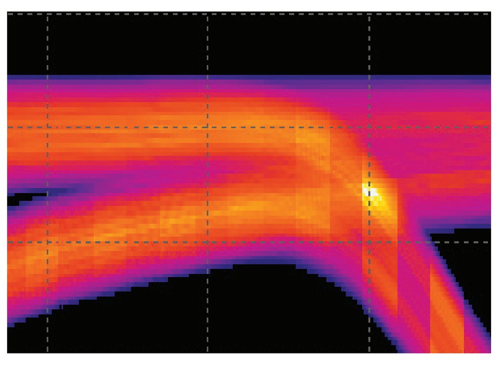


MEASURING AT THE RECEIVER

View the system's influence on the eye diagram







PARAMETRIC

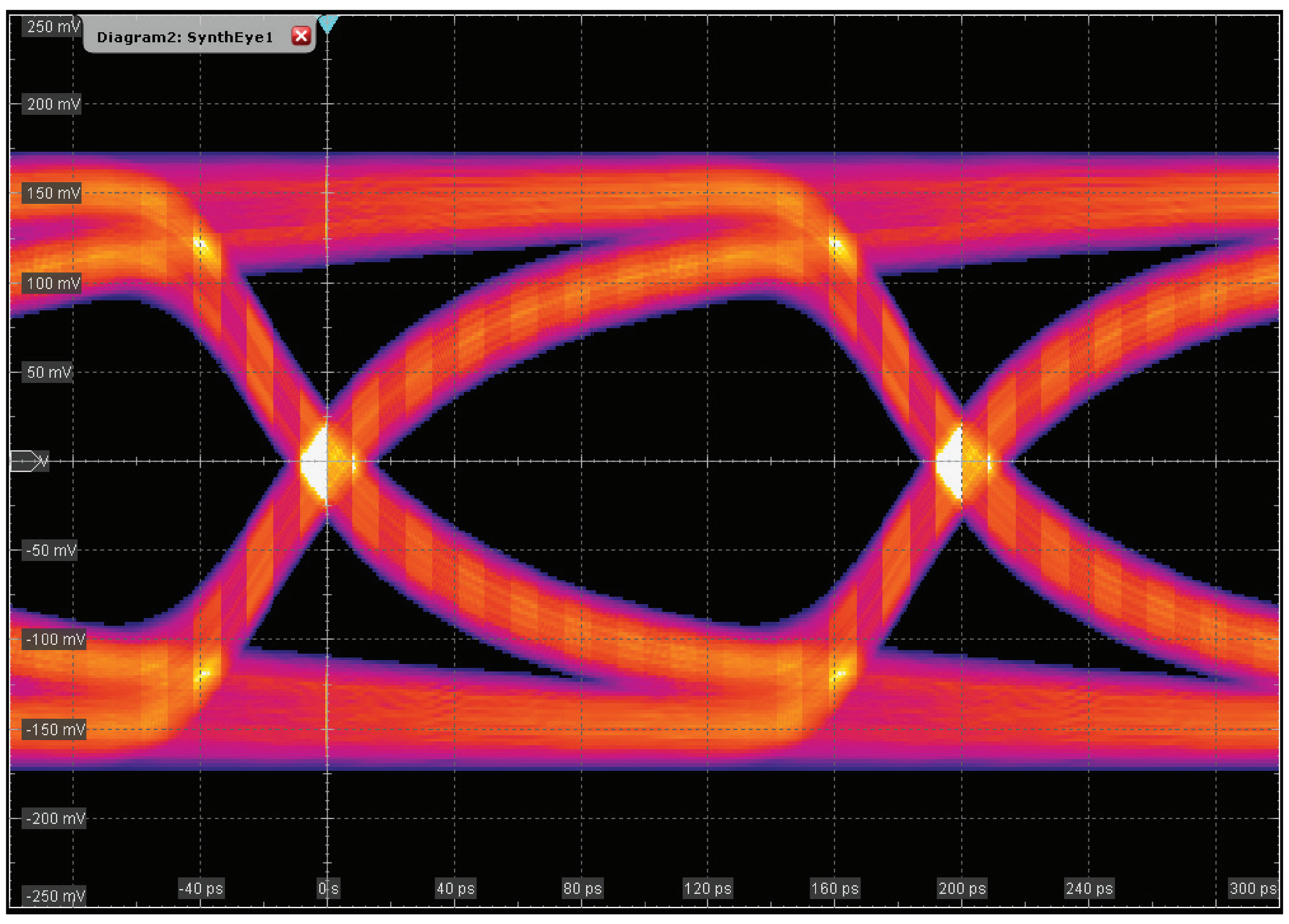
- The channel has frequency dependent losses which reduce the eye height and reduce the eye width
- Typical measurements: eye height, eye width, amplitude, rise time

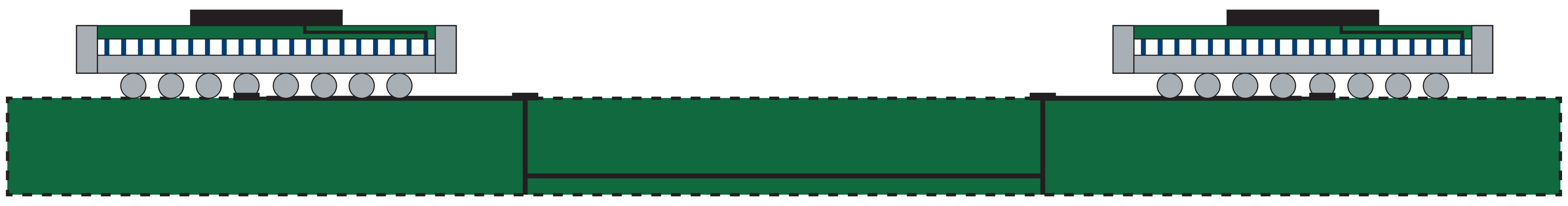
JITTER

- The channel's frequency dependent losses cause data-dependent jitter. Additional jitter sources include crosstalk and EMI
- Typical measurements: data-dependent jitter, total jitter, random jitter, deterministic jitter, and crosstalk

NOISE / INTERFERENCE

- The channel is susceptible to noise and interference which can be seen at the top and bottom of the eye diagram. The two most common sources of noise and interference are EMI and crosstalk
- Typical measurements: total noise, random noise, deterministic noise, data-dependent noise, EMI FFT analysis



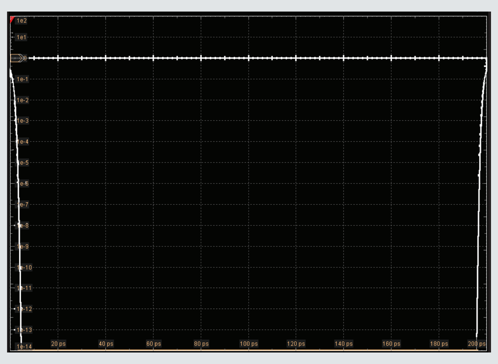


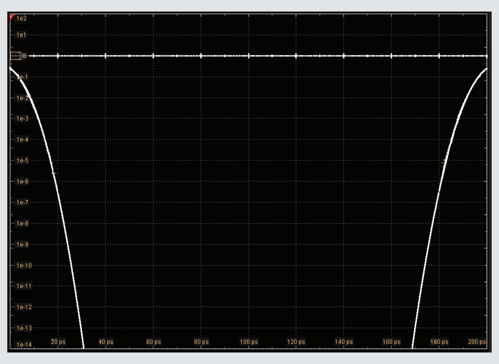
COMMON CHALLENGES

AT THE TRANSMITTER

RANDOM JITTER

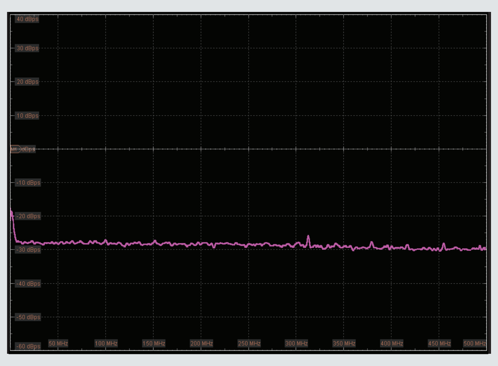
Phase noise can be manifested as RJ of the data signal. The bathtub curve shows the influence of RJ over time

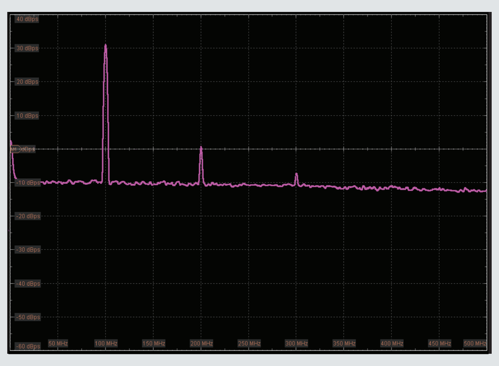




PERIODIC JITTER

Periodic noise sources such as power supply coupling, can add high amplitude periodic jitter. PJ spectrum helps visualize specific jitter tones



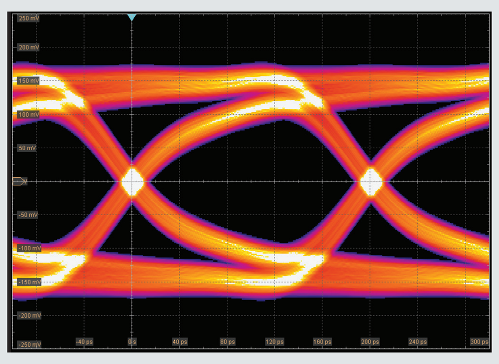


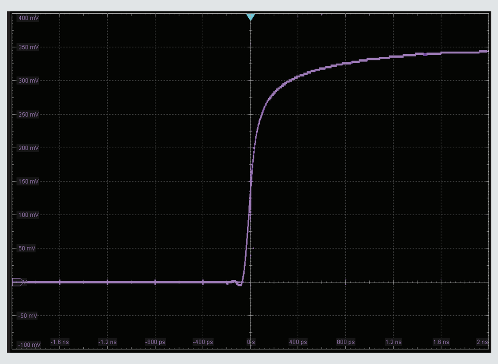
COMMON CHALLENGES

AT THE RECEIVER

LONG CHANNEL

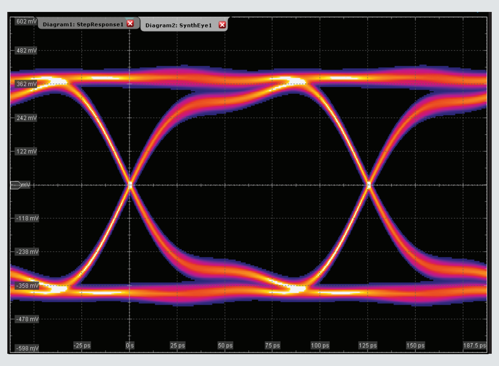
The longer the channel, the higher the signal attenuation due to the dielectric absorption of the channel material

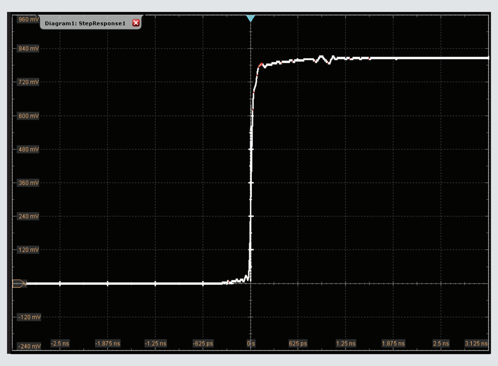




REFLECTIONS

Ringing or overshoot can occur from PCB layout, probing issues or other impedance discontinuities

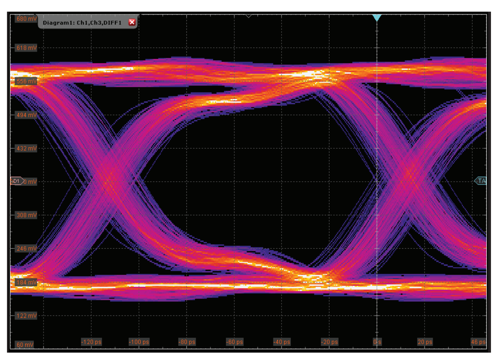




HOW TO GENERATE AN EYE DIAGRAM

ON AN OSCILLOSCOPE

There are three primary ways of capturing an eye diagram. Each of the methods has benefits and trade-offs



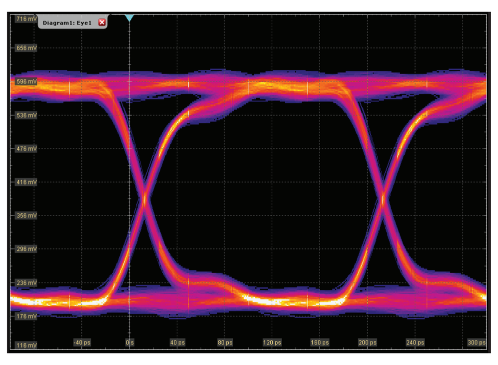
TRIGGERED EYE

In this setup there is a system clock used to trigger the oscilloscope. Each acquisition captures one eye diagram and the oscilloscope overlays them

Benefit: High UI count, see transient events, simple setup

Trade-off: Significant trigger jitter, not consecutive UI, includes time-base wander, live signals only

Requirement: Need to have external clock, or alternatively could trigger directly on data with compromised results



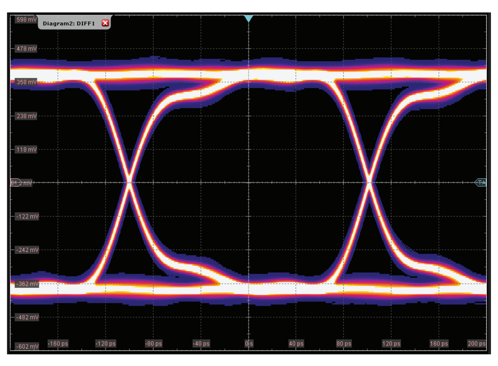
DIGITAL CLOCK RECOVERY

Here the clock is embedded in the data signal and is extracted using hardware or software clock recovery. Each acquisition captures one unit interval and the oscilloscope overlays them

Benefit: Highest UI count, no trigger jitter, see transient events, enables higher layer protocol triggering

Trade-off: Not consecutive UI, live signals only

Requirement: Oscilloscope clock data recovery option, minimum pattern duration for PLL lock



SINGLE ACQUISITION

A single acquisition is captured and the oscilloscope uses software clock recovery to identify each unit interval and overlay them into an eye diagram

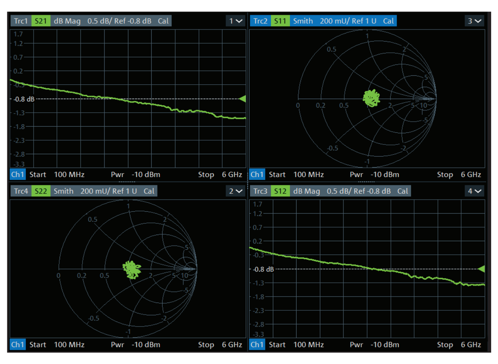
Benefit: Consecutive UI, No trigger jitter, off-line processing, facilitates instrument correlations

Trade-off: Lowest UI count, no transient events

Requirement: Oscilloscope software clock recovery and analysis options

ON A VECTOR NETWORK ANAYLYZER

A VNA can translate measured s-parameters into an eye diagram of the channel



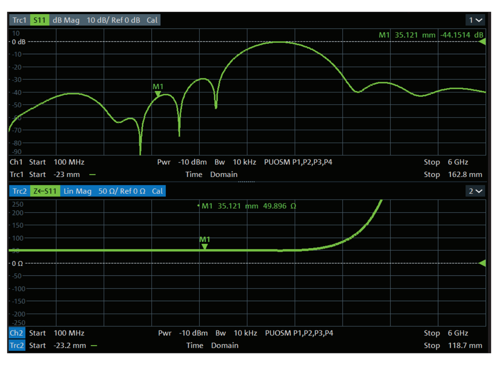
MEASURE S-PARAMETERS

In this setup the VNA measures the complete set of s-parameters of the channel

Benefit: Insight into channel behavior such as crosstalk or frequency dependent attenuation

Recommendation: Measurement accuracy can be improved using de-embedding

Requirement: VNA frequency range covers data rate of the channel. Calibration procedure to establish measurement plane at the device under test



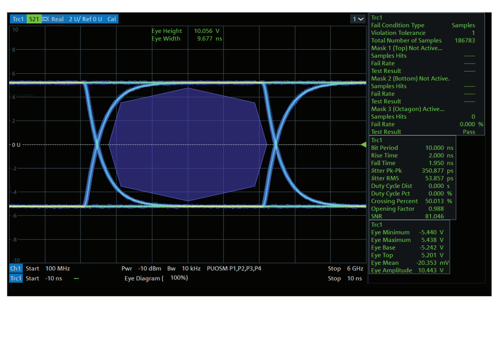
CALCULATE TIME DOMAIN

Using an inverse FFT function, modern VNAs generate equivalent time-domain response

Benefit: Observe behavior in time-domain (reflections) and measure propagation (group delay)

Recommendation: As your channel length goes up, increase the number frequency data points for longer time-domain capture

Requirement: VNA time domain option, DC value extrapolated from s-parameters



DISPLAY EYE DIAGRAM

Add the time-domain response to a test pattern to simulate an eye diagram

Benefit: Evaluate channel performance under varying conditions such as jitter, noise and equalization

Recommendation: Add a mask for protocol specific compliance testing

Requirement: VNA eye diagram option