IN-VEHICLE NETWORKS:
GIGABIT MULTIMEDIA SERIAL LINK(GMSL)

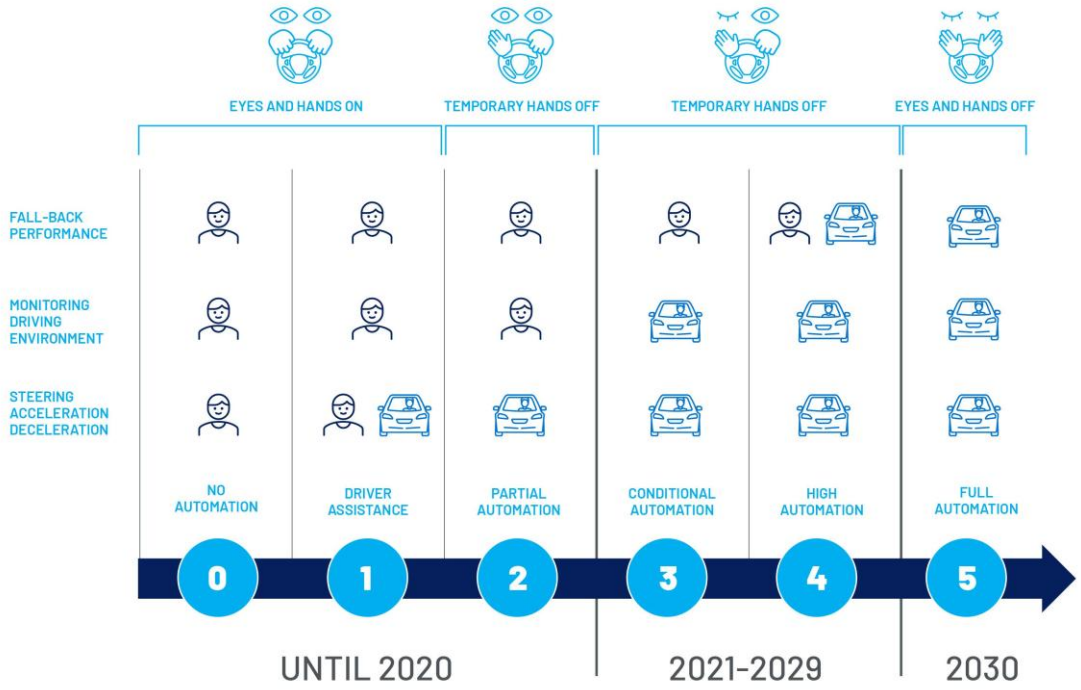
Jason, Product Manager, Oscilloscopes

ROHDE&SCHWARZ

Make ideas real

MARKET AND TECHNOLOGY DRIVERS

- The developing trend from a traditional vehicle design towards ACES requires the secure handling of data from an increased number of complex sensors.





- Moving towards the ACES trends such as fully autonomous driving or connected cars requires:
  - Faster in vehicle networks (IVN) supporting high computing power and high data throughput
  - Reduction of IVN complexity
  - Power consumption and weight efficiency

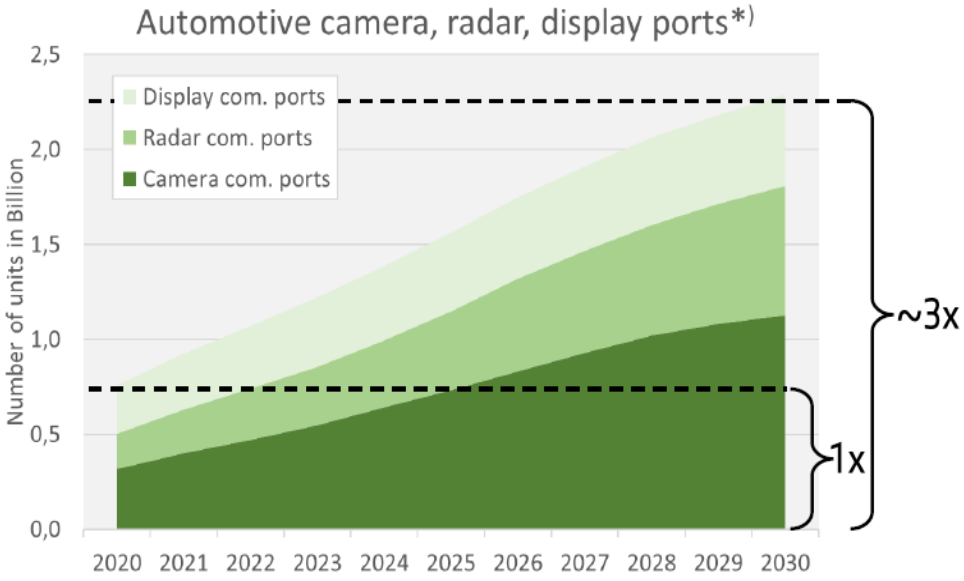
MARKET AND TECHNOLOGY DRIVERS

- New automotive services and migration to higher levels of autonomous driving
  - Increased IVN traffic
  - Required data rate is also increasing

    →High-definition cameras

    →Higher frame rates

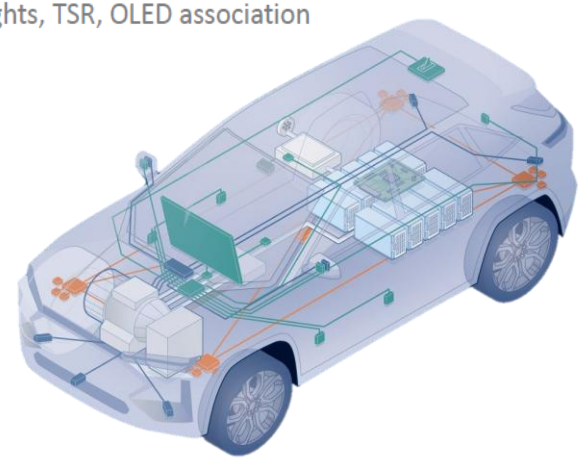
    →4D imaging radar.



*) Sources: mobility foresights, multiple semiconductor vendors, R&S, TechInsights, TSR, OLED association

- Safety critical applications reduce error tolerance

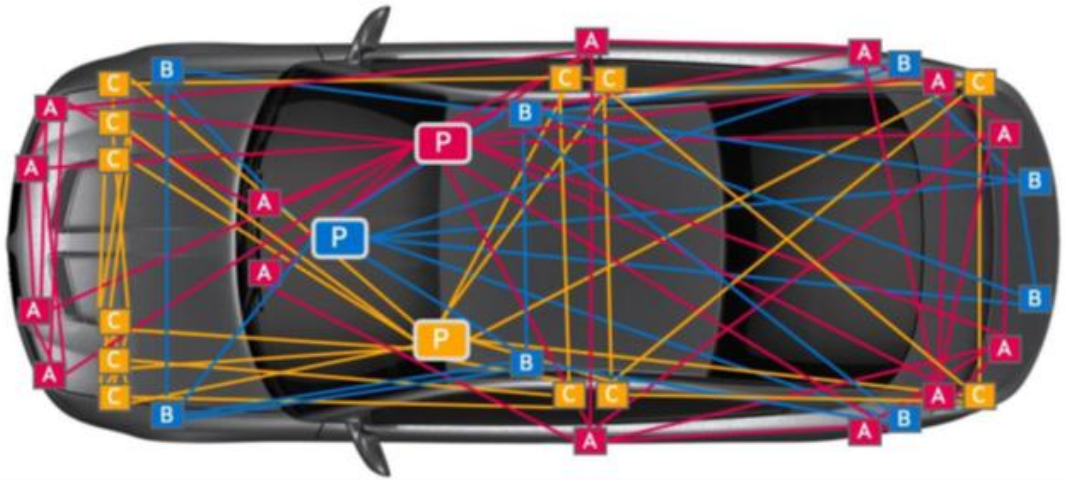
  → Increased need for signal integrity.
- Migration to zonal-orientated IVN architecture to facilitate



TRANSITION FROM DOMAIN TO ZONAL ARCHITECTURE

Domain architecture

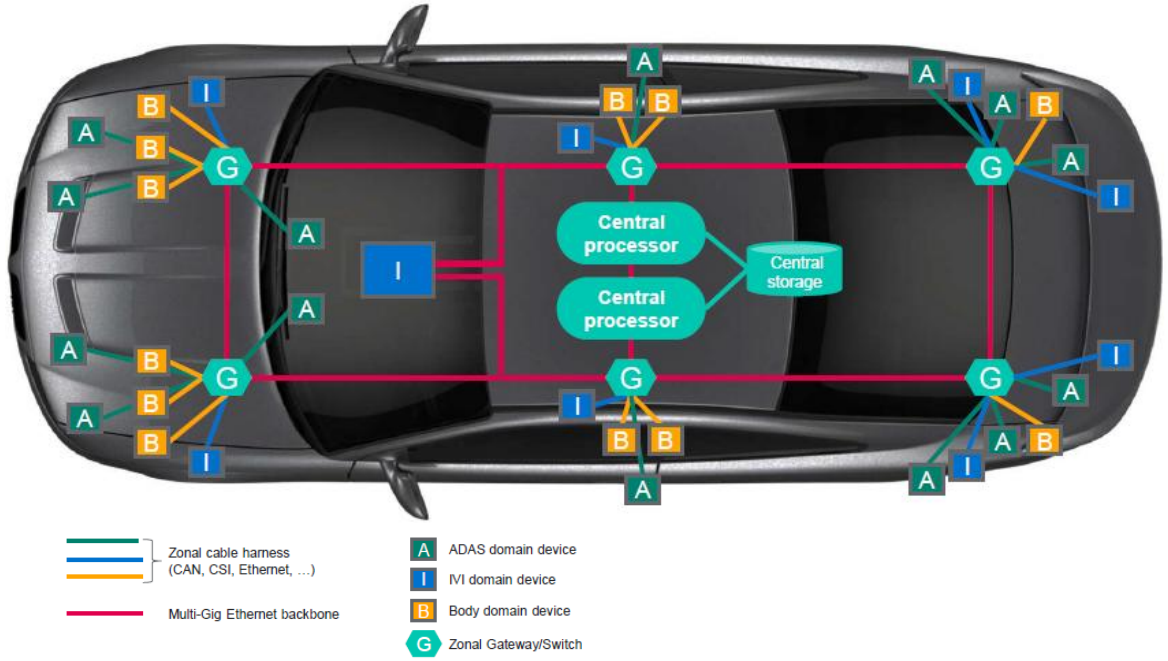
- Central domain controller/high performance computer
- Ability to handle more complex functions
- Consolidation of functions (cost optimization)
- But: cable harness is rigid and expensive



Source: Marvell Automotive Ethernet Congress 2022

Zonal architecture

- Local ethernet gateway per zone
- Ultra high-speed secured backbone between zones
- Centralized SW
- Central computing & storage



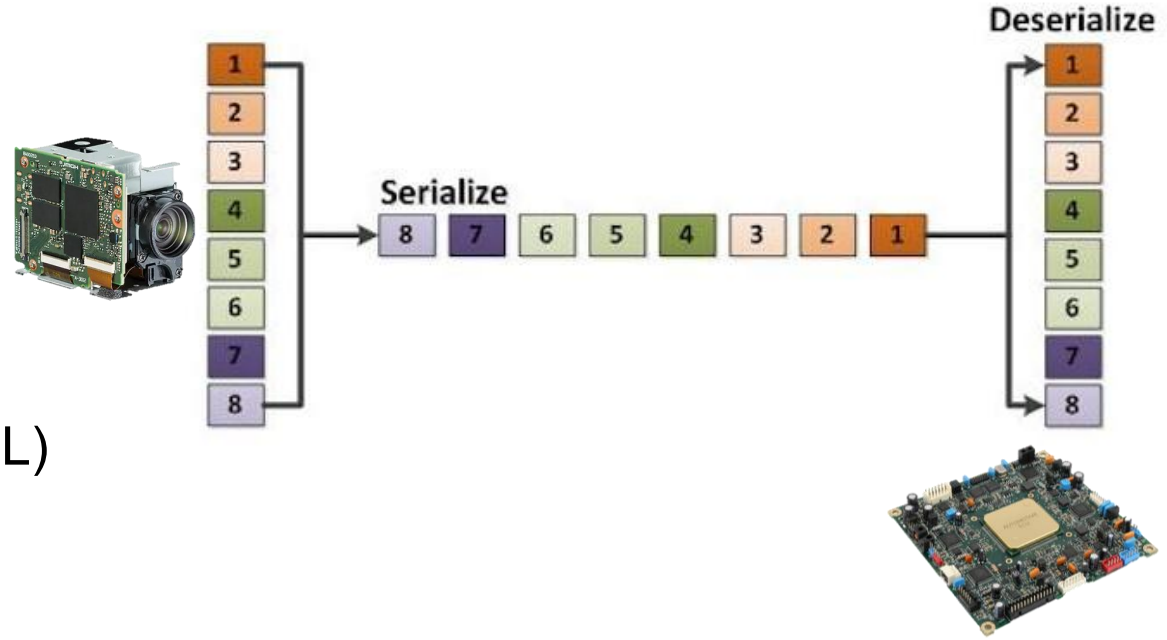
INTRODUCING AUTOMOTIVE ETHERNET

- This IVN technology spanning speeds from 10 Mbps to 10 Gbps, would have been the ideal answer
- Transferring camera/radar/lidar data to an ECU/HPC only requires the high-speed link (over 6 Gbps) to be in one direction. The other direction can be managed by much slower data rates (below 50 Mbps) to send control signals
- However, Ethernet is a fully symmetric communication protocol, therefore inefficient for many sensor to ECU applications
- ***Stipulates the need for an asymmetrical technology***



INTRODUCING SERDES

- Stands for **Ser**ialiser / **Des**erialiser
- Converts parallel data into a fast, serial data stream for transmission, and then converts the serial stream back to parallel data at the receiving end
- SerDes are designed for high throughput use cases (camera/video, radar, lidar, etc.)
- Historically, several SerDes implementations in the market, solutions were not interoperable
- Due to industry demand for open ecosystems, two emerging SerDes technologies:
  - OpenGMSL Association (OGA)
  - Automotive SerDes Alliance Motion Link (ASA-ML)
  - FPD Link, MIPI A-PHY, GVIF



RELEVANT COMMITTEES ADOPTER MEMBERS



























































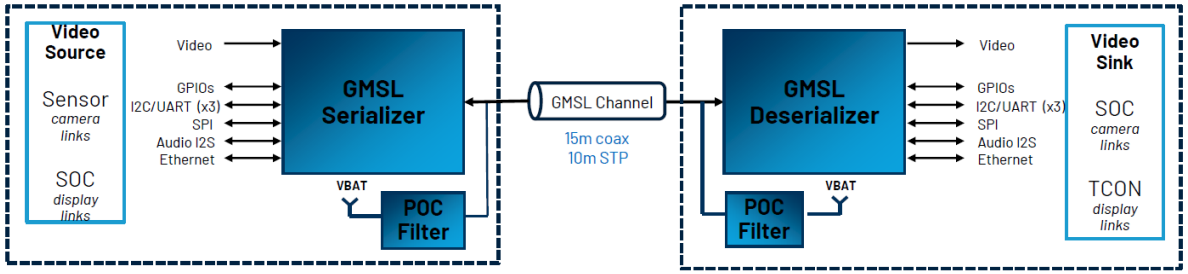
https://www.opengmsl.org/member-companies/

https://auto-serdes.org/about/members/

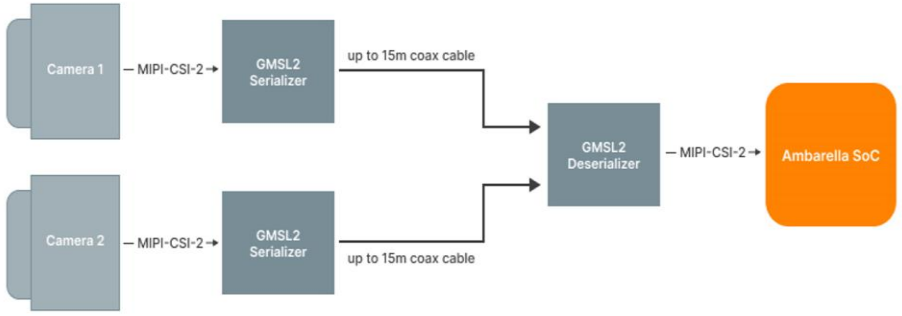
https://opensig.org/members/

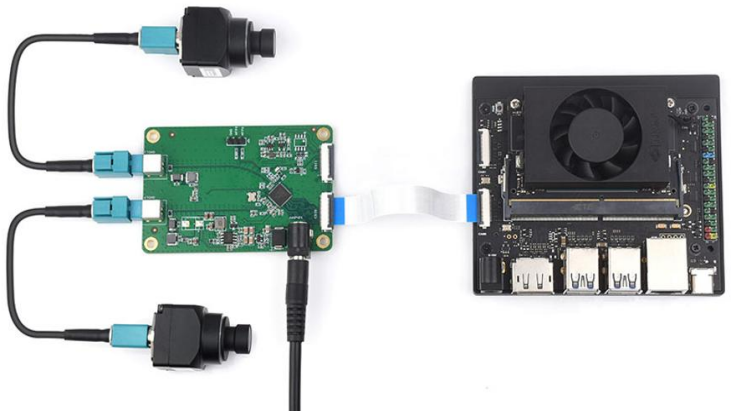
GIGABIT MULTIMEDIA SERIAL LINK (GMSL)

- Developed by Maxim Integrated
  - Acquired by Analog Devices in 2021
- GMSL was introduced in 2008
- Over 25 OEMs implement GMSL in their vehicles

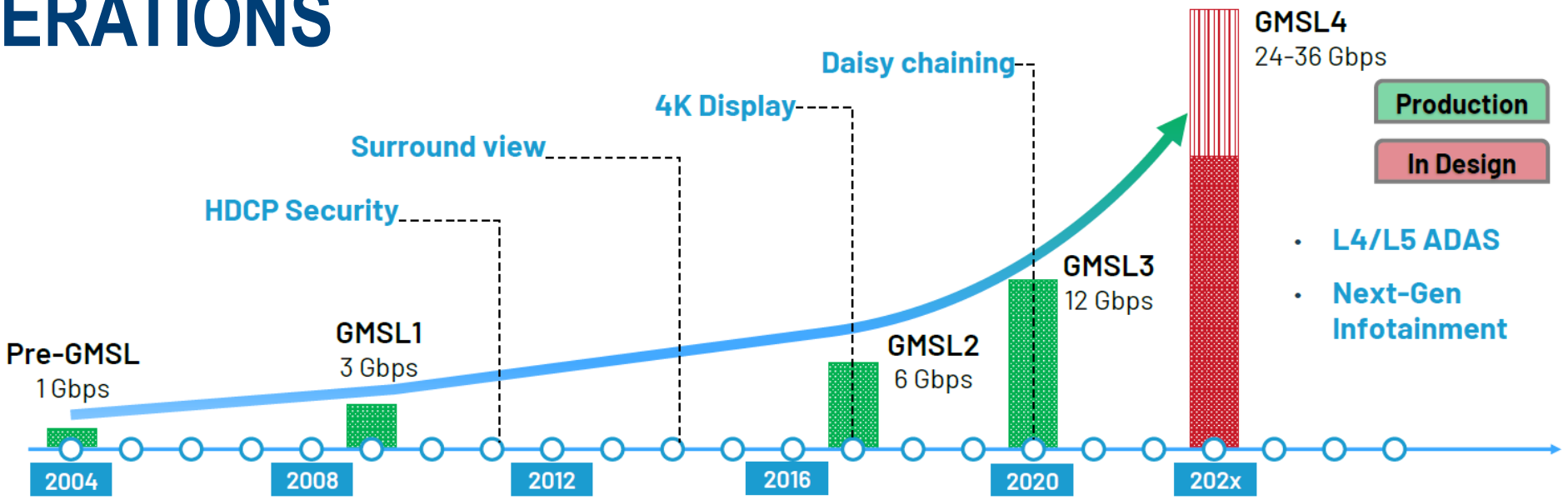


- Full duplex link, but asymmetrical
- 2-wire twisted pair or coaxial
- Provides Simultaneous transmission of real-time data, control, and power over a single wire
  - Bridging Video, Peripherals, Data, Reference Clock and Power over a single cable
- Two Main user-cases: Camera/Sensor and Display
  - Camera/Radar/Lidar → ECU/Processor
  - Processer → display





GMSL – GENERATIONS



	GMSL1	GMSL2	GMSL3	GMSL4
Max Camera resolution	2MP, 30fps	8MP, 36fps	15MP, 36fps 80MP, 60fps	Camera: 15MP+
Display Res (60 Hz)	HD	4K x 1K @60Hz / 4K x 2K @60Hz (DSC)	7K x 1K @60Hz / 10K x 2K @60Hz (DSC)	8K x 2K @60Hz Uncompressed
Speed [Gbps]	3	6	12	?
Symbol rate [Gbaud]	3	6	6	?
Modulation	NRZ	NRZ	PAM4	?

OPENGMSL ASSOCIATION (OGA)

- Established in mid-2025
- Released PHY Specification v3.0 in March 2026
  - Backwards compatible with GMSL2/3
- Downlink line rates up to 16 Gbps per lane
- Uplink data rates up to 187 Mbps per lane



Promoters

ANALOG DEVICES, GEELY, GRL Connecting the World, Qualcomm, SONY, Valeo

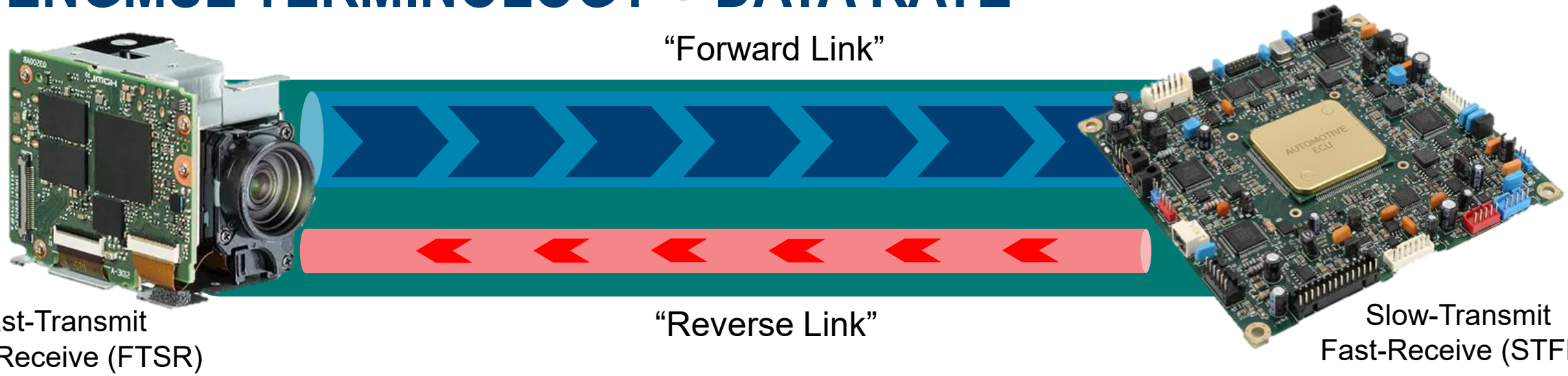
Contributors

alfamation, anapass, APTIV, AXONNE, BitifEye Digital Test Solutions, Coilcraft, CORE, DENSO, elka, ESWIN, ETHERNOVIA, GlobalFoundries, HONDA, JASMIN INFOTECH, KEYSIGHT, XNL, muRata, VELINKTECH, ROHDE&SCHWARZ, ROHM, Rosenberger, Rsemi, SAMSUNG, SMARTSENS, TDK, TZ electronic systems

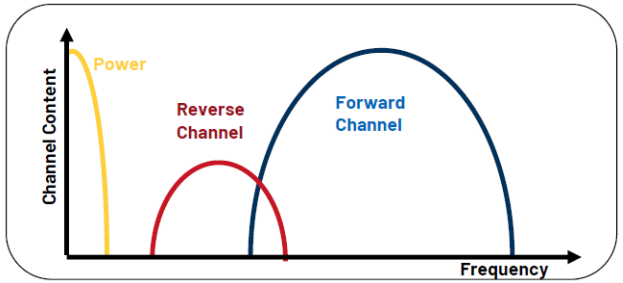
Adopters

ASTRO, GARMIN, onsemi, SmartDV, TELEDYNE LECROY

OPENGMSL TERMINOLOGY + DATA RATE



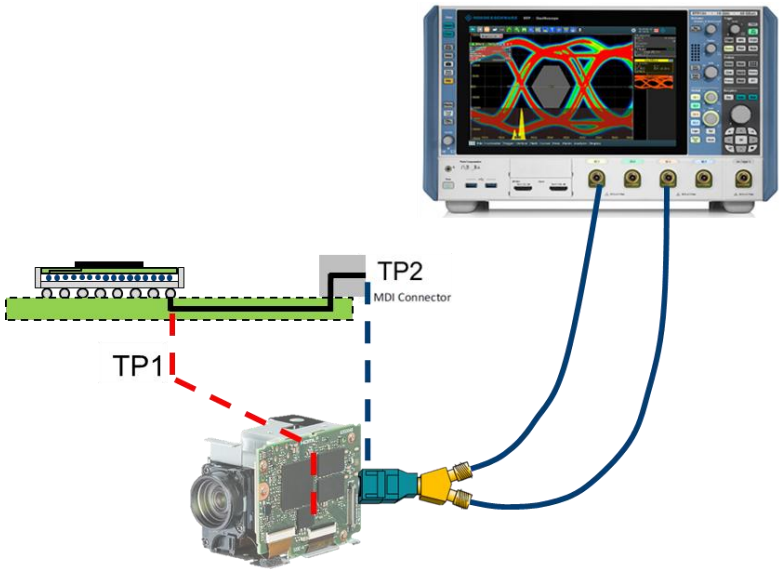
Forward Link Traffic				Reverse Link Traffic			
Link Rate	Line Rate (Gbps)	Modulation	Baud Rate (GBd)	Link Rate	Line Rate (Mbps)	Modulation	Baud Rate (GBd)
LR1	3	PAM2	3		187.5	PAM2	187.5
LR2	6		6				
LR3	6	PAM4	3				
LR4	12		6				



WHERE COMPLIANCE IS MEASURED: TP1 - TP4

TP1 - at the PHY pins

Normative electrical limits are defined here, but probing the PHY directly on a populated board is often difficult or impossible.



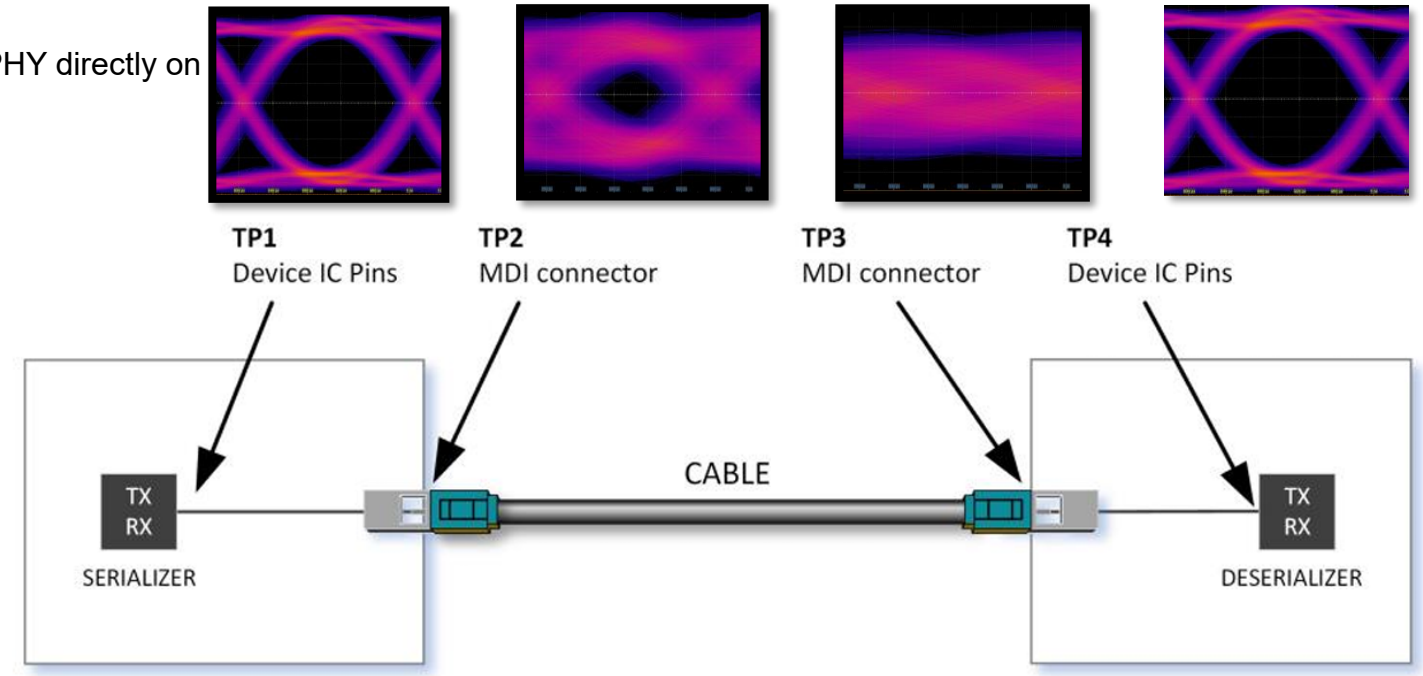


Figure 1. Test Point Definition

TP2 - the exposed connector

The practical measurement point. It includes the PCB trace loss between TP1 and TP2, which must be removed mathematically.

TP3 / TP4 - connector & cable end

Used for link- and cable-level compliance, downstream of the mated connector interface.

6GBPS SINGLE-ENDED EYE MASK

7.1.1 6Gbps Single-Ended (Coaxial Cable Case)

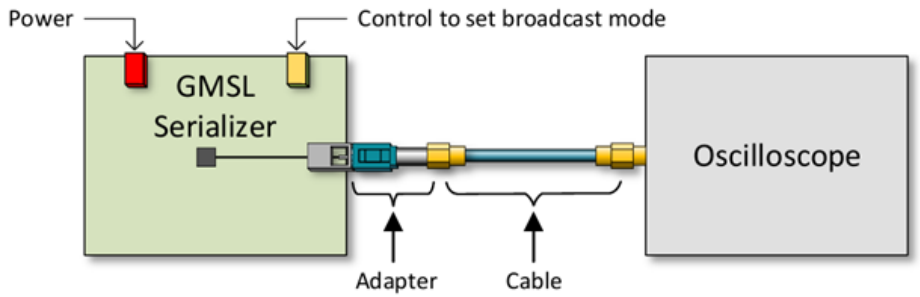
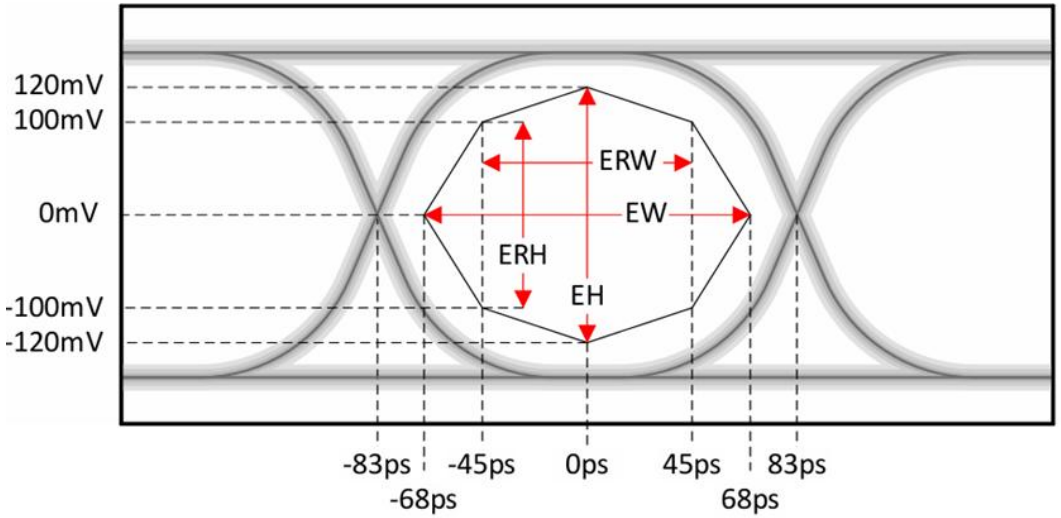
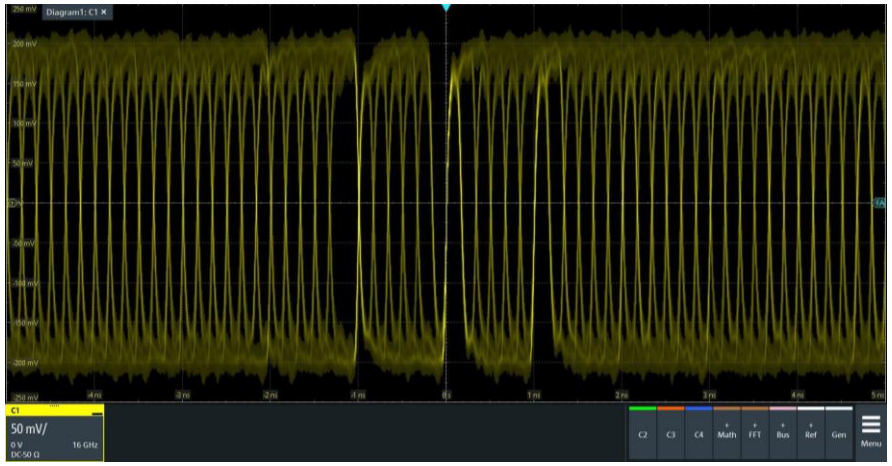


Figure 2. Tx Eye Measurement Test Configuration



TEST PATTERN

Captured as a single-ended eye diagram at TP1/TP2, overlaying many unit intervals at the 6 Gbps symbol rate.



Eye Mask Vertex Points (6Gbps, Single-Ended)

Parameter	Horizontal Location	Vertical Value
Eye Height	Center of unit interval (0ps)	Center of eye opening +120mV, -120mV
Eye Width	-68ps, +68ps	Center of eye opening
Eye Reduced Width	-45ps, +45ps	Center of eye opening +100mV, -100mV
Eye Reduced Height	-45ps, +45ps	Center of eye opening +100mV, -100mV

6GBPS DIFFERENTIAL EYE MASK

7.1.2 6Gbps Differential (STP, SPP or STQ case)

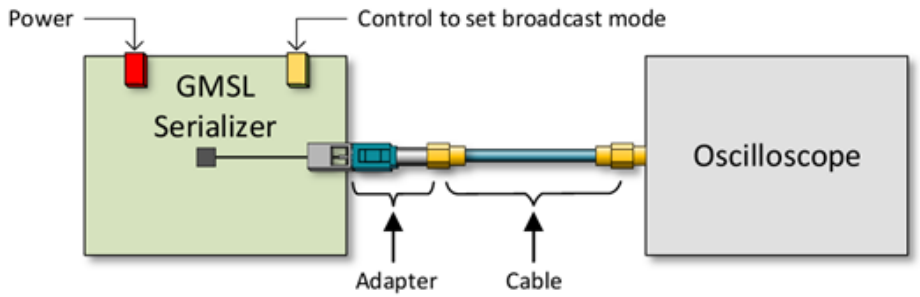
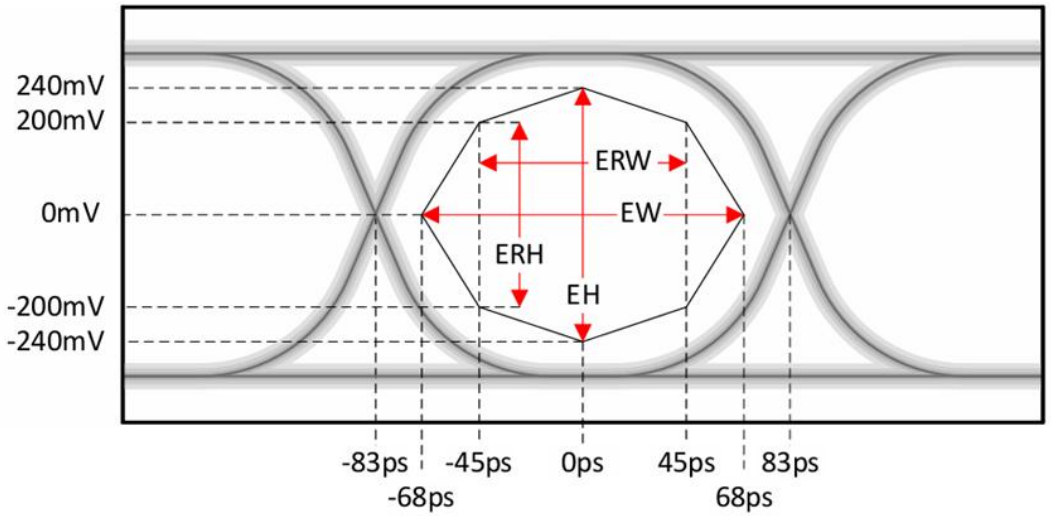
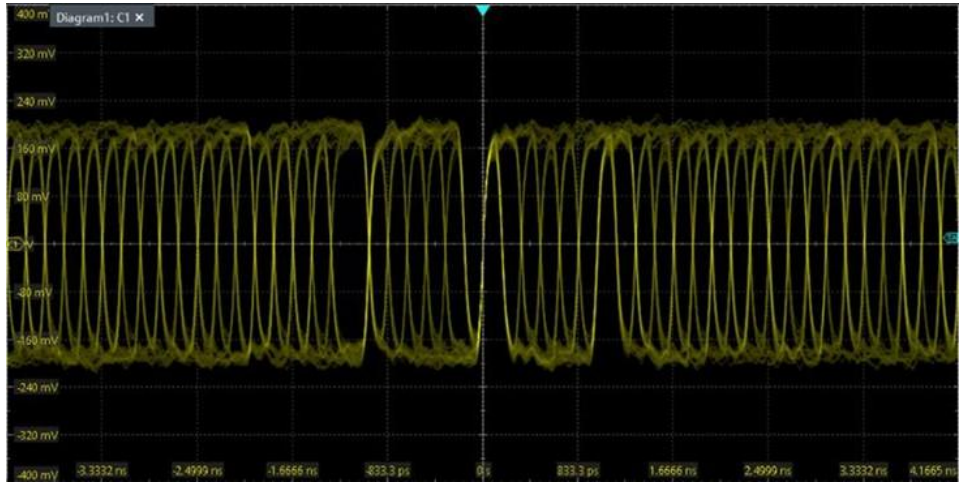


Figure 2. Tx Eye Measurement Test Configuration



TEST PATTERN

Same 6 Gbps acquisition, viewed as the differential signal - what the receiver's differential input actually sees.



Eye Mask Vertex Points (6Gbps, Single-Ended)

Parameter	Horizontal Location	Vertical Value
Eye Height	Center of unit interval (0ps)	Center of eye opening +240mV, -240mV
Eye Width	-68ps, +68ps	Center of eye opening
Eye Reduced Width	-45ps, +45ps	Center of eye opening +200mV, -200mV
Eye Reduced Height	-45ps, +45ps	Center of eye opening +200mV, -200mV

3GBPS SINGLE-ENDED EYE MASK

7.1.3 3Gbps Single-Ended (Coaxial Cable Case)

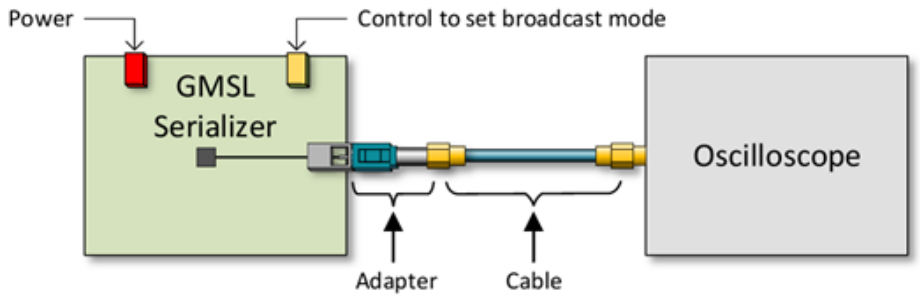
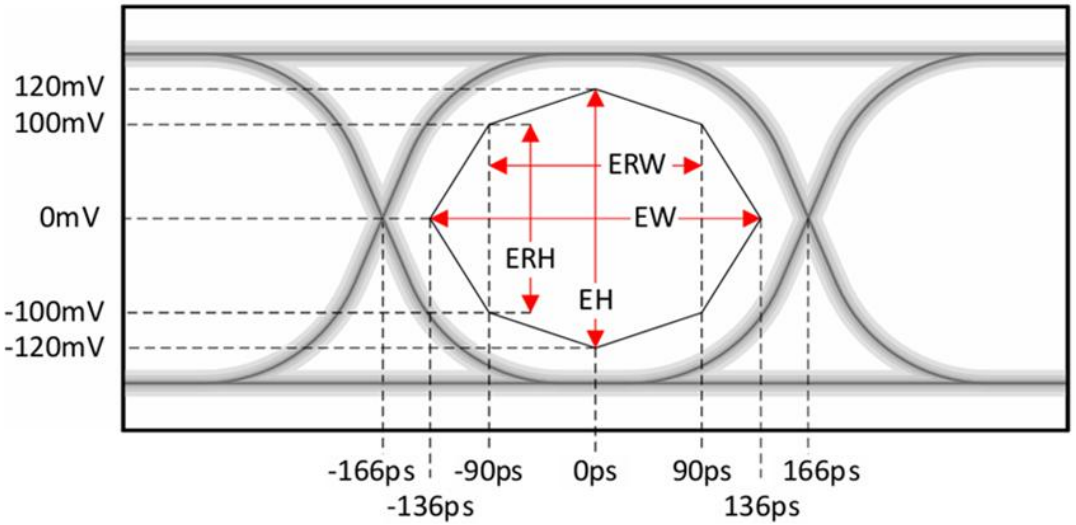
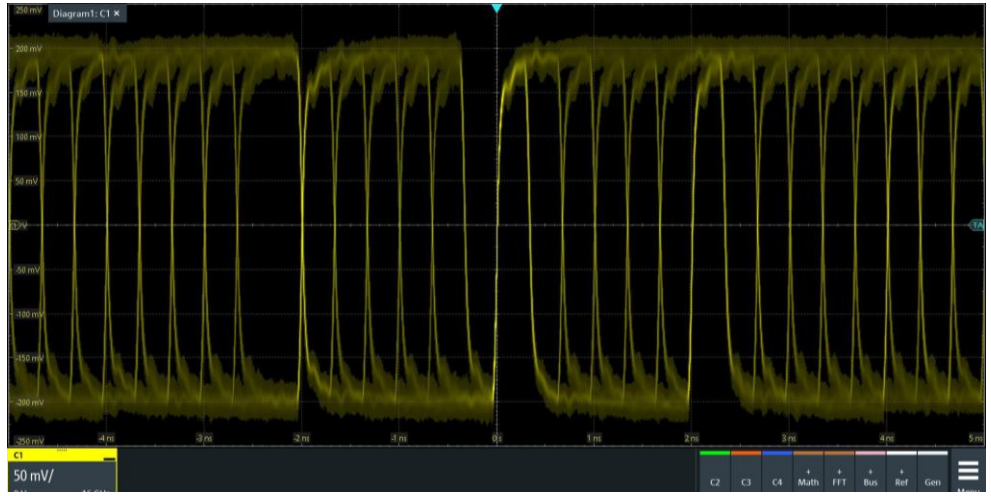


Figure 2. Tx Eye Measurement Test Configuration



TEST PATTERN

Identical single-ended eye capture, repeated at the 3 Gbps symbol rate.



Eye Mask Vertex Points (3Gbps, Single-Ended)

Parameter	Horizontal Location	Vertical Value
Eye Height	Center of unit interval (0ps)	Center of eye opening +120mV, -120mV
Eye Width	-136ps, +136ps	Center of eye opening
Eye Reduced Width	-90ps, +90ps	Center of eye opening +100mV, -100mV
Eye Reduced Height	-90ps, +90ps	Center of eye opening +100mV, -100mV

3GBPS DIFFERENTIAL EYE MASK

7.1.4 3Gbps Differential (STP, SPP or STQ case)

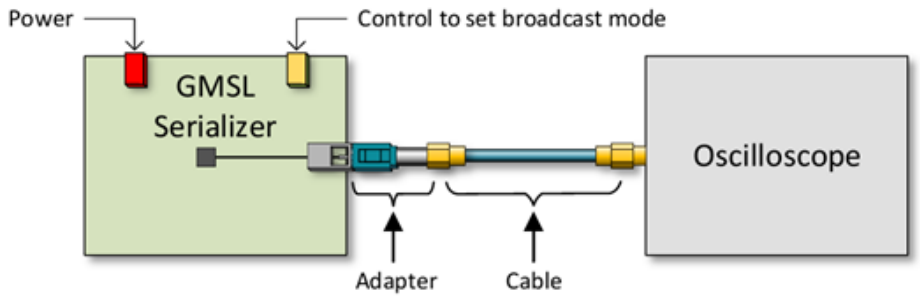
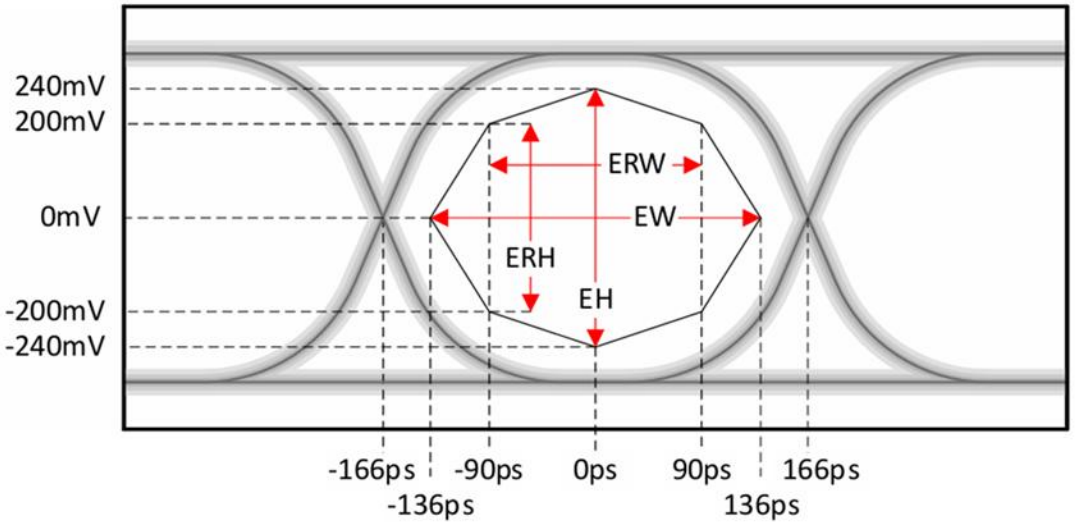
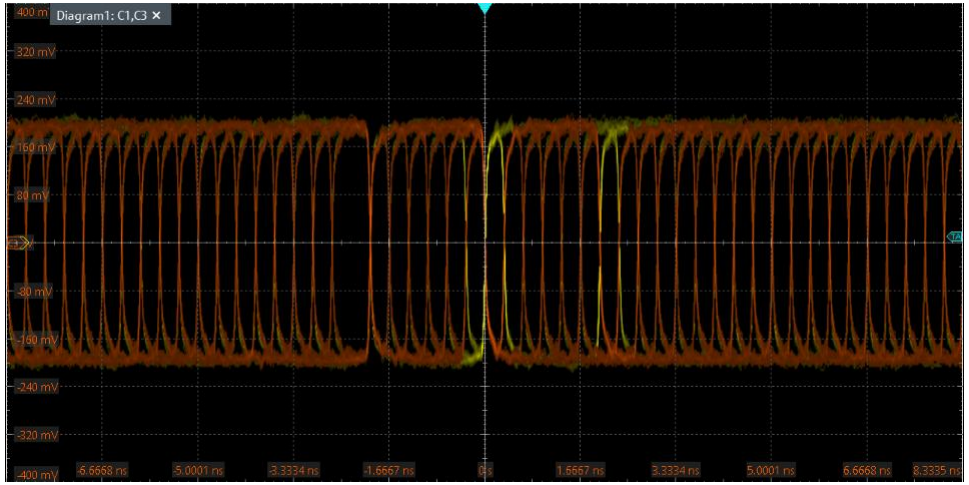


Figure 2. Tx Eye Measurement Test Configuration



TEST PATTERN

Identical differential eye capture, repeated at the 3 Gbps symbol rate.



Eye Mask Vertex Points (3Gbps, Single-Ended)

Parameter	Horizontal Location	Vertical Value
Eye Height	Center of unit interval (0ps)	Center of eye opening +240mV, -240mV
Eye Width	-136ps, +136ps	Center of eye opening
Eye Reduced Width	-90ps, +90ps	Center of eye opening +200mV, -200mV
Eye Reduced Height	-90ps, +90ps	Center of eye opening +200mV, -200mV

NARROWBAND CROSSTALK NOISE MEASUREMENT

7.1.5 Narrowband Crosstalk Limit

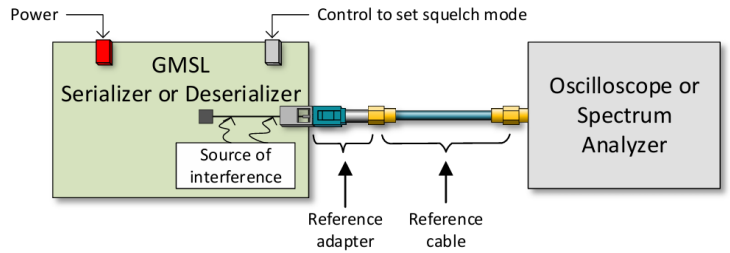


Figure 7. Narrowband Crosstalk Noise Measurement Setup

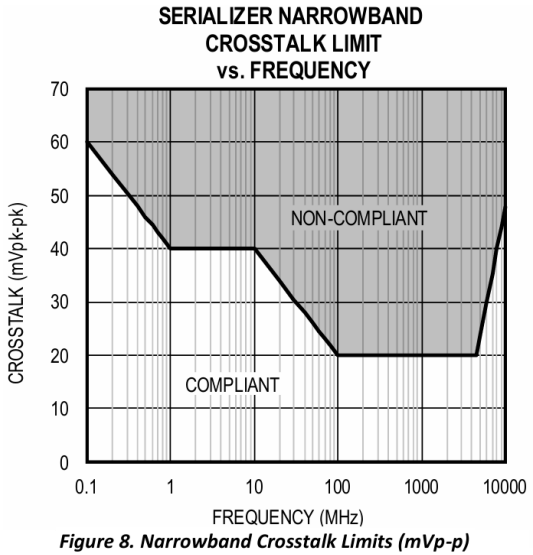


Figure 8. Narrowband Crosstalk Limits (mVp-p)

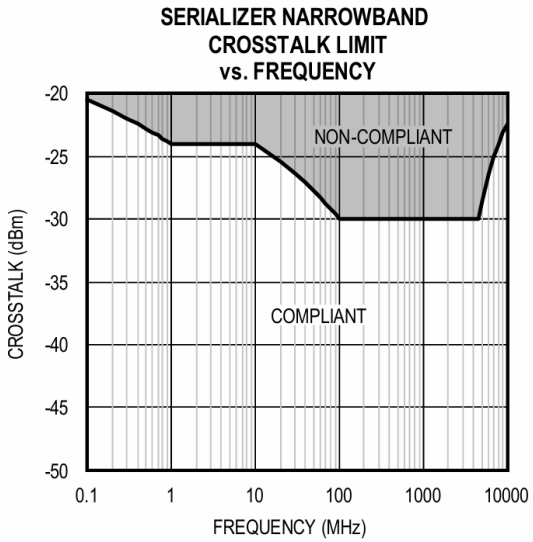
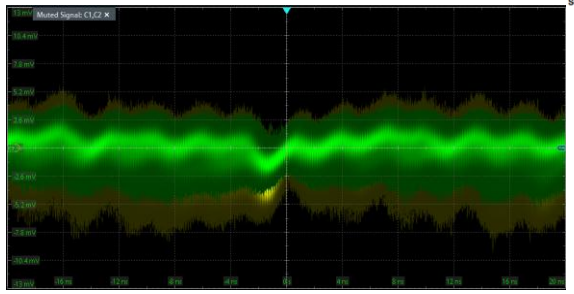
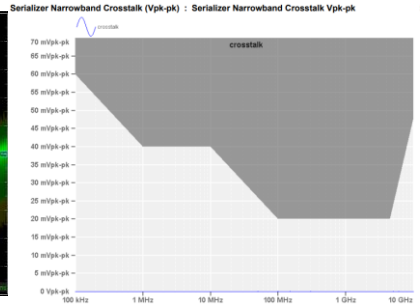


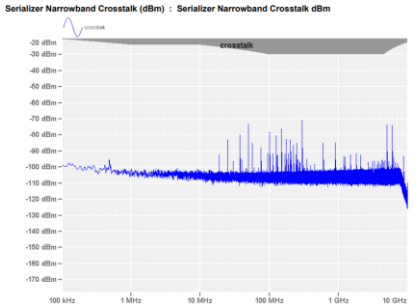
Figure 9. Narrowband Crosstalk Limits (dBm)

TEST PATTERN

Measured as the transmitter's output spectrum while operating in Normal Mode, read at defined frequencies against the crosstalk limit mask.





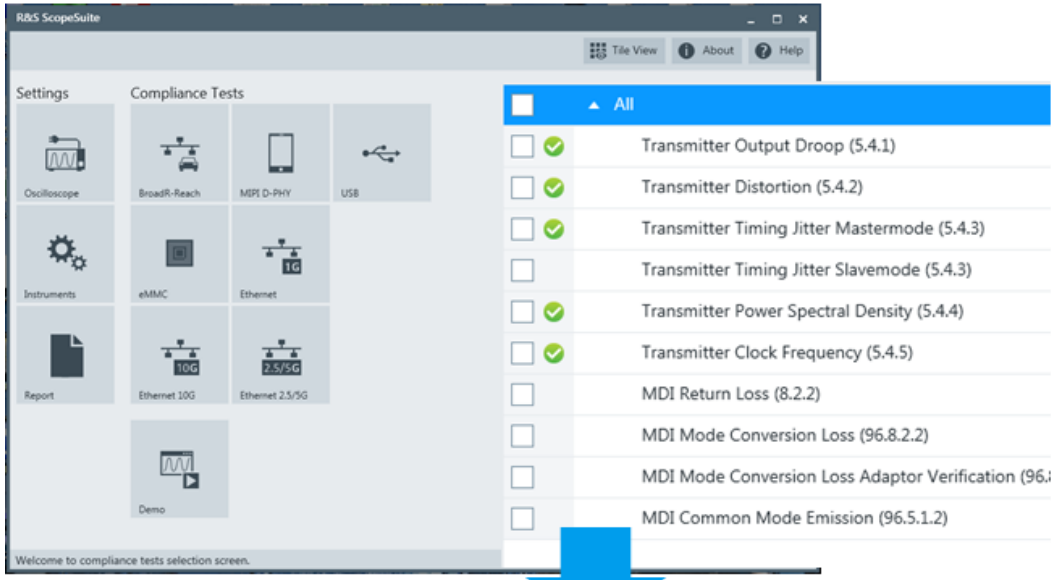


Narrowband Crosstalk Limits at PCBs

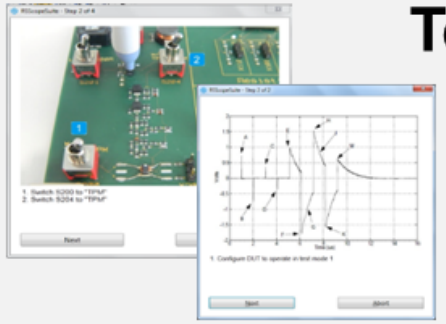
LINK DEVICE	FREQUENCY BAND [MHz]	PEAK-TO-PEAK VOLTAGE LIMIT [mVp-p] (f = FREQUENCY [MHz])
Serializer	$0.1 \le f \le 1$	$40 - 20 \times \log_{10}(f)$
	$1 < f \le 10$	40
	$10 < f \le 100$	$40 - 20 \times \log_{10}(f/10)$
	$100 < f \le 4500$	20
	$4500 < f \le 10{,}000$	$20 + 80 \times \log_{10}(f/4500)$

$$Amplitude\ [dBm] = 10 \times LOG\left(\left(\frac{X[Vp-p]}{2\sqrt{2}}\right)^2 \times 1000/50\Omega\right)$$

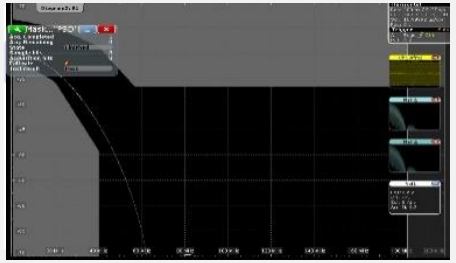
R&S ScopeSuite+
BUILT-IN COMPLIANCE TEST SOFTWARE & REPORTING TOOL



Test



Guided steps



Auto measurements

Pass-Fail results

	Test	Description	Run	Result	Detail
☐	Output Droop		1	✓	2/2
☐	Transmitter Distortion No TX_TCLK No Disturber		1	✓	11/11
☐	Transmitter Timing Jitter Mastermode		1	✓	1/1
☐	Power Spectral Density		1	✗	0/1
☐	Power Spectral Density		2	✓	1/1
☐	Transmitter Clock Frequency		1	✓	1/1

Report



- Screenshot
- Measurement result
- Pass-Fail result
- Test summary

TEST SOLUTIONS FOR GMSL / OPEN GMSL

R&S SPLUS-K107

GMSL Compliance Test Software

- Generation 1, 2 and 3 coverage
- STP and coax support
- Guided setup with automated pass/fail reporting

R&S RTP Oscilloscope

Signal Integrity & Debug Platform

- Real-time de-embedding & differential math
- HW-CDR based live eye, PAM2-8 support
- Fastest eye-diagram acquisition in its class

OpenGMSL - In Development

Closely Following Spec Development

- Tracking PHY Spec v3.0 (March 2026)
- Shares PMA test methodology with GMSL
- Early test collateral planned alongside OGA plugfests