IN-VEHICLE NETWORKS:
AUTOMOTIVE ETHERNET

Jason, Product Manager, Oscilloscopes

ROHDE&SCHWARZ

Make ideas real

AUTOMOTIVE ETHERNET BACKBONE

STANDARD NETWORK ARCHITECTURE

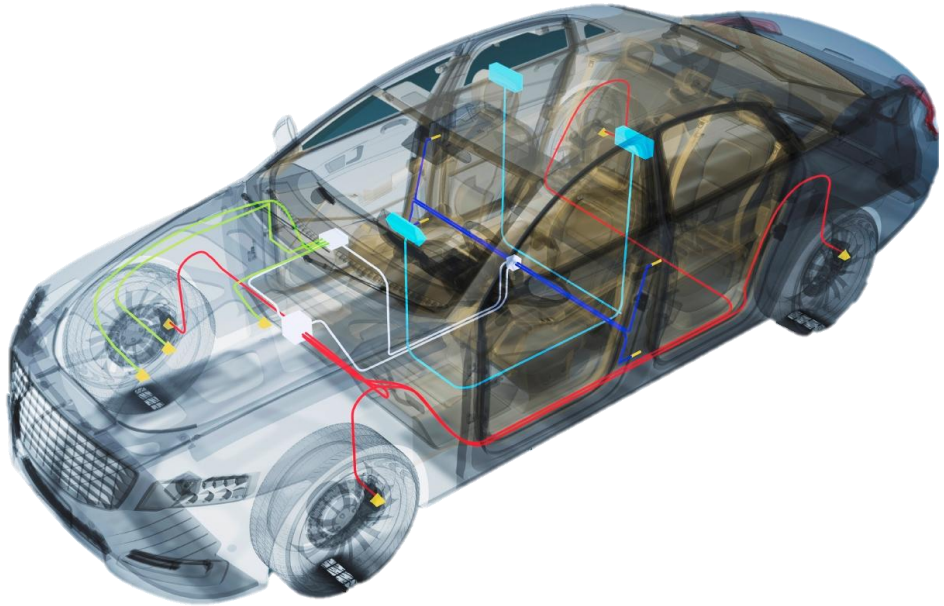
Uses a mature Ethernet ecosystem
Well suited for domain and zonal architectures

SCALABLE BACKBONE

Supports 100 Mb/s to multi-gigabit links
Easy to expand as vehicle data grows

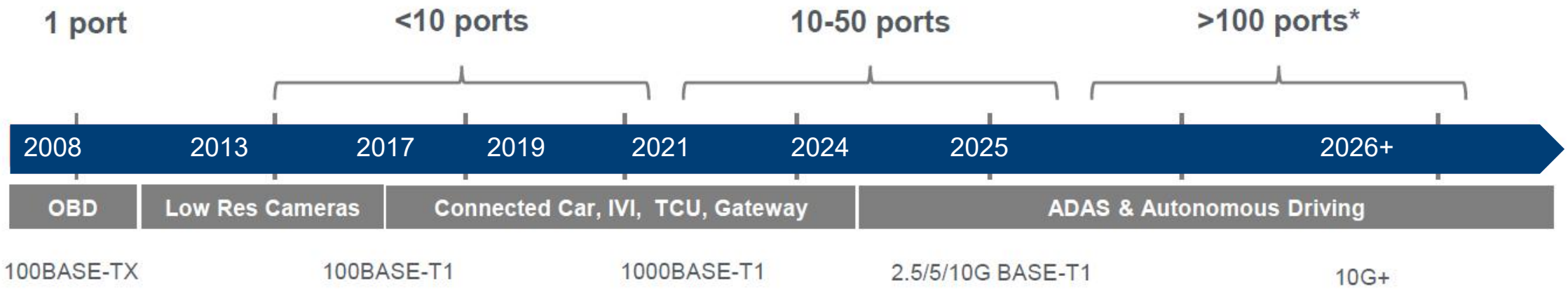
DATA AGGREGATION

Multiple data streams can share one network
Connects sensors, ECUs and central compute



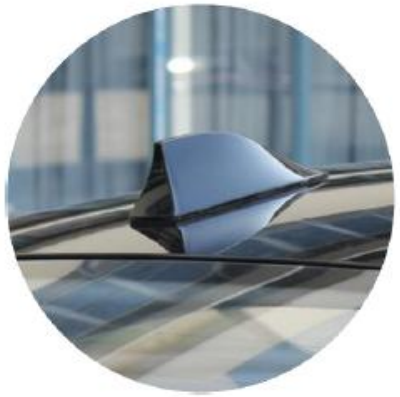
Ethernet provides the scalable backbone for software-defined vehicles.

TRENDS IN AUTOMOTIVE ETHERNET











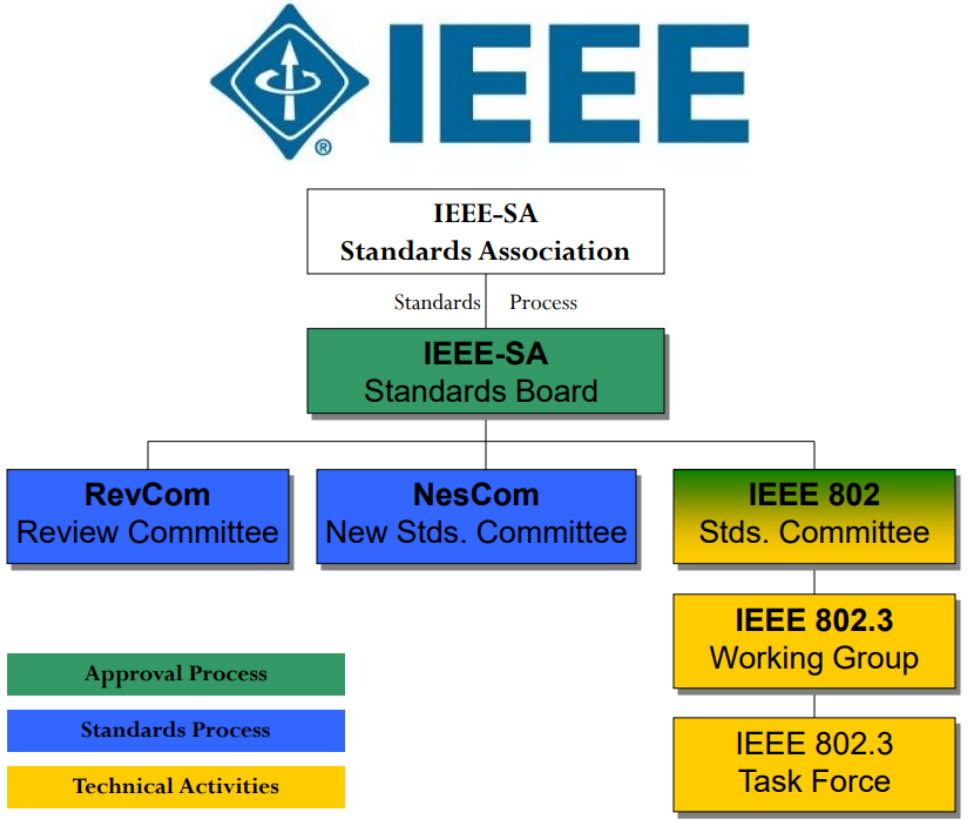


*average Ethernet ports per vehicle

Photo courtesy of Marvell Technology Group

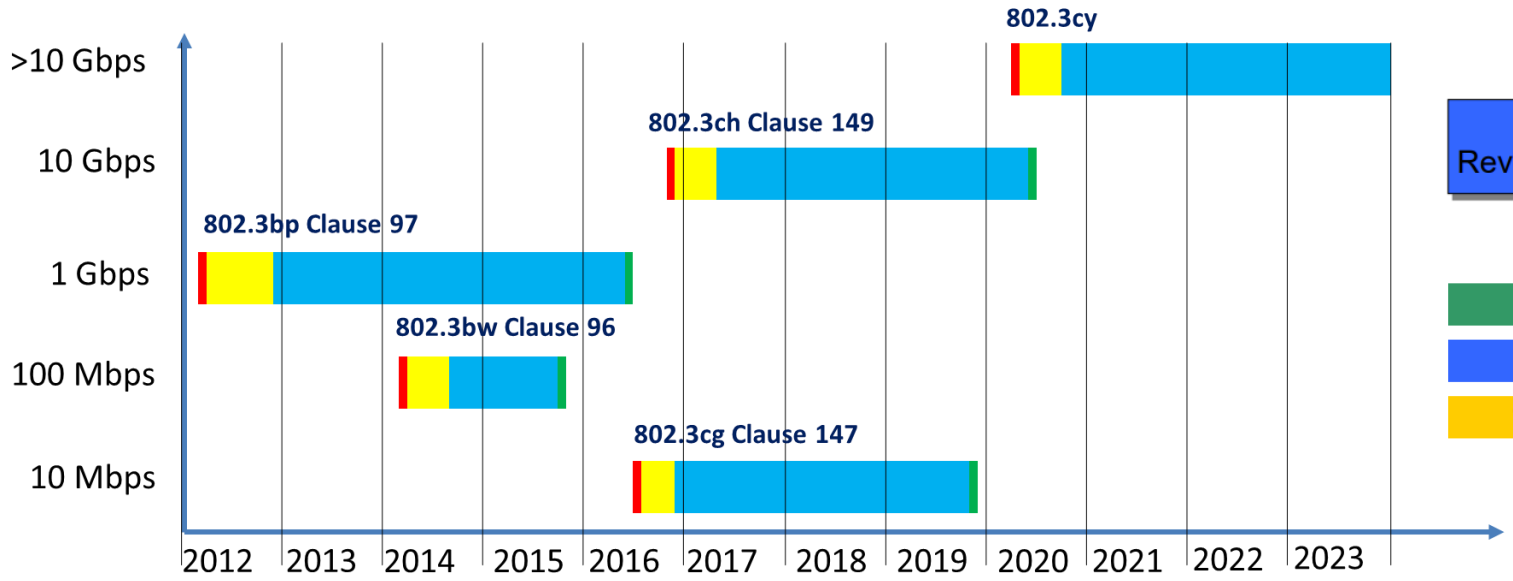
IEEE AND AUTOMOTIVE ETHERNET

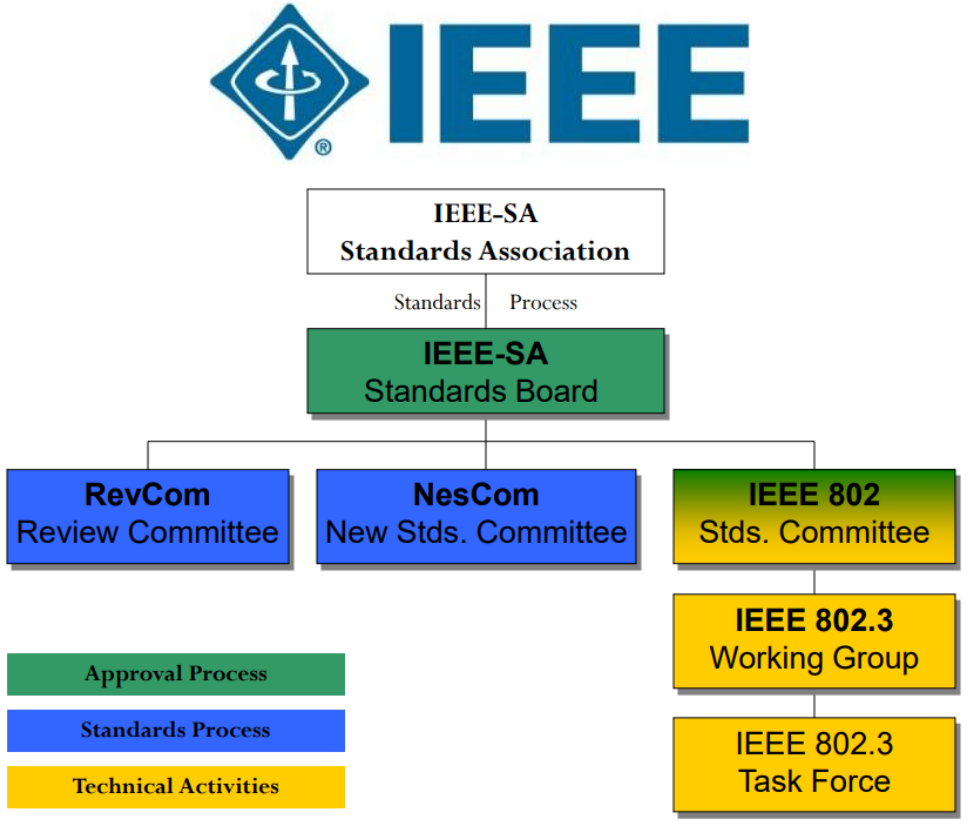
- IEEE develops Ethernet specifications
- IEEE 802.3 is the “Ethernet” Working Group
  - IEEE 802.11 is the “Wireless LAN” Working Group
- “Automotive Ethernet” describes a subset of Ethernet protocols designed for in-vehicle applications
- OPEN Alliance creates CTS based on IEEE 802 specifications



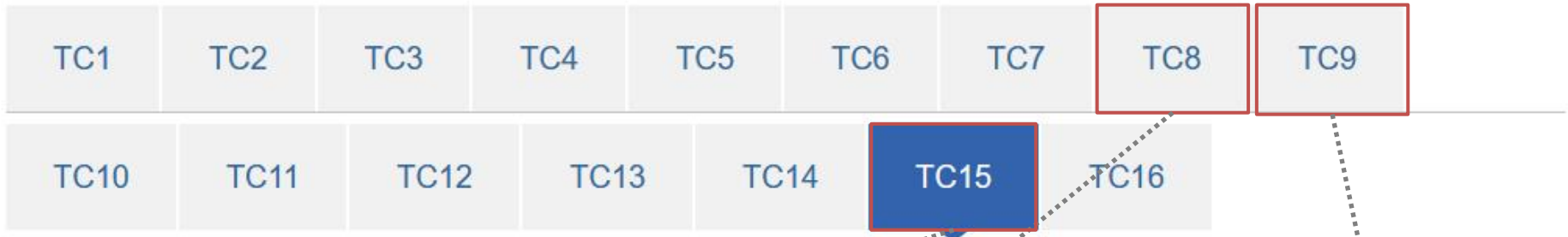
IEEE AND AUTOMOTIVE ETHERNET

Call-For-Interest
Study Group
Task Force
Approved





Tech Committees

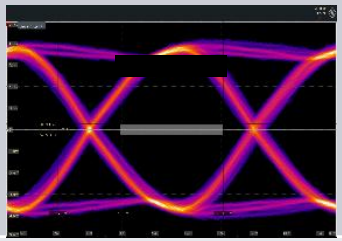
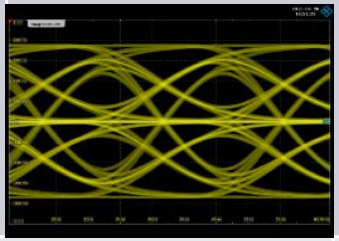
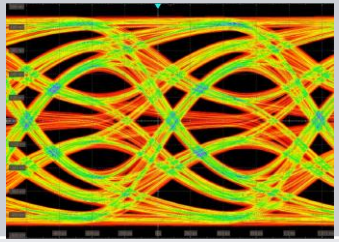
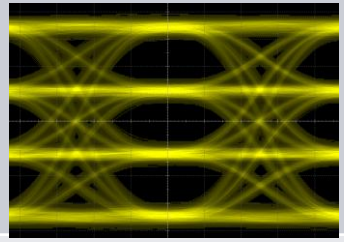
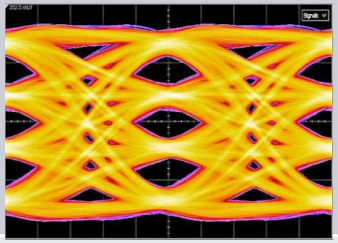


TC15 group created for MultiGig Ethernet for 2.5/5/10GBASE-T1. (PMA under preparation)

1000BASE-T1 Ethernet Channel & Passive Components (v2.3)
NGAuto Channel & Components for 1000BASE-T1
2.5/5/10GBASE-T1 Link Segments (draft v0.3)

Automotive Ethernet ECU Test Specification (v3.0)
Currently supports 100/1000BASE-T1

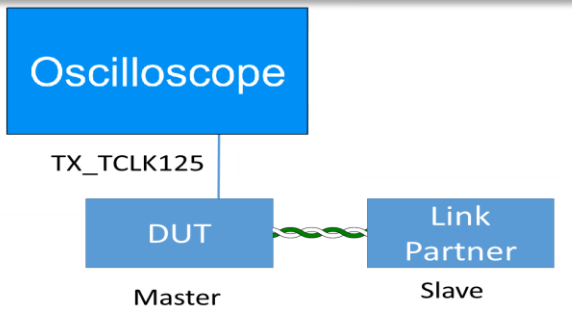
AUTOMOTIVE ETHERNET PHY SPECIFICATIONS

	10BASE-T1S	100BASE-T1	1000BASE-T1	2.5/5/10GBASE-T1	25GBASE-T1
IEEE 802.3 Reference	802.3cg-2019 Clause 147	802.3bw-2015 Clause 96	802.3bp-2016 Clause 97	802.3ch-2020 Clause 149	802.3cy-2023 Clause 165
OPEN Alliance	TC14	TC1	TC12	TC15	TBD
Bit Rate (Gbps)	0.010	0.100	1.0	2.5 / 5.0 / 10.0	25.0
Baud Rate (GBd)	0.0125	0.06666	0.750	1.40625 / 2.8125 / 5.625	14.0625
Encoding	2-Level DME	PAM3		PAM4	
					
Cabling	UTP (Unshielded Twisted Pair)		UTP (STP optional)	STP (Shielded Twisted Pair)	
Use Case	ECUs Sensors	Infotainment Passive ADAS	Backbone Active ADAS	Lossless video transmission Autonomous driving	

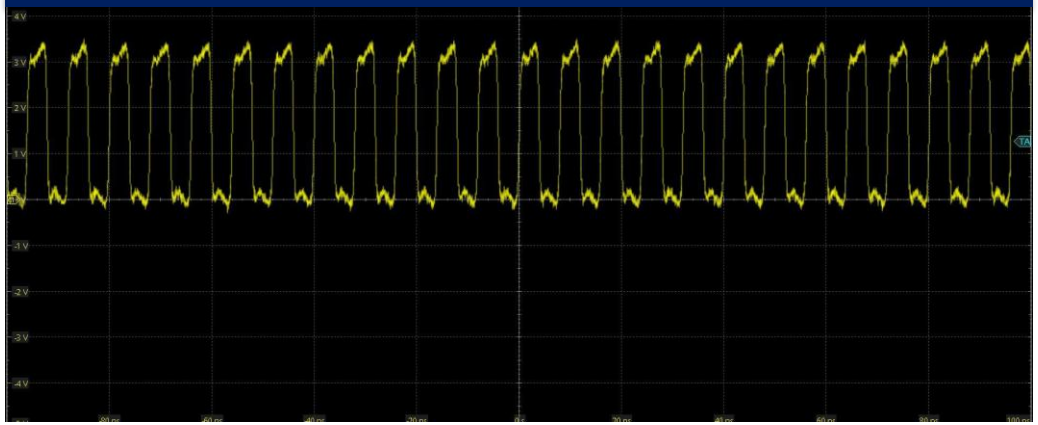
TIMING JITTER(MASTER& SLAVE) (TEST MODE 1)

Test Mode 1

TEST CONFIGURATION



MEASUREMENT / RESULT



OBJECTIVE

Check the transmit clock for low timing jitter.

PATTERN / METHOD

- MASTER mode; LP in SLAVE mode
- Measure 125 MHz TX_TCLK125
- Capture ≥ 1 ms; 5 MHz filter

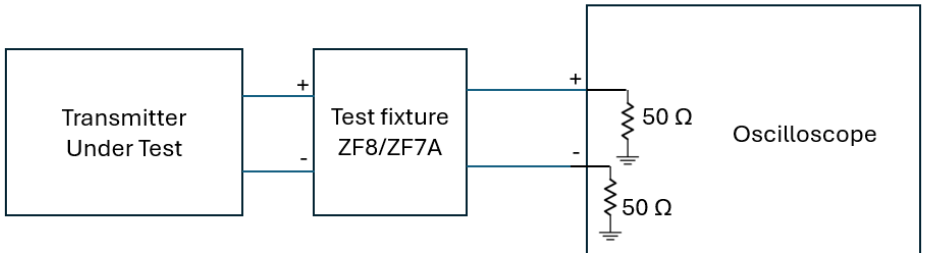
LIMIT

- RMS TIE < 5 ps
- P-P TIE < 50 ps

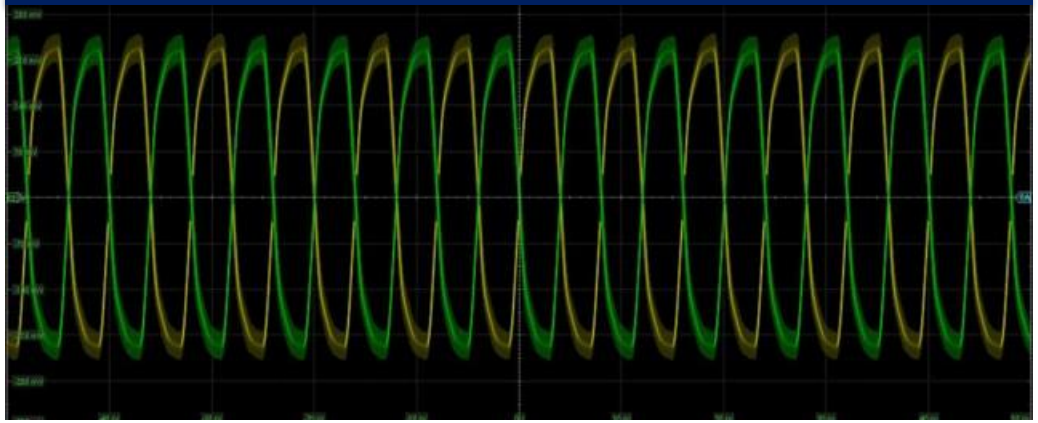
MDI JITTER & CLOCK FREQUENCY (TEST MODE 2)

Test Mode 1

TEST CONFIGURATION



MEASUREMENT / RESULT



OBJECTIVE

Check MDI jitter and transmit clock frequency

PATTERN / METHOD

Pattern: 3×{+1}, 3×{-1}

750 MHz baud → 125 MHz

Measure directly at MDI

LIMIT

RMS jitter < 5 ps; P-P < 50 ps

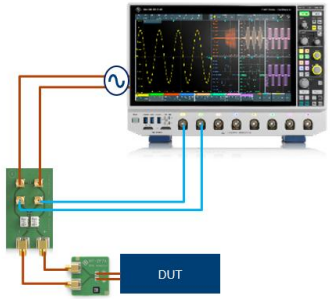
750 MHz ±100 ppm

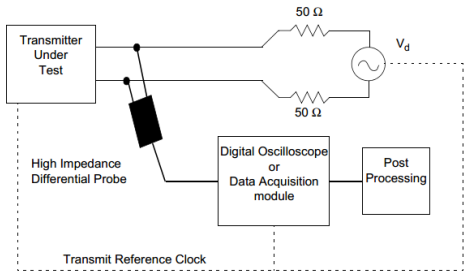
125 MHz: 124.9875–125.0125 MHz

TRANSMITTER DISTORTION (TEST MODE 4)

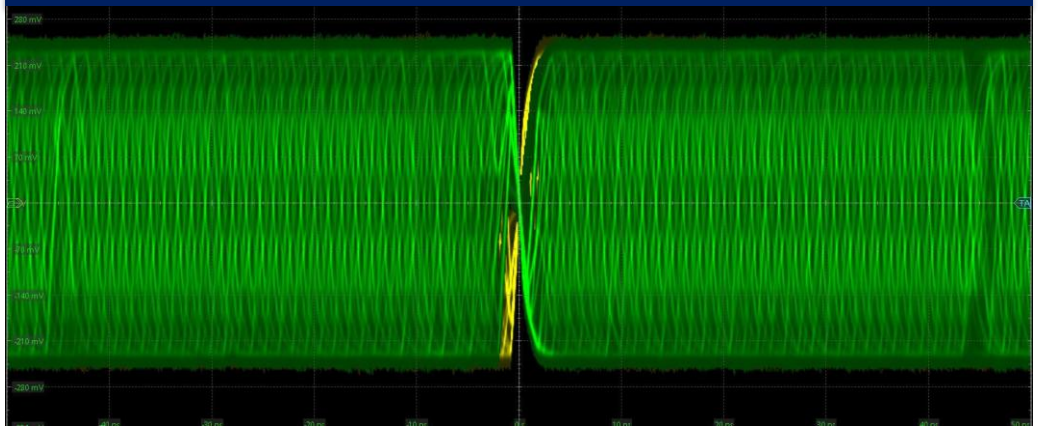
Test Mode 4

TEST CONFIGURATION





MEASUREMENT / RESULT



OBJECTIVE

Check transmitter distortion with a strong disturbance signal.

PATTERN / METHOD

Inject 125 MHz / 3.6 Vpp disturbance

Lock instruments to TX_TCLK125

Evaluate 10 phase positions across 1 UI

LIMIT

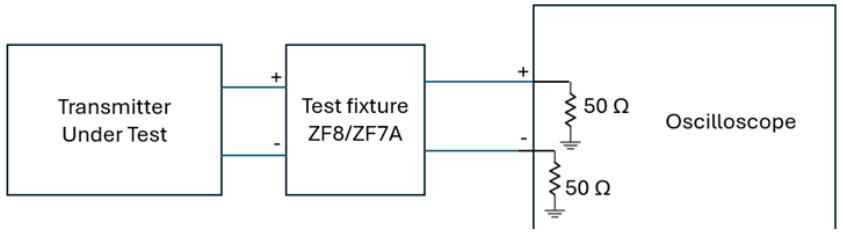
Disturber SFDR > 40 dB

Peak distortion < 15 mV

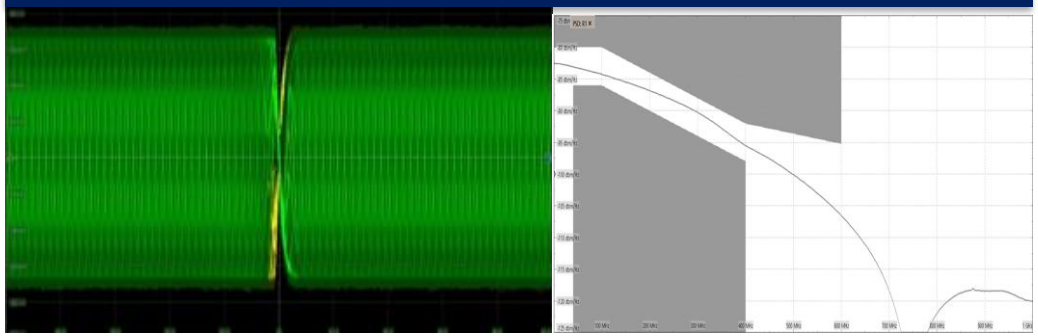
PSD AND POWER LEVEL (TEST MODE 5)

Test Mode 5

TEST CONFIGURATION



MEASUREMENT / RESULT



OBJECTIVE

Check transmit power and PSD mask compliance

PATTERN / METHOD

Test Mode 5 / Idle signal

Measure 1–600 MHz spectrum

RBW 100 kHz; RMS detector

LIMIT

Power < 5 dBm

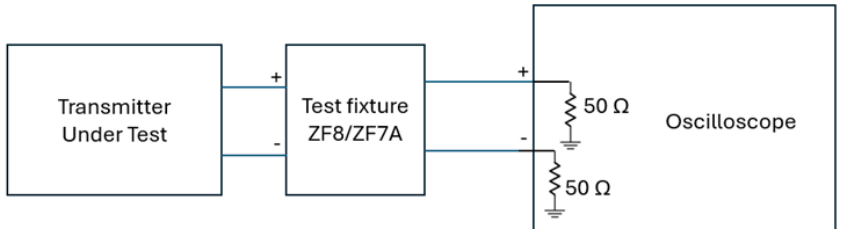
Output < 1.3 Vpp @ 100 Ω

PSD inside Upper / Lower mask

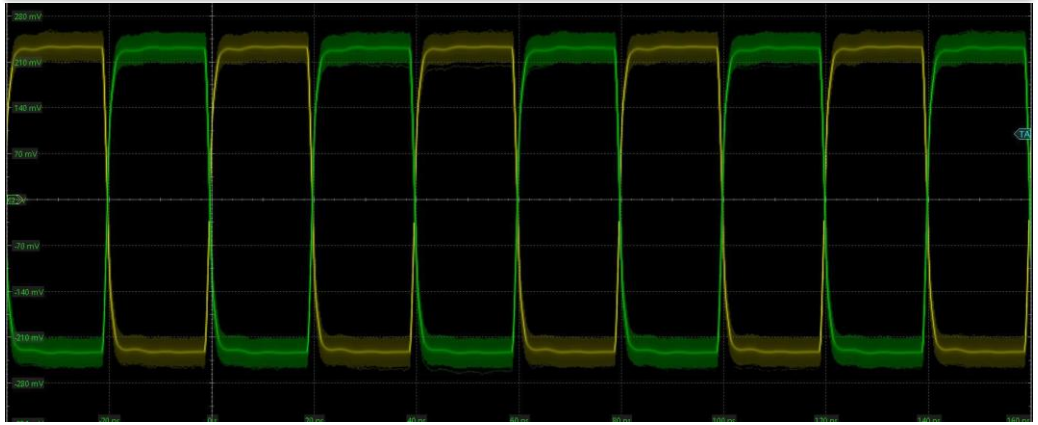
MAXIMUM OUTPUT DROOP (TEST MODE 6)

Test Mode 6

TEST CONFIGURATION



MEASUREMENT / RESULT



OBJECTIVE

Check output-level droop during a long same-level signal.

PATTERN / METHOD

Pattern: 15×{+1}, 15×{-1}

750 MHz baud → 25 MHz square wave

Compare voltage at 4 ns and 16 ns

LIMIT

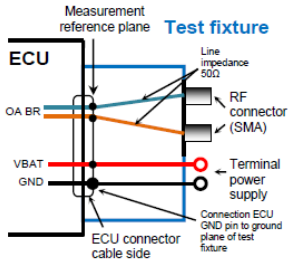
Positive droop < 10%

Negative droop < 10%

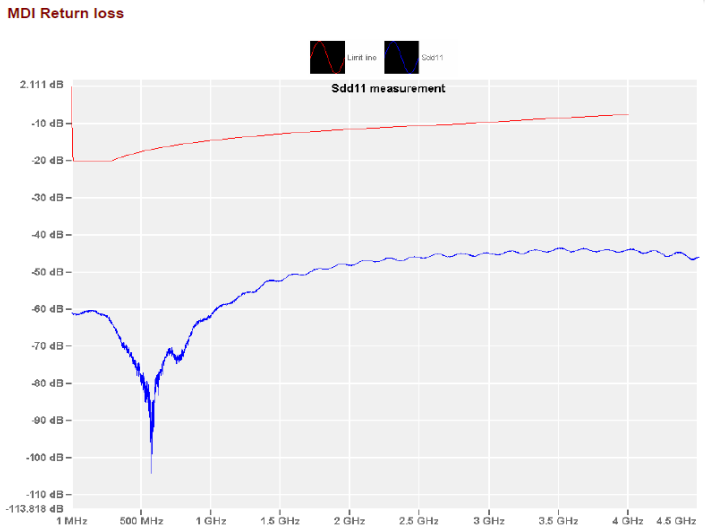
MDI RETURN LOSS (IMPEDANCE MATCHING)

Return Loss 97.7.2.1

TEST CONFIGURATION



MEASUREMENT / RESULT



OBJECTIVE

Check MDI impedance matching and reflected signal.

PATTERN / METHOD

DUT in SLAVE silent mode

AFE off; 100 Ω termination active

Calibrate VNA and de-embed fixture

LIMIT

2–20 MHz: spec limit curve

20–100 MHz: RL ≥ 18 dB

100–600 MHz: spec limit curve

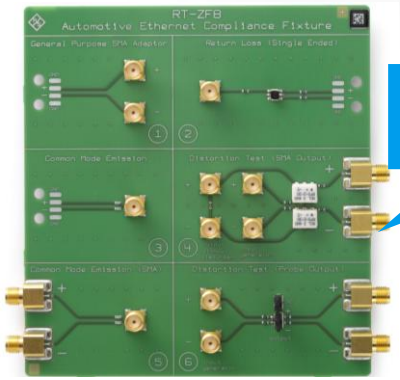
FROM 10BASE-T1 TO 10GBASE-T1 COMPLIANCE TEST



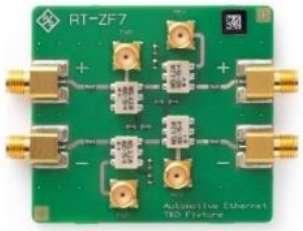
Key Features

- Complete test solution from R&S (PHY layer)
- Includes OEM required test cases
- Future proof solution for Automotive Ethernet
- UNH-IOL uses RTO + ZNB for all automotive Ethernet tests
- Dedicated test fixtures made by R&S – OA TC8 compliant!

New → MultiGBASE-T1 (only a software option – K88)



Compliance Test fixture RT-ZF8



Decoding fixture RT-ZF7



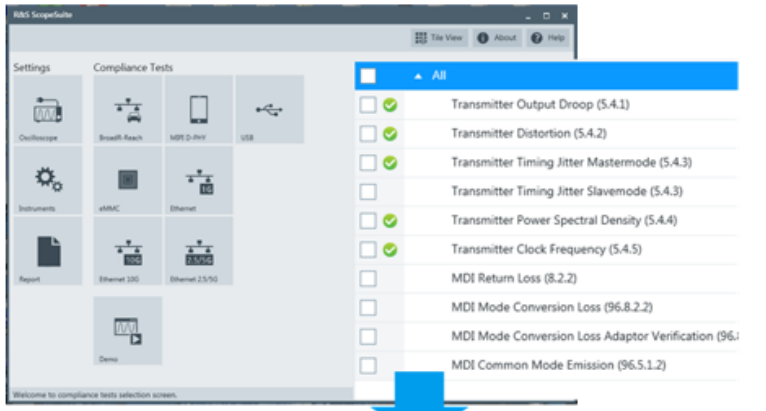
SMA adapter for TD & Compliance RT-ZF7A



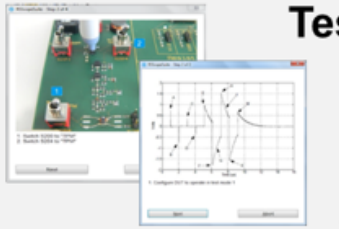
Frequency converter RT-ZF3/6

FROM 10BASE-T1 TO 10GBASE-T1 COMPLIANCE TEST

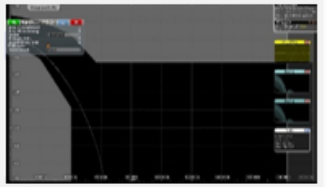
- RTP-K89 for 10BASE-T1
- RTP-K24 for 100BASE-T1
- RTP-K87 for 1000BASE-T1
- RTP-K88 for MultiGBASE-T1



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







