Tektronix

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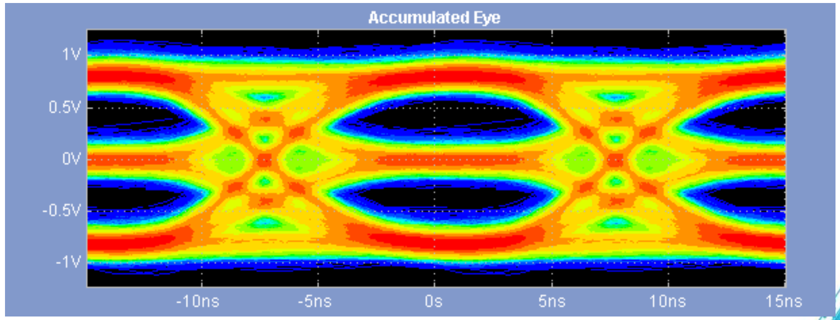
이기웅 2019.11.07



Trends Shaping the Car Industry

A revolution driven by autonomy, connectivity, electrification, and sharing

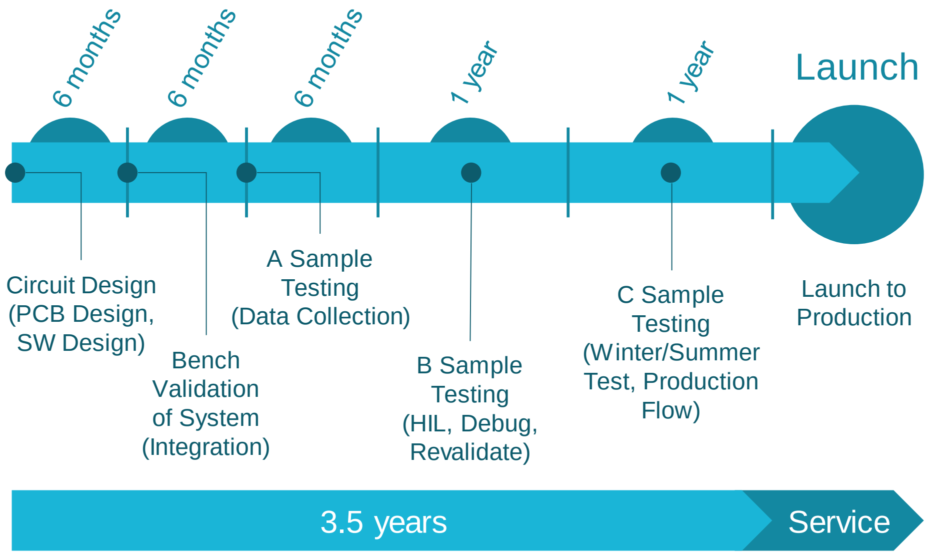
A — Autonomy requires the use of better sensors

C — Connectivity enables new forms of vehicle communication

E — Electrification requires new powertrain technologies

S — Shared mobility creates new standards and testing

Validation Workflow



Electronics is performing critical functions.

The validation methods *(and challenges)* are different now.

Challenges

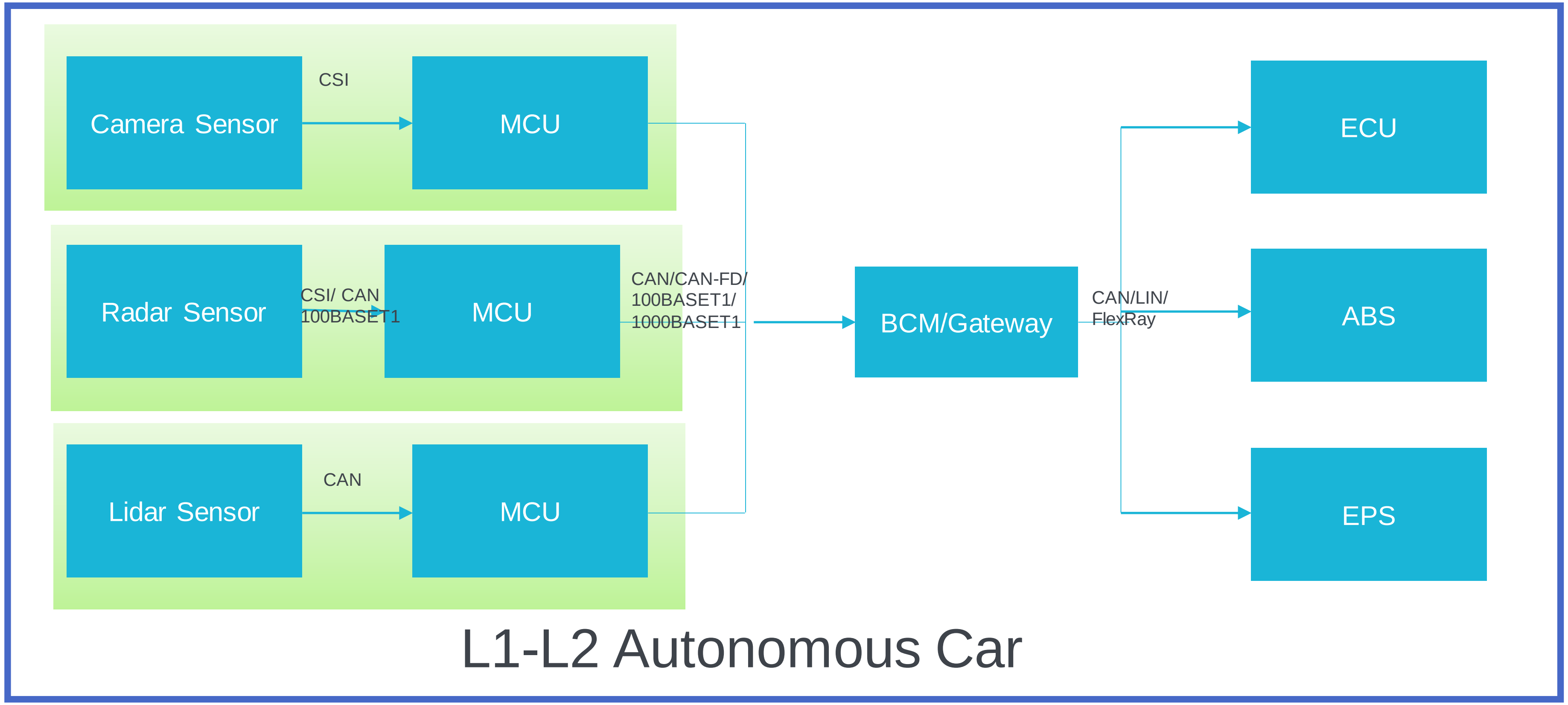
- Liability
- Traceability
- Long Testing Cycles
- Increasing Complexity
- Security
- Huge Amounts of data
- Software Modelling
- Calibration
- Portability

T&M tasks and challenges

• Portability Across Platform • Traceability	• Certificates • Hardware in Loop	• On Road Testing • Data Retention	• Software Modelling • EMI/EMC

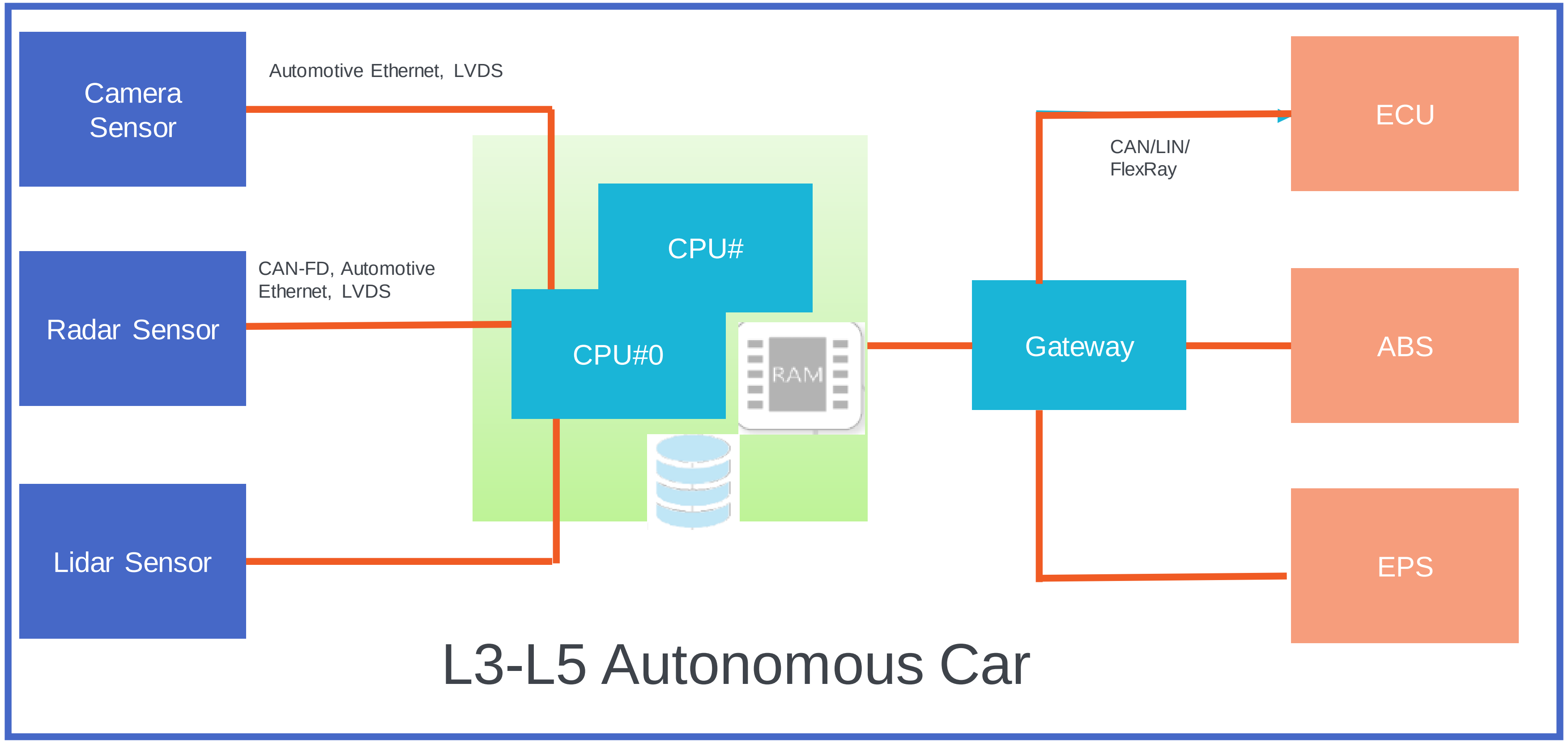
Autonomous Car Block Diagram

SMART SENSOR

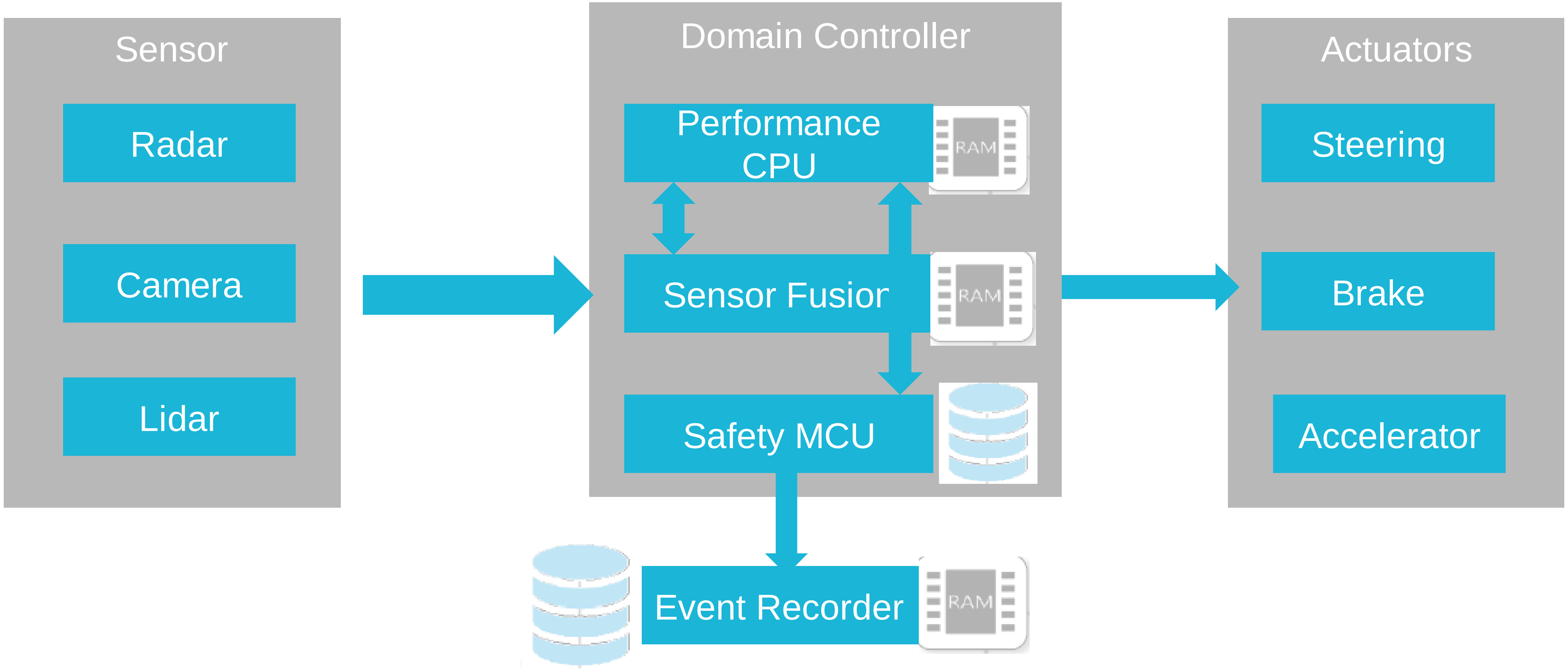


Autonomous Car Block Diagram

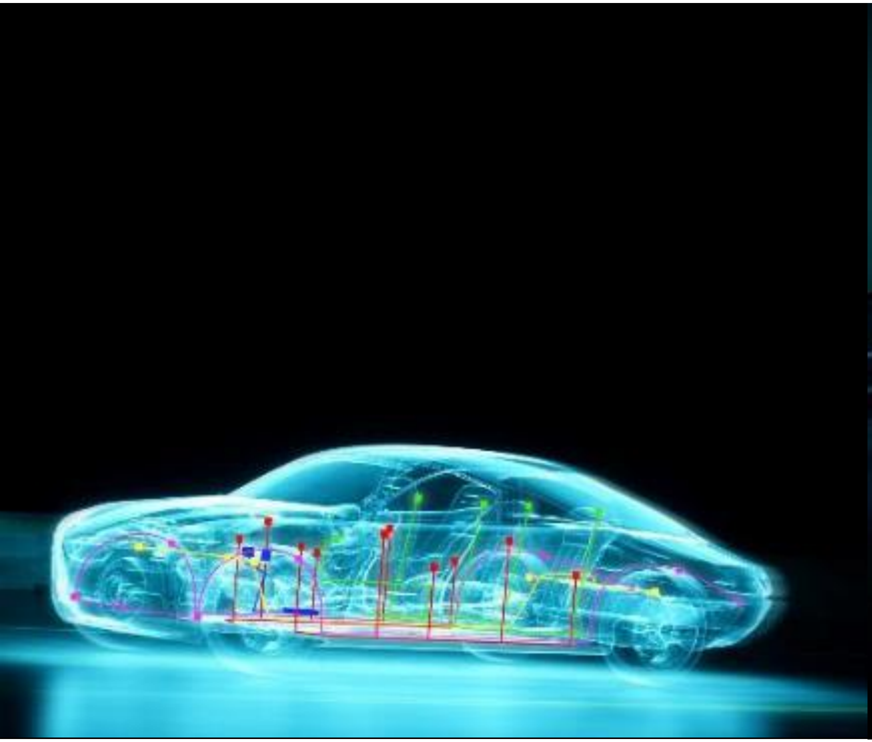
DOMAIN CONTROLLER



ADAS Architecture



Automotive Focus Areas

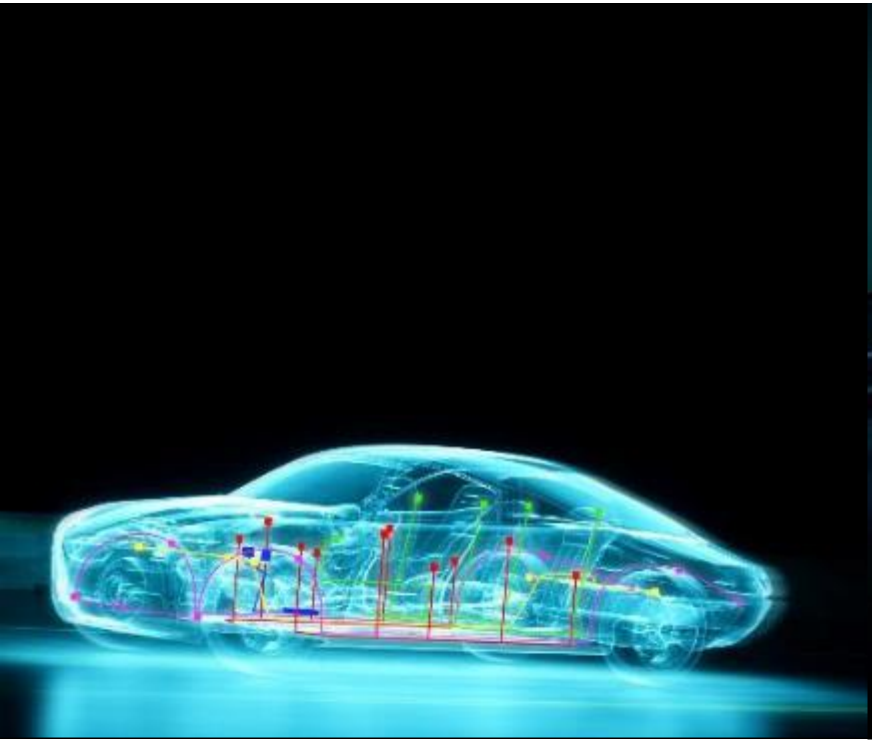


In-Vehicle Networking

Vehicle Sensors

Powertrain & Electrification

Automotive Focus Areas



In-Vehicle Networking

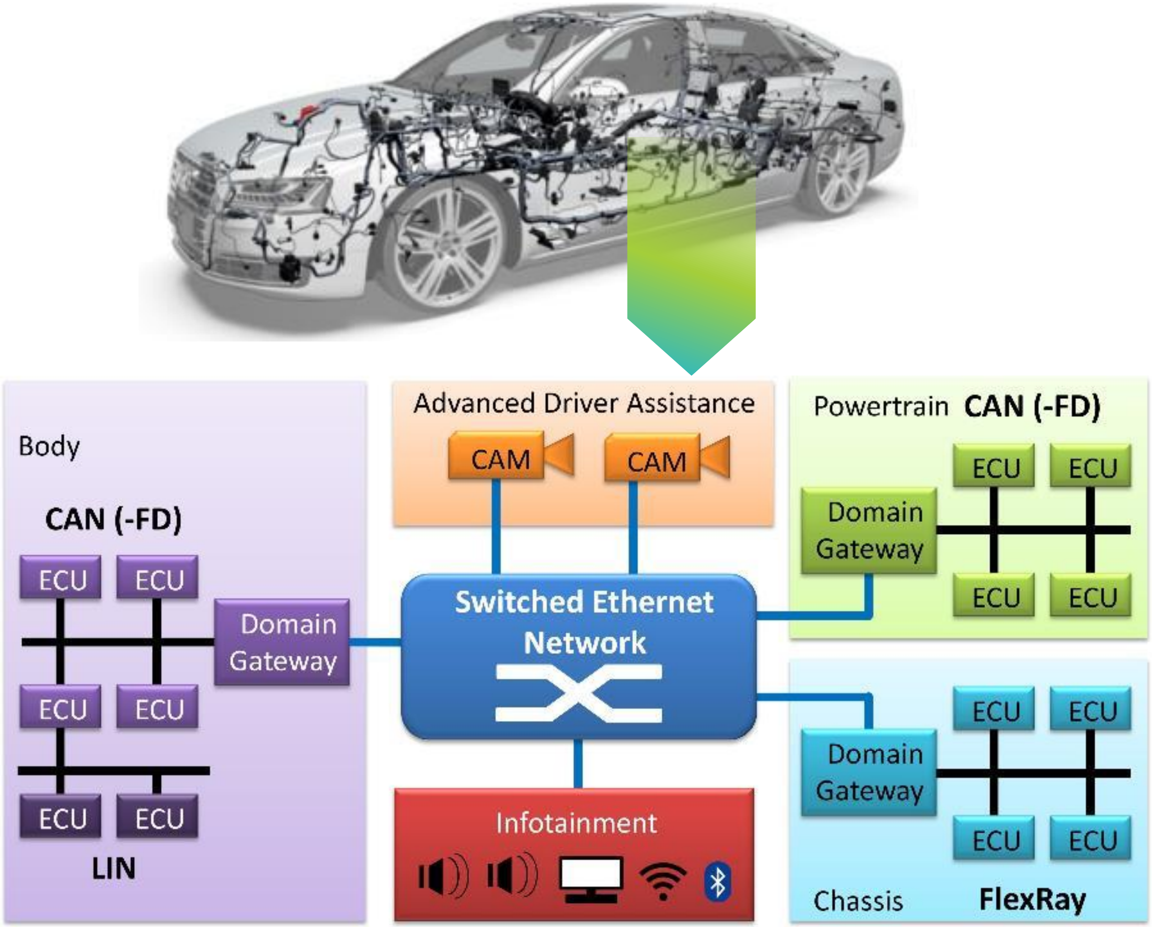
Vehicle Sensors

Powertrain & Electrification

In-Vehicle Networking

BACKBONE OF THE AUTONOMOUS CAR

Development	• Exploding Data rates • Move to Ethernet • Wire Harness Weight
System Validation	• Distance between nodes • Noise Immunity • Interop • Reliability • Bidirectional bus
Production	• Test time • Test Coverage
On Road	• Built in Self Test • Error Detection and recovery
Maintenance	• Rewiring • Start up checks



Source: Dr. Kai Richter and Jonas Diemer of Symtavision and Daniel Thiele, Philip Axer and Dr. Rolf Ernst of Technische Universität Braunschweig

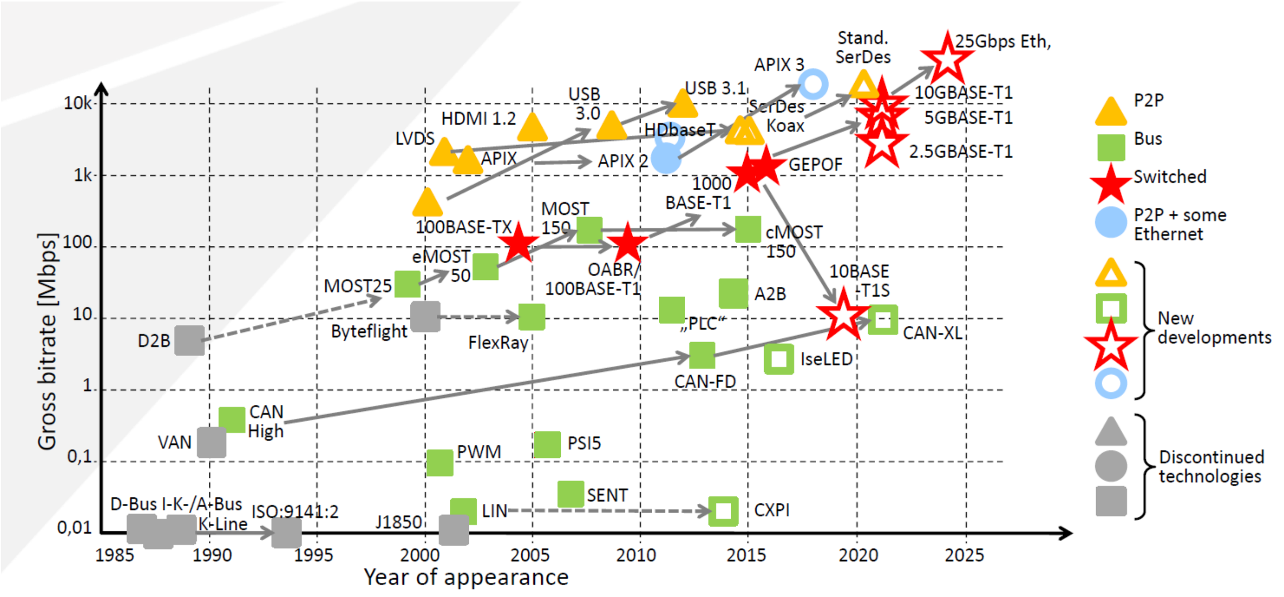
Automotive- New Serial Standards

Trends

- Standardization
- Full-Duplex Signaling
- Modulated signals (*PAM3 / PAM4 / PAM16*)

New standards

- 10BASE-T1 (*IEEE 10mbps*)
- 10GBASE-T1 (*IEEE 10gbps*)
- A-PHY (*MIPI 12gbps*)
- HDBASE-T (*1-6gbps*)
- 25G Ethernet
- Automotive Optical Ethernet



Dr. Kirsten Matheus, BMW AG, Automotive Ethernet Congress 2019

Automotive Ethernet Standard

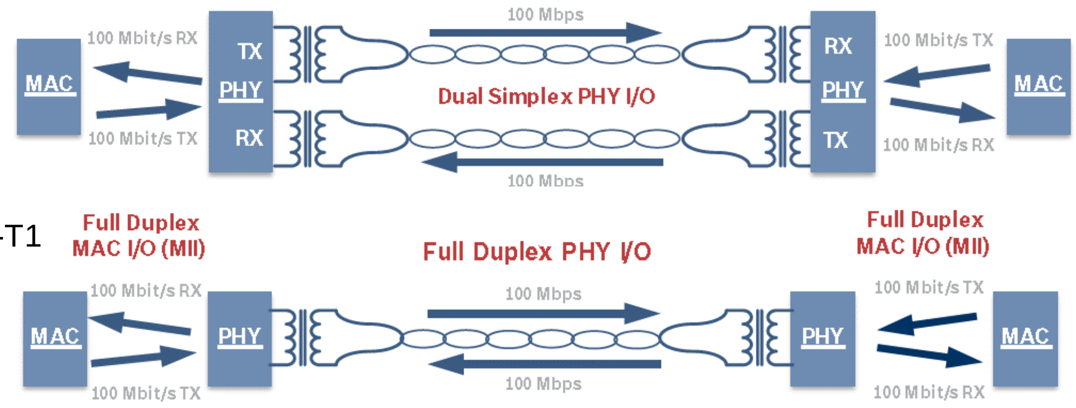
- IEEE Ethernet derivative standard (BroadR-Reach) created by an industry alliance (OABR)
- IEEE has established its own standards 100BASE-T1 (P802.3bw™) and 1000BASE-T1 (802.3bp™)
- Initial deployment focused on 100 Mb/s and 1 Gb/s, early development underway for 10Gbps
- Unshielded single twisted pair cabling designed for automotive use and lower cost
- PAM3 Modulation: Slow rise time, reduces EMI
- Full-Duplex Communication: Reduces cable and increases effective bandwidth

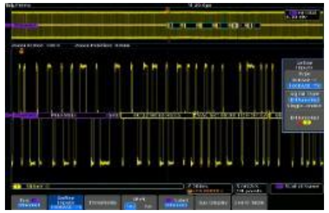
Unshielded single twisted pair cabling designed for use in automotive environments with lower cost

100BASE-T

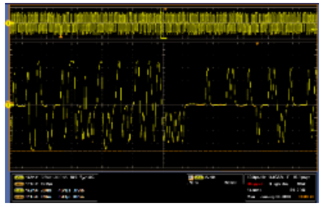
BRR/100BASE-T1

UTPC





TL3



PAM3

Automotive Ethernet Test Requirement

CAN TO AUTOMOTIVE ETHERNET

OSI	CAN
7. Application	Application
6. Presentation	
5. Session	
4. Transport	
3. Network	
2. Datalink	DLL
1. Physical	PHY

Protocol Test

Protocol Decode, Timing Measurement

Eye Diagram.

OSI	Automotive Ethernet
7. Application	Application
6. Presentation	
5. Session	
4. Transport	TCP/UDP
3. Network	IP
2. Datalink	Network Access
1. Physical	100/1000BASE-T1

Protocol Conformance Test

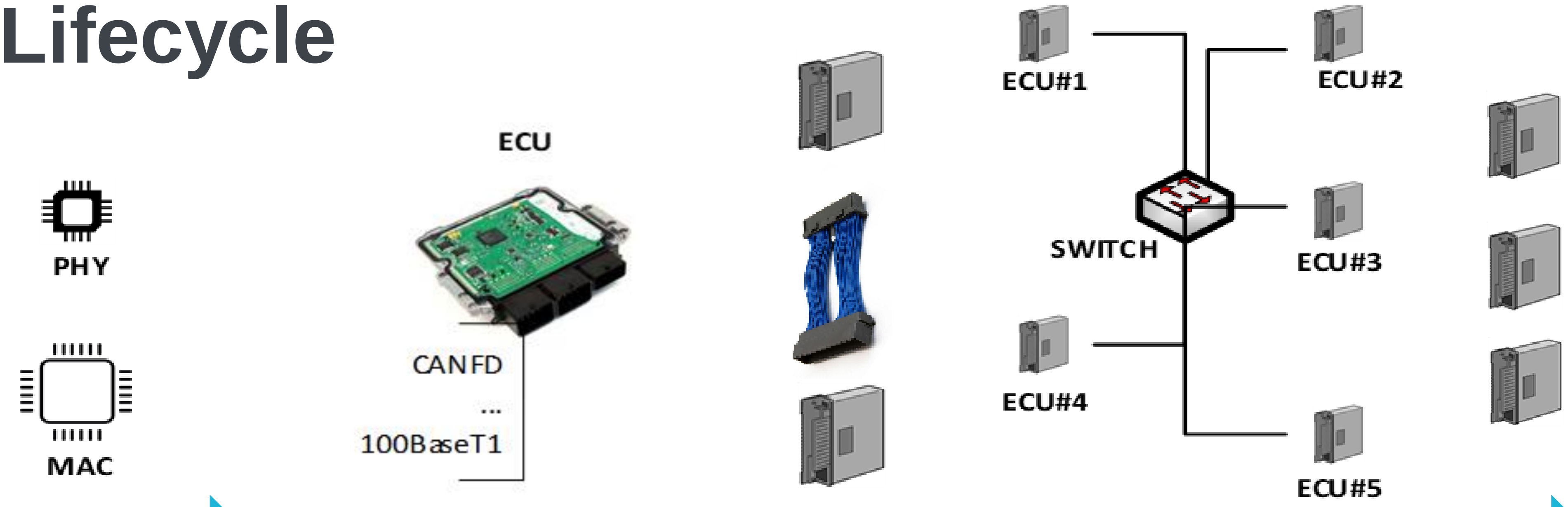
Protocol Decode, Timing Measurement

Eye Diagram, Compliance

Automotive Ethernet

- Compliance Test

IVN - Lifecycle



Semiconductor → Tier 1 → OEM

Semiconductor	Tier 1	Tier 1	OEM
Tektronix	Tektronix	Tektronix	Tektronix
	INTREPID CONTROL SYSTEMS www.intrepidcs.com	INTREPID CONTROL SYSTEMS www.intrepidcs.com	INTREPID CONTROL SYSTEMS www.intrepidcs.com
spirent Promise. Assured.	spirent Promise. Assured.	spirent Promise. Assured.	spirent Promise. Assured.

IVN – Network Layers

Layer 7

Layer 6

Layer 5

Layer 4

Layer 3

Layer 2

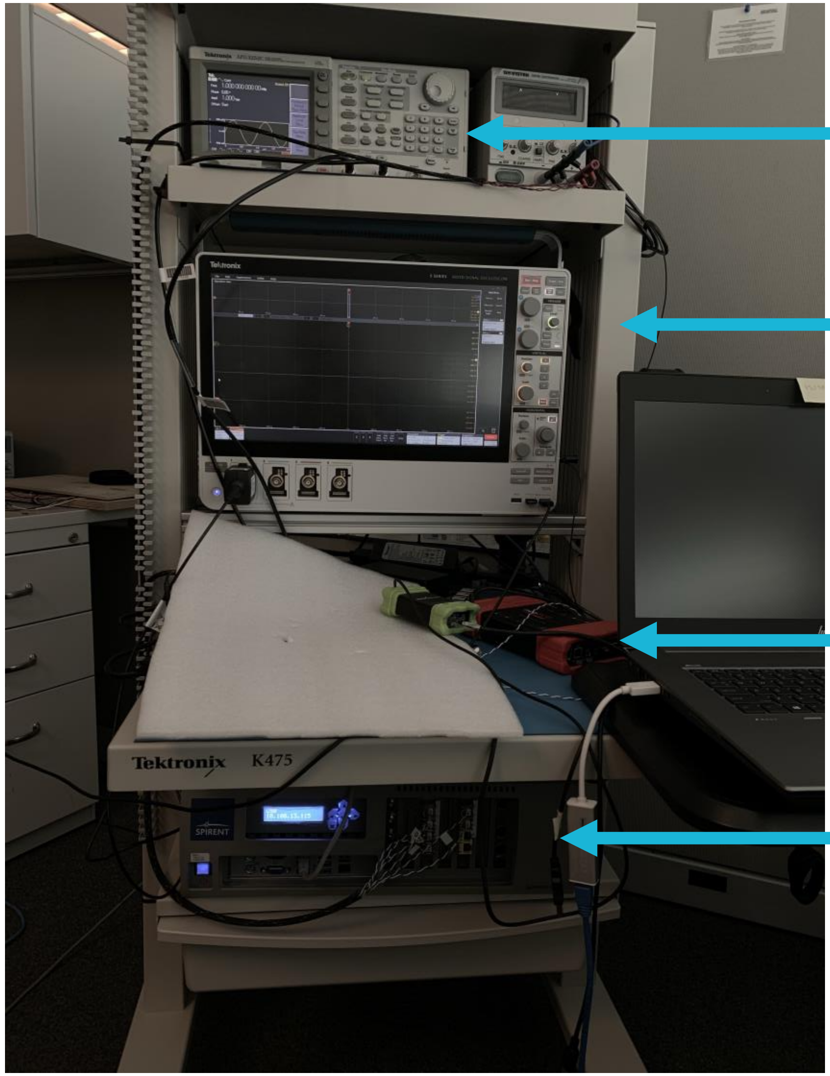
Layer 1

spirent
Promise. Assured.

INTREPID
CONTROL SYSTEMS
www.intrepidcs.com

Tektronix

Example of Integrated solution



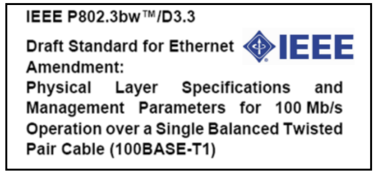
Function Generator

MSO6 series Oscilloscope

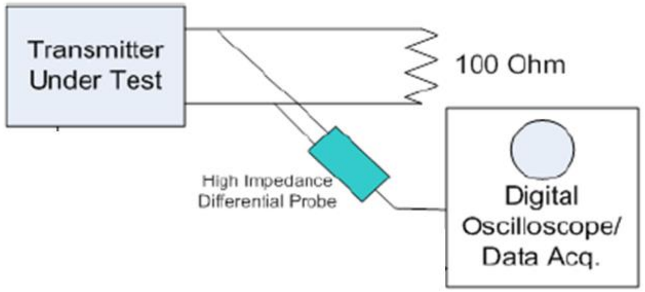
Intrepid CS Rad-Moon and AVB/TSN neoECU

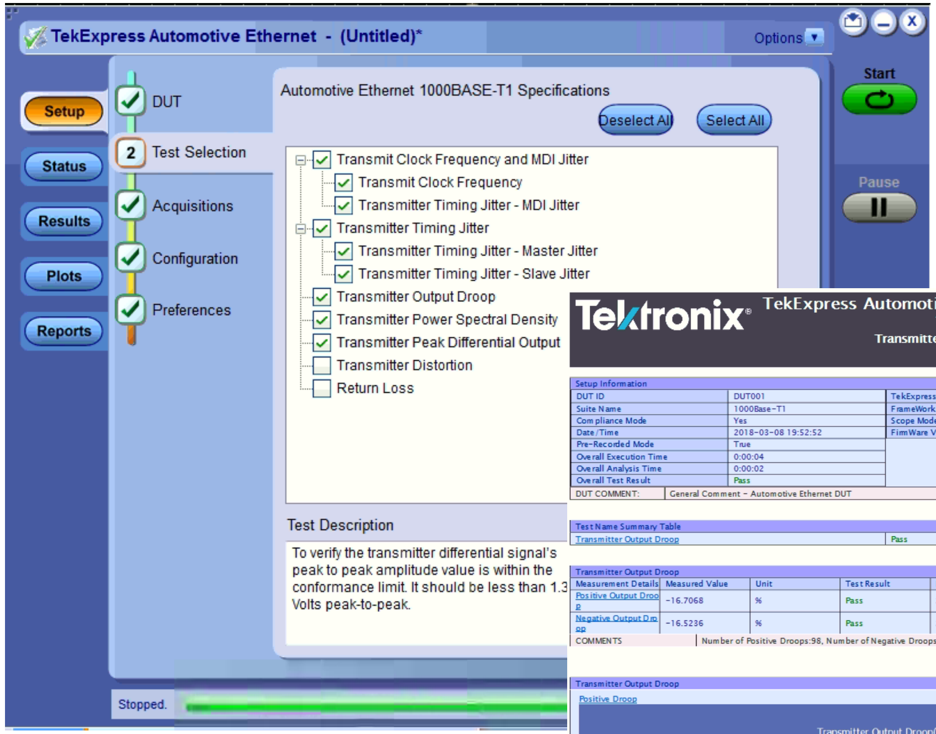
Spirent C50

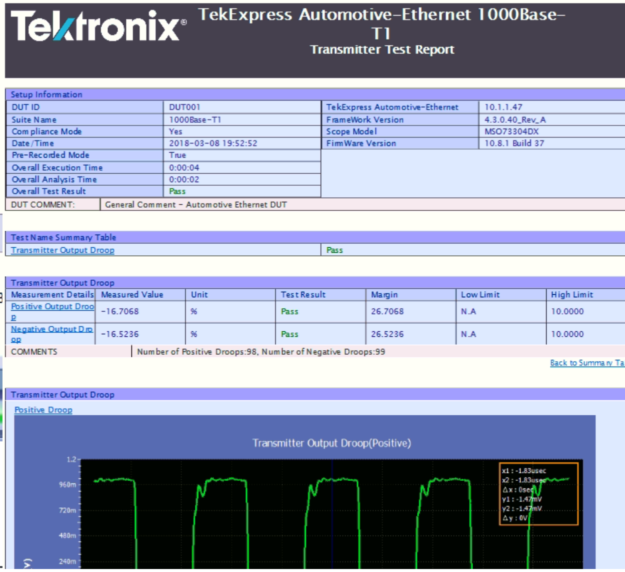
Automotive Ethernet PMA Compliance Test



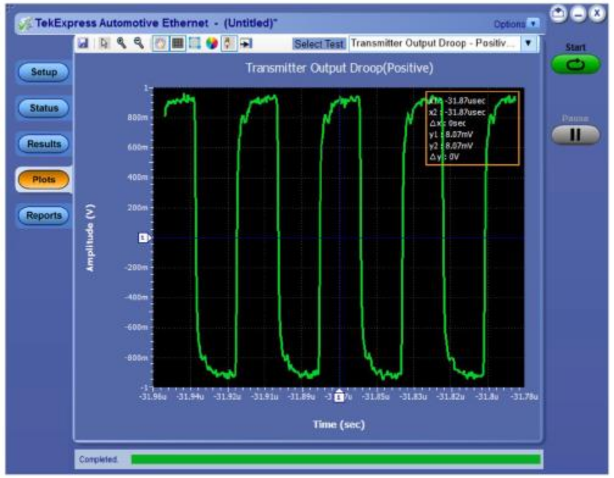
- PHY Media Attachment Compliance Test
- PHY test mode configuration should be provided by PHY vendor
- Transceiver PHY electrical test requirements include:
  - Maximum Output Droop
  - Timing Jitter (master/slave)
  - MDI Output Jitter
  - Distortion
  - Power Spectral Densit
  - Clock Frequency
  - MDI Return Loss
  - Peak Differential Output





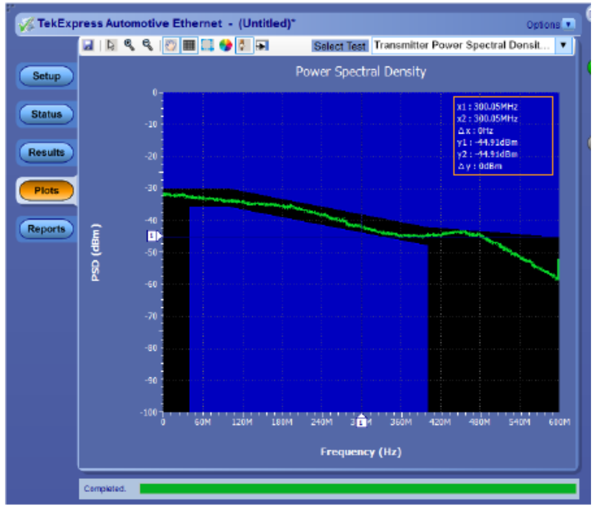


Droop measurement



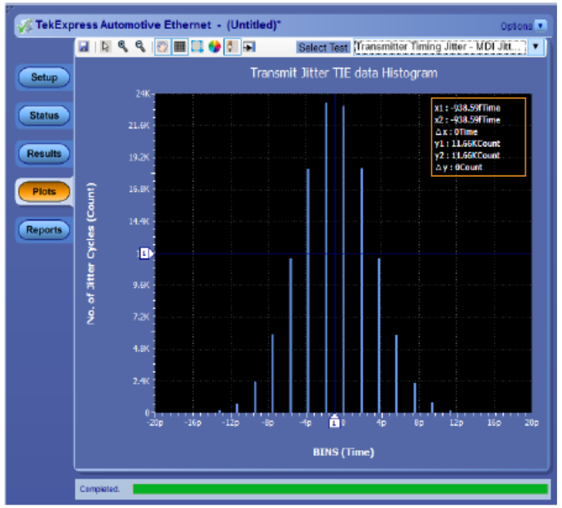
Droop measurement - Positive

Power Spectral Density (PSD)



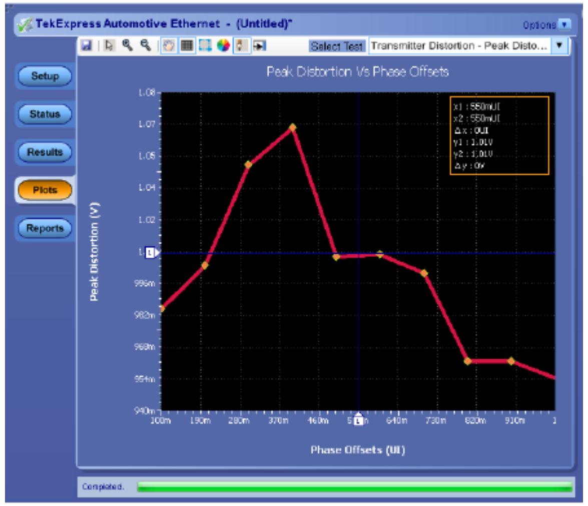
Power Spectral Density (PSD) measurement

MDI Jitter measurement



MDI jitter measurement

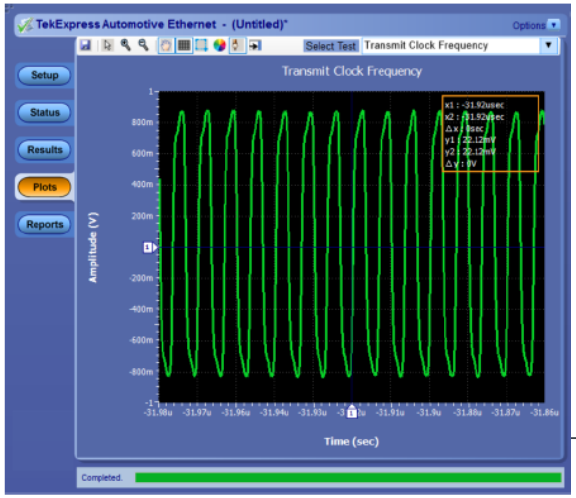
Distortion measurement



Distortion measurement

Return Loss measurement

Jitter and Transmit Clock Frequency measurements



Jitter and Transmit Clock Frequency measurements

Automotive Ethernet

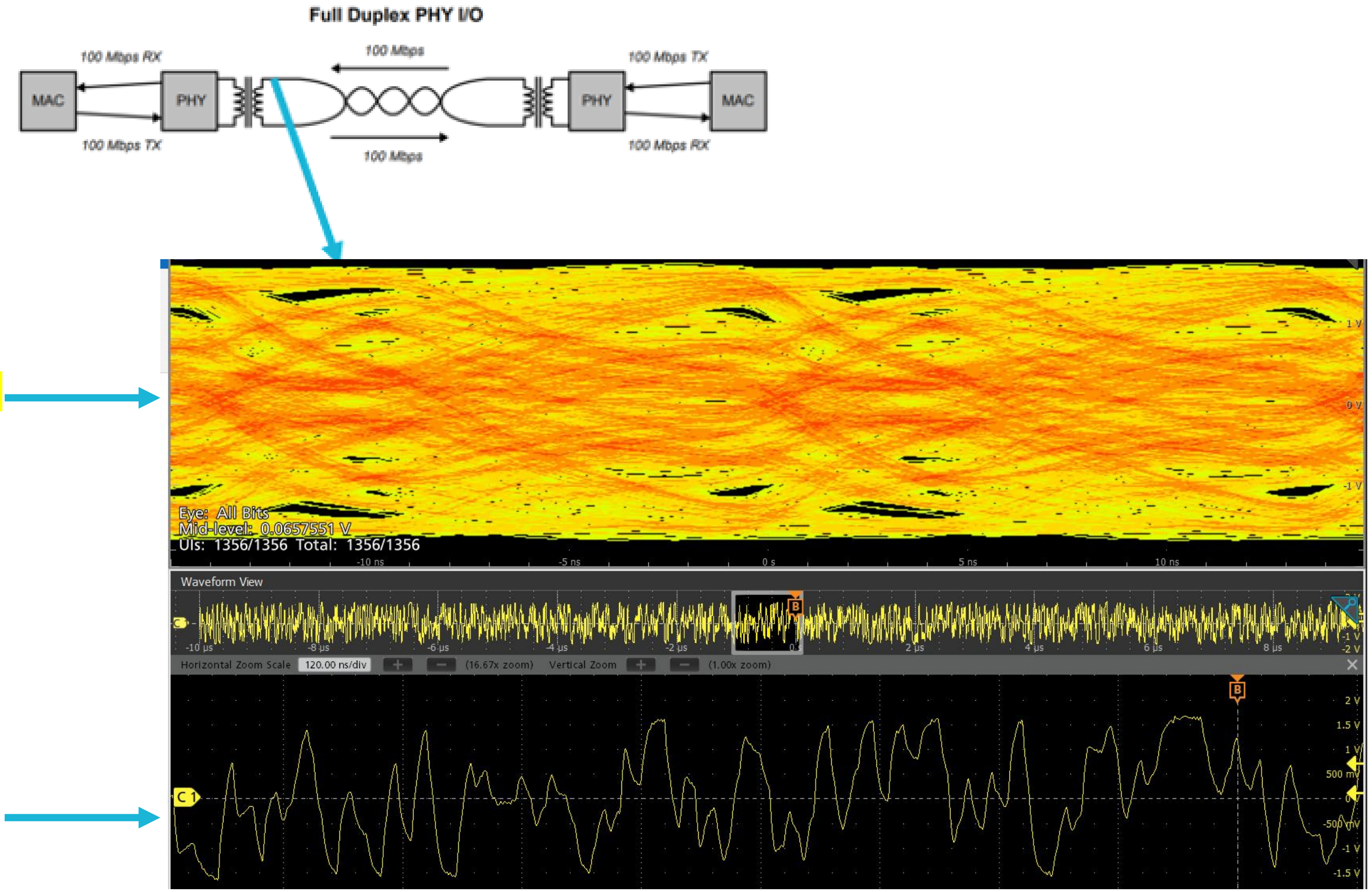
- Eye Diagram Test

Eye Diagram Test- Use case

Customer	DUT Type	DUT	Job to be done
PHY silicon companies	100BASE-T1 PHY Silicon		❑ PHY performance in different Noise condition (Signal Quality Test)
T1 System Integrator and Cable companies	ECU		❑ ECU Performance test under Noise condition (Signal Quality Test)
	System: ECU to ECU, ECU to Sensor		❑ System performance Test with different ECUs or different cable type
	Production ECU		❑ Performance test - Manufacturing variation Test
OEM	Car with Automotive Interface		❑ Performance test under various scenario - Cracking - DC Motor ❑ System level Debug

Eye Diagram Test challenge-1

- Voltage Probe Signal

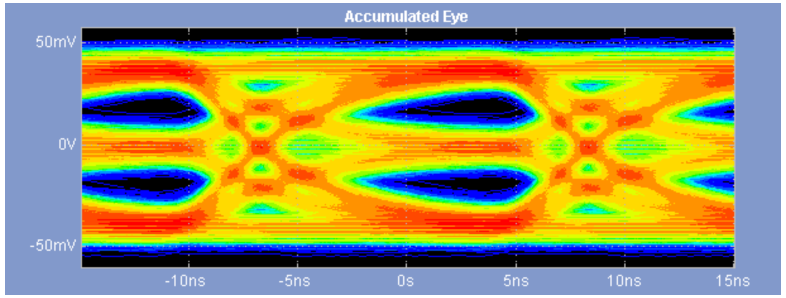


Close Eye Diagram

Multilevel Signal

Eye Diagram Test challenge-2

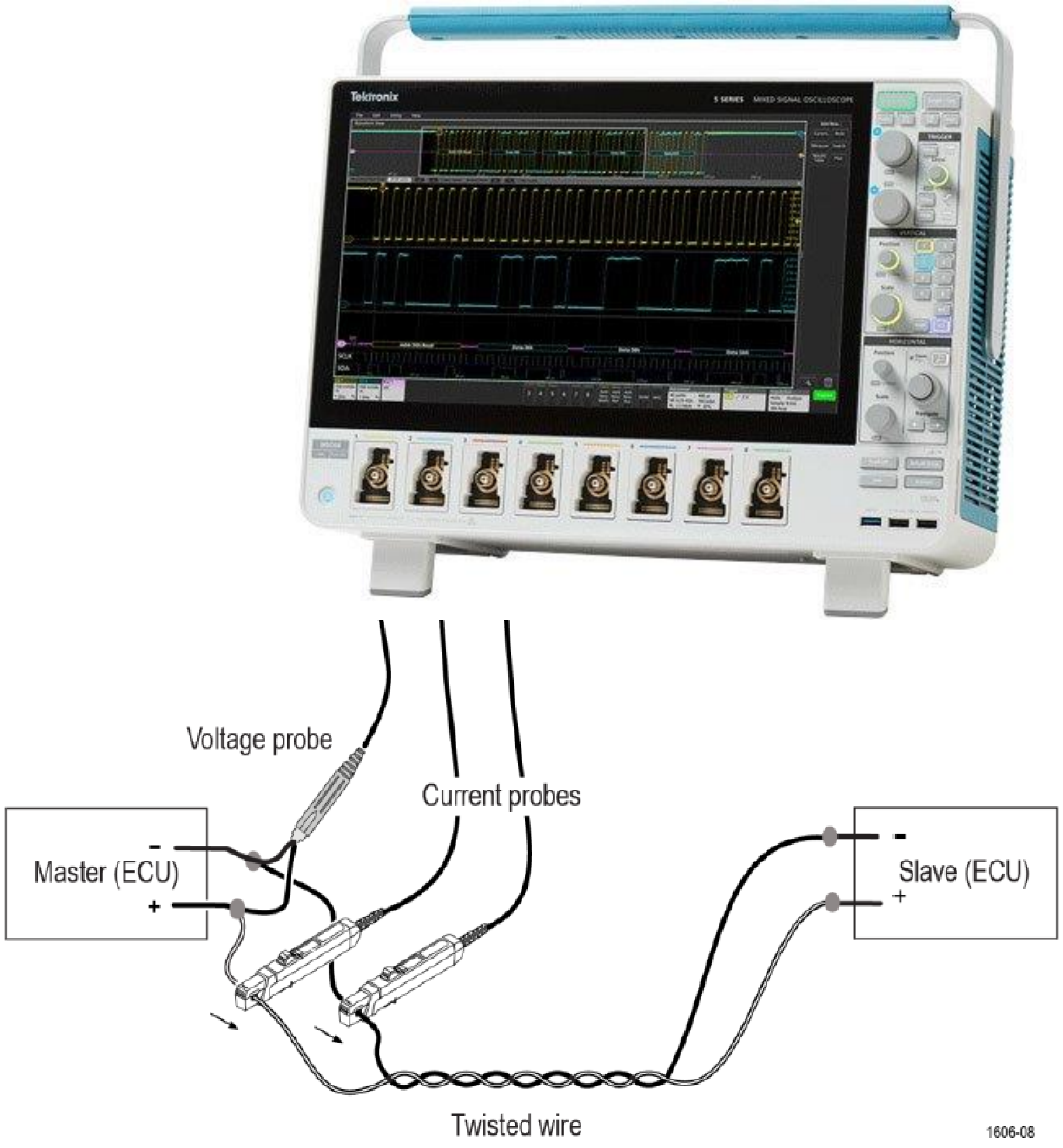
- Directional Coupler:



- Challenges:
  - Cut the cable and disturb the system
  - Directional coupler works on Directivity principle, would not show true Signal for Signal Integrity test
  - Insertion loss, Reflection, Mode conversion loss

Signal Separation

- Tektronix unique (Patent pending) Automotive Ethernet Signal separation solution using Voltage and Current waveform
- Proprietary method to separate Full-duplex signal using Current waveform and Full-Duplex Voltage waveform
- Direct access Probing, no need to break cable, No loading on ECU system
- Provides Master and Slave separated signal



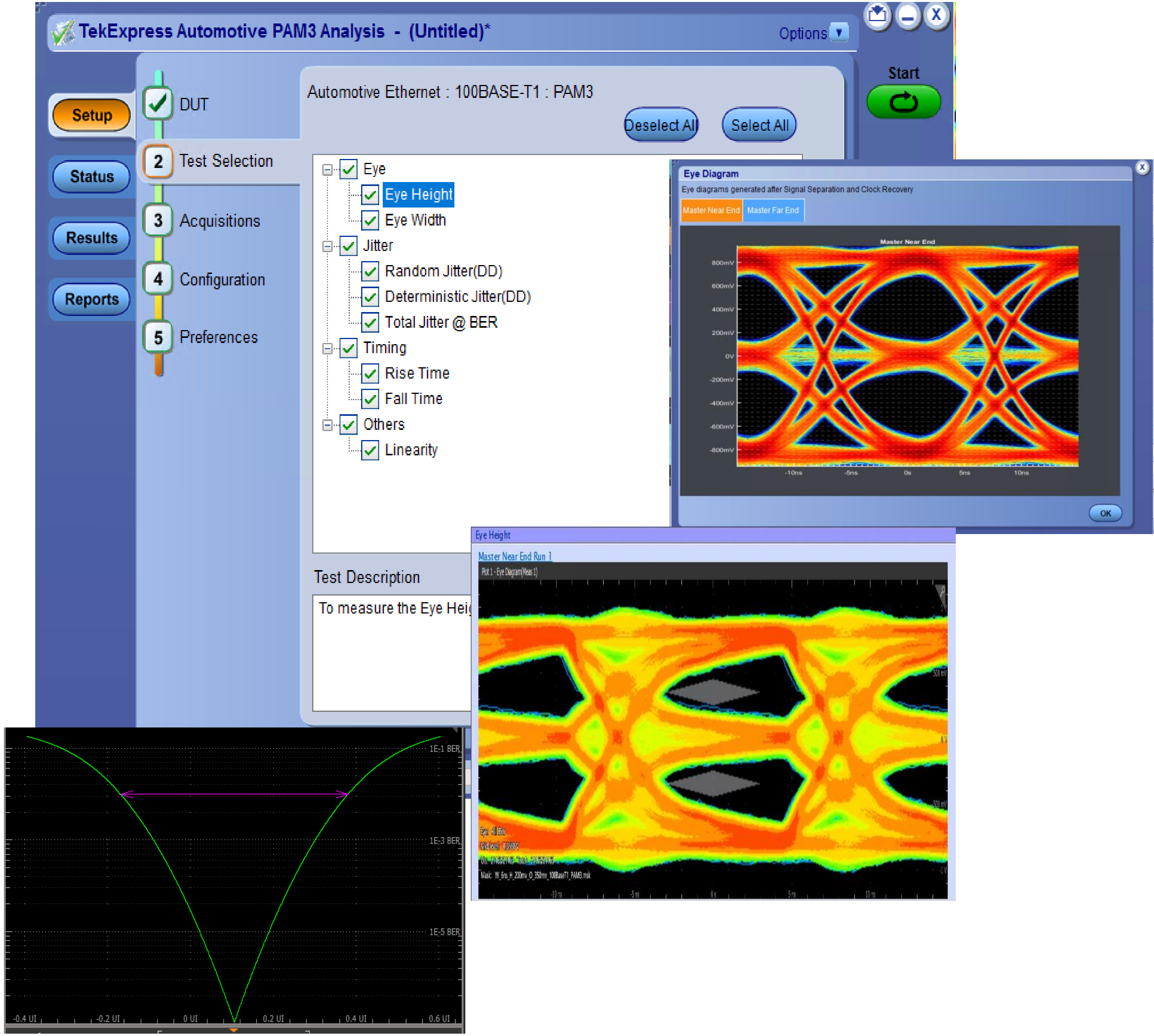
Tektronix Solution

Full-Duplex Signal

PAM3 signal

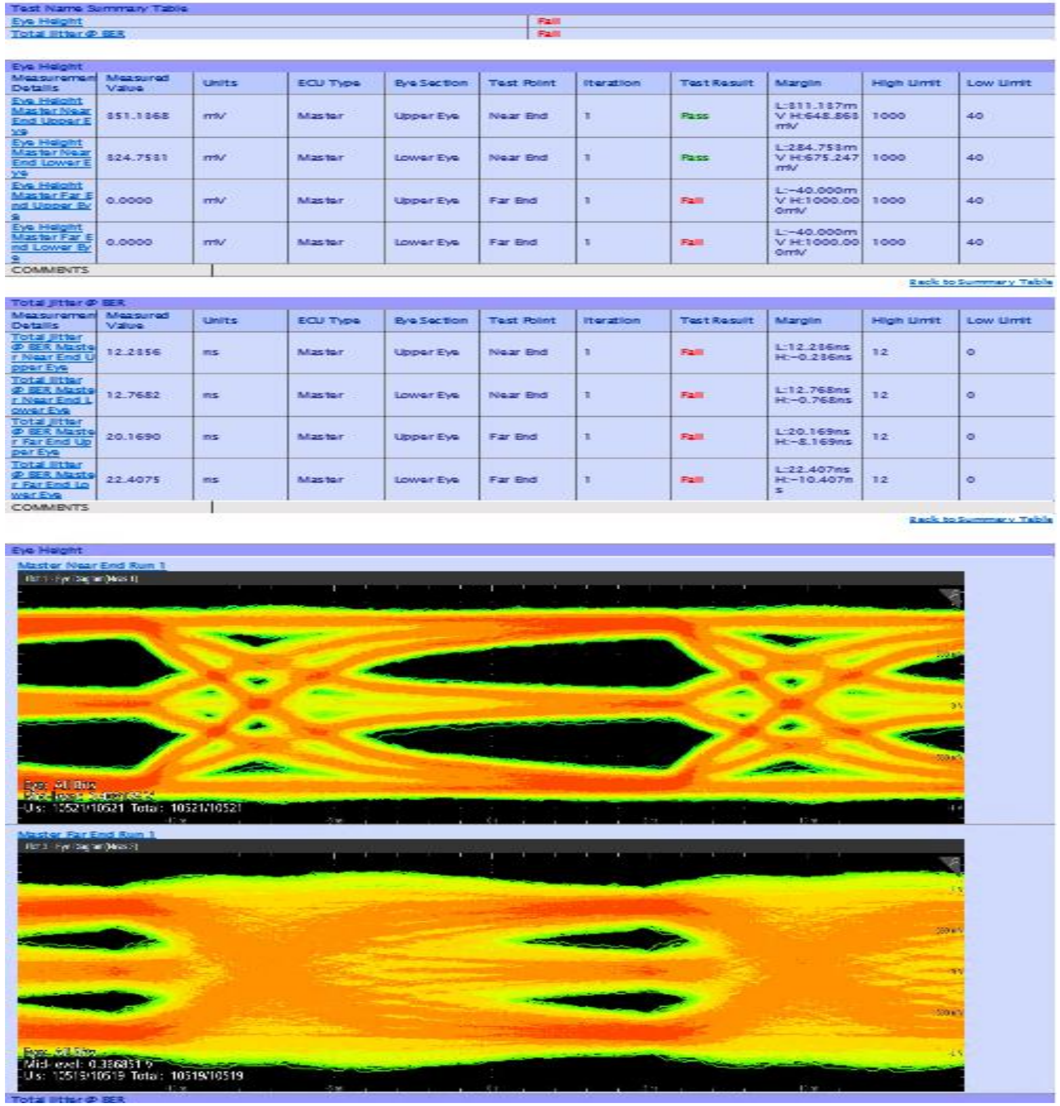
PAM3 Analysis

- Software clock recovery
- PAM3 Eye Height and Width
- PAM3 Linearity
- Jitter Separation
- Bathtub curve (BER)
- Eye Mask test



PAM3 Analysis Report

- Detailed Report with Measured value, Pass/Fail Summary, Limits, Plots



Test Name Summary Table	
Eye Height	Fail
Total Jitter @ BER	Fail

Eye Height

Measurement Details	Measured Value	Units	ECU Type	Eye Section	Test Point	Iteration	Test Result	Margin	High Limit	Low Limit
Eye Height Master Near End Upper Eye	851.1868	mV	Master	Upper Eye	Near End	1	Pass	L:811.187mV H:648.868 mV	1000	40
Eye Height Master Near End Lower Eye	324.7531	mV	Master	Lower Eye	Near End	1	Pass	L:284.753mV H:675.247 mV	1000	40
Eye Height Master Far End Upper Eye	0.0000	mV	Master	Upper Eye	Far End	1	Fail	L:-40.000mV H:1000.000mV	1000	40
Eye Height Master Far End Lower Eye	0.0000	mV	Master	Lower Eye	Far End	1	Fail	L:-40.000mV H:1000.000mV	1000	40
COMMENTS										

Back to Summary Table

Total Jitter @ BER

Measurement Details	Measured Value	Units	ECU Type	Eye Section	Test Point	Iteration	Test Result	Margin	High Limit	Low Limit
Total Jitter @ BER Master Near End Upper Eye	12.2856	ns	Master	Upper Eye	Near End	1	Fail	L:12.286ns H:-0.286ns	12	0
Total Jitter @ BER Master Near End Lower Eye	12.7682	ns	Master	Lower Eye	Near End	1	Fail	L:12.768ns H:-0.768ns	12	0
Total Jitter @ BER Master Far End Upper Eye	20.1690	ns	Master	Upper Eye	Far End	1	Fail	L:20.169ns H:-8.169ns	12	0
Total Jitter @ BER Master Far End Lower Eye	22.4075	ns	Master	Lower Eye	Far End	1	Fail	L:22.407ns H:-10.407ns	12	0
COMMENTS										

Back to Summary Table

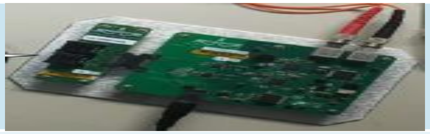
Eye Height

Master Near End Run 1

Master Far End Run 1

Total Jitter @ BER

Eye Diagram Test- Summary

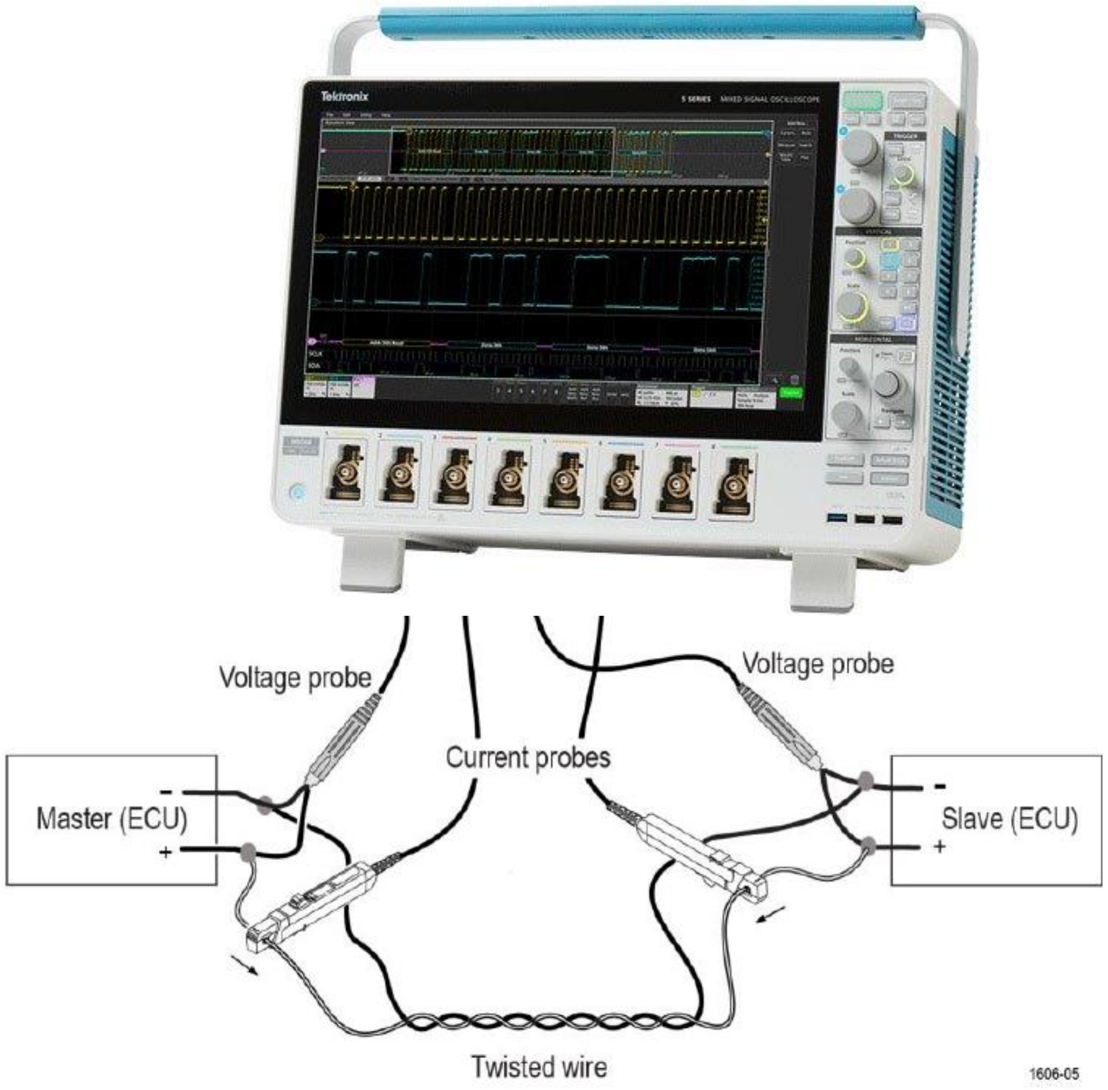
Customer	DUT Type	DUT	Job to be done
PHY silicon companies	100BASE-T1 PHY Silicon		✓ PHY performance in different Noise condition (Signal Quality Test)
T1 System Integrator and Cable companies	ECU		✓ ECU Performance test under Noise condition (Signal Quality Test)
	System: ECU to ECU, ECU to Sensor		✓ System performance Test with different ECUs or different cable type
	Production ECU		✓ Performance test ✓ Manufacturing variation Test
OEM	Car with Automotive Interface		✓ Performance test under various scenario ✓ Cracking ✓ DC Motor ✓ System level Debug

Automotive Ethernet

- Protocol Test

Automotive Ethernet Protocol Decode

- Tektronix unique technique (patent pending) separates traffic from ECU#1 and ECU#2 in Full-Duplex mode
- Shows ECU#1 and ECU#2 Protocol decode simultaneously
- Various search options



Protocol Decode

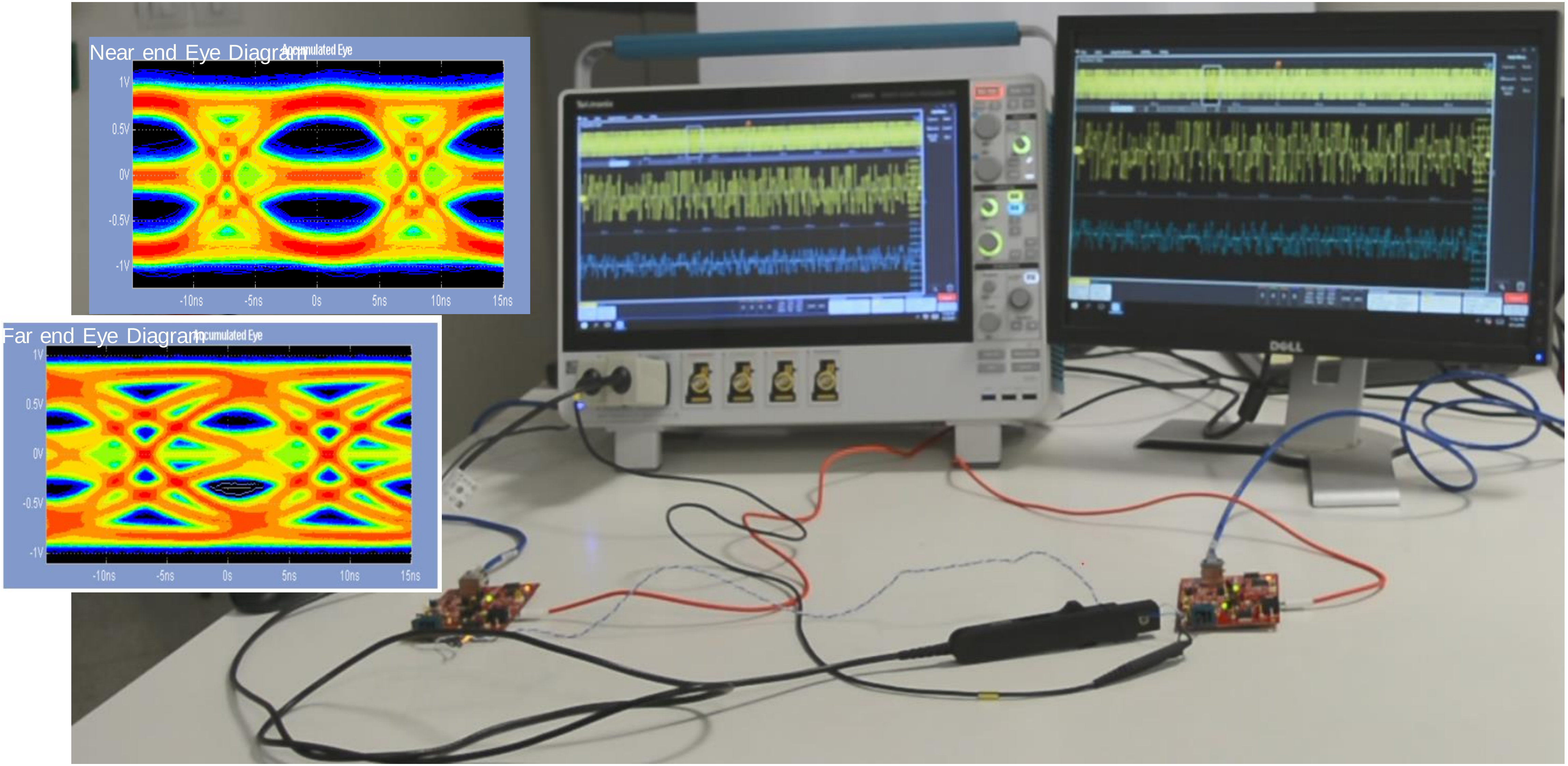
Search Option

Full-Duplex Protocol Decode

Signal Separation solution

DEMO

Automotive Ethernet Test setup



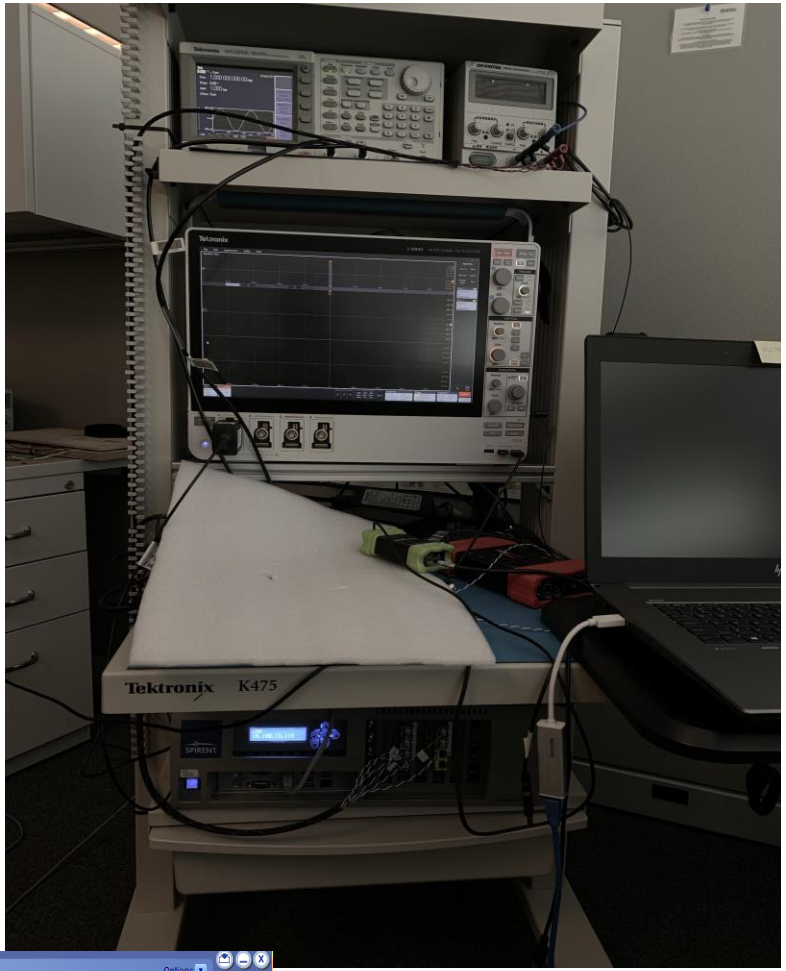
Advantage of Signal Separation

- Ability to see the “real” signal without Insertion Loss which increases diagnosis accuracy
- Easier test set up reduces total test time
- Protocol and Physical layer view in single window to debug faster
- Entire automotive life cycle functions from design through service/maintenance and was designed with ease-of-use in mind

Automotive Ethernet solution

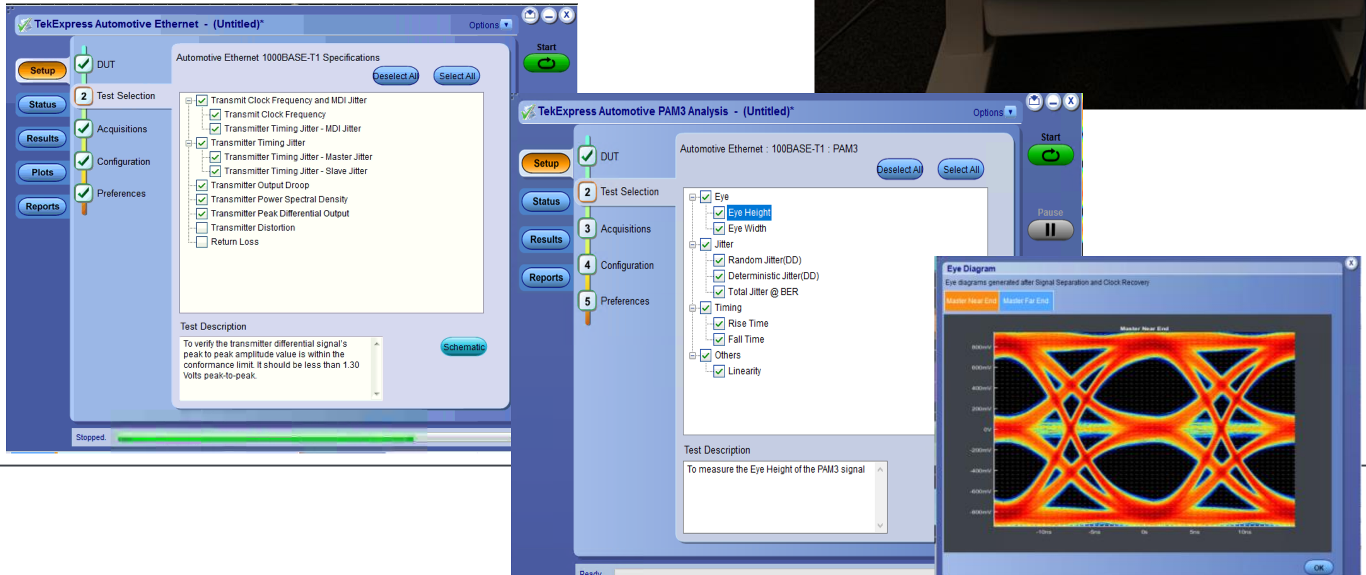
OSI	Automotive Ethernet
7. Application	Application
6. Presentation	
5. Session	
4. Transport	TCP/UDP
3. Network	IP
2. Datalink	Network Access
1. Physical	100/1000BASE-T1

L1-L7 Conformance Test



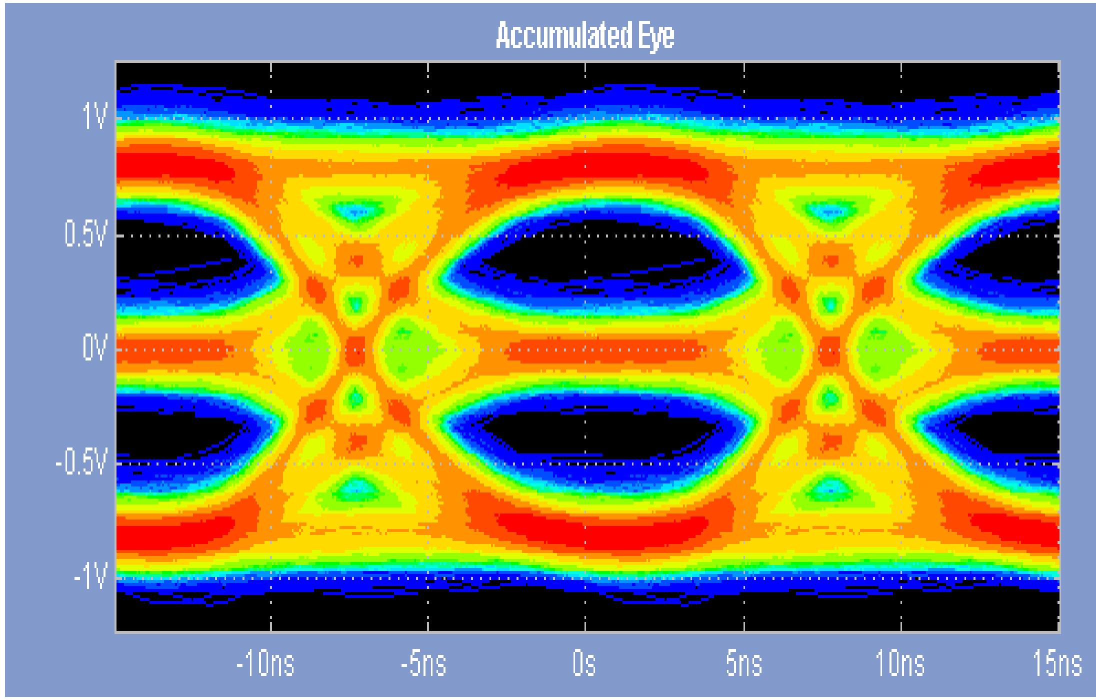
Protocol Decode, Timing Measurement

Eye Diagram, Compliance



Ordering configuration

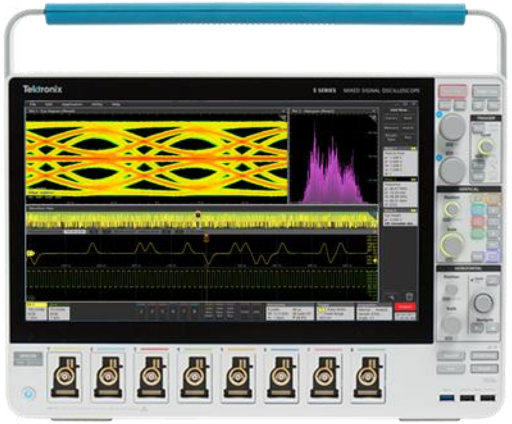
- Oscilloscope: 5/6 series MSO
  - 1 GHz minimum bandwidth (100BASET1)
- Software:
  - 5/6-AUTOEN-SS: Signal Separation
  - 5/6-PAM3: PAM3 Signal Analysis (Prerequisite: 5/6-AUTOEN-SS, DPOJET)
  - 5/6-SRAUTOEN1: 100BASE-T1 Protocol Decode (Prerequisite: 5/6-AUTOEN-SS)
- Probes: TDP1500 (1 or 2 no): Voltage probe
  TCP0030A (1 or 2 no)- Current Probe
- Fixtures: ECU dependent

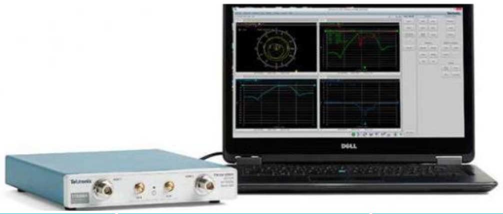


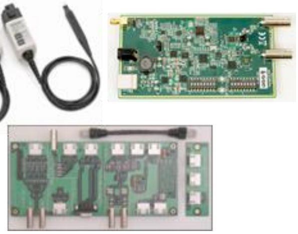
Scope	Scope Options	Probes	Fixture
MSO 5/6 Series	1 GHz bandwidth, Windows, 5/6-AUTOEN-SS, 5/6-PAM3, 5/6-SRAUTOEN1	TDP1500 TCP0030A/P6022	ECU Dependent

Automotive Ethernet Compliance Solution

- Oscilloscope: 5/6 series MSO, MSO/DPO5KB, DPO7KC/70KC
  - 1 GHz minimum bandwidth (100BASET1)
  - 2GHz Minimum bandwidth (1000BASET1)
- Software:
  - 5/6-CMAUTOEN: 1000BASE-T1/100BASE-T1 compliance
  - Optional Advanced jitter software
- Probes: TDP1500 (1 no)- 100BASET1, 2 no for RL
  TDP3500 (1 no)- 1000BASET1, 2 no for RL
- Signal source: Distortion Test only: AFG3152C
  RL and Distortion: AWG5200







Scope	Scope Options	Probes	Fixture 1	Fixture 2	Source
5/6 Series	2 GHz bandwidth, Windows, 5/6-SR AUTO, 5/6-DJA, 5/6-CMAUTOEN	TDP1500 Or TDP3500	TF-XGbT	TF-BRR-CFD	AFG3152C
DPO5K/7K/70K	> 2 GHz bandwidth, BRR, DJA, SR-AUTO	TDP1500 Or TDP3500 (VPI Connector)	TF-XGbT	TF-BRR-CFD	AFG3152C

Automotive Reference

- Automotive website: www.tek.com/automotive
- Automotive Ethernet: www.tek.com/automotive/automotive-ethernet
- Automotive Power: www.tek.com/power-efficiency/market-your-power-conversion-designs
- EMI/EMC: www.tek.com/application/electromagnetic-interference-emi-and-electromagnetic-compatibility-emc

Thank you!