Putting The Future In Motion With Automotive Ethernet And Mainstream Serial Buses

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KEYSIGHT TECHNOLOGIES

Agenda

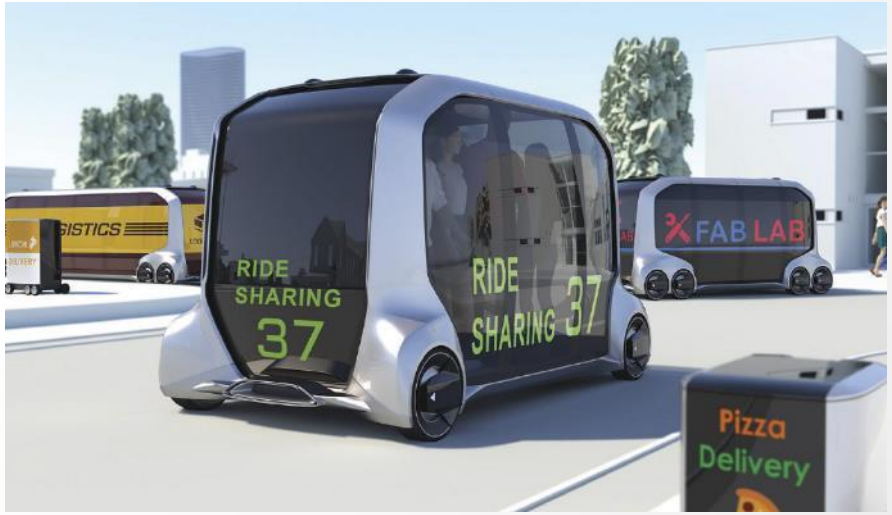
WHAT YOU CAN EXPECT

- What is Automotive Ethernet?
- Challenges of moving to a new standard
- Solution Details

Autonomous Driving System

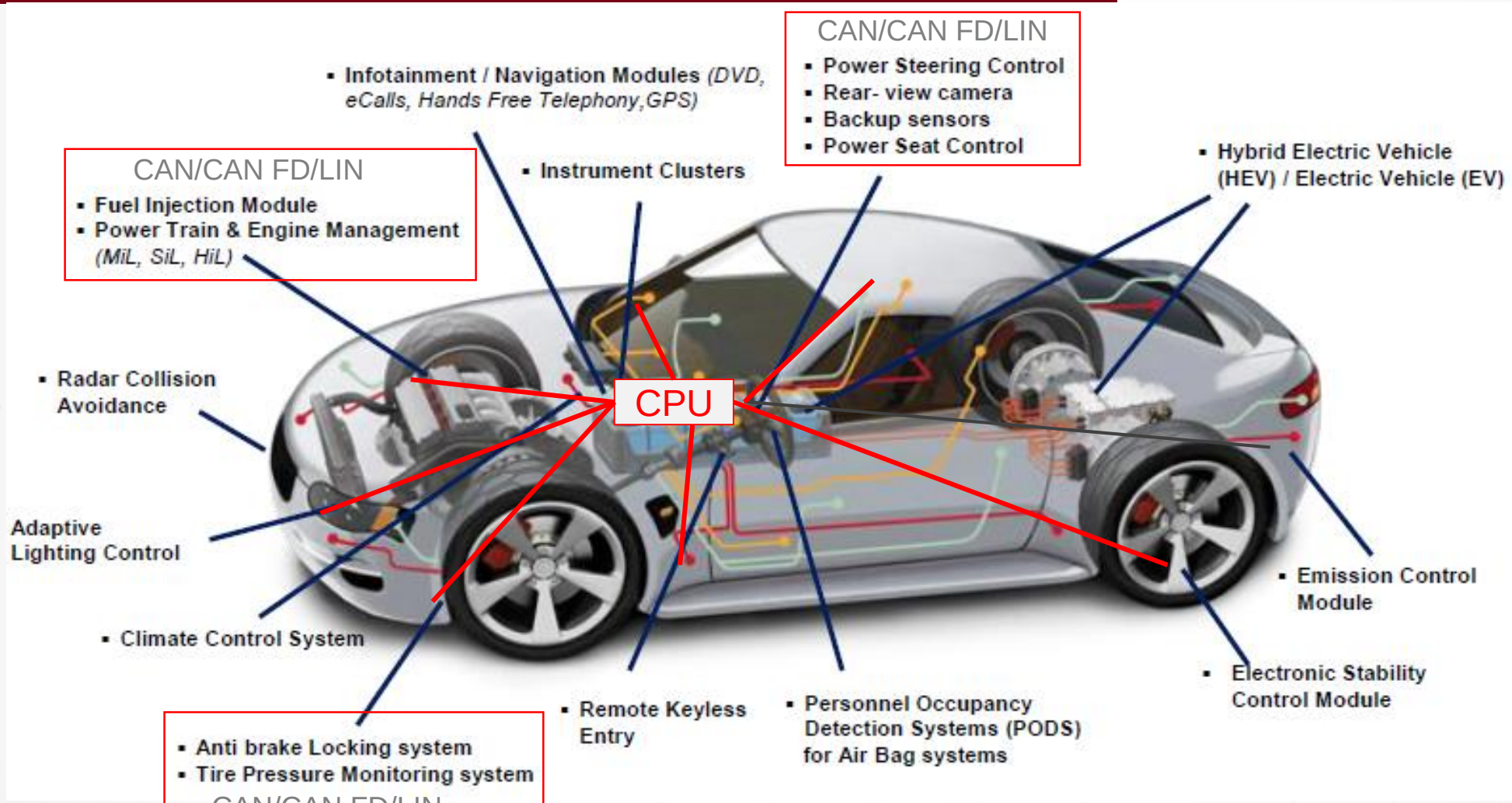
BENEFITS

- Safer world with 90% fewer car accidents
- More productive life from less traffic congestion and driving time
- Better energy efficient transportation and environmental benefits
- More efficient car-sharing and car-utility
- Better urban land utilization
- More innovations, investments and newer business models
- And, more



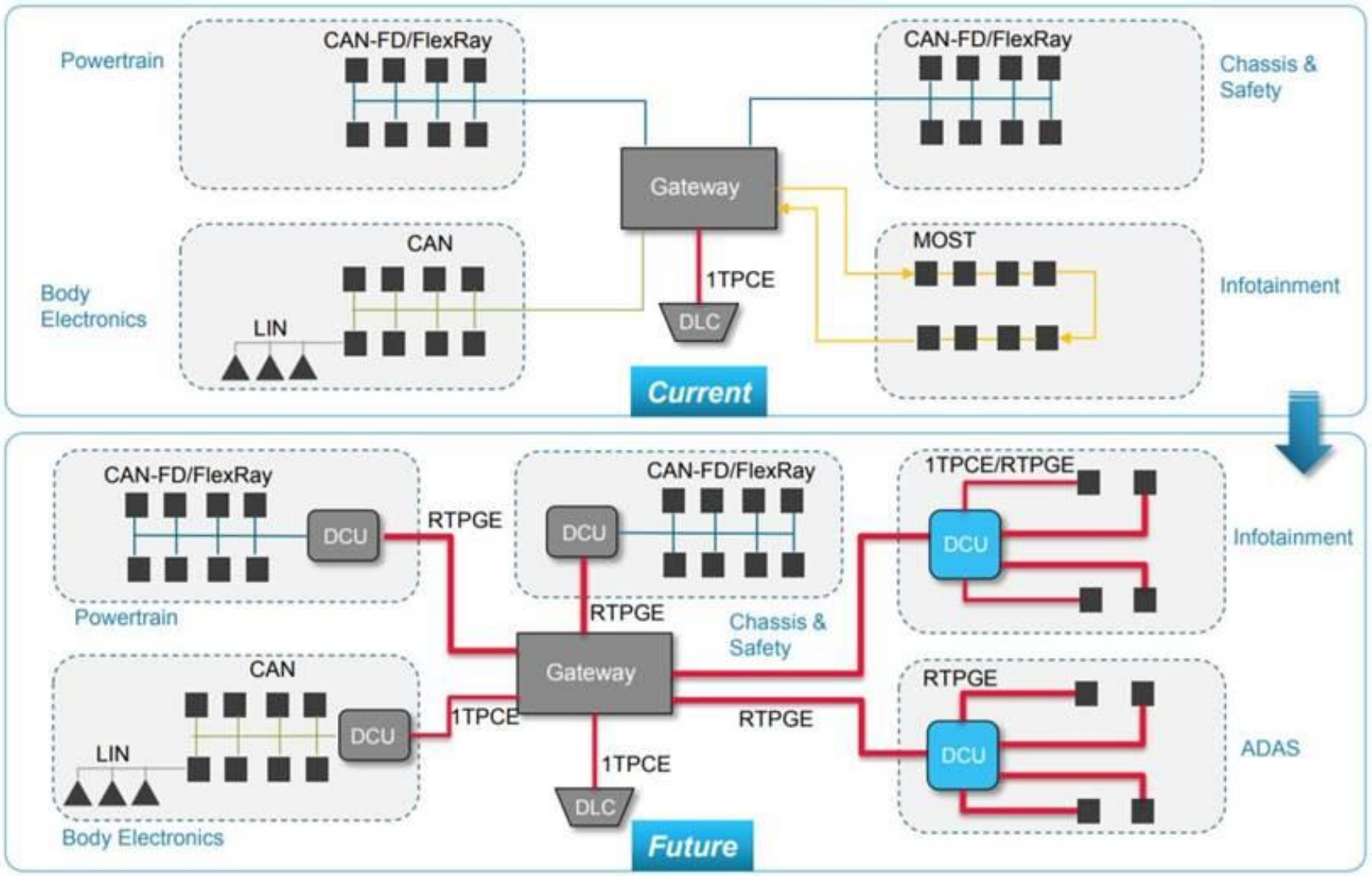
Future Car Network

ETHERNET IS THE BACKBONE



Automotive Ethernet into the future

HOW USE WILL EVOLVE



1TPCE = 1 Twisted Pair [c] 100Mb/s Ethernet

RTPGE = Reduced Twisted Pair Gigabit Ethernet

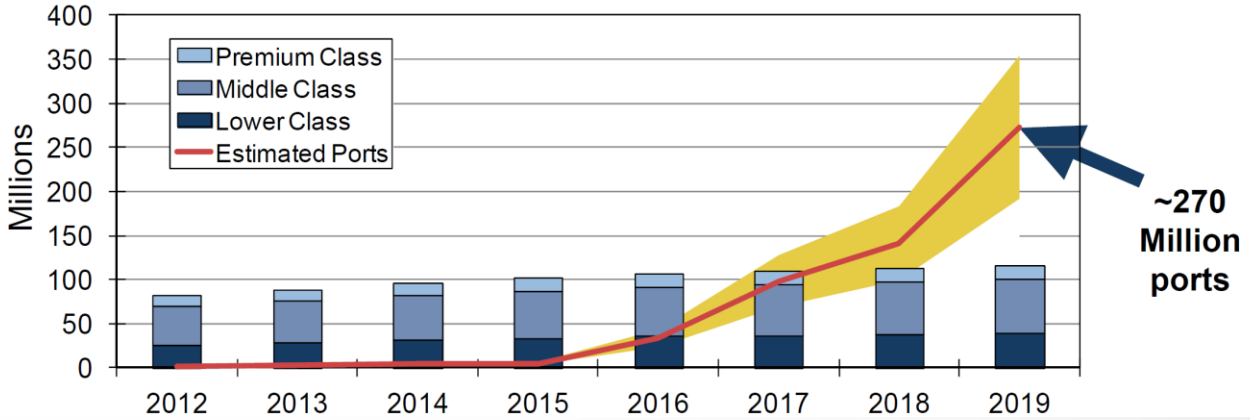
Automotive Ethernet

MARKET NEEDS

Increase in ECUs, Signals and Especially Bandwidth

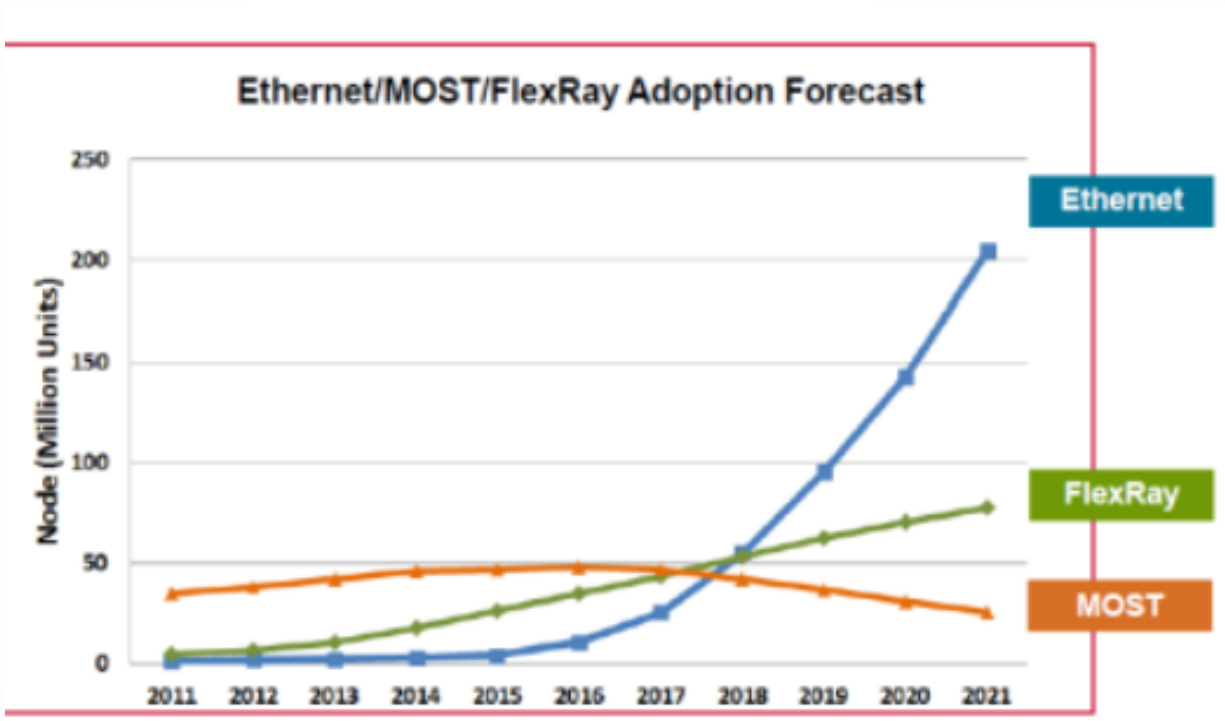
Forecast

- Up to 35 ports (20 avg.) in premium class vehicles and 20 (8 avg.) in medium class vehicles that have Ethernet
- Chart data was compiled by Bosch



Automotive Ethernet Adoption Forecast

PROJECTIONS OF ADOPTION



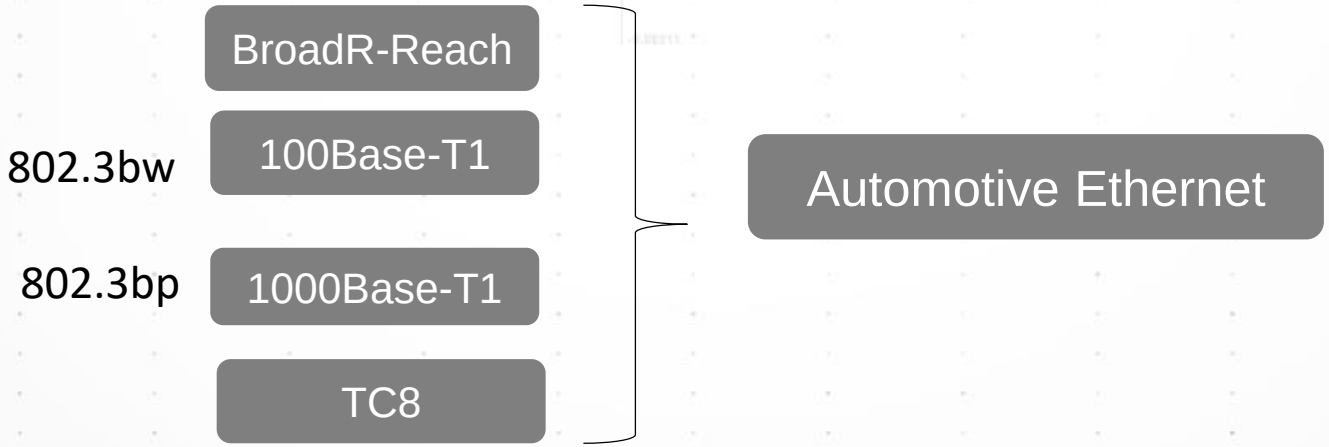
Ethernet adoption forecast

(Source: High-speed automotive bus demand estimates 2015 by Strategy Analytics)

Industry Terms

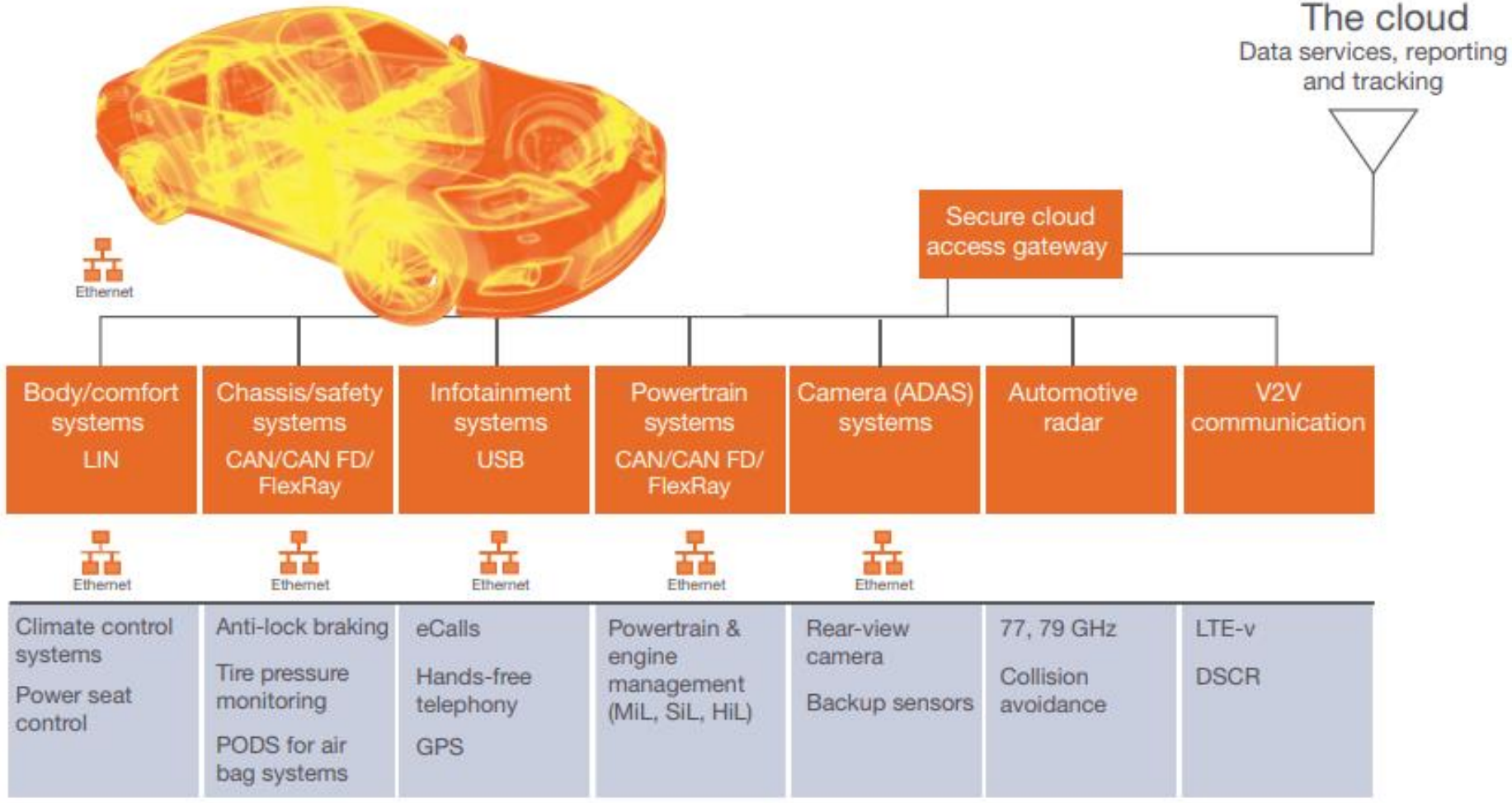
CONNECTED CAR, AUTOMOTIVE ETHERNET, BROADR-REACH

- **Connected Car** is connected to the internet, driven by safety and luxury
- **Automotive Ethernet:** electrical, bandwidth, latency, synchronization and network management requirements specific to automotive market.
- Automotive **Ethernet physical layer** standard for use in automotive applications.
  - 100BASE-T1 an IEEE standard developed in likeness of BroadR-Reach
  - All of these standards maintained by OPEN Alliance



What is Automotive Ethernet?

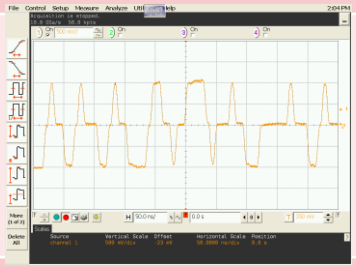
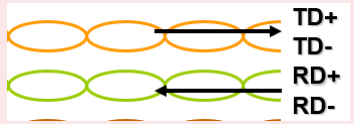
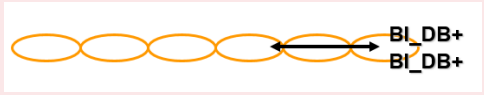
WHY ARE MANUFACTURERS SWITCHING?



The Connected Car

Fast Ethernet vs Automotive Ethernet

100BASE-TX VS 100BASE-T1

	Ethernet 100BASE-TX (IEEE802.3)	Automotive Ethernet 100BASE-T1 (IEEE802.3bw)	Automotive Ethernet 1000BASE-T1 (IEEE802.3bp)
Data Rate	100 Mbps	100 Mbps	1000 Mbps
Signal	**MLT3** 	PAM3 @ 66.667 Mb/s 	PAM3 @ 750 Mb/s 
Modulation	4B5B	4B/3B	80B/81B
Length	100 m	15 m	
Connector	RJ45	Not Defined Depending on OEMs and models	
Cable	Two Twisted Pair Single Direction 	One Twisted Pair Bi Directional 	

802.3bw vs 802.3bp

100BASE-T1 VS 1000BASE-T1

	100BASE-T1	1000BASE-T1
IEEE standard	802.3bw	802.3pb
Data rate	100 Mbps	1000 Mbps
Symbol rate	66.66 MHz	750 MHz
DUT clock	66.66 MHz	125 MHz
Coding	PAM3	PAM3
Disturbing signal (TM4)	5.4 Vpp @ 11.11 MHz	3.6 Vpp @ 125 MHz
Length	15 m (copper)*	15 m (copper)*

*40m is also supported for the link segment in applications requiring additional physical reach (industrial and automation controls and transportation – aircraft, railway, bus, heavy trucks.)

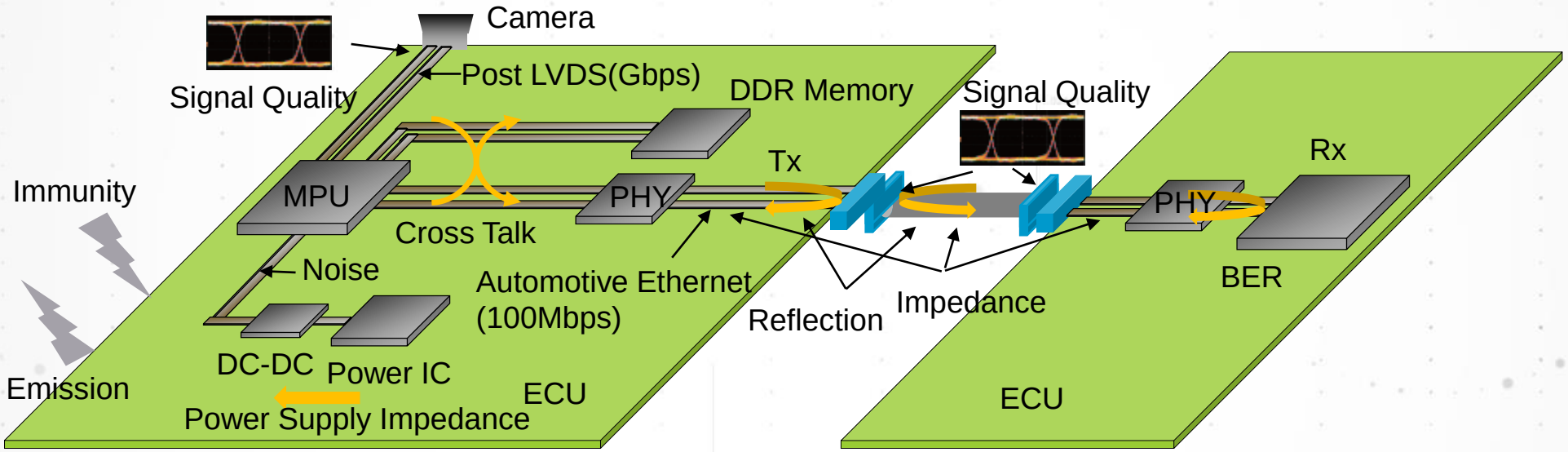
Agenda

WHAT YOU CAN EXPECT

- What is Automotive Ethernet?
- Challenges of moving to a new standard
- Solution Details

Autonomous Driving System

HIGH FREQUENCY BOARD DESIGN CHALLENGES



Noise
- International standard
- OEM Standard

Bus
- Signal Quality
- Tx Test
- Rx Test

Link Segment
- Impedance
- Cross Talk
- Reflection
- Loss

DC Power Supply
- Signal quality
- Impedance
- Noise
- DC-DC

Challenges of new standards

COMPLIANCE REQUIREMENT

CHALLENGES

- Unknown specifications
- New instrumentation and setups
- More complex than low speed serial
- Test cases cover Tx, Rx, harness/connectors
- Interoperability

COST

- Time

Agenda

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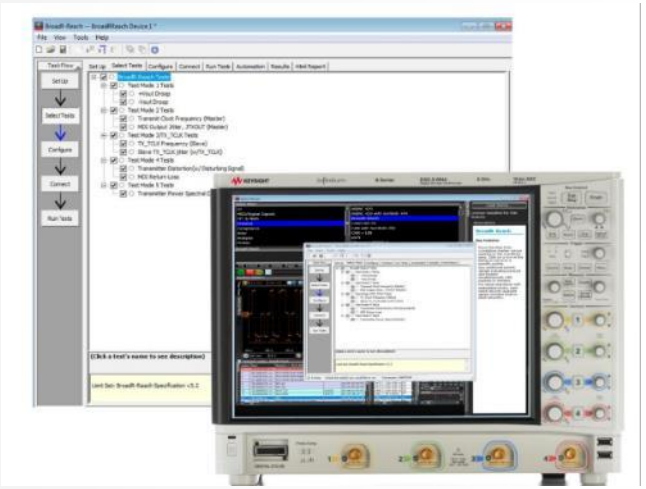
Keysight Automotive Ethernet solutions

UNIQUE TEST COVERAGE

Transmitter



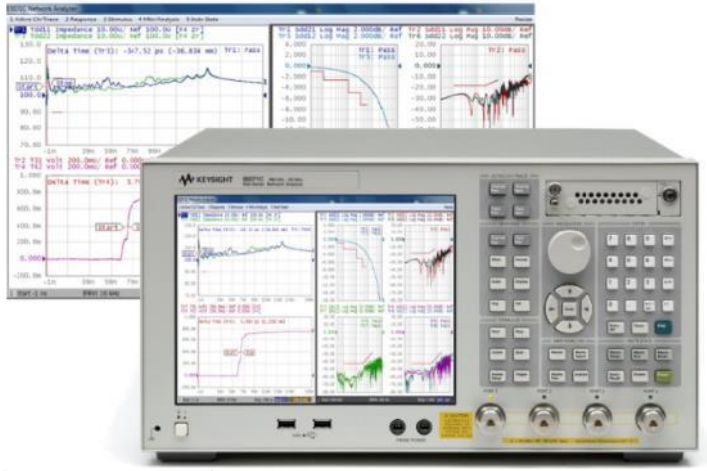
E6961A Automotive Ethernet Transmit

- ❖ **Complete 1000BASE-T1 & 100BASE-T1 compliance (including TC*)**
- ❖ **Protocol trigger & decode**

Solution components

- Oscilloscope, ENA, Spectrum Analyzer, AWG
- Fixtures, cables, adapters
- Software

Link Segment



E6963A Automotive Ethernet Link Segment

- ❖ **Industry-first 100% test coverage harness & connector**
- ❖ **Guided test setup and pass/fail report with margin analysis**

Solution Components

- ENA Vector Network Analyzer
- Cables and adapters
- Software

Receiver

E6962A Automotive Ethernet Receiver

- ❖ **Industry-first Bit Error Rate verification**
- ❖ **Easy-to-follow setup and pass/fail report generation**

Solution Components

- PXIe mainframe, controller, digitizer and AWG
- Cables and adapters
- Software

E6961A Automotive Ethernet Tx Compliance Solution

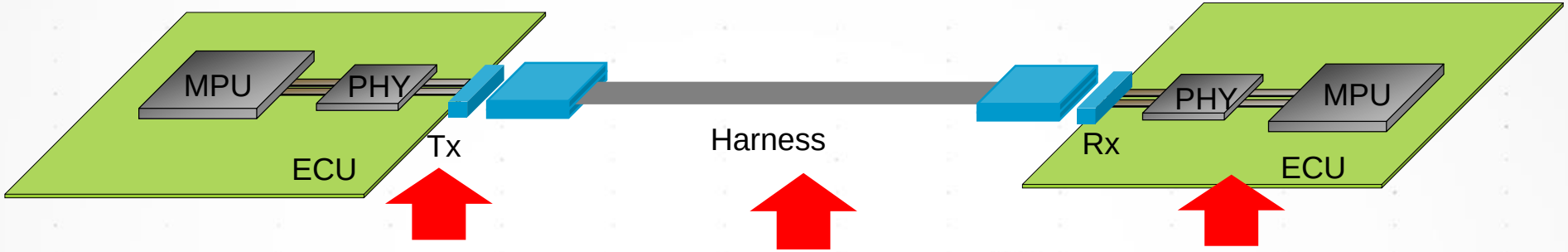
E6960A 802.3BP 1000BASE-T1 TX COMPLIANCE APPLICATION

N6467B 802.3BW (BROADR-REACH) COMPLIANCE APPLICATION

N8847A 802.3BW (BROADR-REACH) PROTOCOL TRIGGER & DECODE

E6964A 802.3BW (BROADR-REACH) MDI S-PARAMETER SOFTWARE

Overview of 100BASE-T1 Tests



Transmitter

Link Segment

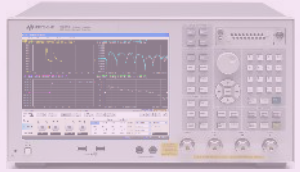
Receiver

S series Scope
for Signal Quality

E5071C Network Analyzer
for Sdd11, Sdc11

N6467B /E6960A/E6959A
Compliance Test Software

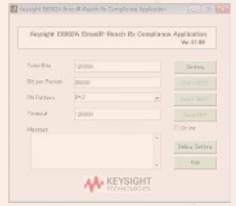
All 3 compliance applications available in 1 part number: **E6958A**



E5071C opt TDR

E6963A Compliance Test Software

M9010A + M3302A



E6962A Rx Test Software

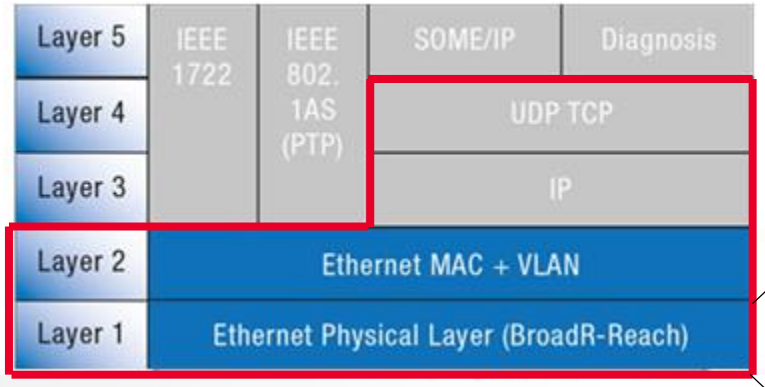
Comparing the tests

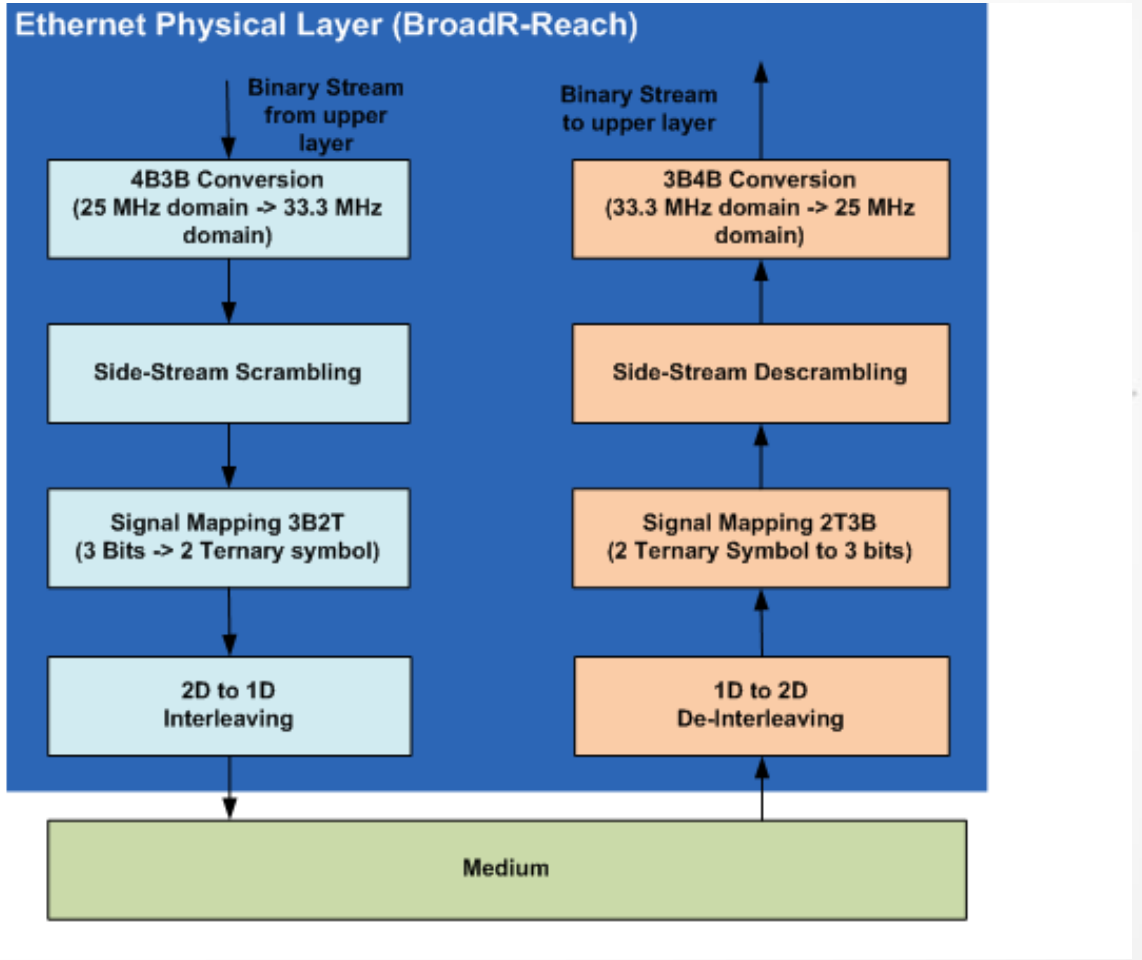
Test name	IEEE 100BASE-T1 BroadR-Reach (N6467B)	OPEN Alliance ECU (E6959A)	IEEE 1000BASE-T1 (E6960A)
Transmitter output droop	96.5.4.1	96.5.4.1 2.2 OABR_PMA_TX_01	97.5.3.1
Transmitter distortion	96.5.4.2	96.5.4.2 2.2 OABR_PMA_TX_08	97.5.3.1
Transmitter timing jitter	96.5.4.3/ 96.5.4.5	96.5.4.3/ 96.5.4.5 2.2 OABR_PMA_TX_02	97.5.3.3
Transmitter power spectral density	96.5.4.4	96.5.4.4 2.2 OABR_PMA_TX_04	97.5.3.4
Transmitter peak differential	96.5.6 (IEEE test only)	N/A	97.5.3.5
Transmit clock frequency	96.5.4.5	96.5.4.5 2.2 OABR_PMA_TX_03	97.5.3.6 97.5.2
MDI return loss	96.8.2.2	96.8.2.2 2.2 OABR_PMA_TX_05	97.7.2.1
MDI mode conversion	N/A	2.2 OABR_PMA_TX_06	N/A
MDI common mode emission	N/A	2.2 OABR_PMA_TX_07	N/A

All 3 compliance applications available in 1 part number: **E6958A**

Protocol Triggering & Decode

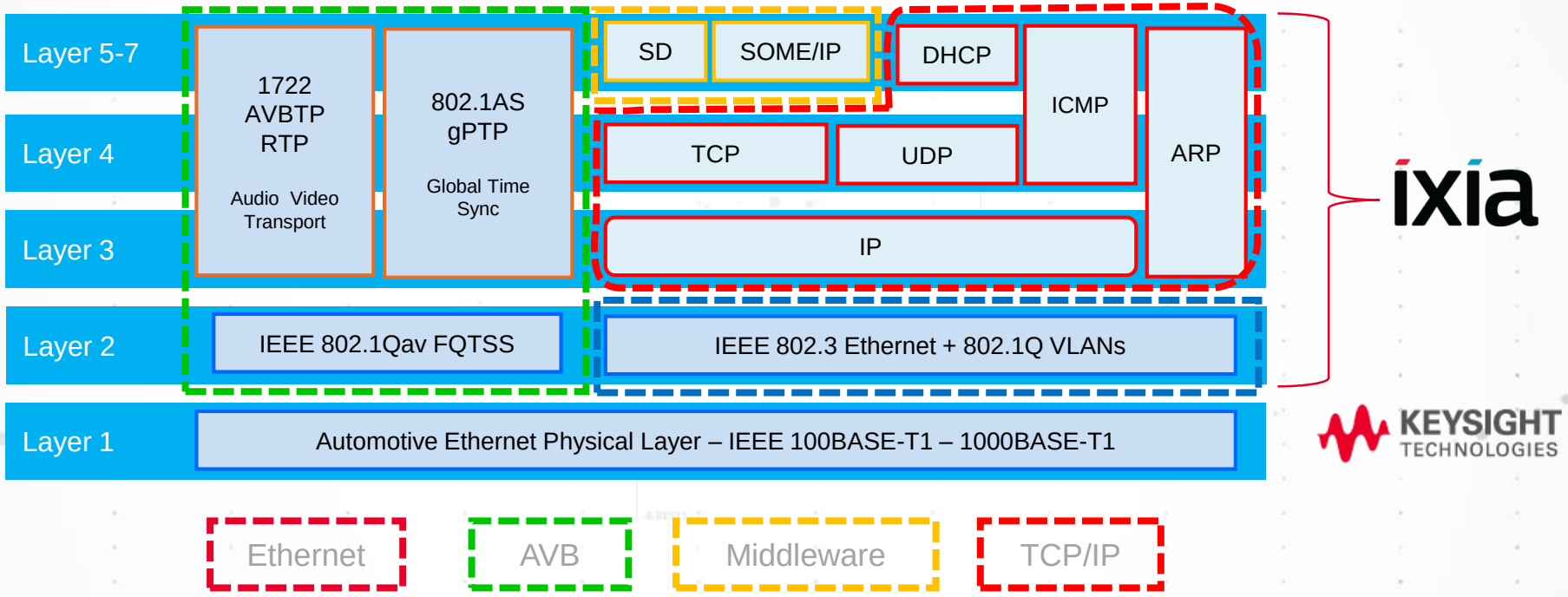
ISO OSI LAYER MODEL OF ETHERNET AND PHY LAYER





Expanded customer value through IXIA

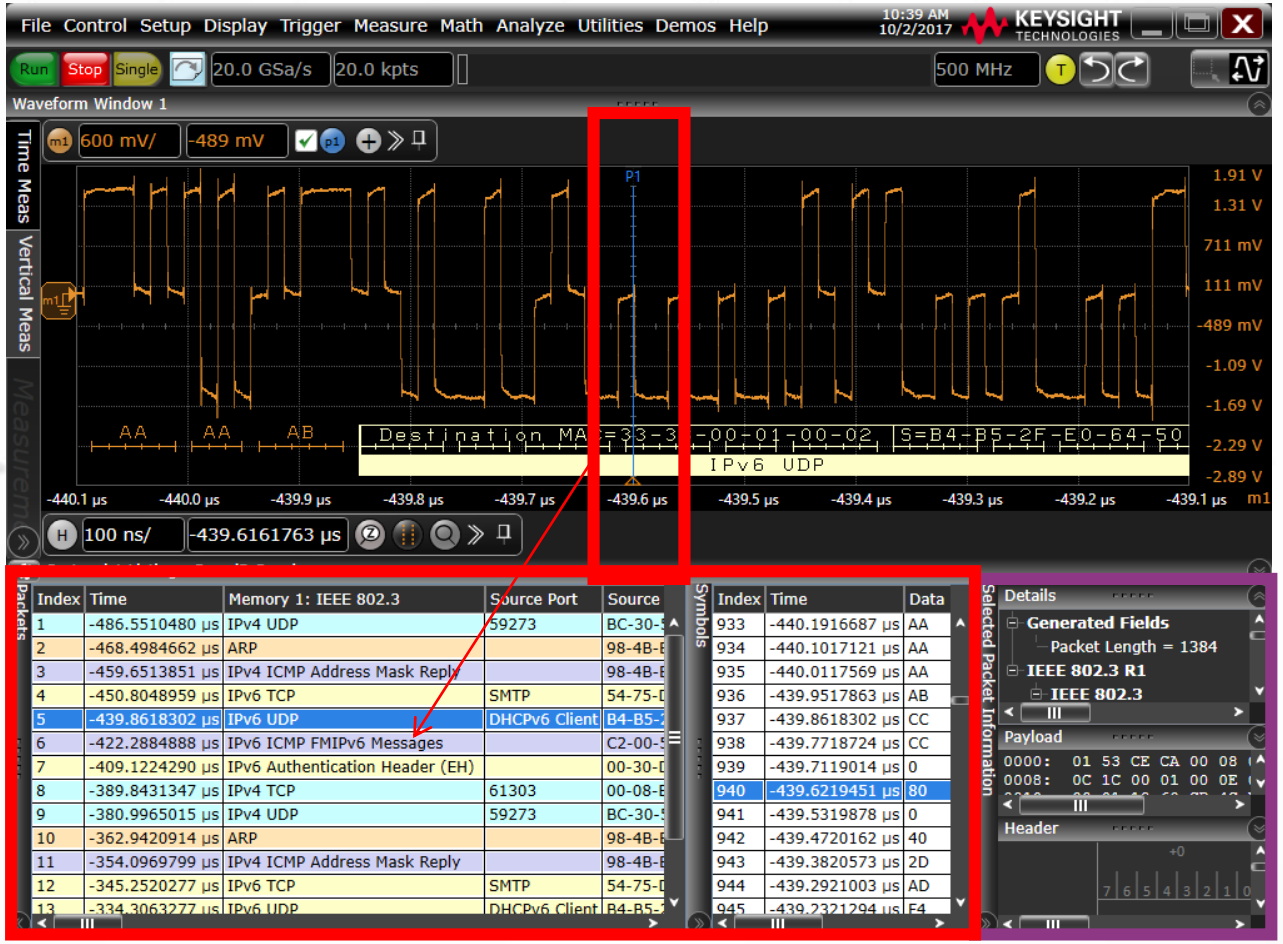
HOW KEYSIGHT AND KEYSIGHT FIT TOGETHER

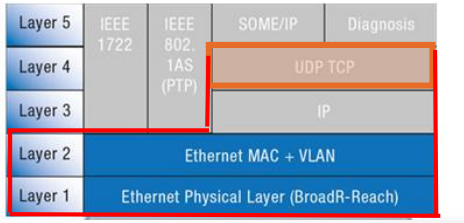


Ixia Hardware Platforms for AVB/TSN

Keysight N8847A

PROTOCOL TRIGGERING AND DECODE

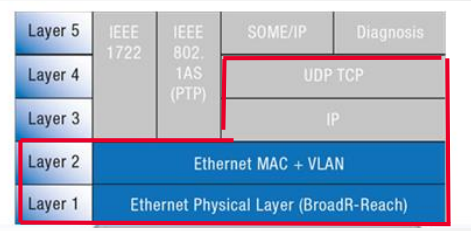


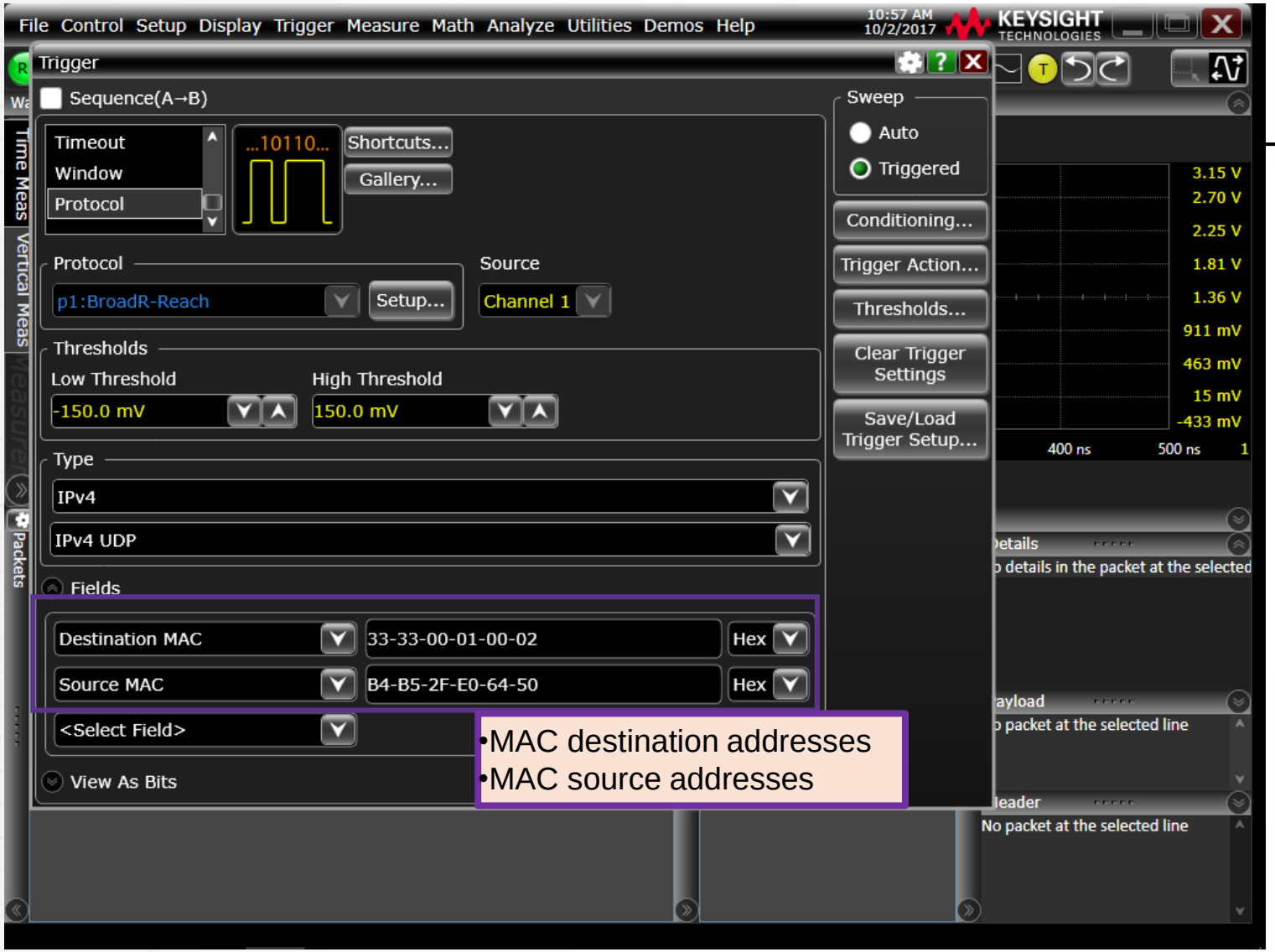


Blue marker in the Waveform window that time correlates the waveform with the Packets and Symbols Listing

Selected Packet Details Payload/Header - showing layer 4 in the PHY stack

N8847A can Trigger on a specific event



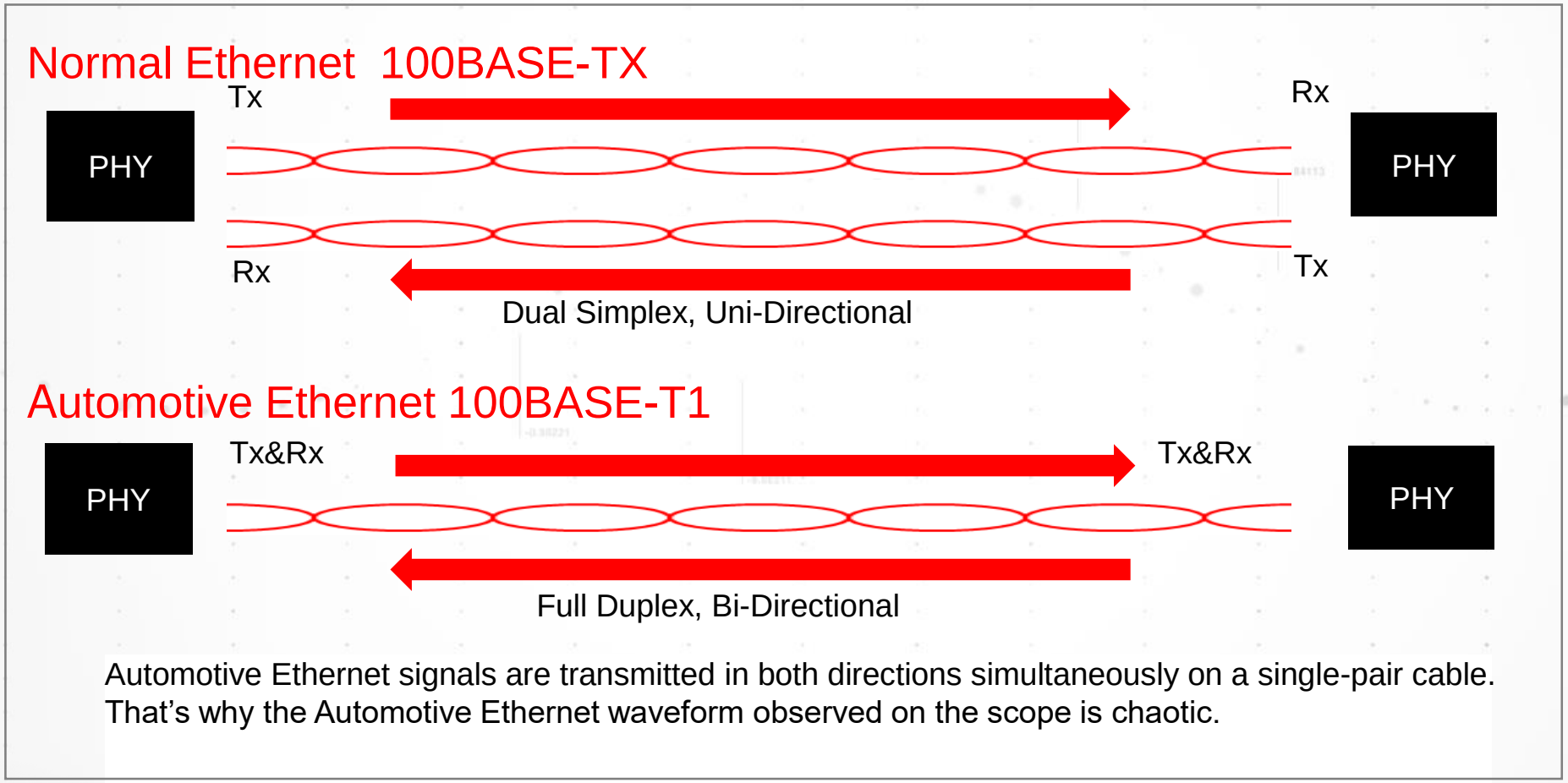


N8847A can Decode, Trigger and Search

- MAC destination addresses
- MAC source addresses
- MAC length/type
- ARP header
- IPv4 header/payload
- IPv6 header/payload
- UDP header
- TCP header/payload
- Frame check sequence – FCS
- Cyclic redundancy check - CRC
- Errors
- 802.1Q (VLAN)
- 802.AD

Bidirectional signal

CREATES ISSUES FOR PROTOCOL AND ANALYSIS



Automotive Ethernet signals are transmitted in both directions simultaneously on a single-pair cable. That's why the Automotive Ethernet waveform observed on the scope is chaotic.

E6962A Automotive Ethernet Rx compliance solution

SOFTWARE, ACCESSORIES, HARDWARE

Required tests for compliance

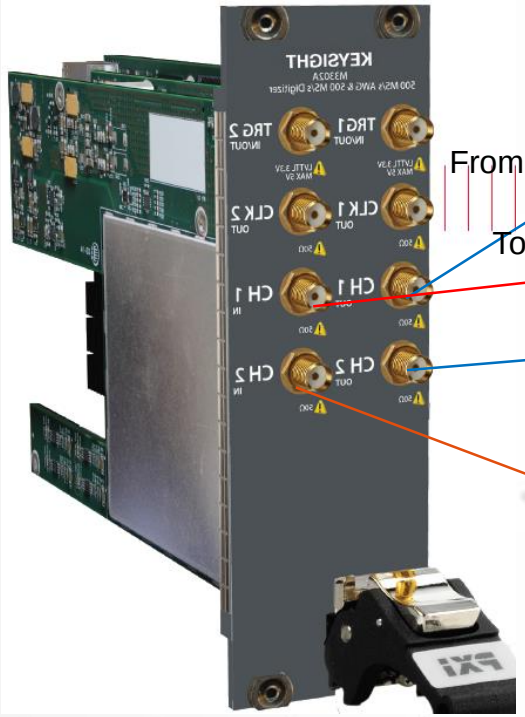
E6962A 100BASE-T1 RECEIVER TESTS

Receiver tests

Target Specification	Parameter
IEEE802.3bw 2015	96.5.5.1 – Bit Error Rate Verification
Open Alliance BroadR-Reach Physical Layer Transceiver Specification for Automotive Application V3.2 June 24, 2014	5.5.1 Bit Error Rate Verification
Open Alliance Automotive Ethernet ECU Test Specification (TC8 ECU and Network Test) January 15, 2016	OABR_PMA_RX_01

E6962A Receiver Test Setup

COMPLETE BER TEST



M3302A Combo Module

11636B Power Splitter

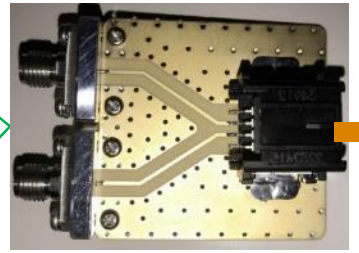
From AWG D+

To DIG D+

From AWG D-

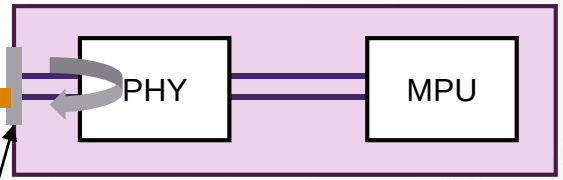
To DIG D-

11636B Power Splitter



Example of Custom Test Fixture

Wire Harness (15m)



Custom Test Fixture

DUT
Customers have to set PHY to **remote loopback mode**

E6962A Receiver Test

TYPICAL TEST SETUP AND BENEFIT

BENEFITS

- Simplifies receiver compliance testing.
- Automatically configures all of the required test equipment reducing the overall test time.
- Diagrams to show you how to make connections to the device under test.
- Creates a printable pass/fail HTML report with margin analysis

E6962A can make a *TRUE* BER test

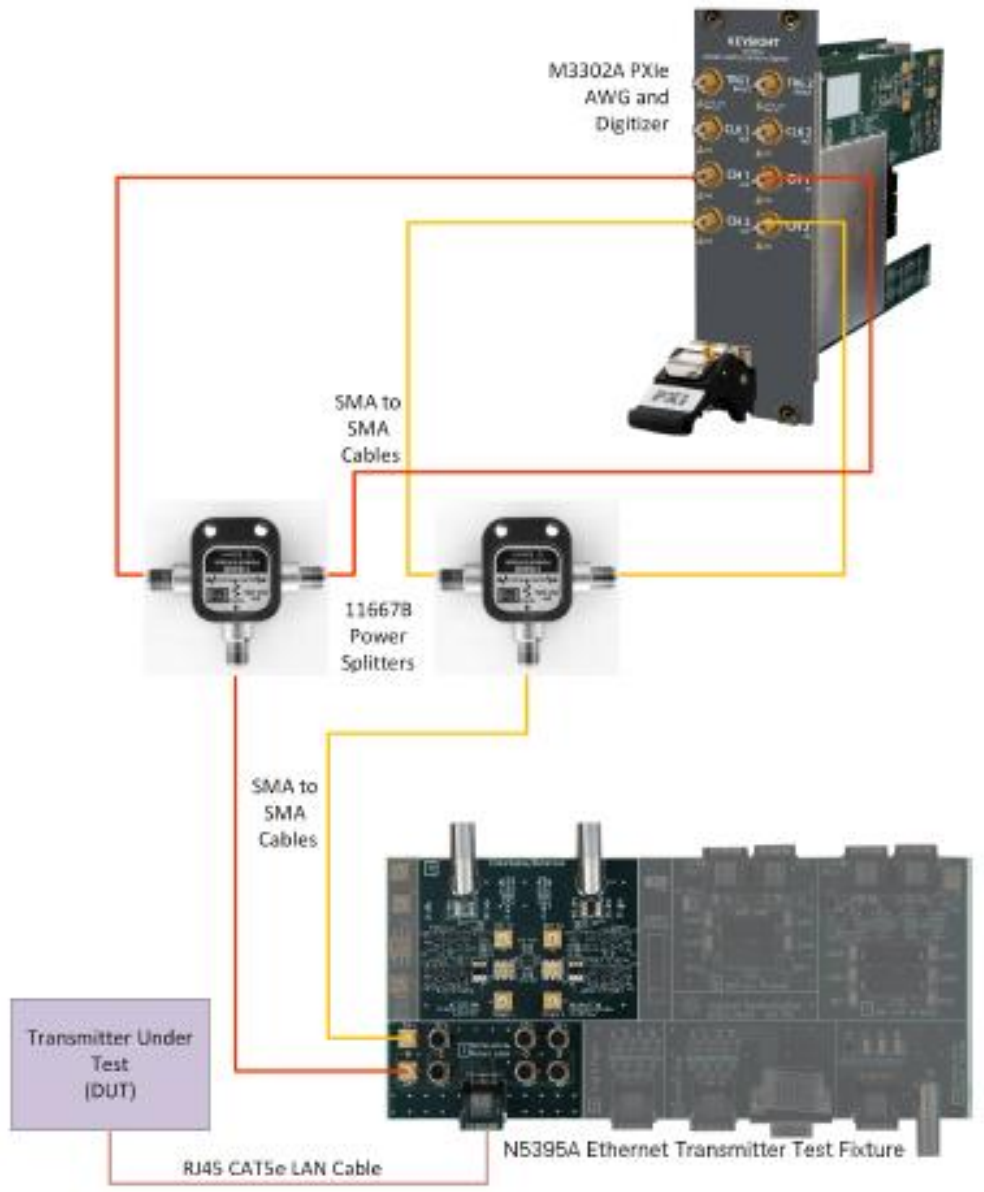


Figure 4 Receiver BER Test Setup

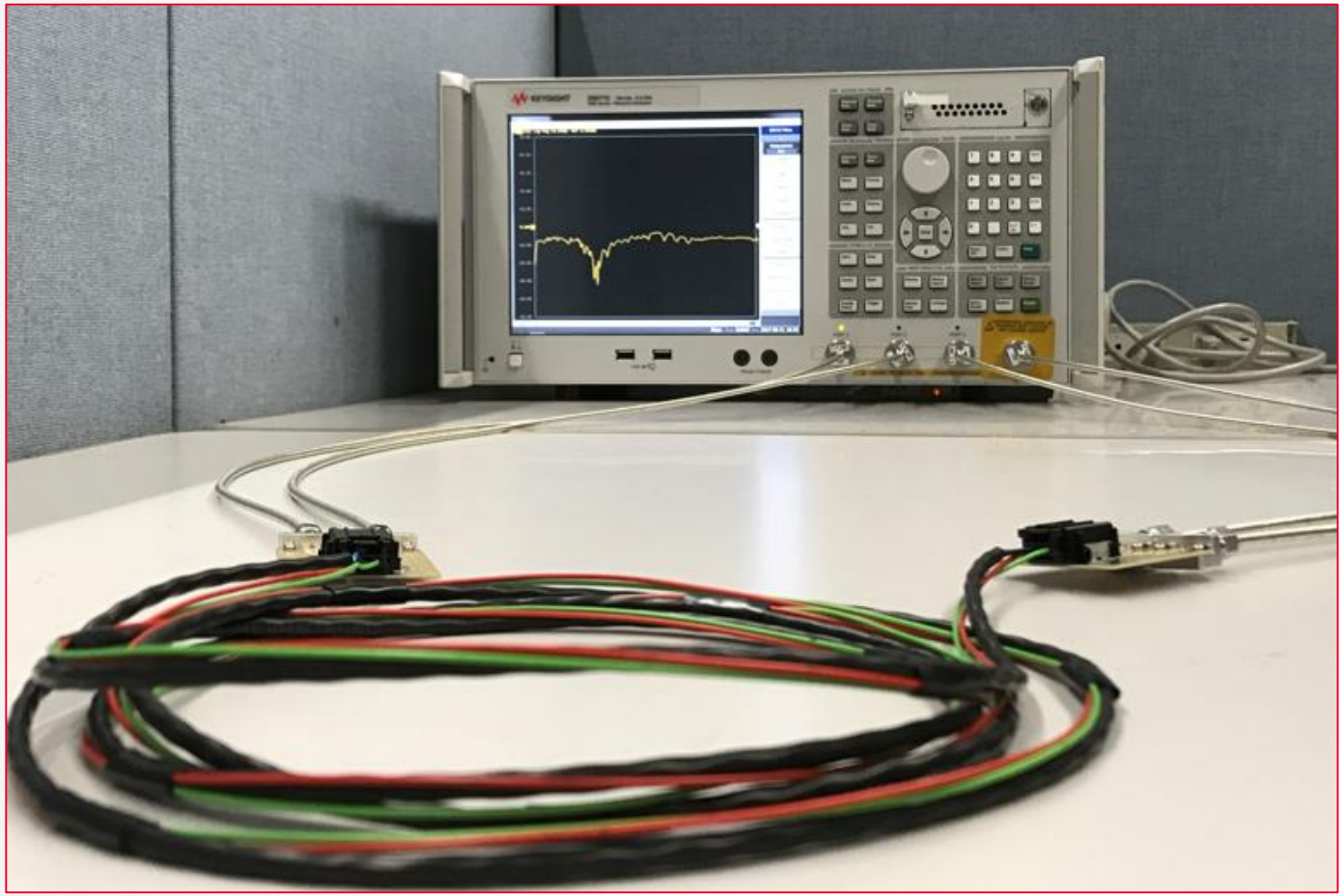
E6963A Automotive Ethernet Link Segment Compliance Solution

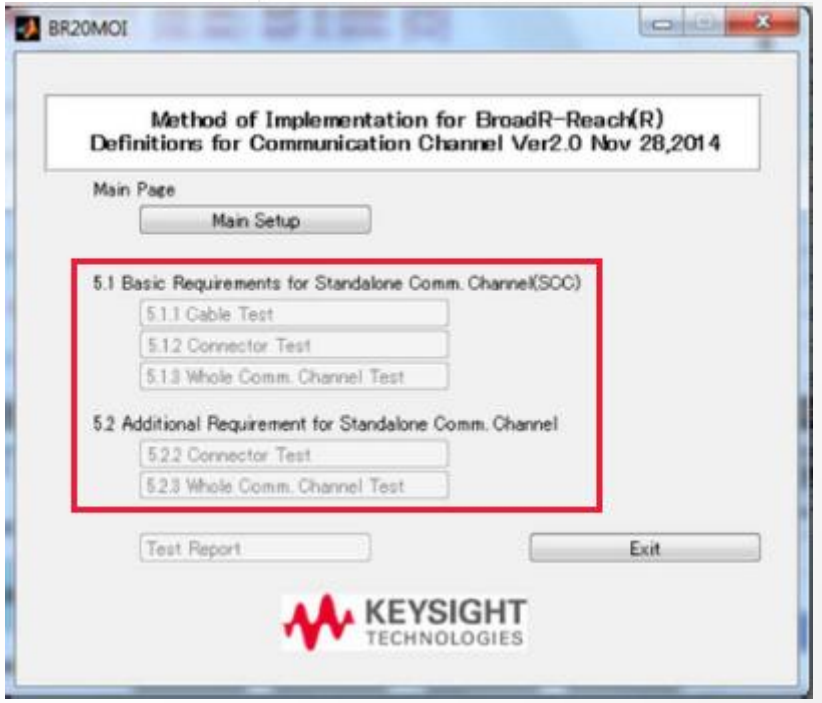
Required tests for compliance

E6963A 100BASE-T1 LINK SEGMENT

	Target Specification	Parameter	Measurement Equipment
Link segment tests	**Definition for Communication Channel ver 2.0**	**5.1.1 Cable Test** CIDM, IL, RL, LCL, LCTL	4port Vector Network Analyzer with opt TDR is required. *Both differential reflection and transmission have to be measured*
		5.1.2 Connector Test CIDM, Intra Pair Skew, IL, RL, LCL, LCTL	
		5.1.3 Whole Communication Channel Test CIDM, IL, RL, LCL, LCTL	
		5.2.2 Connector Test for Alien Crosstalk ANEXT, AFEXT, ANEXTDC, AFEXTDC	
		5.2.3 Whole Communication Channel Test (4 around 1) PSANEXT, PSAACRF, ANEXTDC, AFEXTDC	

Test Setup for Harness Connector Test

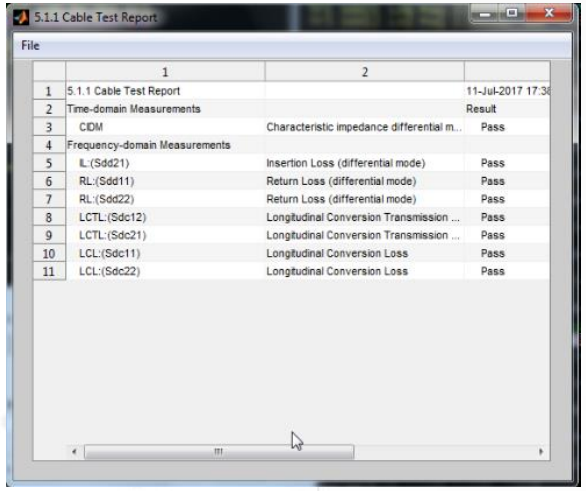




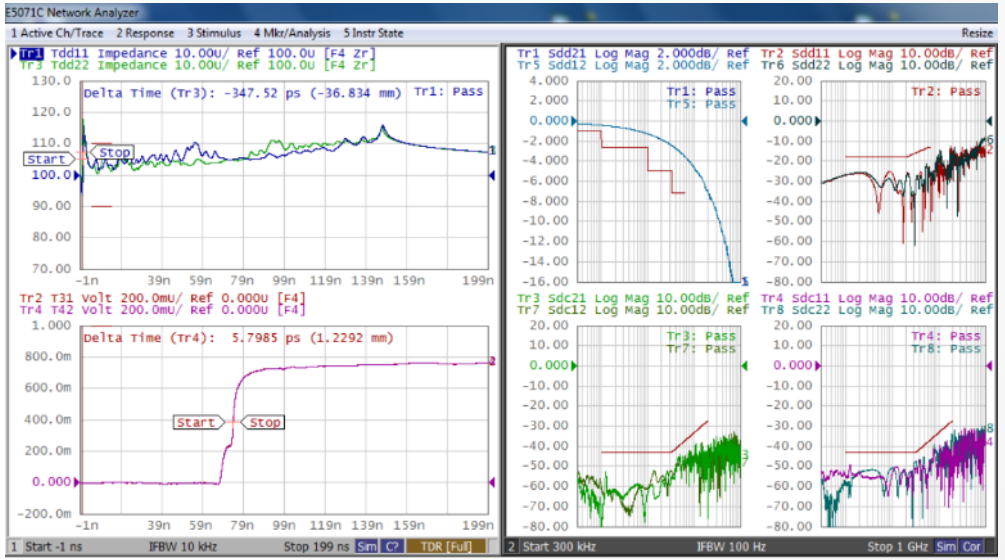
Harness/Connector

GUI AND SAMPLE REPORT

- Produces pass/fail report
  - Open Alliance Definition for Communication Channel ver 2.0
  - *(except Sdsxx test)*
    - ✓ 5.1.1 Cable Test
    - ✓ 5.1.2 Connector Test
    - ✓ 5.1.3 Whole Communication Channel Test
    - ✓ 5.2.2 Cable Test
    - ✓ 5.2.3 Whole Communication Channel Test
- Saving Test Data
  - Touch stone, CSV, Screenshot files
- Automated VNA setup and execution



Test Report Example – Pass/Fail List

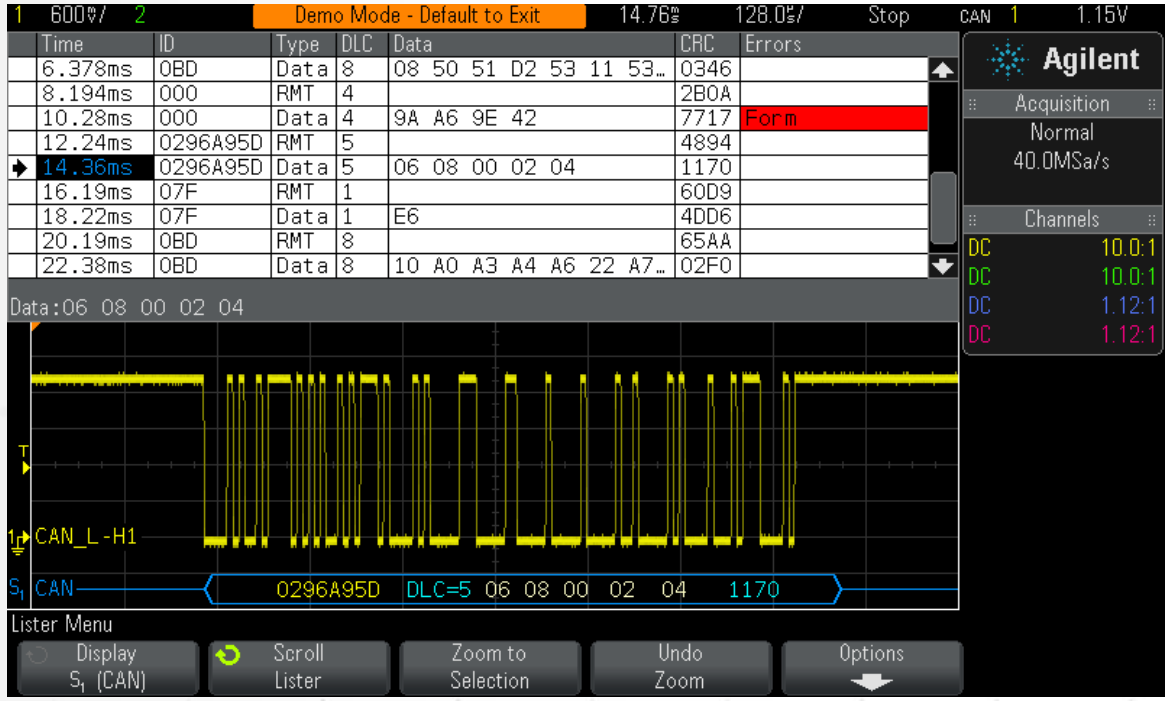


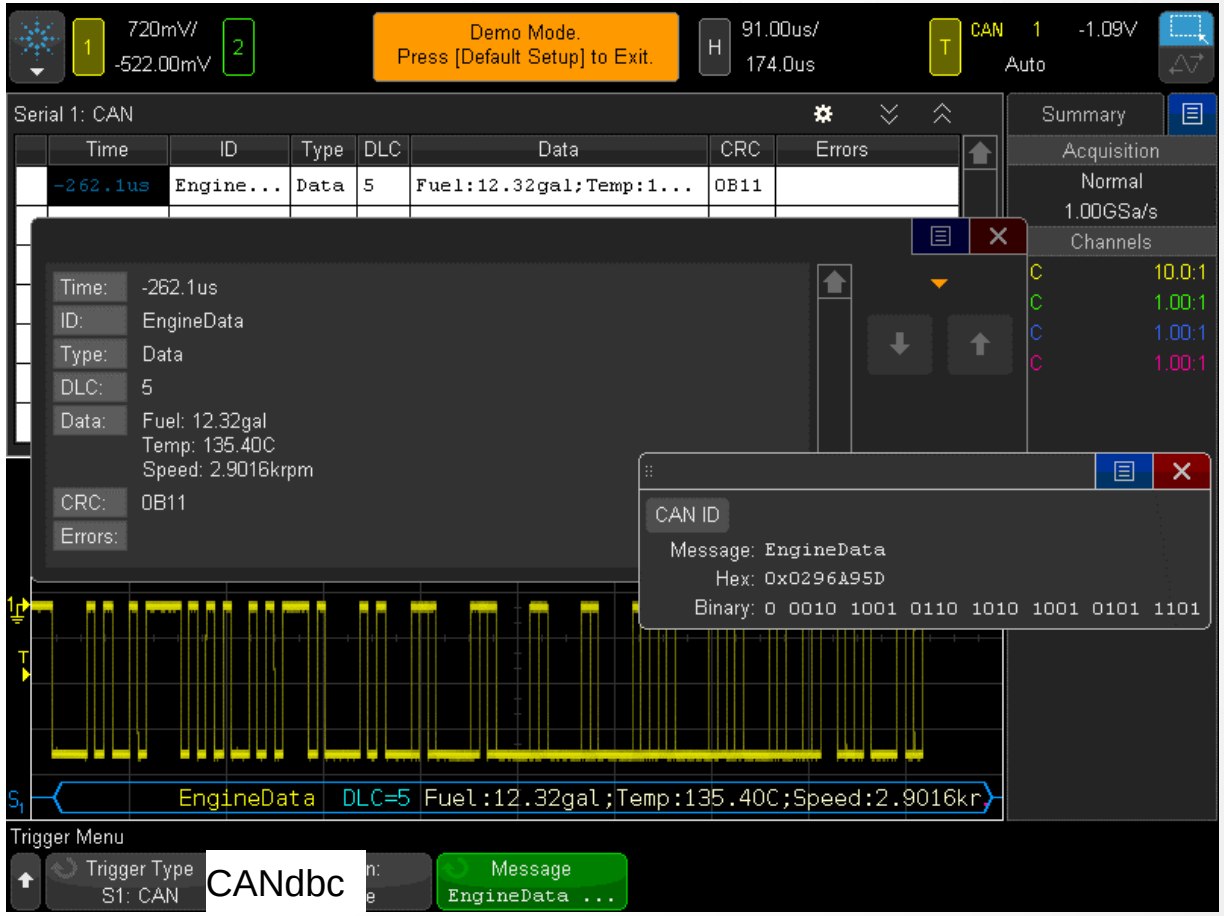
Test Result Example – E5071C screenshot of limit test

Buses Protocol Decode & Triggering

CAN / CAN-FD / LIN / SENT / CXPI / FLEXRAY

CAN Triggering and Analysis

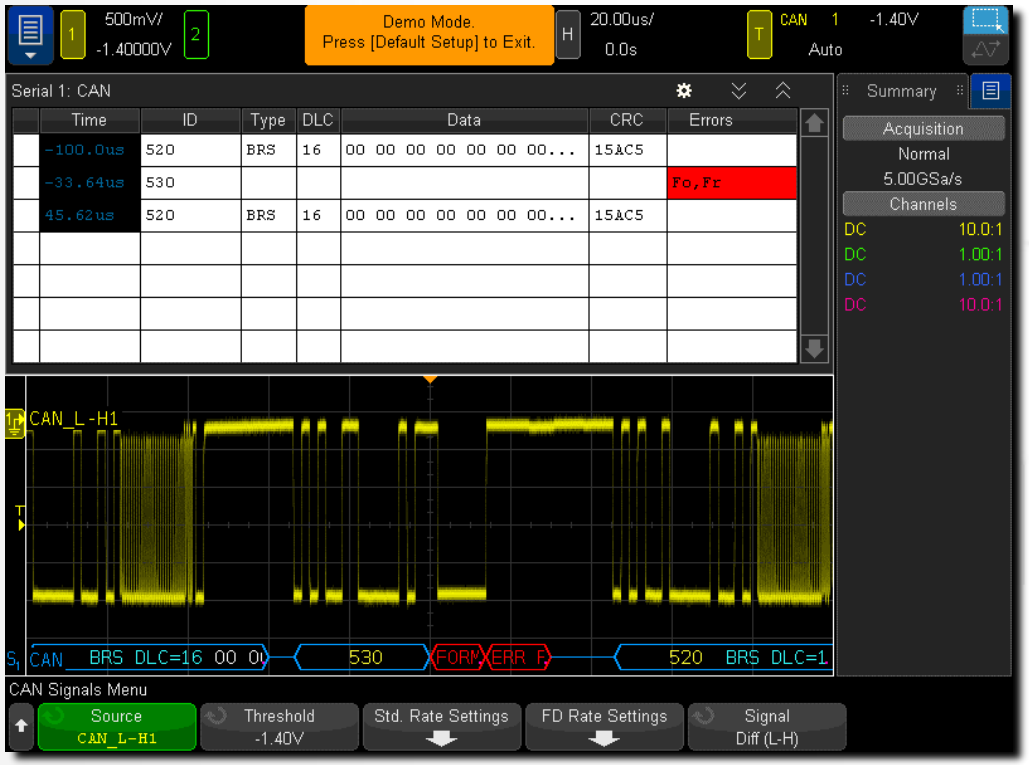




CANdbc

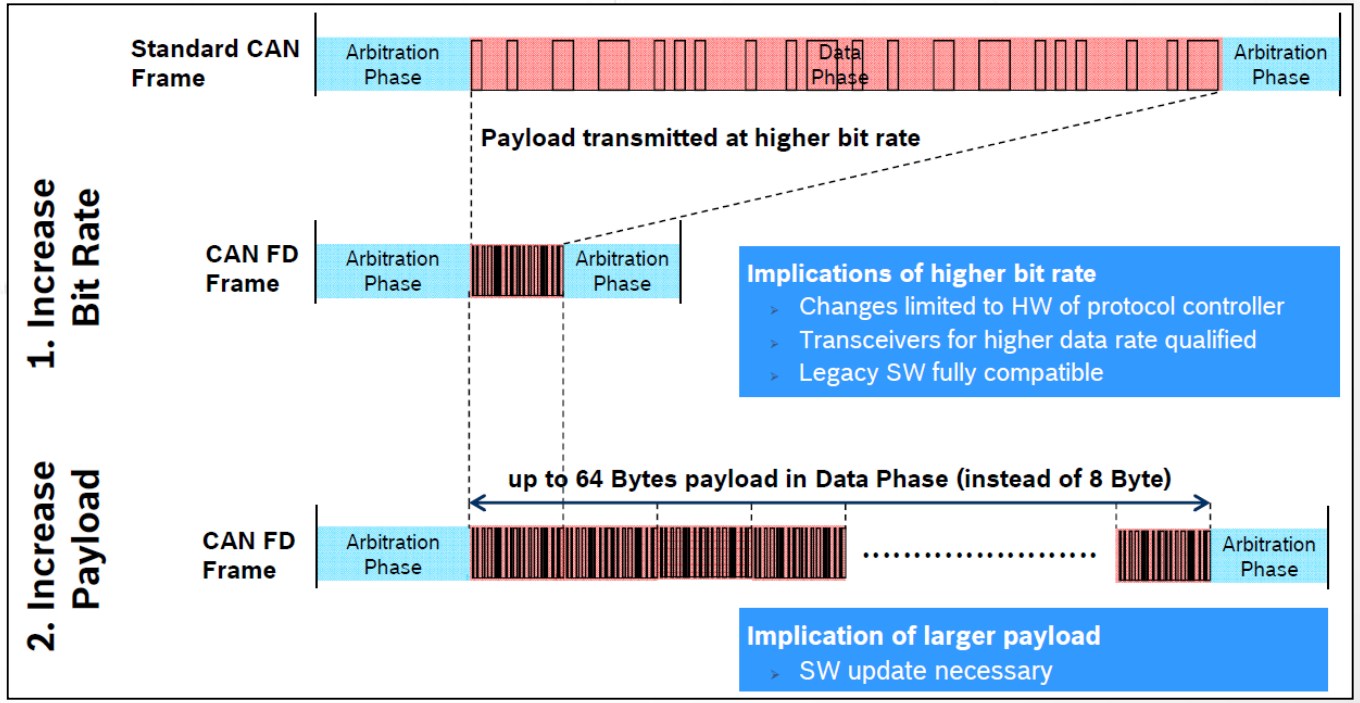
- Signals: 2-wire differential with embedded clock
  - ✓ Multi-node, asynchronous clocking, event-driven with arbitration
- Primary application: Automotive, industrial automation, medical
- Baud rate: Up to 1 Mb/s
- Encoding: NRZ with bit stuffing

CAN-FD Triggering and Analysis

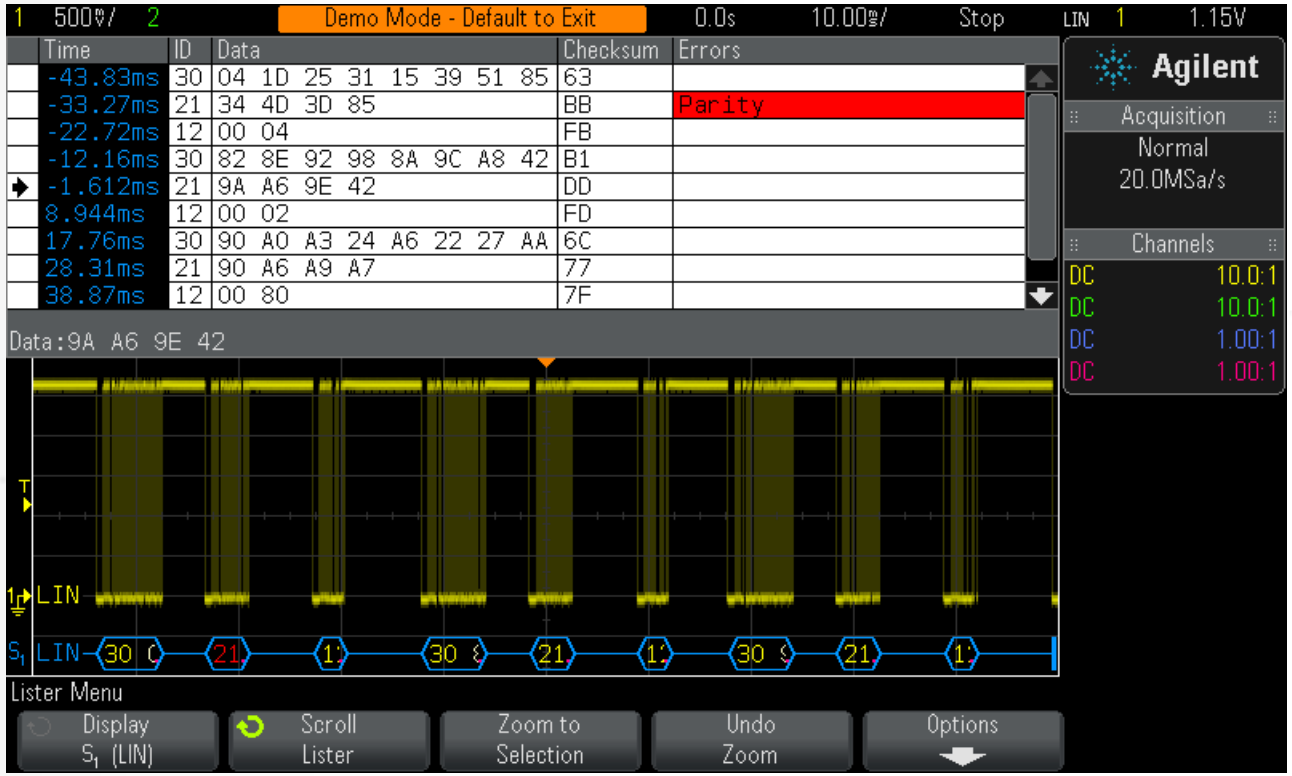


Unchanged

- Arbitration
- Acknowledge mechanism
- NRZ Encoding
- Differential
- Bus Topology

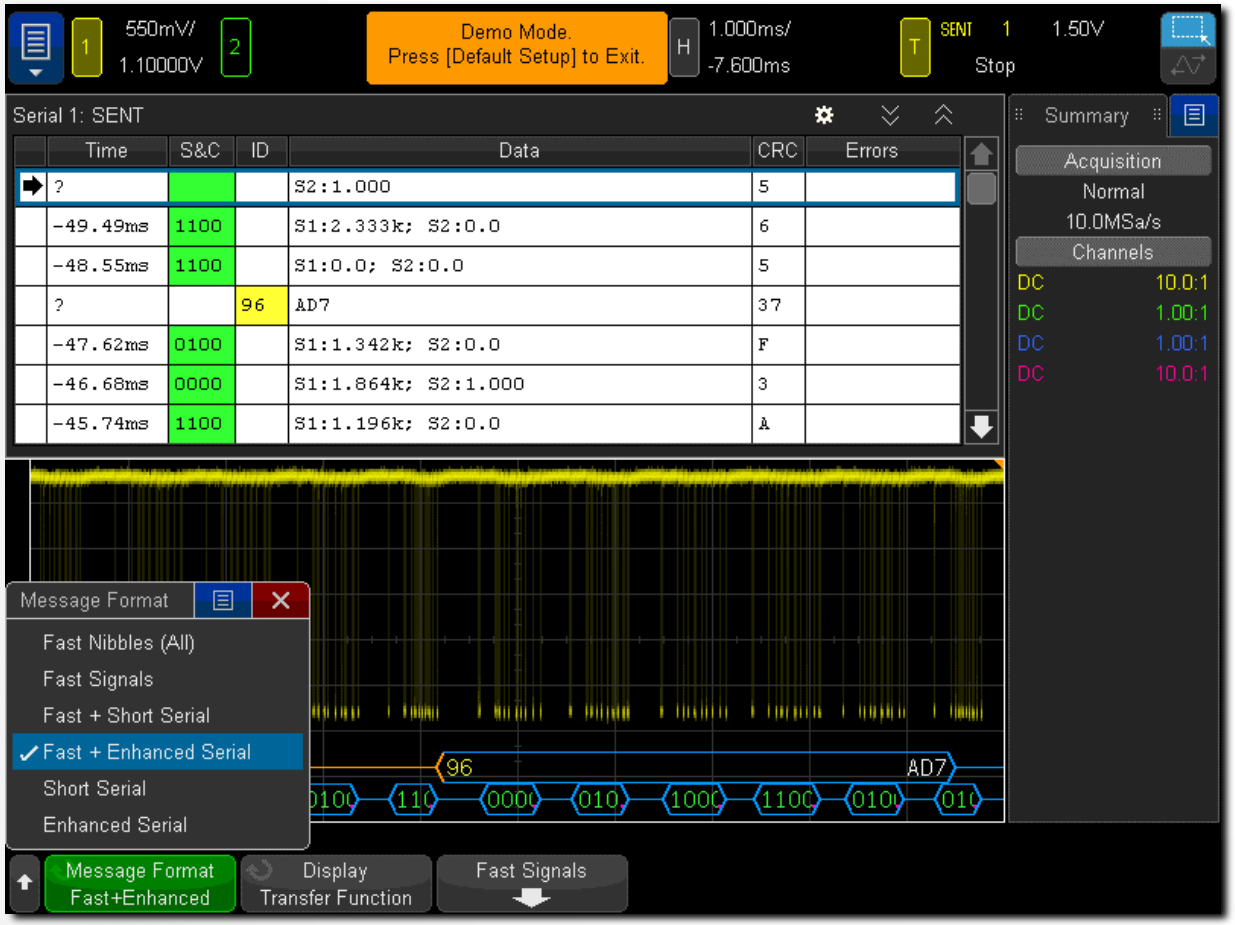


LIN Triggering and Decoding



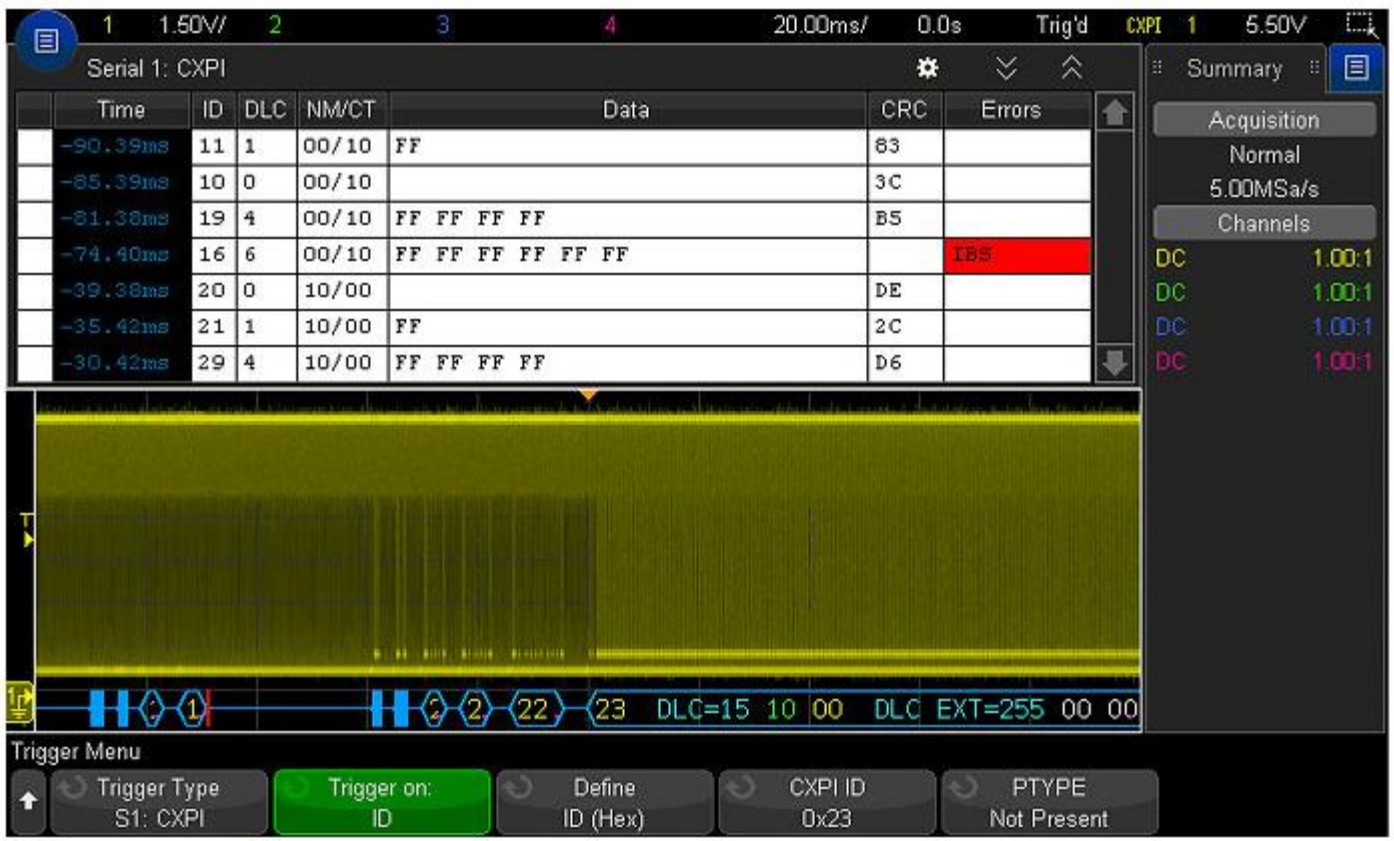
- Signals: 1-wire, single-ended, with embedded clock
- Master/Slave relationship
- Primary application: Non-safety-critical automotive (windows, lock, etc.)
- Baud rate: Up to 625 kb/s

SENT Triggering and Analysis



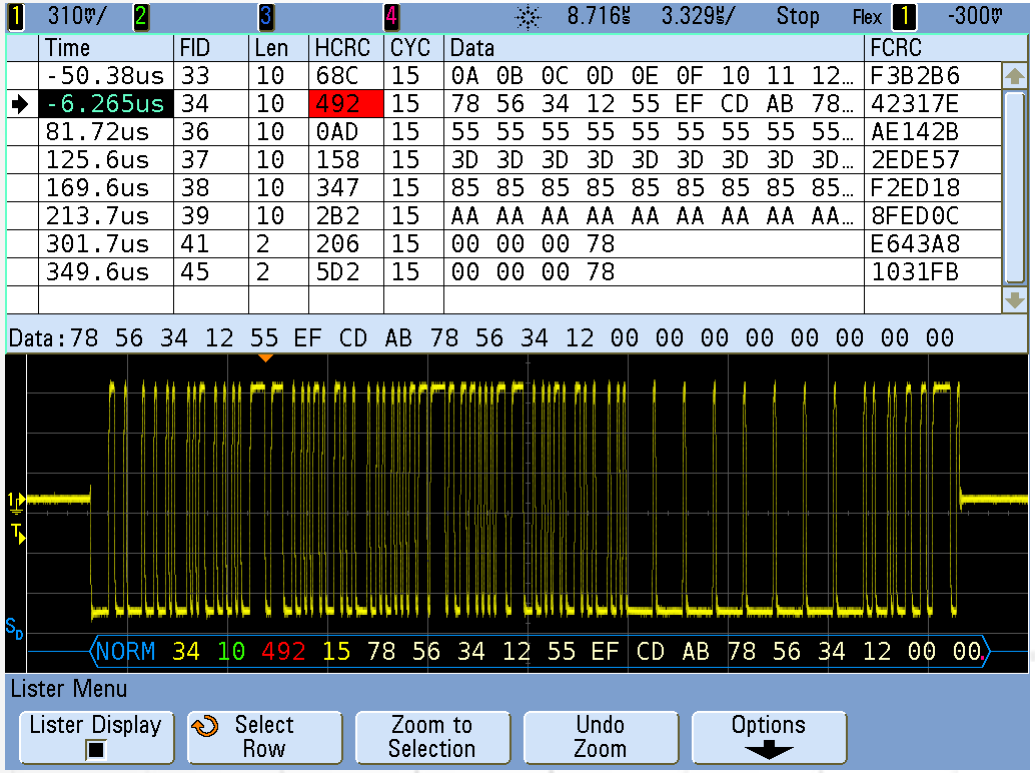
- Signaling: Single-ended (referenced to ground)
- Primary application: Serially transmits automotive analog sensor data to ECUs
- Minimum “tick” time: 3 µs
- Encoding: Pulse-width modulation by nibble (12 ticks = 0, 27 ticks = F)

CXPI Triggering and Analysis



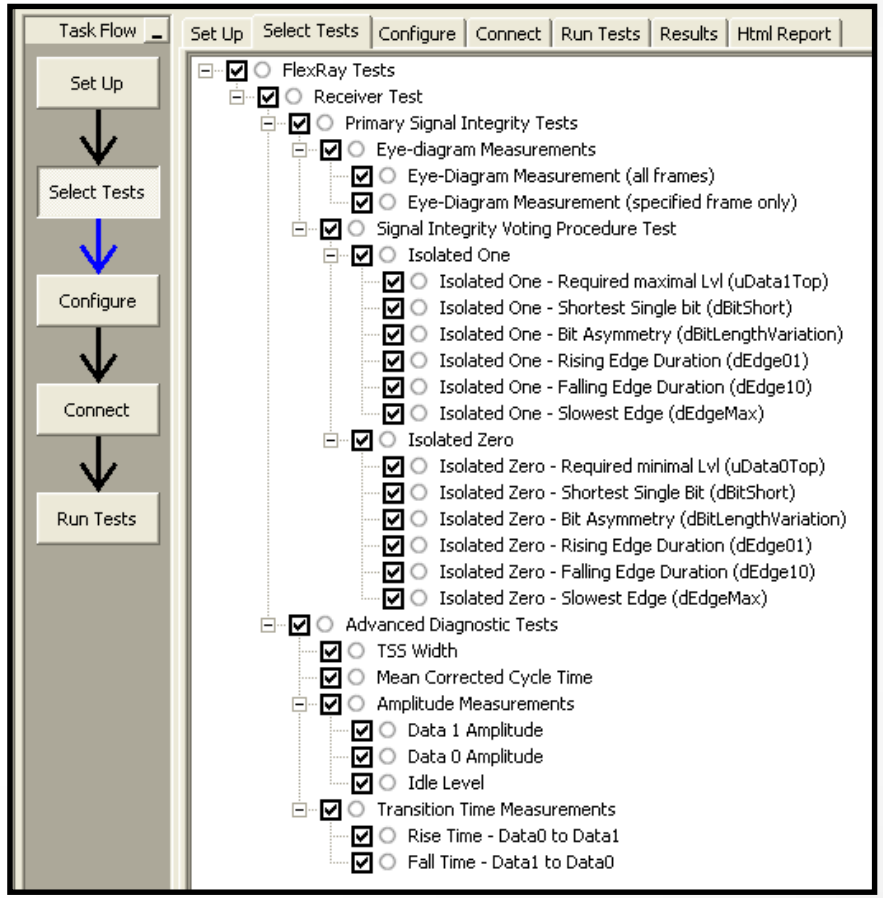
- Signaling: Single-ended (referenced to ground)
- Primary application: Serially transmits automotive analog sensor data to ECUs
- Minimum “tick” time: 3 µs
- Encoding: Pulse-width modulation by nibble (12 ticks = 0, 27 ticks = F)

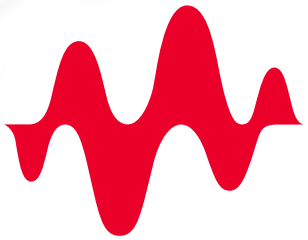
FlexRay Triggering and Analysis



- Signals: 2-wire, differential, with embedded clock
- Primary application: safety-critical automotive (drive-by-wire)
- Baud rate: Up to 10 Mb/s
- Protocol: NRZ, multi-node synchronous bus/time-division-multiple-access (TDMA)

FlexRay Physical Layer Conformance Test App





KEYSIGHT
TECHNOLOGIES