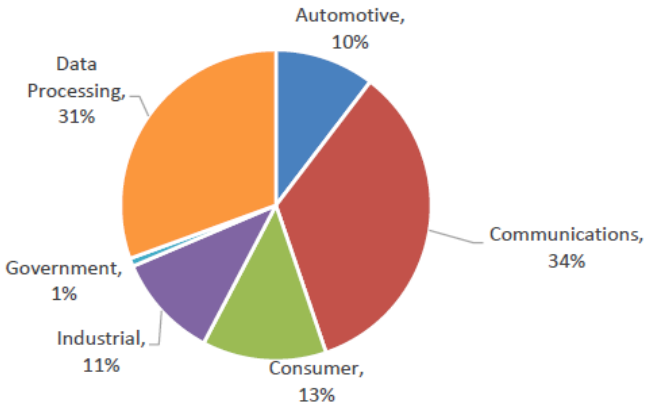
Tektronix

Automotive Ethernet 최신동향과 스펙/Tektronix 테스트 solution

OCT 2018 이기응

Automotive Micro Drivers

- Safety
  - Airbags, TPMS, Backup camera
  - NHTSA sets initiatives ($4B over 19 years) to accelerate ADAS
- Fuel economy
  - Japan sets light commercial vehicle fuel standard to increase fuel economy by 26%
  - U.S. sets fuel-economy goals of 54.5 MPG by 2025
- Emissions
  - U.S. sets 45–50 % reduction in CO2 emissions per mile by 2025
  - Germany has pledged to cut carbon dioxide emissions by 80 to 95 percent by 2050
- Social & customer needs
  - Connected car
  - UBER, ZIP CAR, BMW Drivenow



Source: WSTS 2014

Automotive Applications

Autonomous Car	Telematics	Infotainment	In-vehicle network	Powertrain	Sensors	Body and Comfort
• L0 to L5 • Rear/front/side cameras • Blind spot detection • Auto parking • V2V/V2I	• Cellular • V2X • GPS • WiFi • Bluetooth • NFC	• Navigation systems • Audio/video entertainment • HMI (touch, voice, haptic) • Heads-up display • Hands-free phone	• Automotive control busses enable communication between ECUs, sensors, actuators, etc	• Fuel delivery • Engine management • Emission controls • Electronic steering • Electronic braking • Transmission controls • Active suspension • Battery systems • Motors (hybrid/ electric) • Wireless Charging	• Air Bags • Electronic stability control • Tire pressure monitoring • Adaptive cruise control • Blind spot warning • Auto braking • Multiple Sensors • Sensor Nano Technology	• Door • Window • Lighting • TPMS • RKE • Adaptive lighting
Radar + Camera+ Lidar+CPU+DDR4 +Flash+PCIe + Network standards	5G, LTE, HSPA, GSM, CDMA, 802.11AD	CPU+DDR4/LPDDR4+PCI+Flash+ HDMI+I2S+USB +SATA/SAS	CAN, LIN, FlexRay, SENT, CXPI, PSI5, 100/1000BASE-T1, FPD-Link, HD-BASET	WGB component, Battery, Invertor-Convertor, Motor, Battery charging, Power Efficiency Testing	Component Testing, ECU Testing	LED component Test, Keyless Protocol Testing

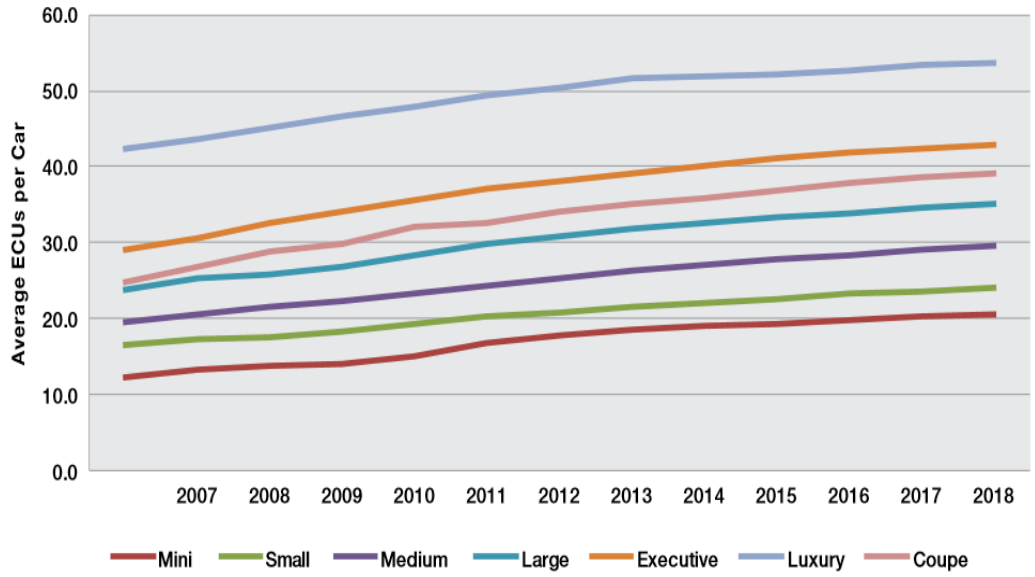
In-Vehicle Network Standards

Industry trends

In-Vehicle Network

NETWORKS ON WHEELS

- ECUs communicate with each other over In-Vehicle Network (IVN)
- On Average there are 30-40 ECUs in luxury car
- Each ECU have at least one IVN node
- Typically 60-80 IVN nodes per car

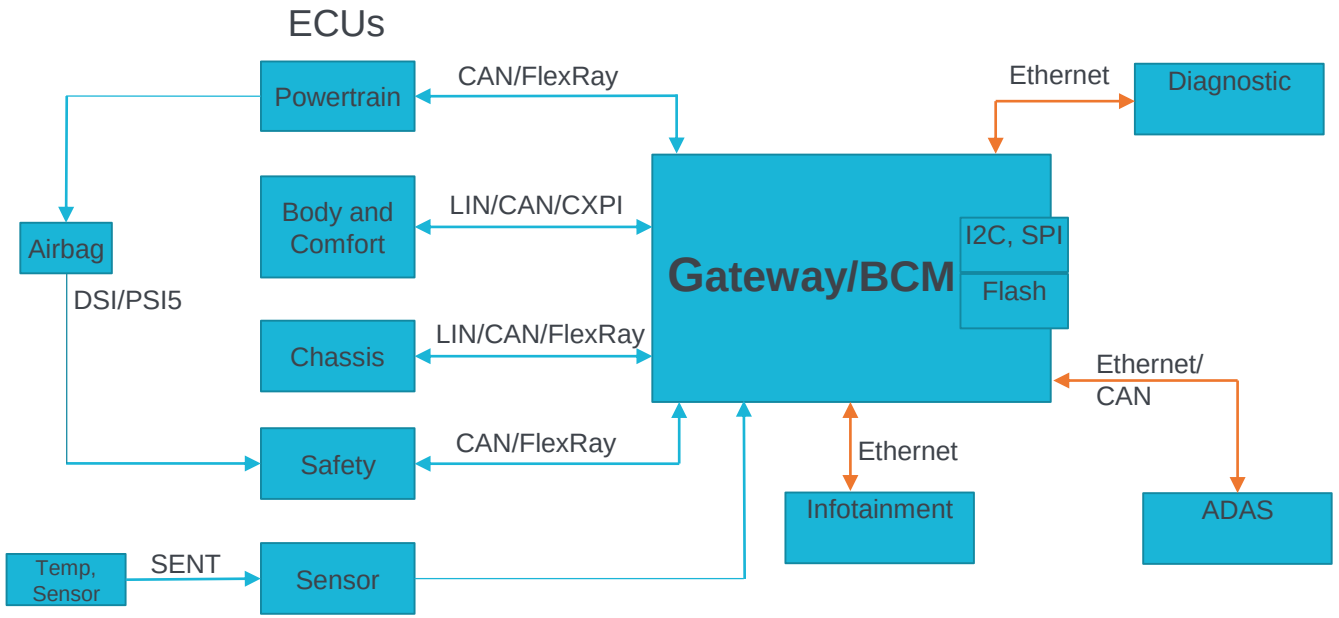


Source: Strategy Analytics

In-Vehicle Network

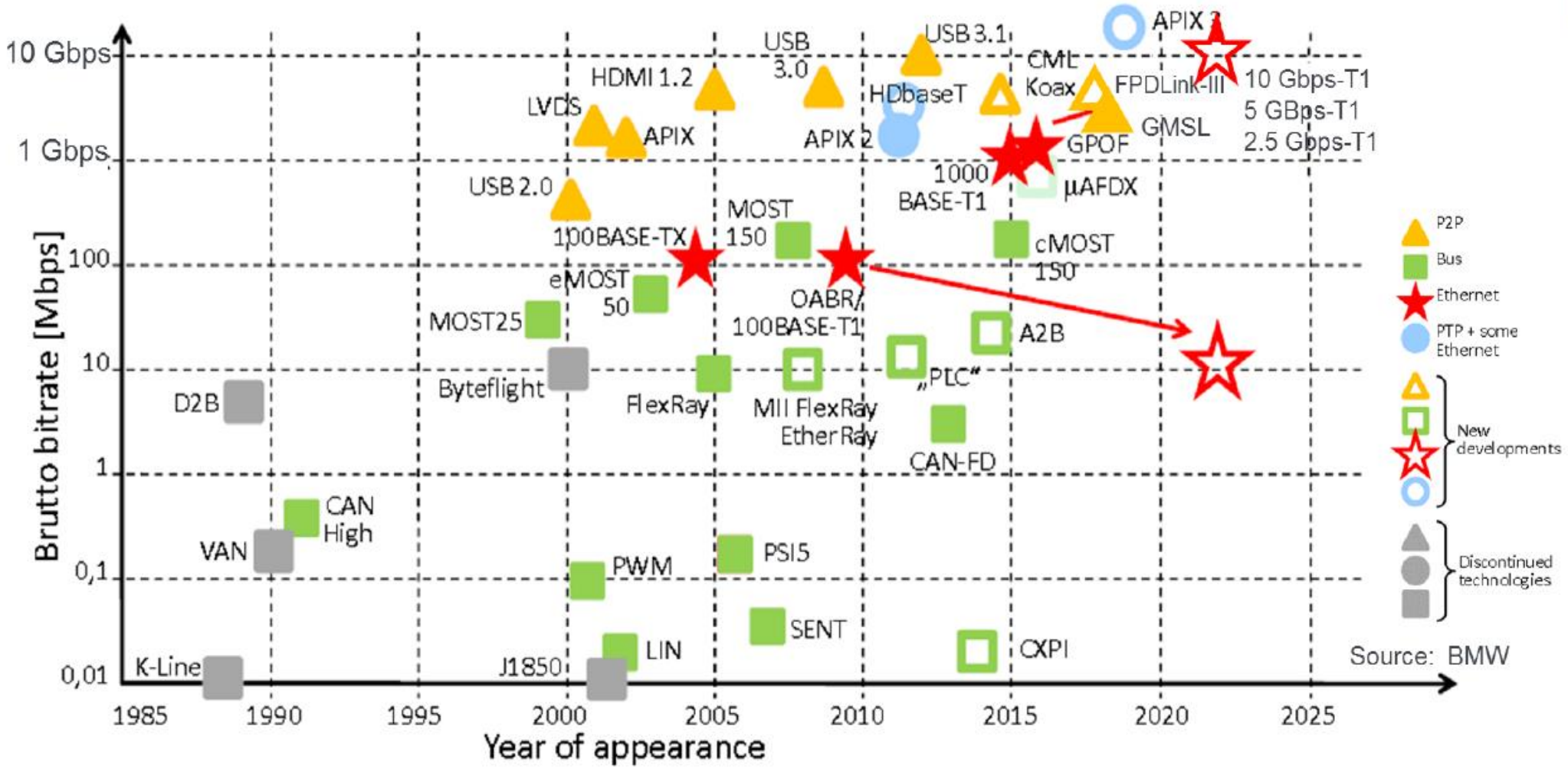
AUTOMOTIVE REQUIREMENTS PLACE HEAVY DEMANDS

- Low cost
- Reliable
- Withstand harsh environment
- Low power



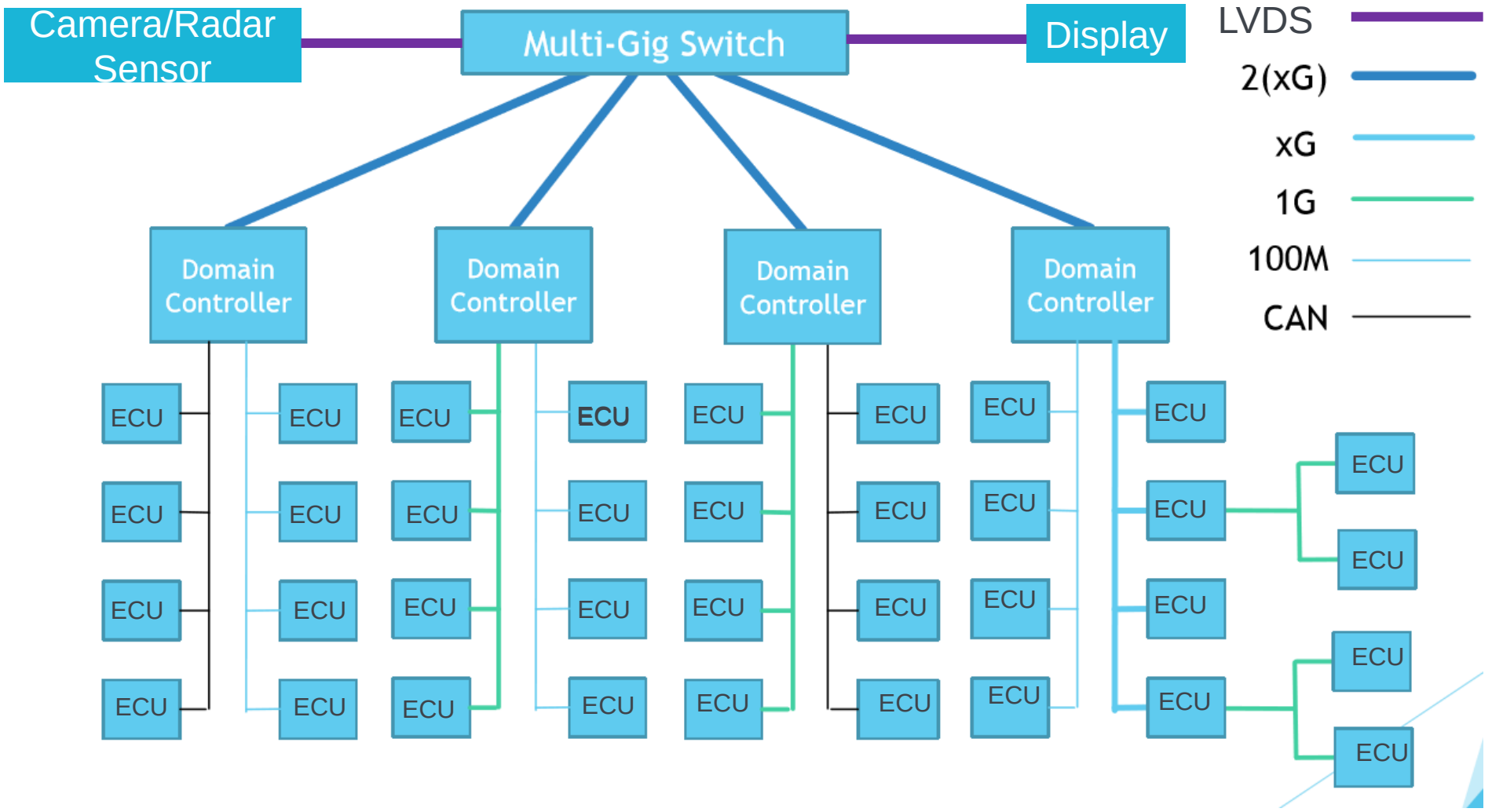
- New applications like Infotainment, Autonomous car, Connected car are driving IVN speed increases

Automotive Serial Standard Trends



Technology	Data Rate
LVDS	2 Gbps
HDBaseT	4/8 Gbps PAM16
APIX	3 Gbps
GMSL	3.12 Gbps
FPD-Link III	4.16 Gbps
1000BASE-T1	1 Gbps PAM3

In-Vehicle Network

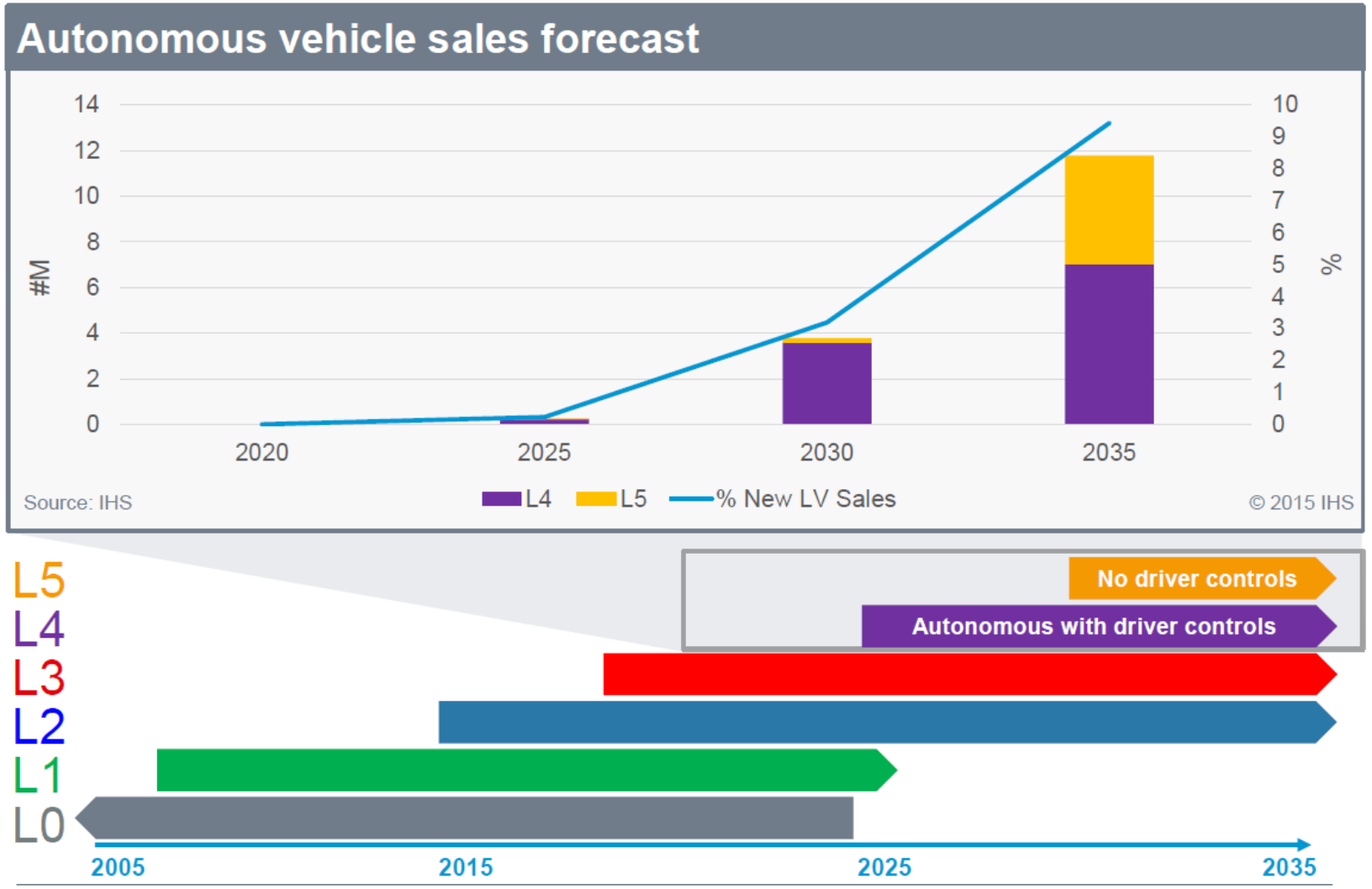


Autonomous Driver Assistance System

Level of Automation

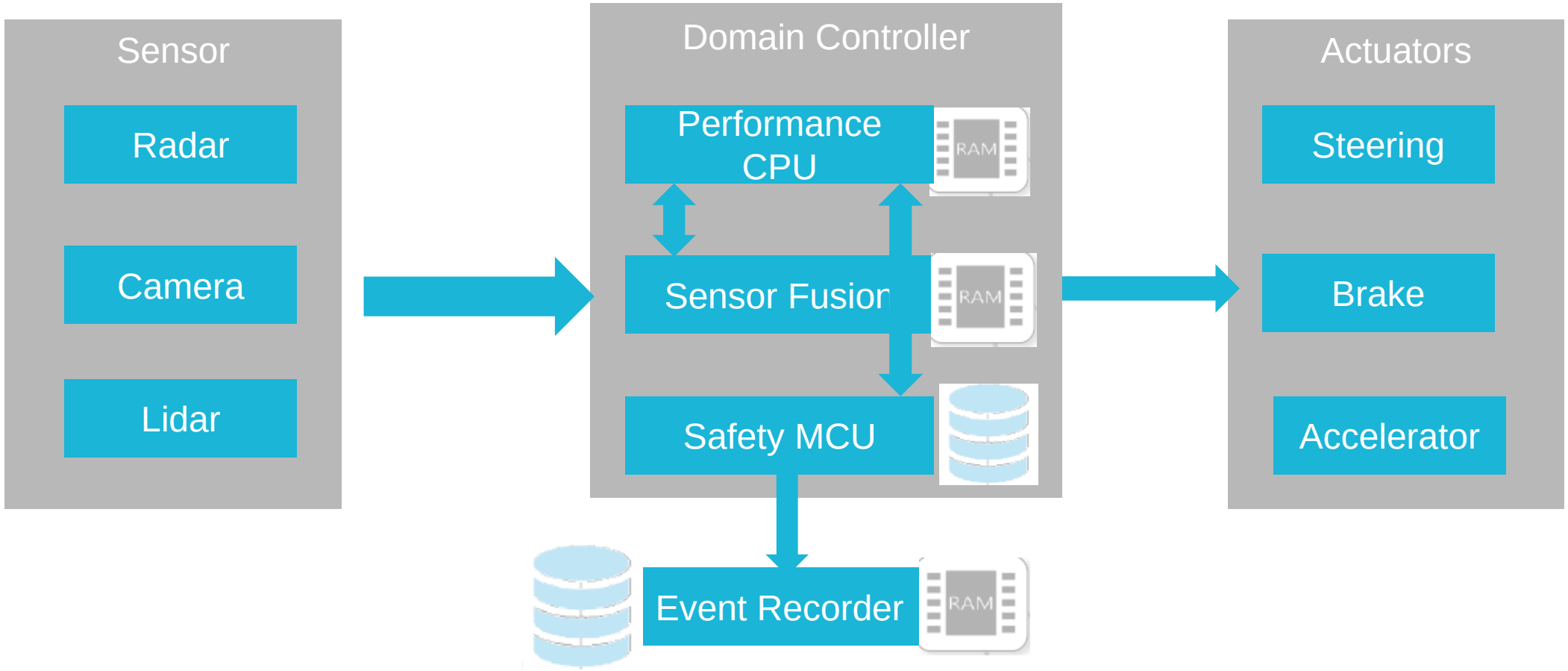
SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability *(Driving Modes)*
***Human driver* monitors the driving environment**						
0	**No Automation**	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	**Driver Assistance**	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	**Partial Automation**	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes
***Automated driving system* ("system") monitors the driving environment**						
3	**Conditional Automation**	the *driving mode*-specific performance by an *automated driving system* of all aspects of the dynamic driving task with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes
4	**High Automation**	the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes
5	**Full Automation**	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**

ADAS Adaptation



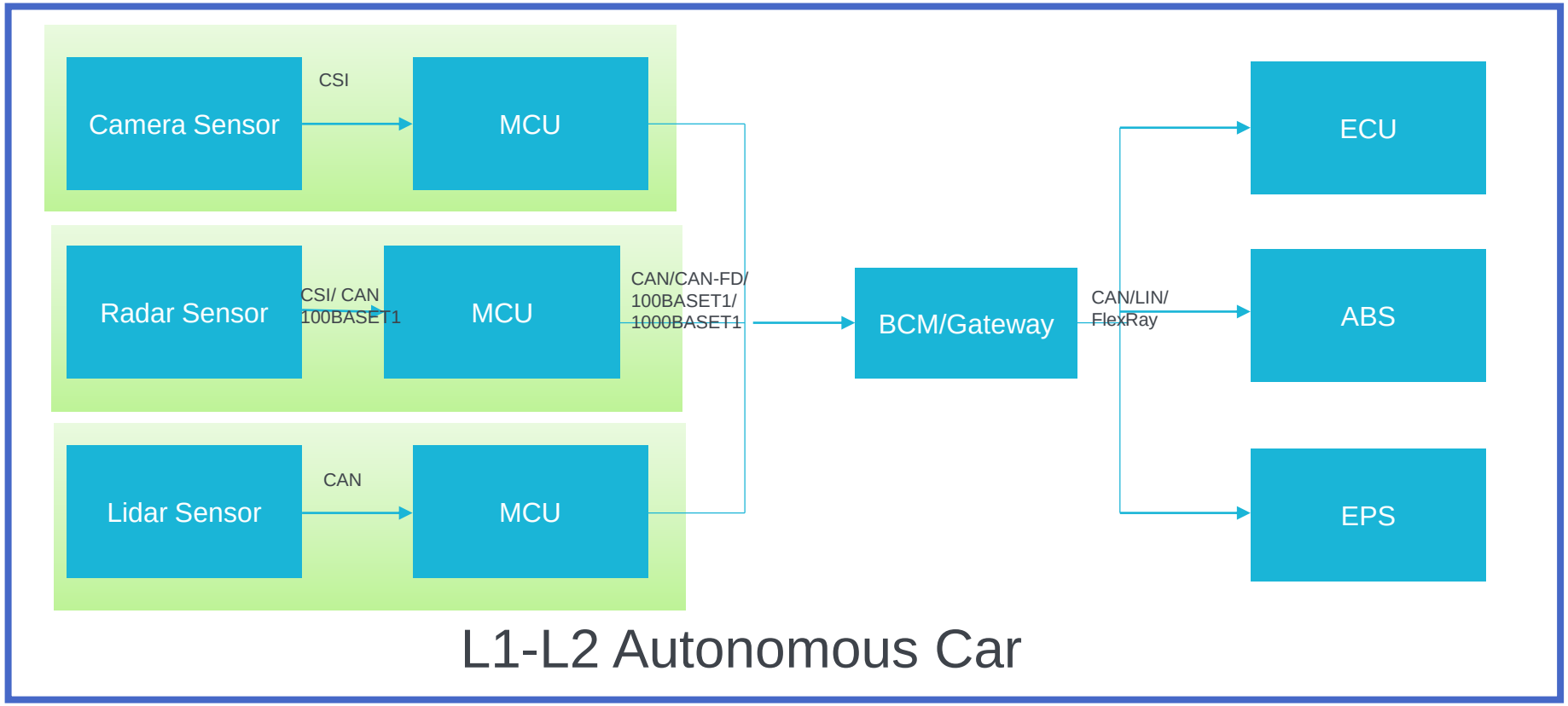
source.: IHS Automotive Seminar Frankfurt / June 2015

ADAS Architecture



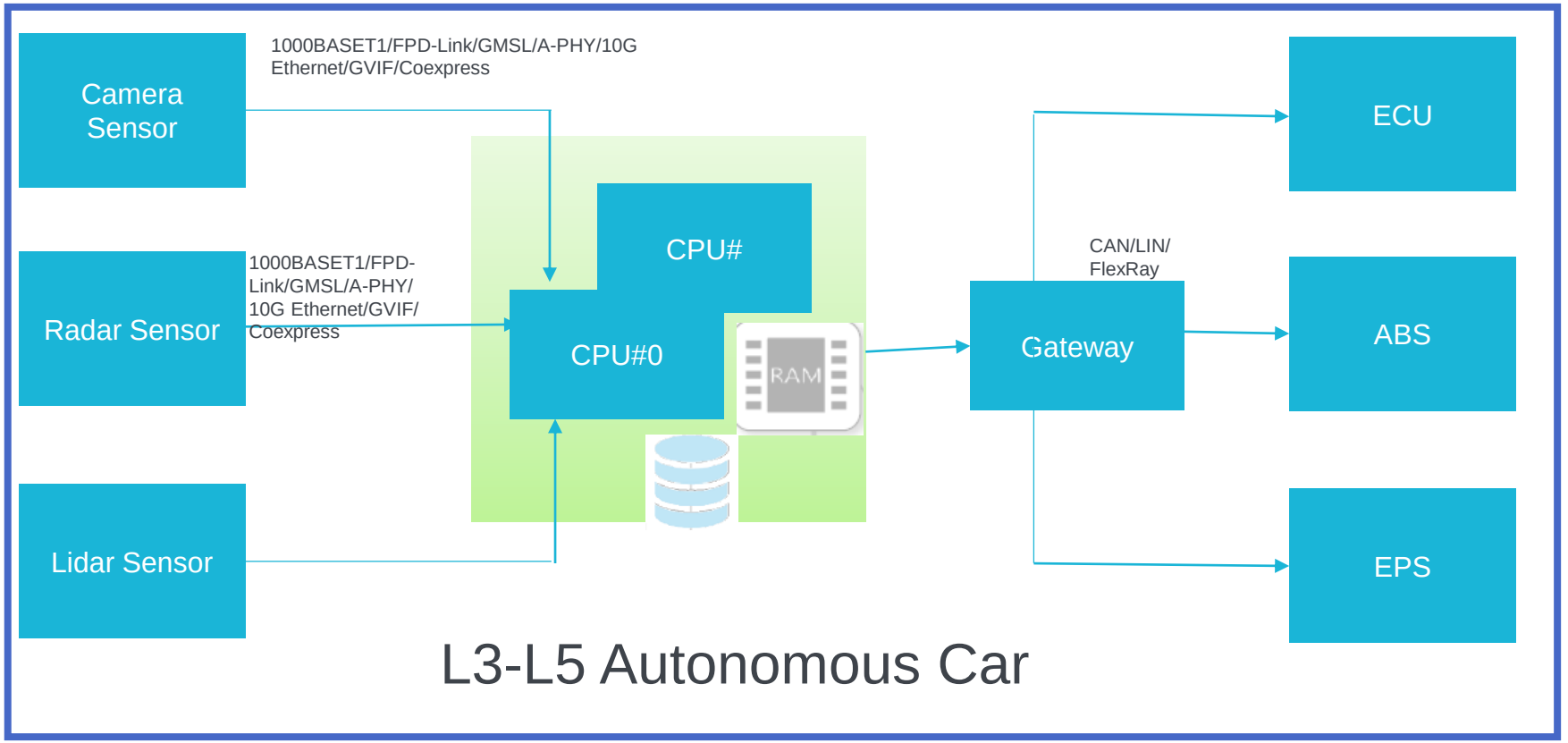
Autonomous Car Block Diagram

SMART SENSOR



Autonomous Car Block Diagram

DOMAIN CONTROLLER



ADAS Technologies

ADAS Technologies

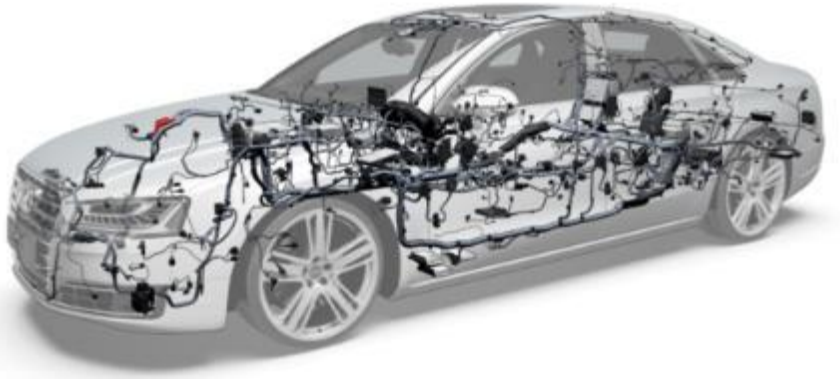
ADAS			
Technology	**L1-L3**	**L4-L5**	**New Technologies**
Camera	D-PHY 1.2 (4 Camera)	D-PHY 1.2 (8-10 Camera)	
Radar	77GHz (1GHz BW)	77GHz (4GHz BW)	
Lidar			
ECU	CPU, DDR3, PCIeG2/3, eMMC	LPDDR4, PCIeG3, UFS	LPDDR5/GDDR6, PCIeG4, NVMe
Sensor Interface	100BASE-T1, CAN-FD	FPD-Link, GMSL, GVIF, HDBASE-T, CoeXpress	Multigigabit Ethernet, A-PHY, 1000BASE-T1, 10BASE-T1, PCIe

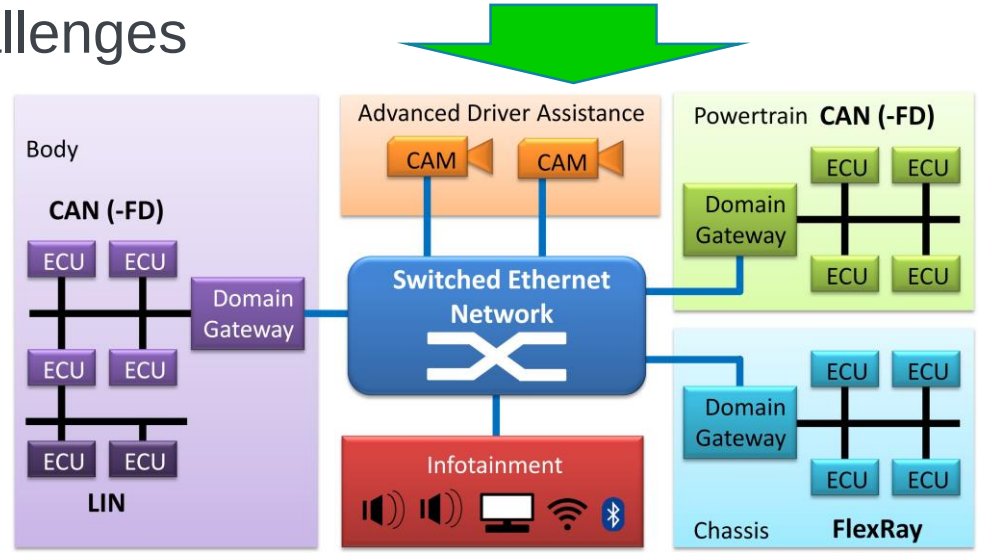
Automotive Ethernet

From datacenter to passenger car

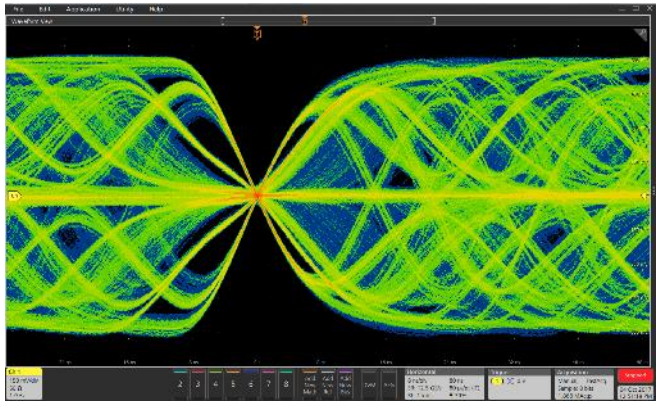
Why Automotive Ethernet?

- Enables support for high data rate applications (ADAS, IVI)
  - Low latency for ADAS (<250us)
- Well-proven technology but customized for automotive needs
- Co-exists with lower speed buses (CAN-FD, LIN, etc.)
- Creates new design validation & testing challenges





1000BASE-T1 PAM3



Automotive Ethernet Standard

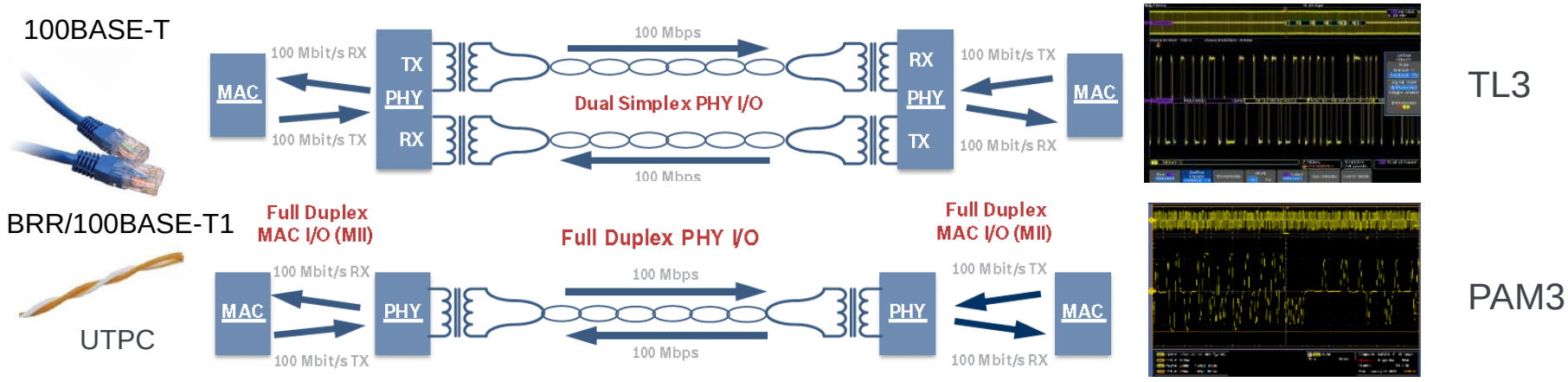
THE EVOLUTION

- 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 but early development underway for 1 Gb/s
- **Multigigabit Ethernet** which would address need beyond 1G is at spec development stage

Automotive Ethernet Standard

BASED ON ESTABLISHED ETHERNET STANDARDS, ADAPTED FOR AUTOMOTIVE

- Unshielded single twisted pair cabling designed for automotive environment and lower cost
- Higher Bandwidth compared to CAN FD (15Mbps), FlexRay (10Mbps), MoST (150Mbps)
- Can reuse existing Application Layer Ethernet stack
- Uses PAM3 signaling

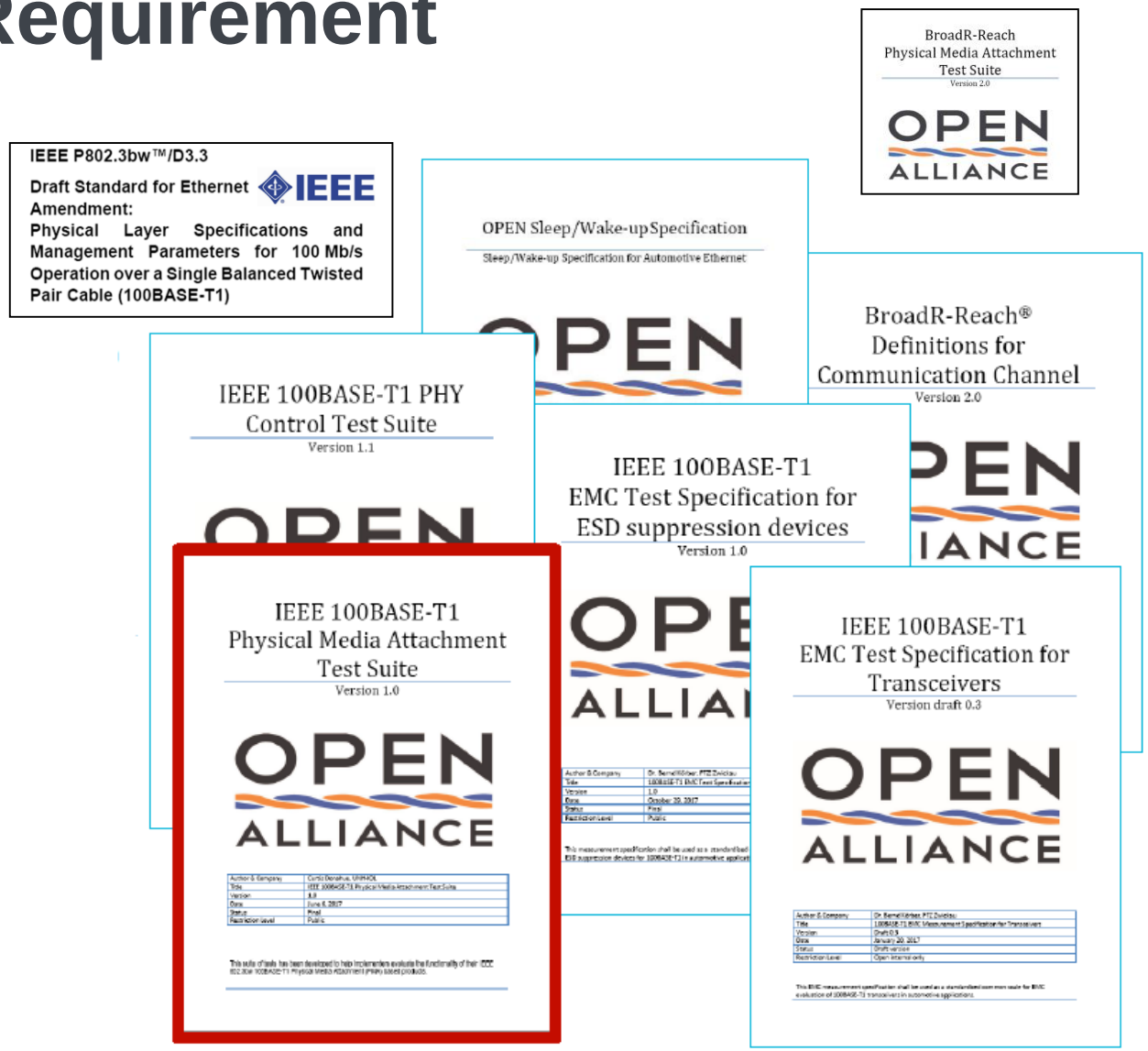


Automotive Ethernet Compliance

Ensuring performance and interoperability

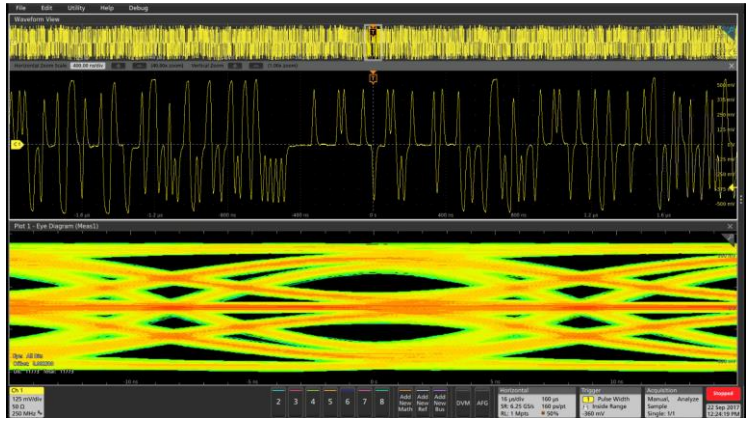
Automotive Ethernet Test Requirement

- Multiple testing needs including physical layer (PMA) transceiver, receiver, communication channel, and EMC
  - PHY Media Attachment Test suit
  - EMC Test for Common Mode Chock
  - Interop Test
  - PHY Control Test
  - Physical coding Sublayer test
  - Communication Channel Test
  - Open Sleep/wakeup Test
  - EMC Test for Trans receiver
  - EMC Spec for ESD suppression devices



Automotive Ethernet PMA Test Specification

- 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 Density
  - Clock Frequency
  - MDI Return Loss
  - Peak Differential Output
- PAM3 signaling



IEEE P802.3bw™/D3.3
Draft Standard for Ethernet Amendment:
Physical Layer Specifications and Management Parameters for 100 Mb/s Operation over a Single Balanced Twisted Pair Cable (100BASE-T1)

BroadR-Reach Physical Media Attachment Test Suite
Version 2.0
OPEN ALLIANCE

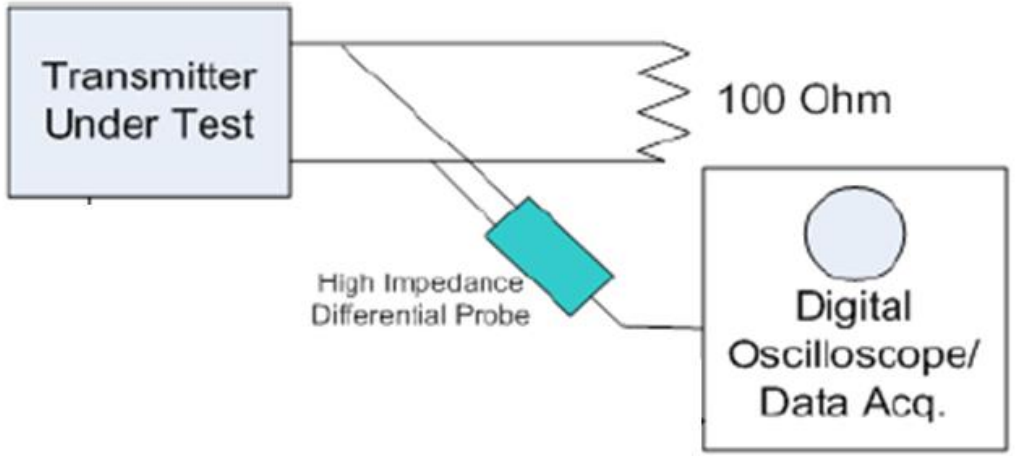
Group 1: Electrical Measurements	
Maximum Transmitter Output Droop	Test 5.1.1
Transmitter Distortion	Test 5.1.2
Transmitter Timing Jitter (MASTER, SLAVE)	Test 5.1.3
Transmitter Power Spectral Density	Test 5.1.4
Transmit Clock Frequency	Test 5.1.5
MDI Return Loss	Test 5.1.6
MDI Mode Conversion Loss	Test 5.1.7
Transmitter Peak Differential Output	Test 5.1.8

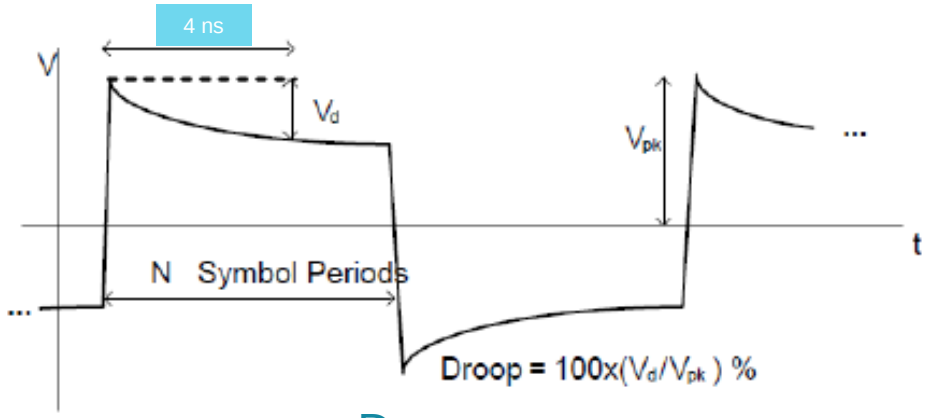
1000BASET1 Measurement	Spec ID
Tx Droop Measurement	5.3.1
Tx Distortion Measurement	5.3.2
Tx_TCLK125 Jitter	5.3.3
Tx_TCLK125 Jitter	5.3.3
MDI_output_Jitter	5.3.3
Tx PSD	5.3.4
Tx Peak Diff output	5.3.5
Tx Clock Frequency	5.3.6
MDI Return Loss (S11)	7.2.1
MDI Mode Conversion loss	7.2.2

* PMA: Physical Media Attachment

Maximum Droop Test

- Droop Measurement
  - Configure Test Mode 1
  - Transmit fifteen {+1} symbols followed by fifteen {–1} symbols continually
  - Value of signal 4ns after initial peak, shall be less than 10.0%
  - Calculate Vpk and Vdelay as shown below
  - Vd= Vpk-Vdelay
  - Droop= vd/vpk%



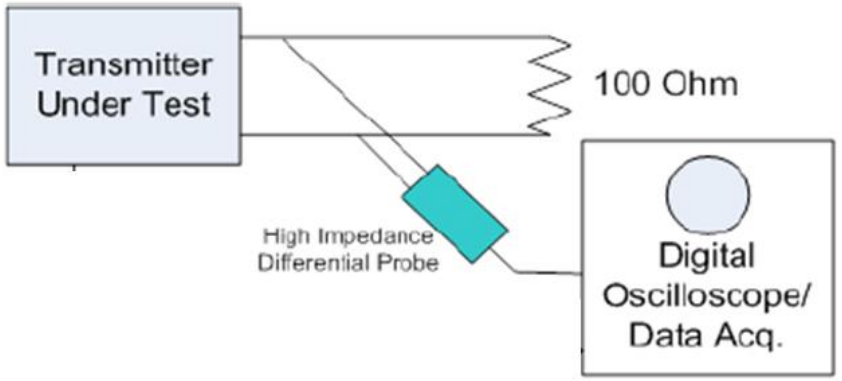


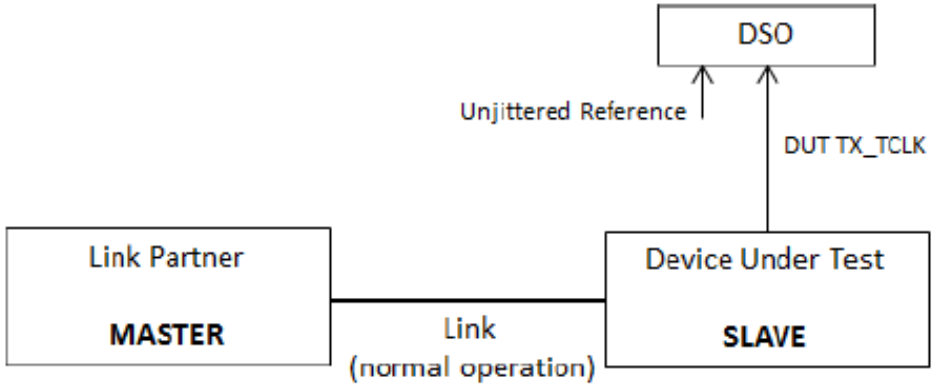
Droop

Droop

Clock Frequency and Jitter Tests

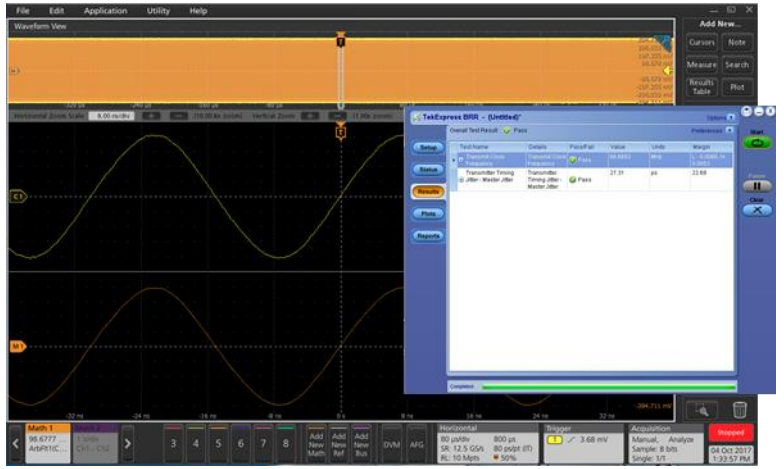
- Clock Frequency Measurement
  - PHY device must have a symbol transmission rate of 750 MHz ± 100ppm (master clock should be 125 MHz)
- Timing Jitter (master & slave) Measurement
  - Transmitter clock measurement
  - RMS PHY output jitter shall be less than 5 ps
  - Slave jitter requires un jittered reference,
  - RMS PHY jitter shall be less than 10ps for Slave





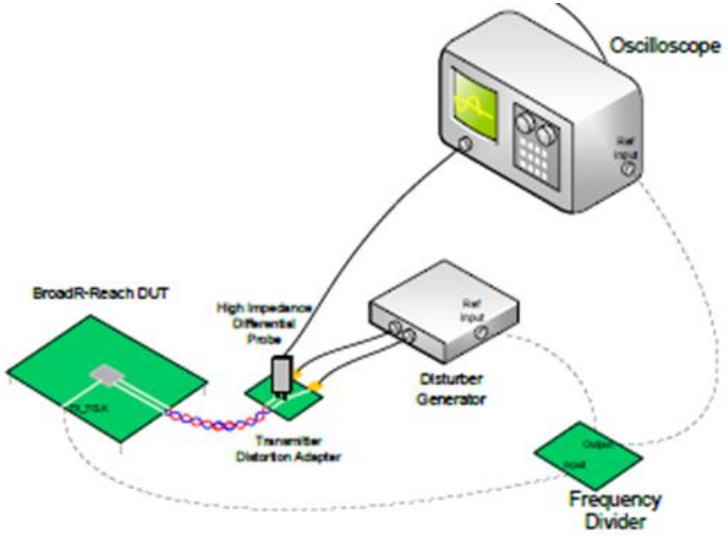
Slave Jitter

Clock Frequency & Jitter

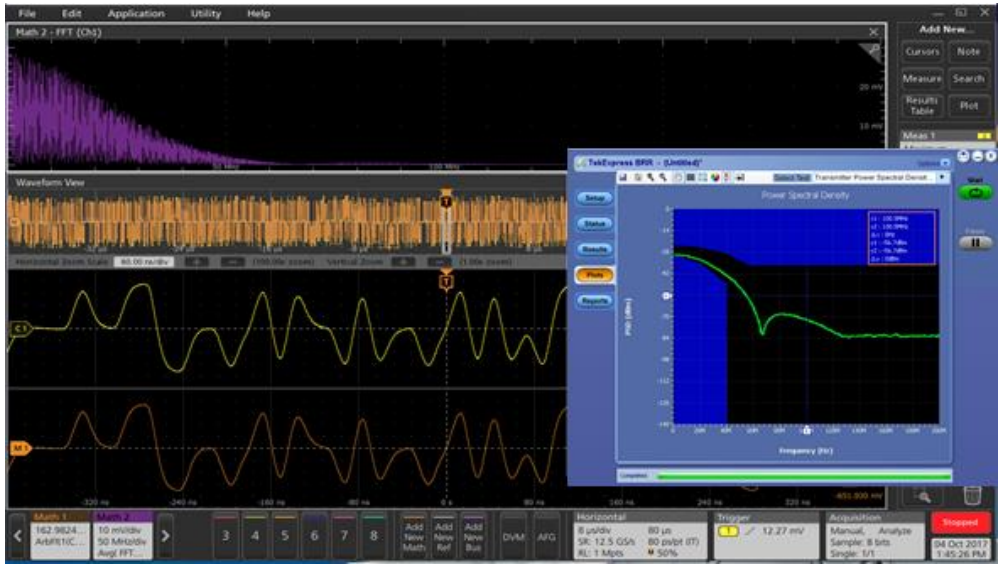


Power Spectral Density

- Power Spectral Density
  - Configure Test Mode 5
  - Random sequence of ternary (PAM3) codes {-1, 0, +1}
  - Max & min mask defines limits at 4 specific frequencies
  - RBW = 10 KHz, VBW = 30 KHz, Sweep time > 60 seconds
  - Compliance test spec allows use of scope or spectrum analyzer

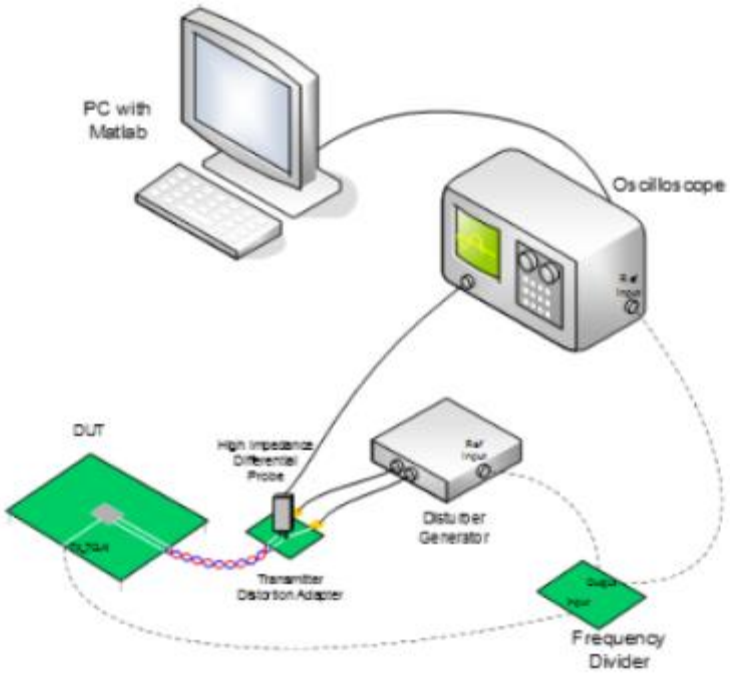


PSD

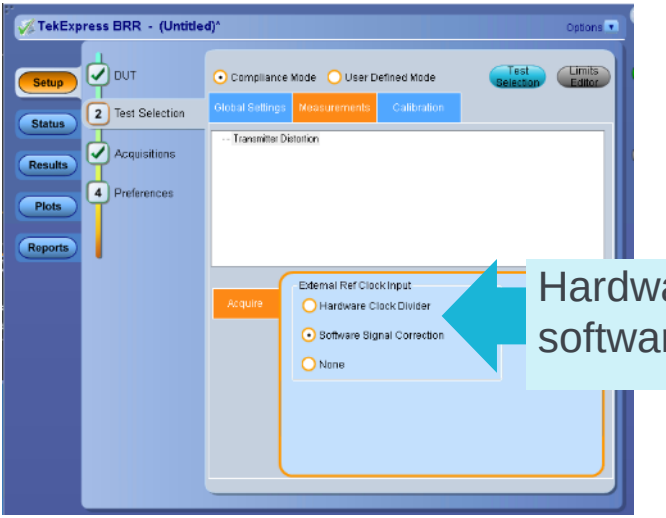


Distortion Test

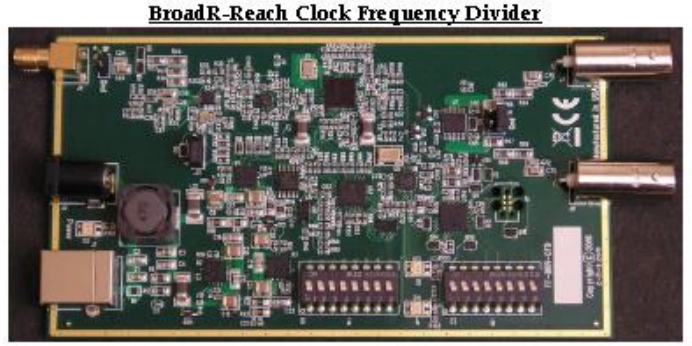
- Distortion Measurement
  - Peak distortion values should be less than 15 mV for at least 10 measured equally spaced phase
  - Requires generator to provide 125 MHz distortion signal which is 1/6 symbol rate
  - Requirement to synch scope and generator with PHY Tx-TCLK (distortion results are higher without this technique)
  - Alternative to hardware synch is software correction



Distortion

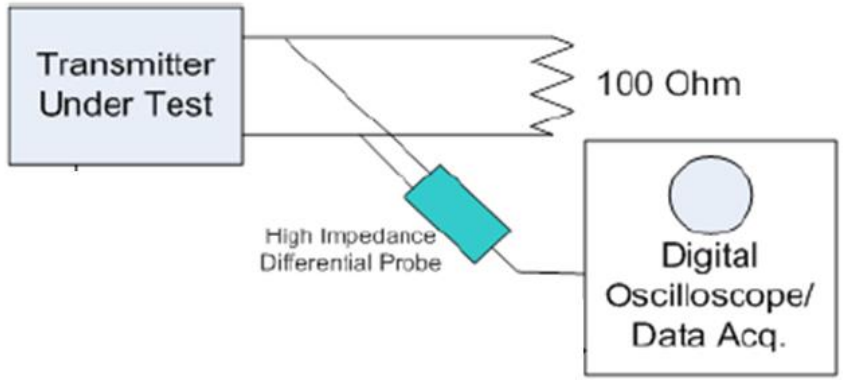


Hardware or software support

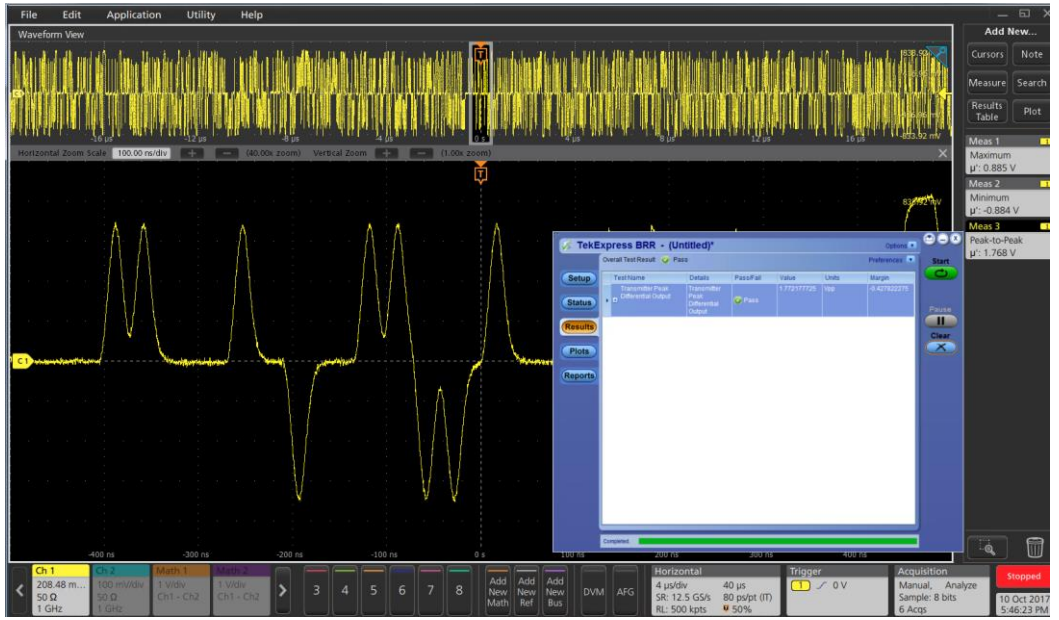


Tx Peak Differential Output Test

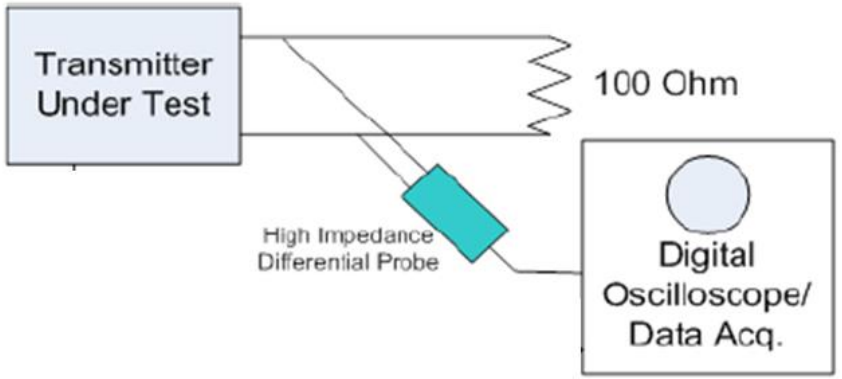
- Peak Differential Output Test
  - Peak-to-peak differential amplitude shall be less than 2.2 VPP when measured with a 100 Ω termination
  - DUT is configured as MASTER and in the TRAINING state of the PHY Control state
  - Configured for Test Mode 5, described as “Normal operation at full power”



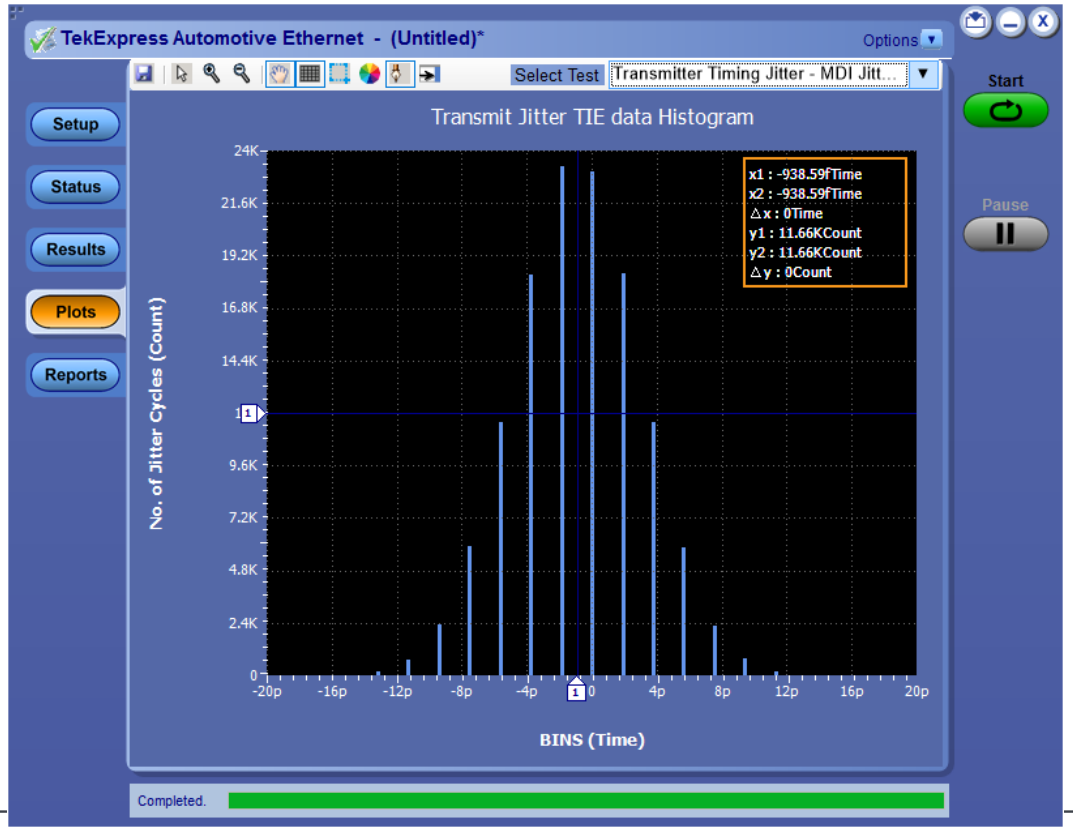
Differential Output



MDI Output Jitter



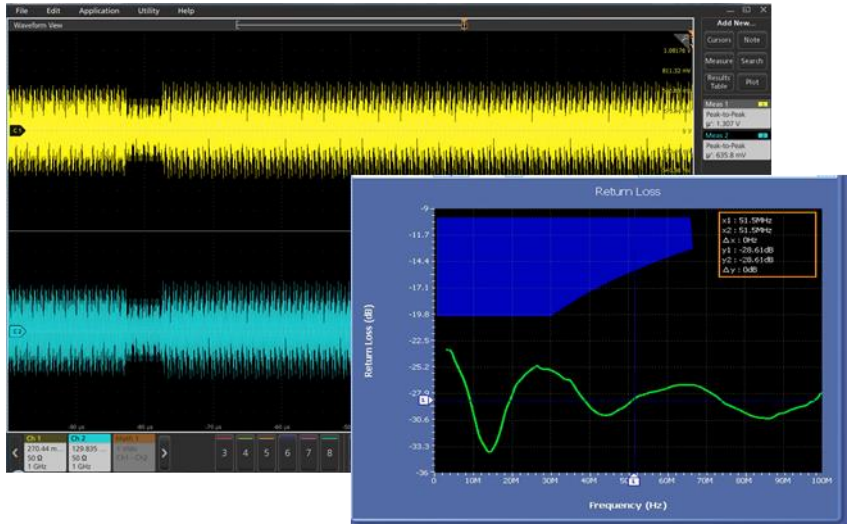
- MDI output Jitter
  - Transmit three {+1} symbols followed by three {–1} symbols continually
  - RMS PHY MDI output jitter shall be less than 5 ps

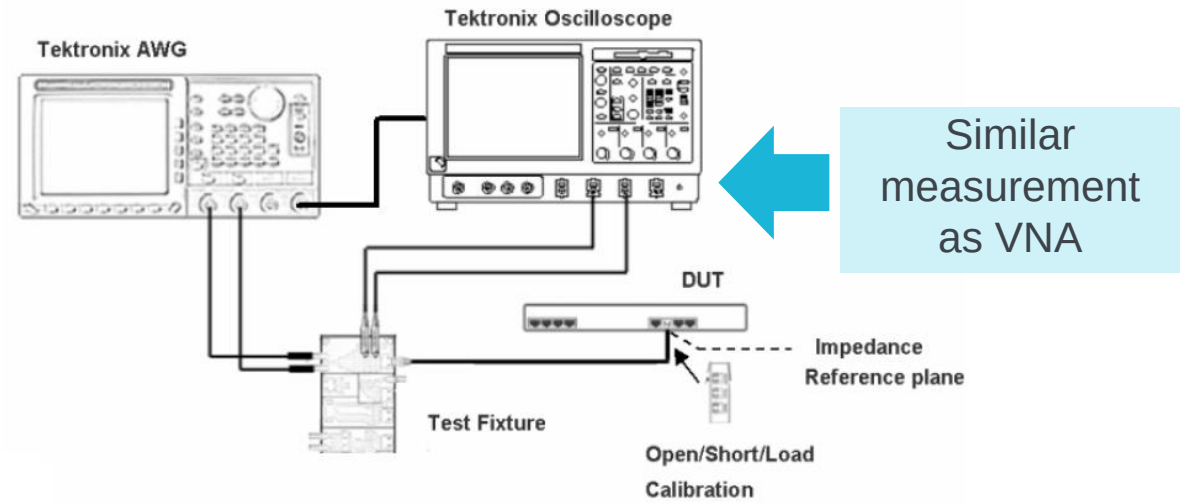


MDI (connector) Return Loss Test

- Return Loss Measurement
  - Measurement is focused on the connector and not the link (cable) return loss
  - Test spec references VNA or scope as measurement tool
  - Return loss measured at the MDI shall be at least 18 dB (1 to 20 MHz), and at least 18-10*log10(f/20) dB (20 to 66 MHz)
  - Max & min mask defines limits at 4 specific frequencies
  - Tek has patented approach using scope and AWG (same equipment used for other tests)

Return Loss using scope



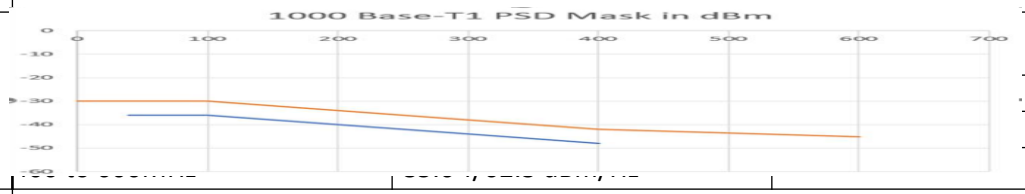


Similar measurement as VNA

100BASE-T1 compliance

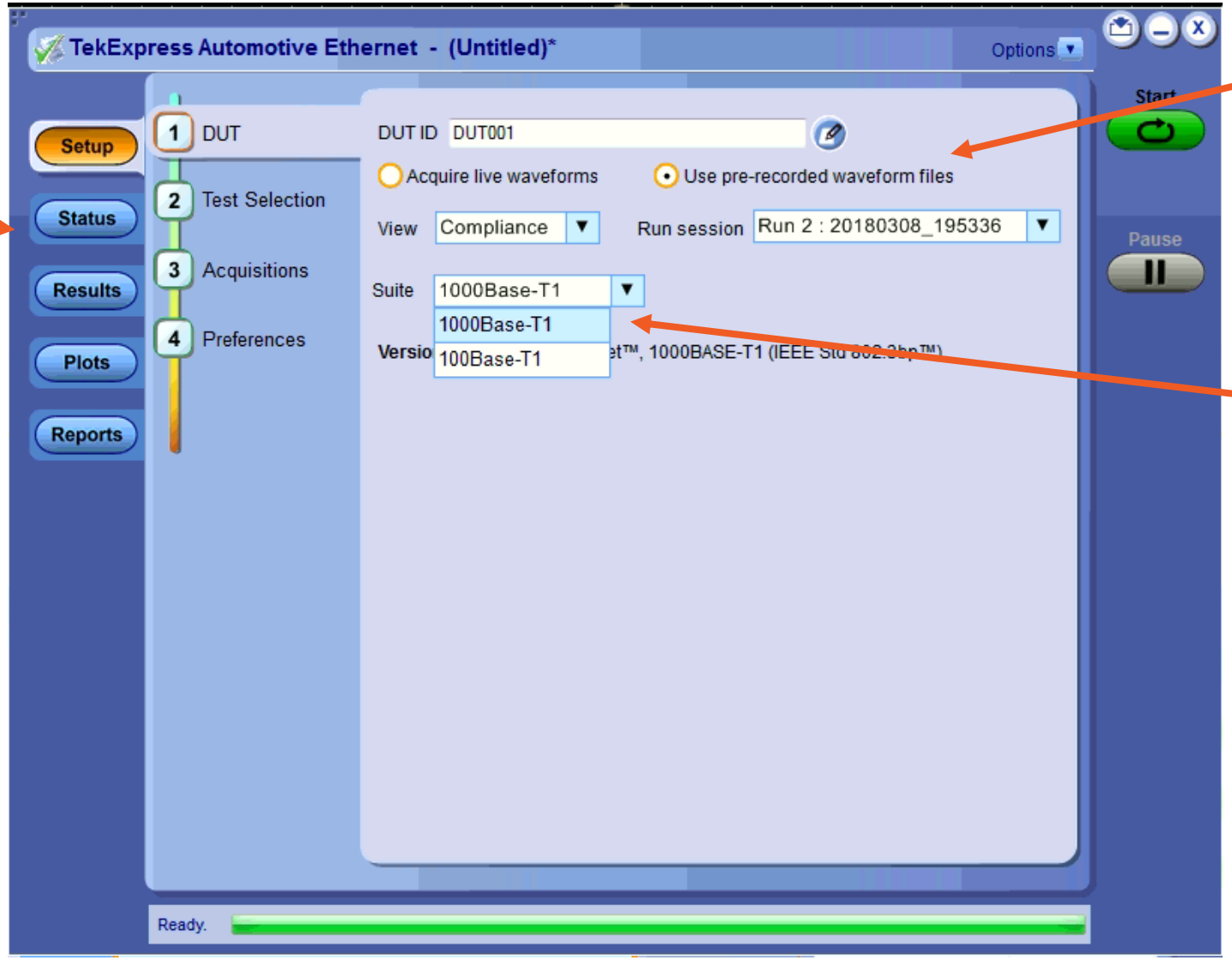
100BASE-T1 Electrical Measurement					
Measurement	**Test Mode**	**Pin**	**Test Pattern**	**Spec**	**Instrument**
Tx Droop Measurement	1	BI_DA	Transmit fifteen {+1} symbols followed by fifteen {–1} symbols continually	Max Droop after 500ns of 45%	Scope
Tx Distortion Measurement	4	BI_DA	Transmit the sequence of symbols generated by the scrambler generator polynomial per Equation (97–12) when in test mode 4, 40us long	>15mV	Scope+ AWG
Clock Jitter (Master)	2	BI_DA	Frequency reduced version of Transmit symbol clock	RMS Jitter <50ps (Master)	Scope
Clock Jitter (Slave)	3	BI_DA	Frequency reduced version of Transmit symbol clock	RMS Jitter <150ps (Slave)	Scope
Tx Power spectral Density (PSD)	5	BI_DA	Sequence of -1, 0, +1	**Freq** / **PSD Upper** / **PSD Lower** @1MHz / -23.3 dBm / -30.9dBm @20MHz / -24.8 bBm / -35.8dBm @40MHz / -28.5dBm / -49.2dBm 57MHz -200MHz / -36.5dBm	Scope
Tx Peak Diff output	5	BI_DA		<2.2Vpp	Scope
Tx Clock Frequency	2	BI_DA	+1, -1 Clock sequence	66.66 MHz ± 100ppm	Scope
MDI					
MDI Return Loss (S11)	4	BI_DA	PAM3 Data pattern	below 18dB (1-20MHz) 18*10log(f/20) dB (20-66MHz	Scope +AWG/VNA
MDI Mode Conversion loss (Sdc11)		BI_DA	Coming soon		

1000BASE-T1 Compliance

1000BASE- T1 Electrical Measurement					
Measurement	**Test Mode**	**Pin**	**Test Pattern**	**Spec**	**Instrument**
Tx Droop Measurement	6	BI_DA	Transmit fifteen {+1} symbols followed by fifteen {–1} symbols continually	Less than 10% measured with respect to an initial value at 4 ns after the zero crossing and a final value at 16 ns after the zero crossing	Scope
Tx Distortion Measurement	4	BI_DA	Transmit the sequence of symbols generated by the scrambler generator polynomial when in test mode 4, 40us long	Less than 15 mV for at least 10 measured equally spaced phases	Scope+ AWG
Tx_TCLK125 Jitter	1	BI_DA	Frequency reduced version of Transmit symbol cloclk	>5ps RMS, >50ps pp	Scope
Tx_TCLK125 Jitter	1	BI_DA	Frequency reduced version of Transmit symbol clock	>10ps RMS, >100ps pp	Scope
MDI_output_Jitter	2	BI_DA	Transmit three {+1} symbols followed by three {–1} symbols continually	>5ps RMS, >50ps pp	Scope
Tx PSD	5	BI_DA	Sequence of -1, 0, +1		Scope
Tx Peak Diff output	5	BI_DA	Sequence of -1, 0, +1	<1.3Vpp	Scope
Tx Clock Frequency	2	BI_DA	+1, -1 Clock sequence	750MHz +- 100ppm	Scope
MDI					
MDI Return Loss (S11)	4	BI_DA	PAM3 Data pattern		Scope + AWG/VNA
MDI Mode Conversion loss (Sdc11)		BI_DA		Coming Soon	

Automated Compliance

Wizard-based automation

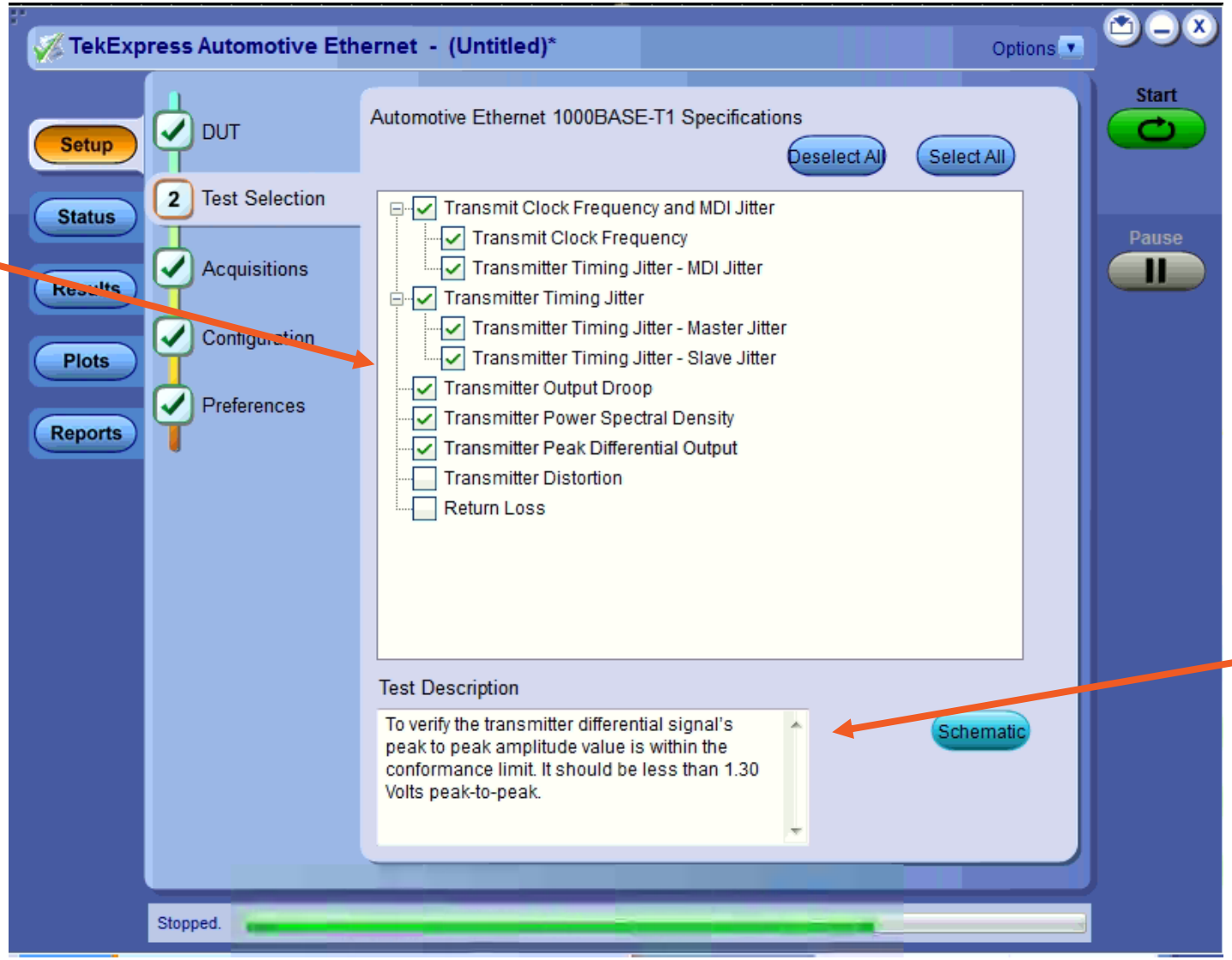


Live or offline testing

Latest 100/1000BASE-T1 support

Test Selection

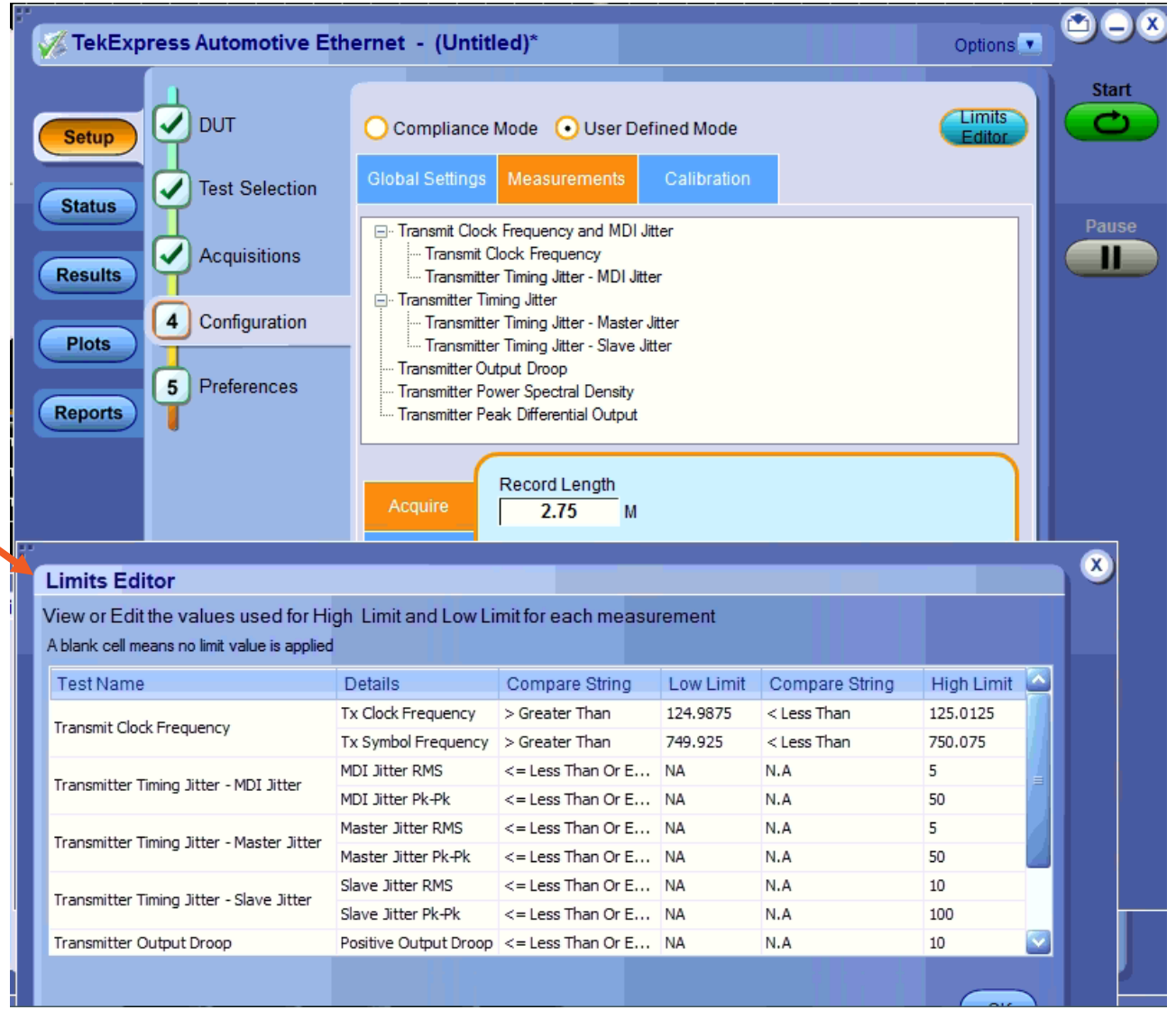
Select multiple tests



Test description with connection diagram

User-Defined Mode

Set your own custom limits



Test Name	Details	Compare String	Low Limit	Compare String	High Limit
Transmit Clock Frequency	Tx Clock Frequency	> Greater Than	124.9875	< Less Than	125.0125
	Tx Symbol Frequency	> Greater Than	749.925	< Less Than	750.075
Transmitter Timing Jitter - MDI Jitter	MDI Jitter RMS	<= Less Than Or E...	NA	N.A	5
	MDI Jitter Pk-Pk	<= Less Than Or E...	NA	N.A	50
Transmitter Timing Jitter - Master Jitter	Master Jitter RMS	<= Less Than Or E...	NA	N.A	5
	Master Jitter Pk-Pk	<= Less Than Or E...	NA	N.A	50
Transmitter Timing Jitter - Slave Jitter	Slave Jitter RMS	<= Less Than Or E...	NA	N.A	10
	Slave Jitter Pk-Pk	<= Less Than Or E...	NA	N.A	100
Transmitter Output Droop	Positive Output Droop	<= Less Than Or E...	NA	N.A	10

Automated Report Generation

Report with Pass/Fail, Margin and Plots

Tektronix®

TekExpress Automotive-Ethernet 1000Base-T1

Transmitter Test Report

Setup Information			
DUT ID	DUT001	TekExpress Automotive-Ethernet	10.1.1.47
Suite Name	1000Base-T1	FrameWork Version	4.3.0.40_Rev_A
Compliance Mode	Yes	Scope Model	MSO73304DX
Date/Time	2018-03-08 19:52:52	FimWare Version	10.8.1 Build 37
Pre-Recorded Mode	True		
Overall Execution Time	0:00:04		
Overall Analysis Time	0:00:02		
Overall Test Result	Pass		
DUT COMMENT:	General Comment - Automotive Ethernet DUT		

Test Name Summary Table	
Transmitter Output Droop	Pass

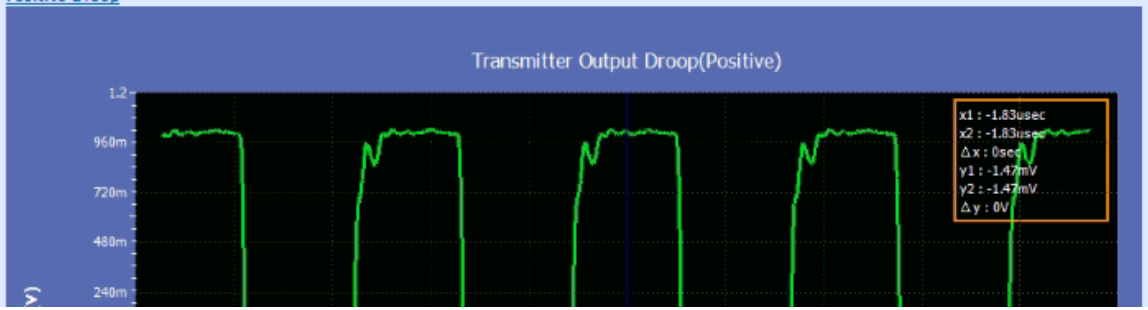
Transmitter Output Droop

Measurement Details	Measured Value	Unit	Test Result	Margin	Low Limit	High Limit
Positive Output Droop	-16.7068	%	Pass	26.7068	N.A	10.0000
Negative Output Droop	-16.5236	%	Pass	26.5236	N.A	10.0000
COMMENTS	Number of Positive Droops:98, Number of Negative Droops:99					

Back to Summary Table

Transmitter Output Droop

Positive Droop



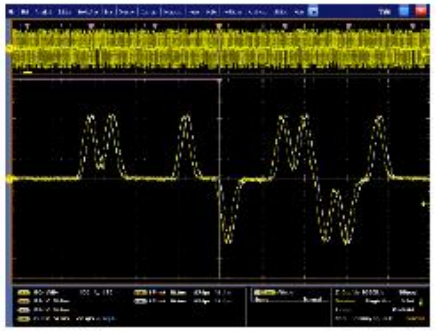
Automotive Ethernet Signal Qualification

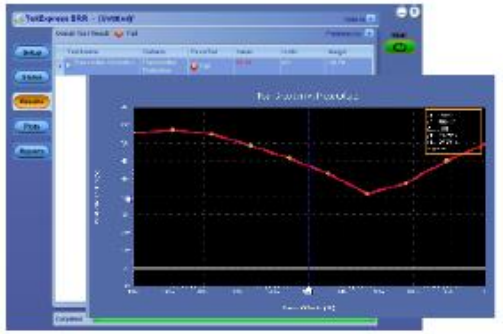
Validation and debugging

Signal Qualification

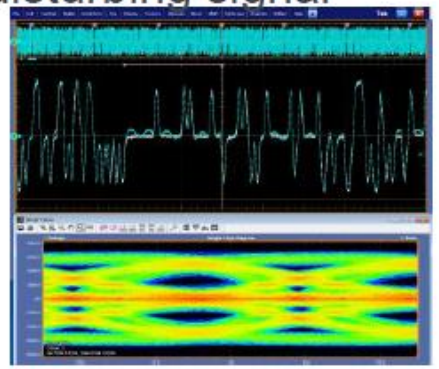
- Compliance software is being used for design and validation
- What do you do when a measurement fails?
- How would you run Signal Qualification?
- Design validation extends beyond PHY and can include Cabling and System level Test

Compliance failure without disturbing signal

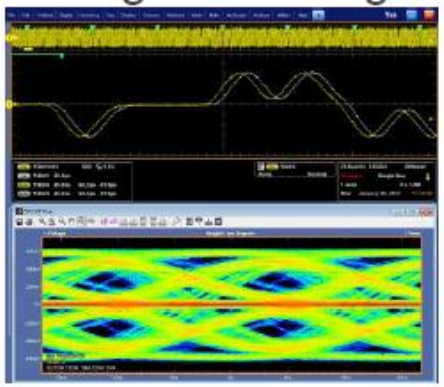


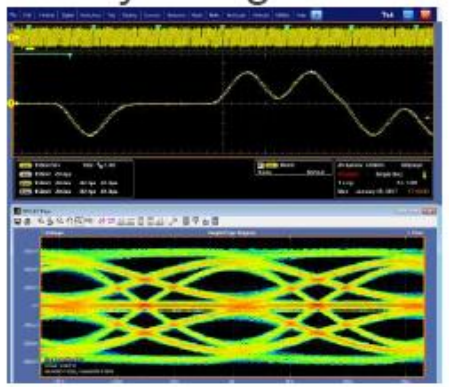


Distortion analysis with disturbing signal



Timing error using DPOJET eye diagram

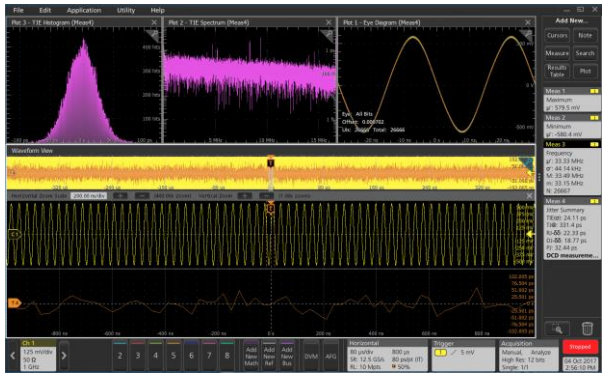




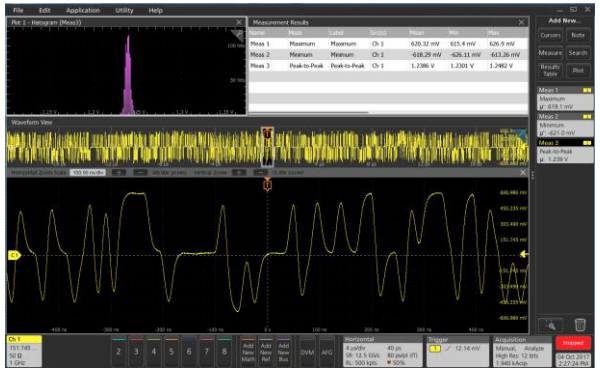
Signal Qualification

COMPLETE VALIDATION AND DEBUG ENSURES PASSING COMPLIANCE TESTS

- Signal qualification can be performed using scope's advanced measurement and analysis tools ahead of compliance testing
- Designs can validated under different operating and stress conditions
- Characterization can include jitter analysis, voltage/timing measurements and eye diagram analysis of PAM3 signaling
- Correlate results and debug if needed against compliance tests



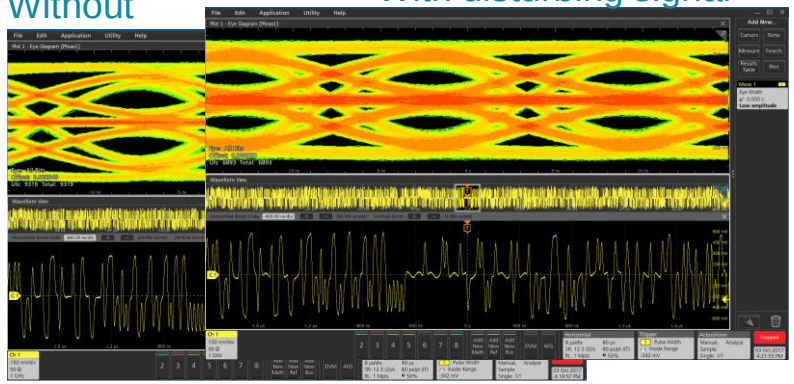
PHYJitter/timing analysis



Differential amplitude profile

Without

With disturbing signal

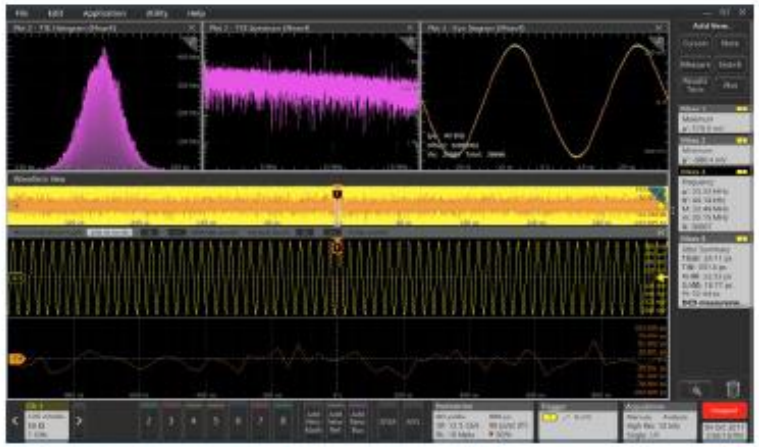


Distortion signal eye analysis

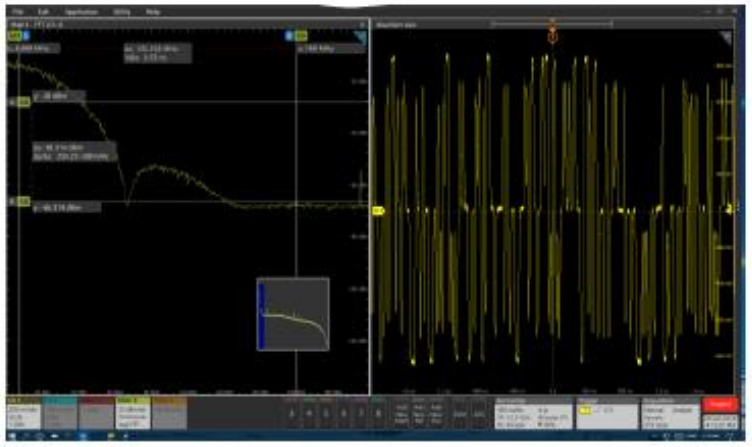
Validation and Compliance flow

Validation/Debug

Compliance

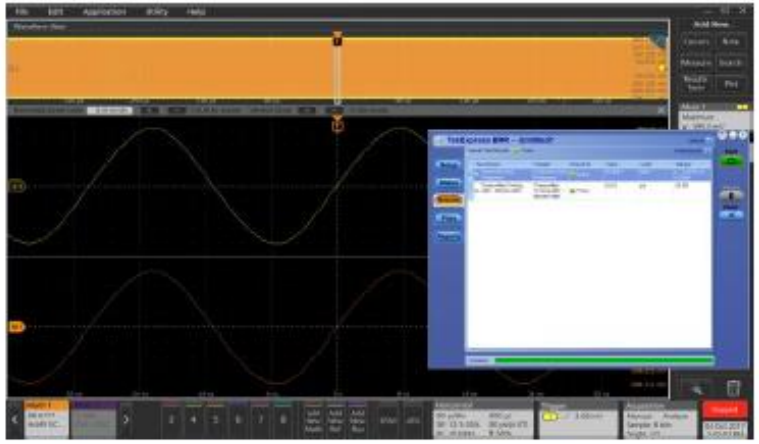


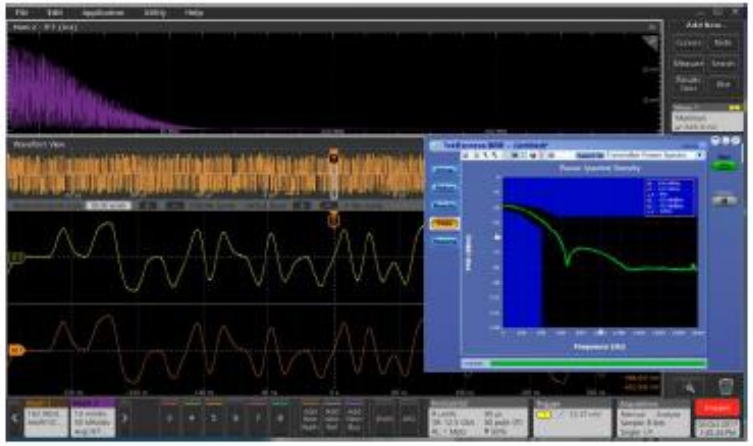
Tx Clock Frequency & Jitter



Tx Power Spectral Density

Tx Droop



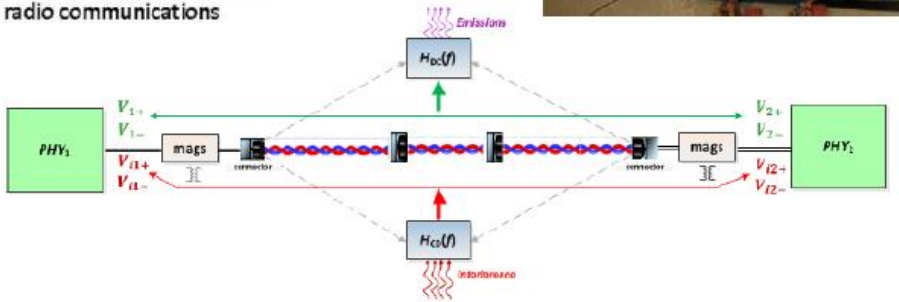


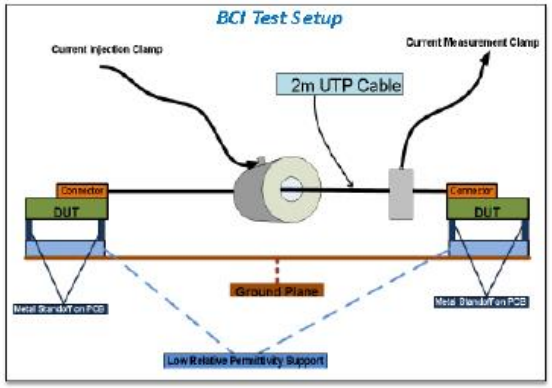
Automotive Ethernet Signal Qualification

EMI/EMC Test

Automotive Ethernet EMC Test

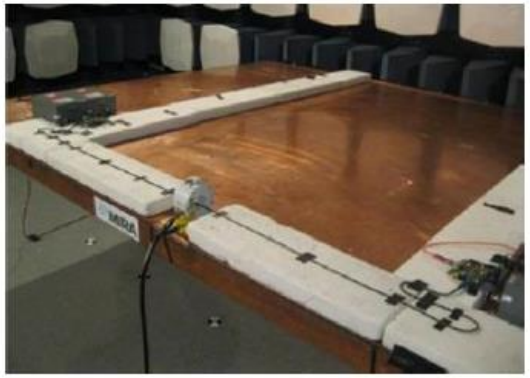
- EMC test requirements are not standardized
- Unbalanced impedance of ECU and cabling with cause common mode noise to interferes with data signal and cause malfunction of ECU electronics
- Bulk Current Injection Test (BCI ISO11452-4)
  - Used for component level testing (DUT, cable, connectors,
  - Interference is injected (1 MHz to 400 MHz) through the current injection clamp
  - Common Mode (CM) coupling to a differential pair channel
  - BCI test is widely used by automotive due to easy setup, repeatability and direct correlation to in-car noise models



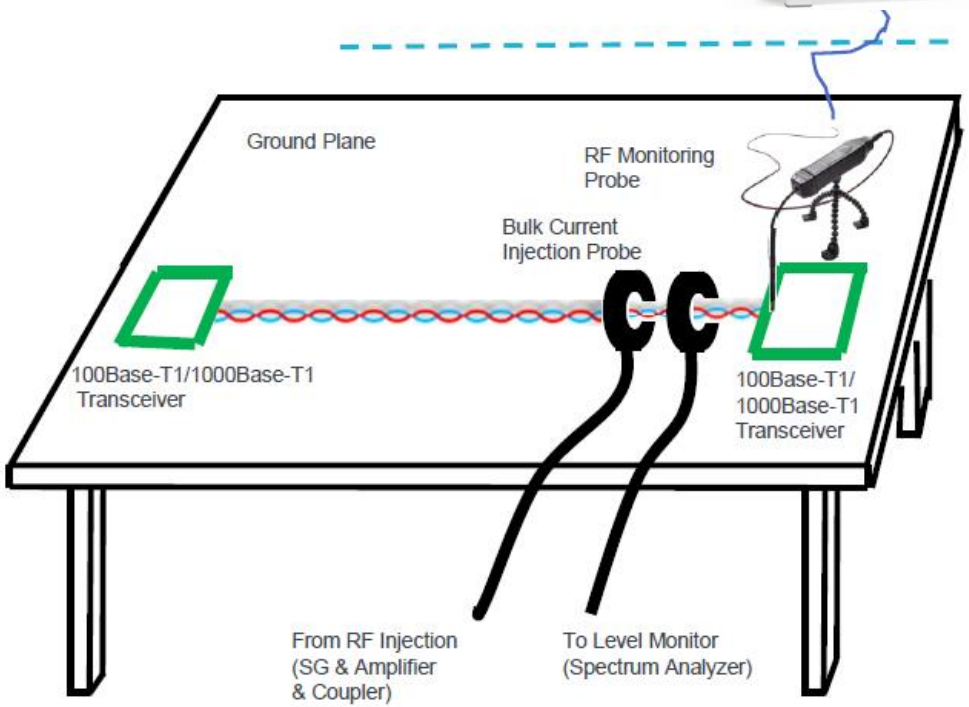


Debug of BCI Immunity Test

- Measure actual voltage amplitude caused by RF Injection
- Check transceiver operates correctly under BCI injection of 1 MHz-400 MHz
- High CMRR performance of TIVM1L (IsoVu) is very effective
- Place oscilloscope outside of shield room



Scope outside test chamber

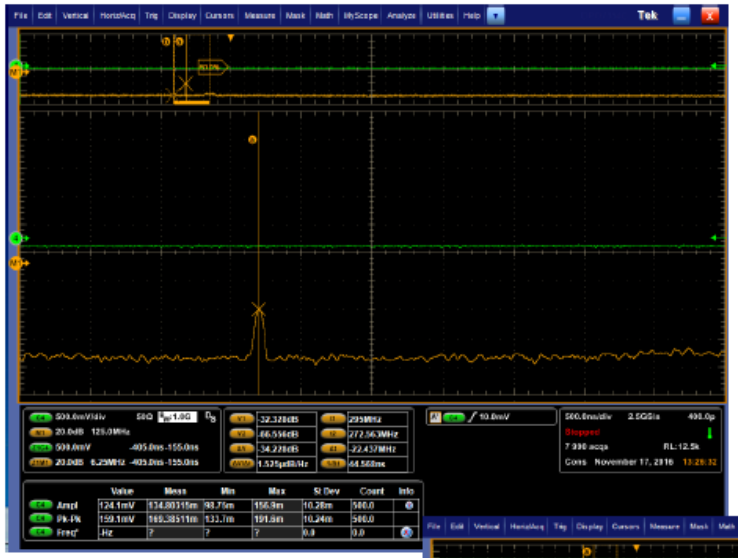


BCI Test Result with IsoVu

- Evaluate probe susceptibility to EMI field from RF injection placed near DUT but floating
- Connect IsoVu to DUT to evaluate true signal and debug

Isovu connected to receiver

Open Input (floating) with IsoVu



Near zero due to CMRR performance & shielding

Open Input with P6251

Poor CMRR performance showing band of noise

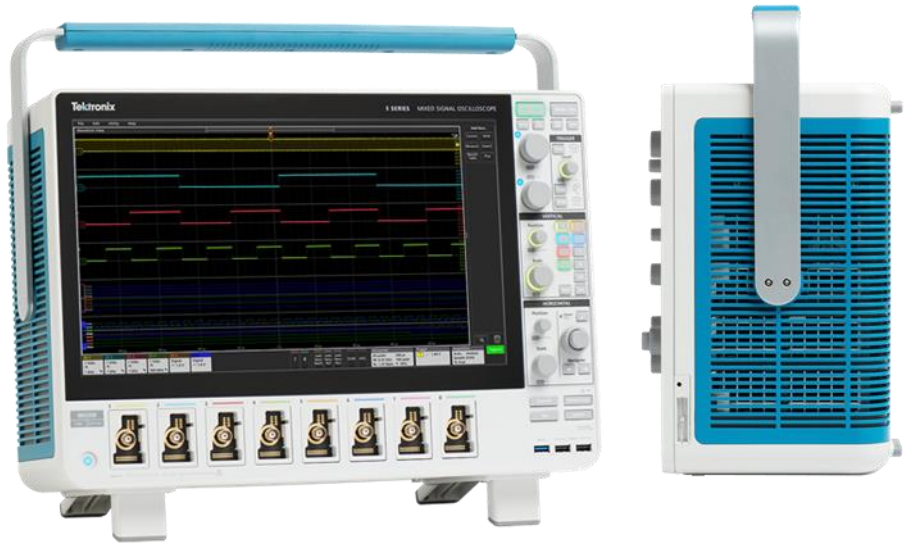
Automotive Ethernet Testing

Tektronix Solutions

Hardware Platform

THE MOST FLEXIBLE AND CAPABLE SCOPE FOR AUTOMOTIVE APPLICATIONS

5 Series MSO	MSO54	MSO56	MSO58
Bandwidth	350 MHz,	500 MHz, 1 GHz,	2 GHz
Maximum Analog Channels	4	6	8
Maximum Digital Channels (optional in 8 channel increments)	32	48	64
Sample Rate (all A&D ch.)	6.25 GS/s		
Standard Record Length (all A&D ch.)	62.5 M		
Max. Opt. Record Length (all A&D ch.)	125 M		
Waveform Capture Rate	500,000 wfms/s		
ADC Resolution	12 bits		
Vertical Resolution	8 bits at 6.25 GS/s 12 bits at 3.125 GS/s Up to 16 bits w/ High Res		
Arbitrary/Function Generator	Up to 50 MHz (opt.)		
Integrated DVM & Trigger Freq. Counter	Free with product registration		
Price Range	$12,600 − $40,600		

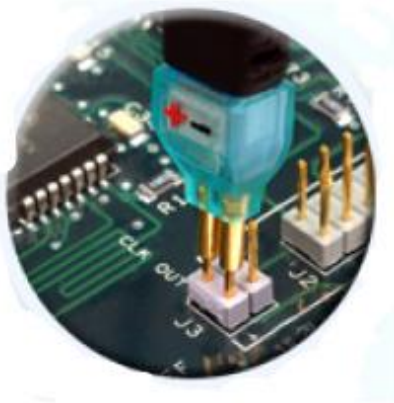


Oscilloscope
Logic Analyzer
Arbitrary/Function Generator
Protocol Analyzer
DVM
Trigger Frequency Counter

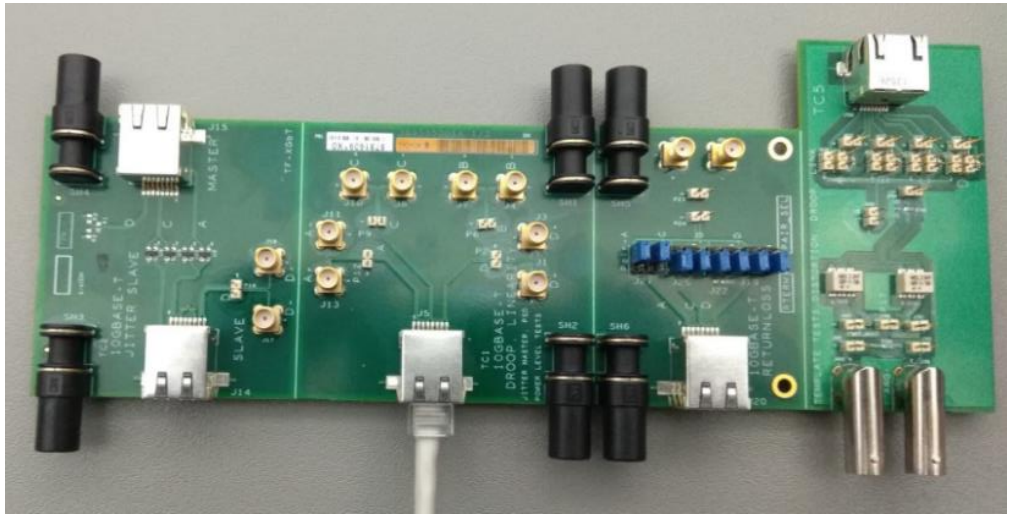
Hardware Platform

	MSO/DPO5000	DPO7000	MSO/DPO70000
Bandwidth	350 MHz-2 GHz	500 MHz-3.5 GHz	4GHz to 33GHz
Maximum Analog Channels		4 channels	
Maximum Digital Channels (optional)	16	-	16
Sample Rate	5 GS/s - 10 GS/s	5 GS/s - 40 GS/s	25 GS/s - 100 GS/s
Standard Record Length	25M	25M	25M
Max. Opt. Record Length	125M	500M	500M
Waveform Capture Rate	>250,000 wfms/s	>250,000 wfms/s	>300,000 wfms/s
ADC Resolution		8 bits	

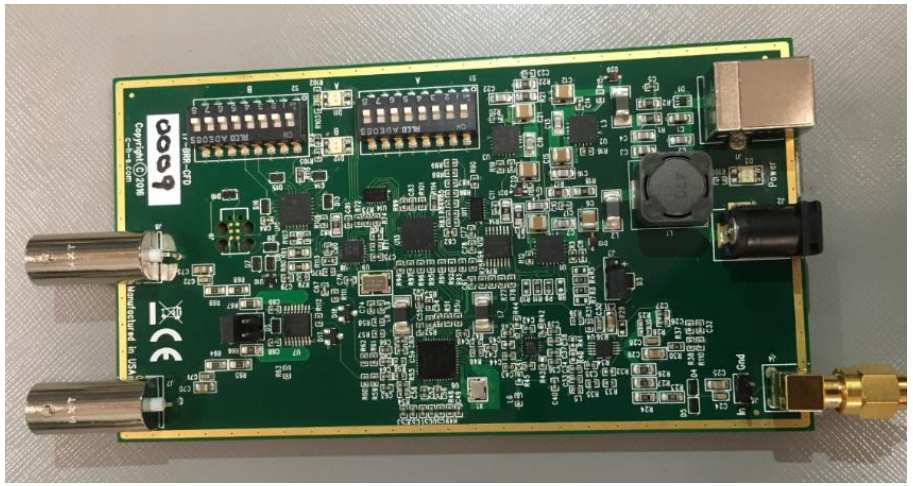
Signal Access



TDP3500 Probe



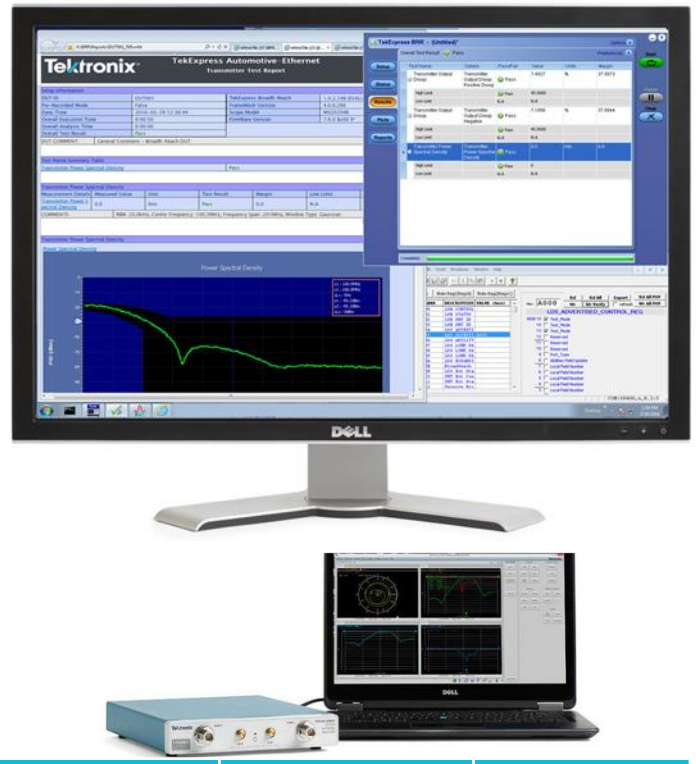
TF-XGbT Fixture

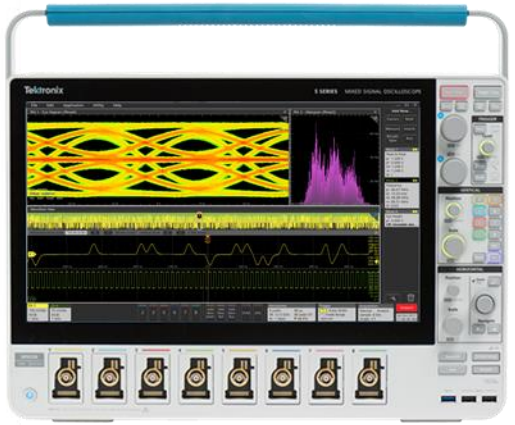


Clock Divider

Automotive Ethernet Compliance Solution

- Oscilloscope: MSO 5 Series, MSO/DPO5KB, DPO7KC/70KC
  - 1 GHz minimum bandwidth (100BASET1)
  - 2GHz Minimum bandwidth (1000BASET1)
- Software:
  - 5-CMAUTOEN: 1000BASE-T1/100BASE-T1 compliance
  - Optional Advanced jitter software
  - Optional protocol decode
- Probes: TDP1500 (2 required)- 100BASET1
  TDP3500 (2 required)- 1000BASET1
- Signal source: AFG3152C- 100BASET1,
  AWG5200-1000BASET1 or VNA





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

What’s coming up

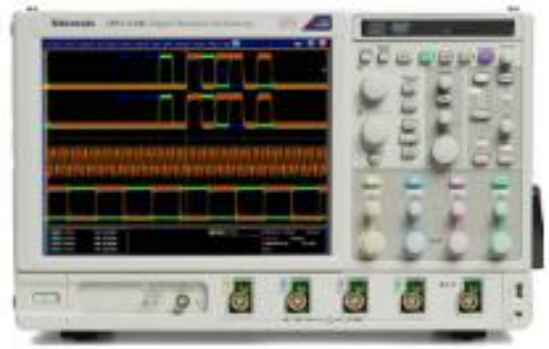
- VNA support for Return Loss and MDI Mode conversion Loss measurement
- Software Clock Recovery for 1000BASE-T1 Distortion measurement
- SMA Cable support
- Multiple Run: Configure specific measurement to run N times
- PAM3 Analysis (Eye Diagram, Rise time Measurement etc.)

Why Tektronix

- Ease of use: Complete Automated measurements with Pass/Fail Report
- Signal Qualification: Powerful Debug and Validation using DPOJET, Run measurement in continues mode for Signal quality test under different voltage, Temperature and noise environment.
- Multipurpose Instrument: Return loss using proven, patented scope-based measurement
- Complete Portfolio for Automotive: Tektronix offers EMI/EMC, ESD, BCI, Power Measurement, High Speed standards like DDR, PCIe, USB, MIPI, LVDS etc compliance solution for Automotive Applications.
- Future Proof: Tektronix is actively working on future Automotive Ethernet standards (Contact Tektronix representative for more info)

In-Vehicle Network Portfolio

Platform	Standards supported	Measurements supported	Advantage
MDO3000 MDO4000C	CAN, CAN-FD, LIN, FlexRay	Protocol, Signal Qualification, EMI/EMC, ESD Test, Power Measurement	4 Analog Channel, 16 Logic channel, Dedicated Spectrum Analyzer
5 Series MSO	CAN, CAN-FD, LIN, FlexRay, SENT, 100BASE-T1, 1000BASE-T1	Protocol, Compliance, Signal Qualification, ESD test, Power Measurement	8 Analog Channel, 64 Logic channel, 12 bit ADC
MSO/DPO5000B DPO7000C MSO/DPO70000	CAN, LIN, FlexRay, 100BASE-T1, 1000BASE-T1	Protocol, Compliance, Signal Qualification, ESD test, Power Measurement	4 Analog channel, 16 logic channel, 2GHz to 70GHz, supports high speed standards like DDR, PCIe, MIPI, USB, 10G Ethernet, HDMI, DP, Flash memory etc.



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

Tektronix

Thank you!