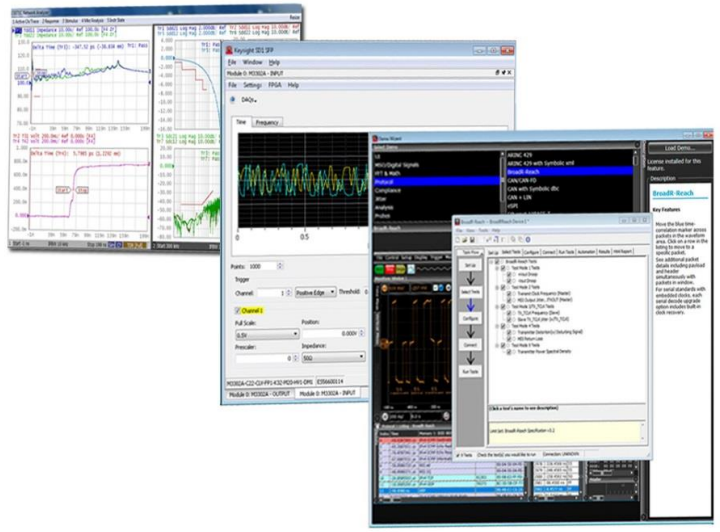
Automotive Ethernet 적용에 대한 도전 과제 및 Keysight 전략과 솔루션



Jan. 23 2018

Dong-Hyun, Seo

KEYSIGHT TECHNOLOGIES

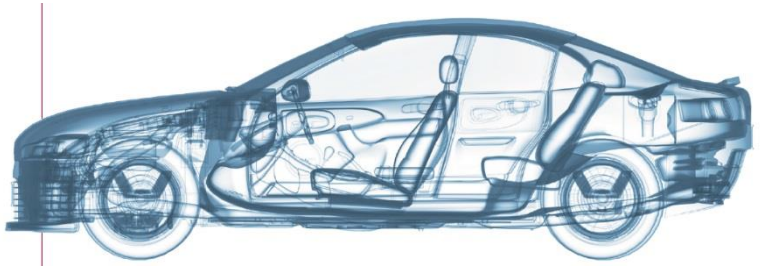
Agenda - what you can expect

What Is Automotive Ethernet?	Industry terms, Why Buy

What Are We Launching?

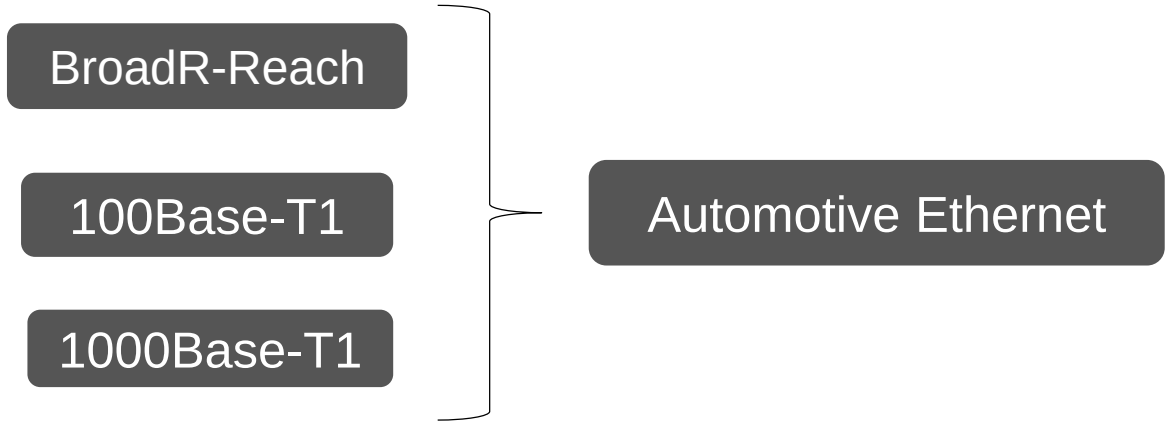
Product Overview

Industry terms

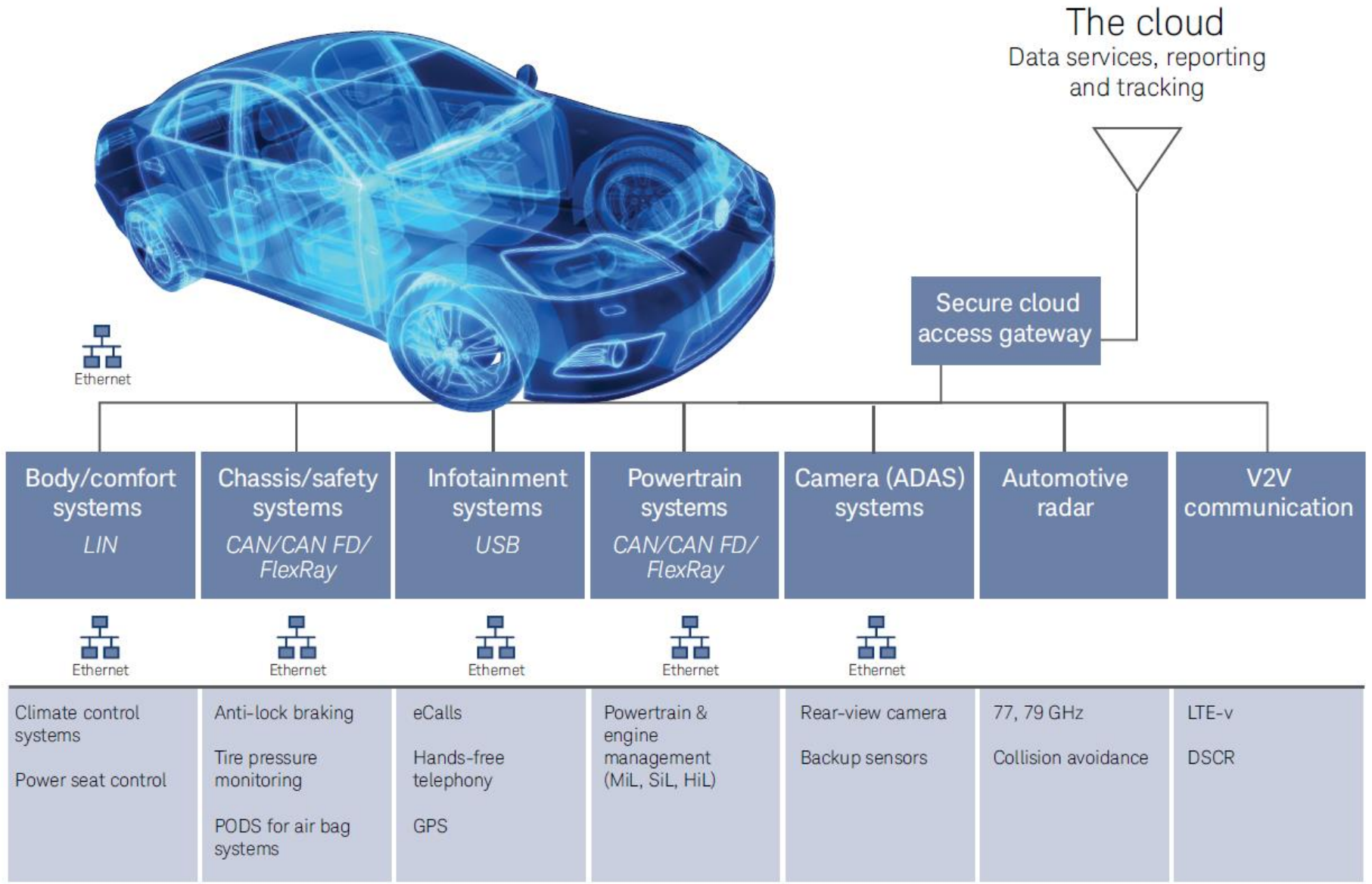


Connected Car, Automotive Ethernet, BroadR-Reach

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

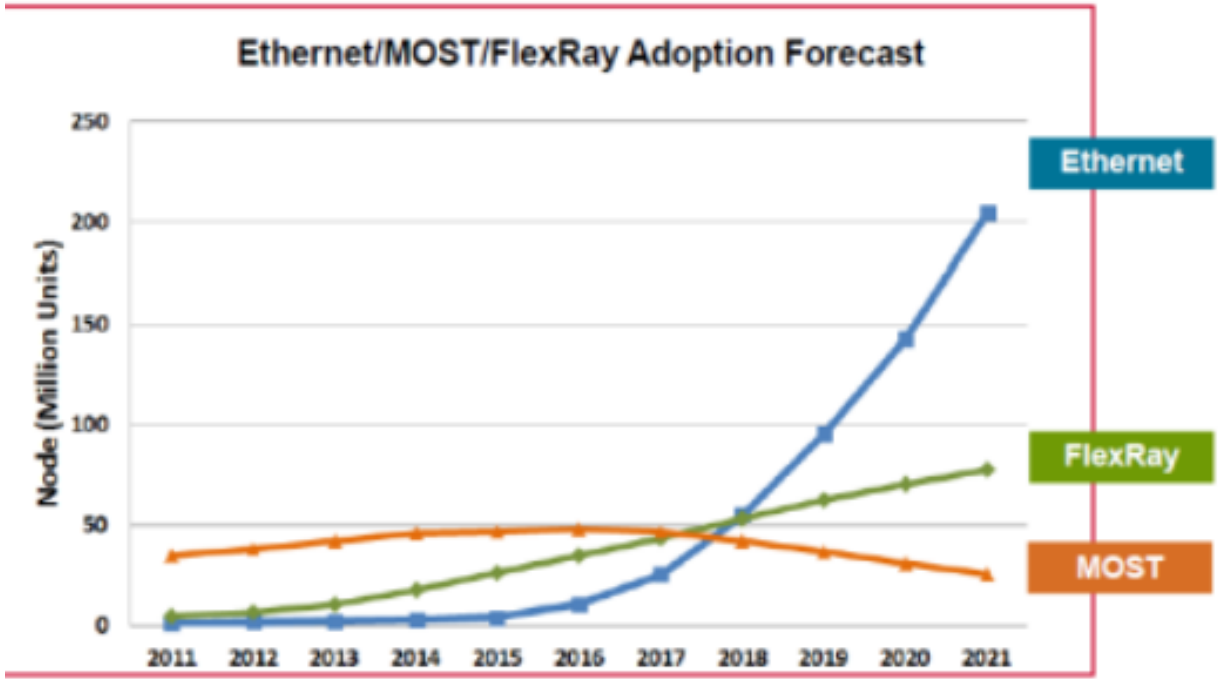


What Is Automotive Ethernet? Why Are Manufacturers Switching?



Automotive Ethernet Adoption Forecast

Projections of adoption

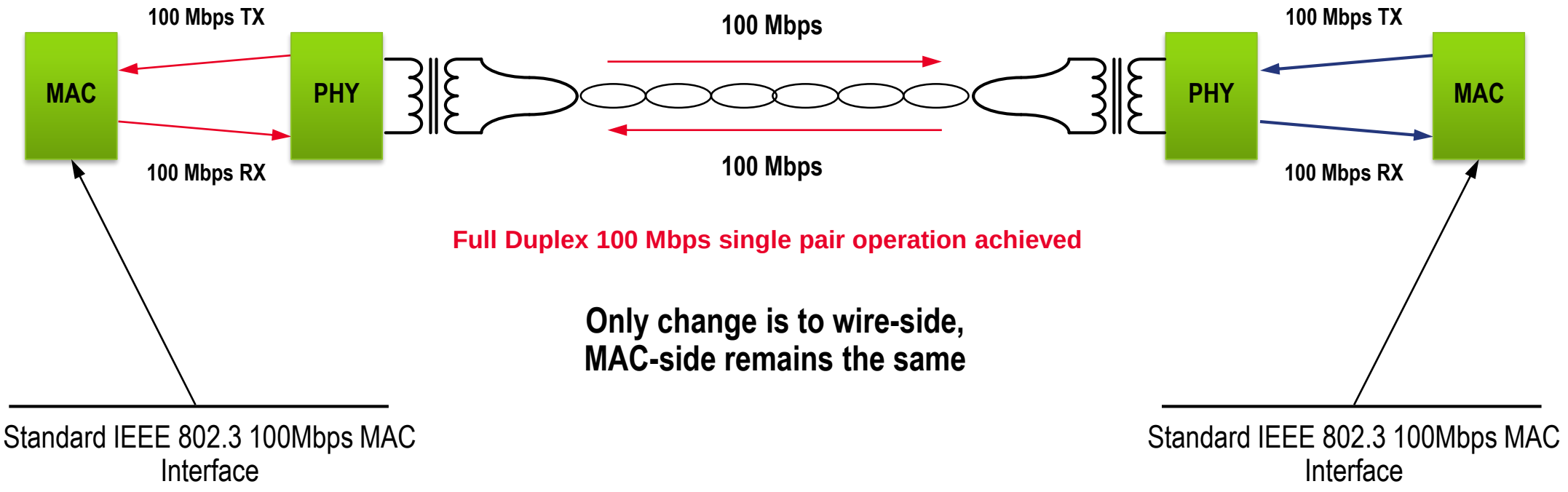


Ethernet adoption forecast

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

Cabling and Signal Communication

100 Mbps symmetrical operation using standard Ethernet PHY components



Full Duplex 100 Mbps single pair operation achieved

Only change is to wire-side, MAC-side remains the same

(Source : Automotive Update, Broadcom, 2012/2)

Agenda - what you can expect

What Is Automotive Ethernet?

What Are We Launching?

Keysight offerings, Product Highlights

Product Overview

What Are We Launching?

Existing BroadR-Reach (100Mb/s) N6467A/B

Transmitter output droop +/-
Transmit clock frequency (master), master TxOut jitter
Transmit clock frequency (slave), slave TxClk jitter
Transmitter distortion, MDI return loss
Transmit power spectral density

New Solutions

100Mb/s

Transmitter test N6467B – Update to include additional test for Full coverage for 100Mb/s
MDI S-parameter E6964A
Protocol trigger & decode N8847A

Receiver test E6962A – BER test

Link Segment test E6963A – Full coverage

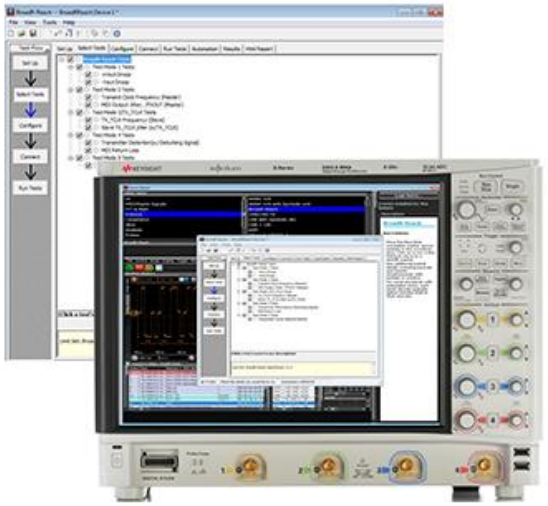
1000Mb/s

Transmitter test E6960A – Full coverage NOT including protocol trigger & decode

Keysight Automotive Ethernet Solutions

Unique test coverage across 100Base-T1 Tx, Rx and Link Segment, as well as 1000Base-T1 Tx tests

Transmitter



Link Segment

Receiver

E6961A Automotive Ethernet Transmit

- **Complete 1000Base-T1 & 100Base-T1 compliance**
- **Industry-first Protocol trigger & decode**
- **Industry-first MDI S-parameter test** *Medium Dependent Interface*

Solution components (orderable under one number)

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

E6963A Automotive Ethernet Link Segment

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

Solution Components (orderable under one part number)

- ENA Vector Network Analyzer
- Cables and adapters
- Software

E6962A Automotive Ethernet Receiver

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

Solution Components (orderable under one part number)

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

KEYSIGHT TECHNOLOGIES

Keysight Automotive Ethernet Tx Solution

What is it? Why Buy?

Transmitter

E6961A Automotive Ethernet Transmit

- ❖ **Complete 1000Base-T1 & 100Base-T1 compliance**
- ❖ **Industry-first Protocol trigger & decode**
- ❖ **Industry-first MDI S-parameter test** *Medium Dependent Interface*

Solution components (orderable under one number)

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

What is it?

- ❖ **Compliance software for both 1000Base-T1 & 100Base-T1 Transmit tests**
- ❖ **Protocol trigger & decode software**
- ❖ **MDI S-parameter software**
- ❖ **All software, accessories and necessary hardware are structured under one model number.** (NOTE: both accessories and hw are optional)

Hardware configurations are different for different tests

- Transmitter general setup = scope + compliance software + Ethernet test fixture
- Transmitter Power spectral Density test = scope+ optional SA + Ethernet test fixture
- Transmitter Return loss test = scope + ENA + Ethernet test fixture
- Transmitter distortion test = scope + AWG + Freq divider card + Ethernet test fixture

Why Buy?

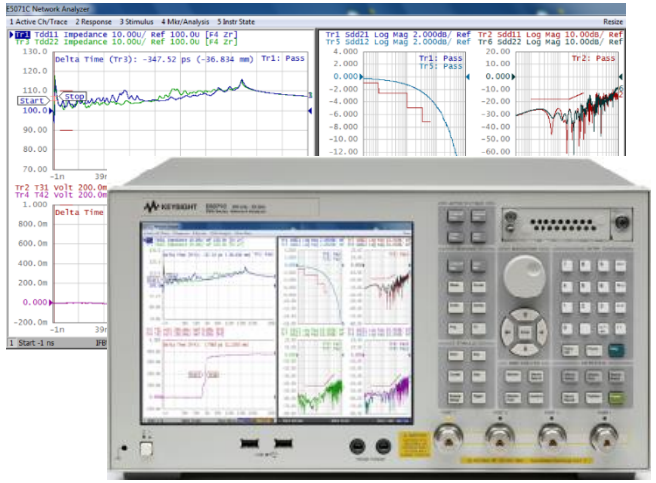
- ❖ **To ensure compliance to 100Base-T1 or 1000Base-T1 IEEE standards**
- ❖ **Easy to follow test setup and configuration directions**
- ❖ **Pass/Fail report with margin analysis**
- ❖ **Save time for other tasks**

KEYSIGHT TECHNOLOGIES

Keysight Automotive Ethernet Link Segment Solution

What is it? Why Buy?

Link Segment



What is it?

- ❖ **Compliance software for 100Base-T1 Link segment**
- ❖ **All software, accessories and necessary hardware are structured under one model number.** (NOTE: both accessories and hw are optional)

Hardware configurations

- Software runs on an ENA – E5071C

E6963A Automotive Ethernet Link Segment

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

Solution Components (orderable under one part number)

- ENA Vector Network Analyzer
- Cables and adapters
- Software

Why Buy?

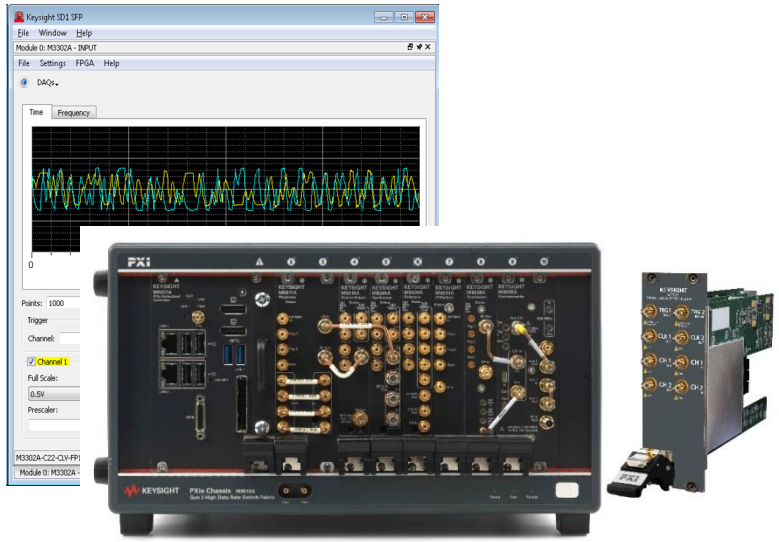
- ❖ **To ensure compliance to 100Base-T1 Link segment tests**
- ❖ **Save time from the manual calculation and extra work , configuration and testing up to 20 ports**
- ❖ **Easy to follow test setup and configuration directions**
- ❖ **Pass/Fail report with margin analysis - taking the manual error out**

KEYSIGHT TECHNOLOGIES

Keysight Automotive Ethernet Rx Solution

What is it? Why Buy?

Receiver



What is it?

- ❖ **Compliance software for 100Base-T1 Receiver tests**
- ❖ **Software, accessories and necessary hardware are structured under one model number.** (NOTE: both accessories and hw are optional)

Hardware configurations are different for different tests

- PXIe hardware
- Software runs on and controls PXIe instrumentation

E6962A Automotive Ethernet Receiver

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

Solution Components (orderable under one part number)

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

Why Buy?

- ❖ **To ensure compliance to 100Base-T1 BER requirements**
- ❖ **Validation of BER count objectively**
- ❖ **Easy to follow test setup and configuration directions**
- ❖ **Automatically configures all of the required test equipment**
- ❖ **Pass/Fail report with margin analysis**
- ❖ **Save time for other tasks**

KEYSIGHT TECHNOLOGIES

Agenda - what you can expect

What Is Automotive Ethernet?

What Are We Launching?

Product Overview

KEYSIGHT TECHNOLOGIES

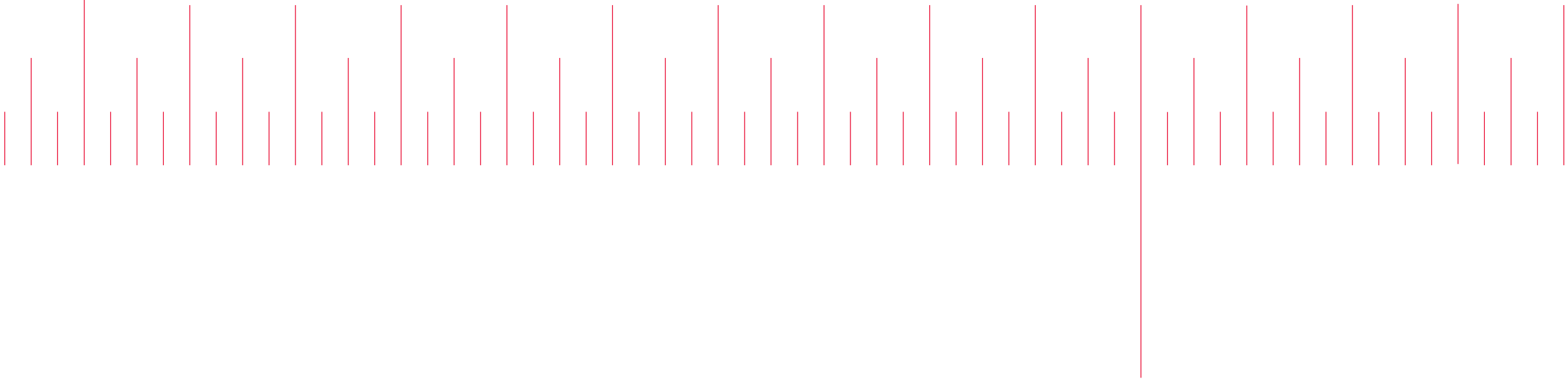
E6961A Automotive Ethernet Tx Compliance Solution

E6960A 1000Base-T1 Tx Compliance Application

N6467A/B BroadR-Reach Compliance Application (100Base-T1 compliant)

N8847A BroadR-Reach Protocol Trigger & Decoder (100Base-T1 compliant)

E6964A BroadR-Reach MDI S-parameter software (100Base-T1 compliant)

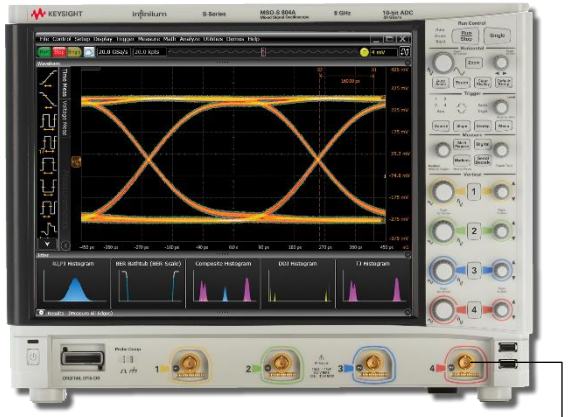


KEYSIGHT TECHNOLOGIES

Tx Test setup N6467A/B and E6960A

Industry's **unique and only** test coverage for protocol as well as compliance

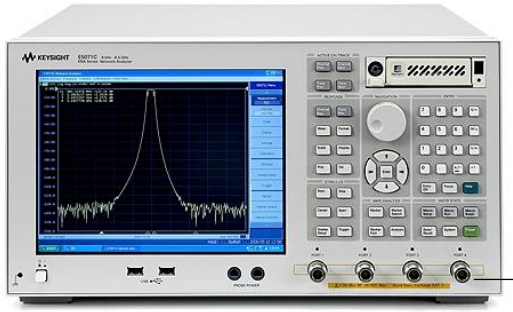
DSOS254A
High-Definition Oscilloscope: 2.5 GHz, 4 Analog Channels, 800 Mpts memory



33622A Waveform Generator, 120 MHz, 2-channel

N9010A EXA
EXA Signal Analyzer: 10 Hz to 44 GHz, -163 dBm DANL @1 GHz

Frequency Divider Board



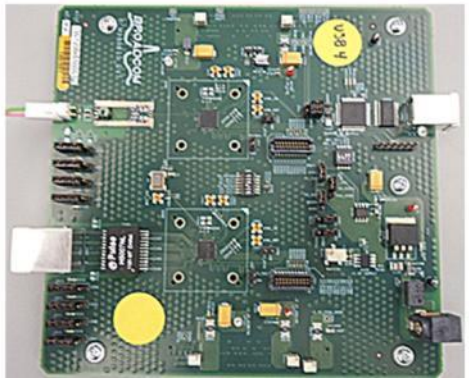
E5071C
ENA Vector Network Analyzer: 5 Hz to 20 GHz

BroadR-Reach cable

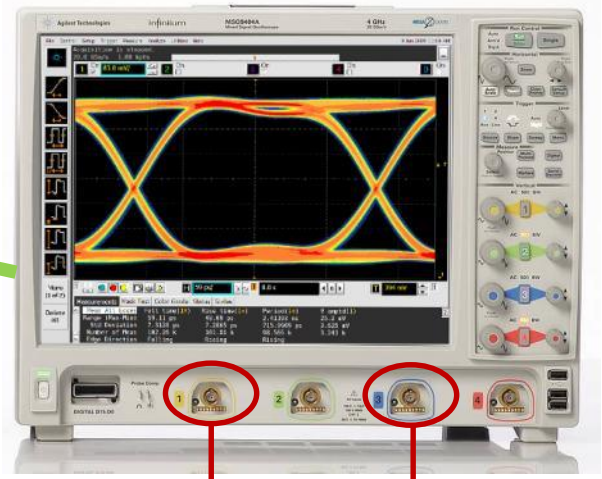
Tx Test setup N6467A/B and E6960A

DSOS254A 2.5 GHz or better

USB Cable from
DUT to scope



DUT



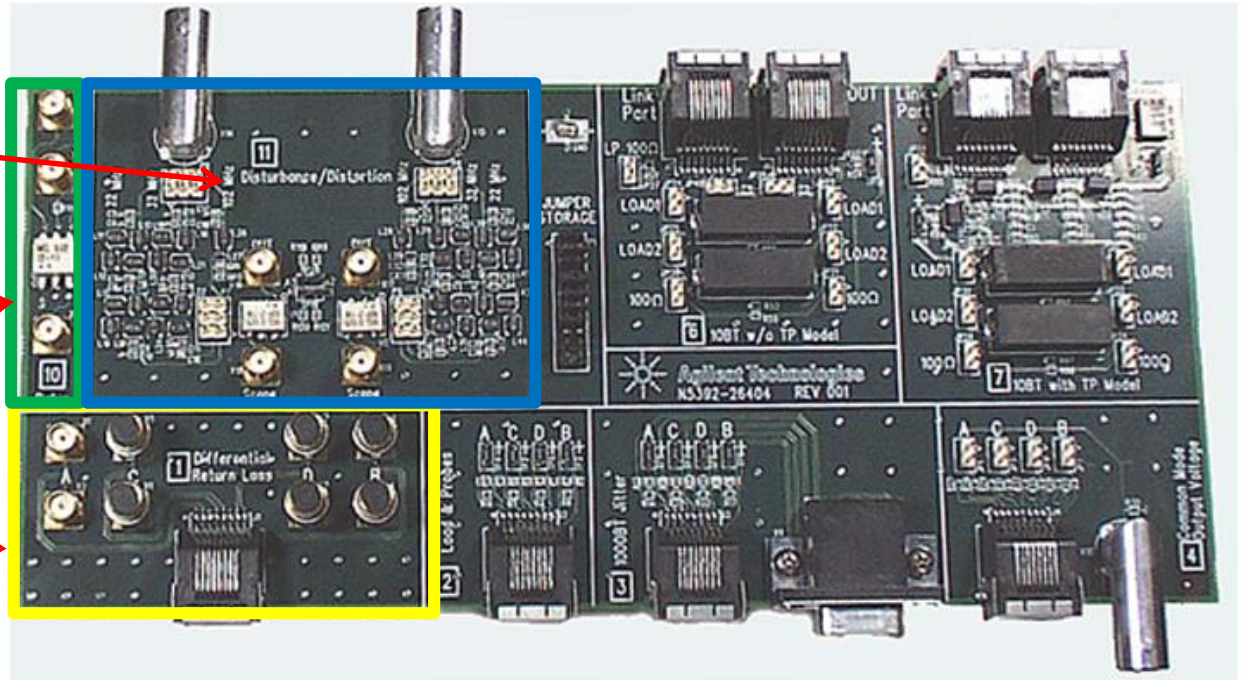
Twisted pair cable from DUT
to connector board

BNC Cables from connector board to scope

Keysight Ethernet Fixture if used for Breakout

- Supports
  - Automotive BroadR-Reach specification
  - 10/100/1000 Ethernet compliance spec
- Includes:
  - Fixture
  - 2 Ethernet Cables
  - Calibration fixture

- Disturbing signal test section (Blue)
- Balun used for Power spectrum density test (Green)
- Break out board used for RJ45 connections (Yellow)



Overview of Transmitter Tests – E6960A

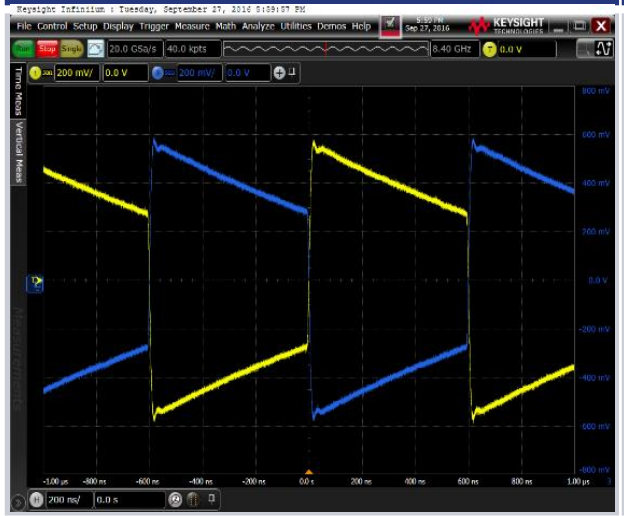
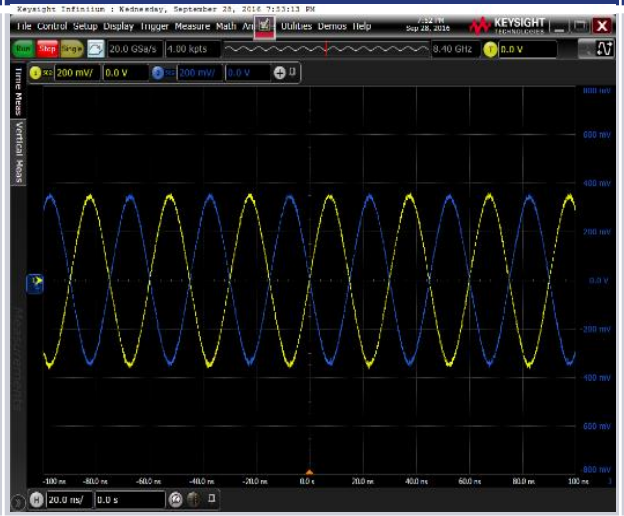
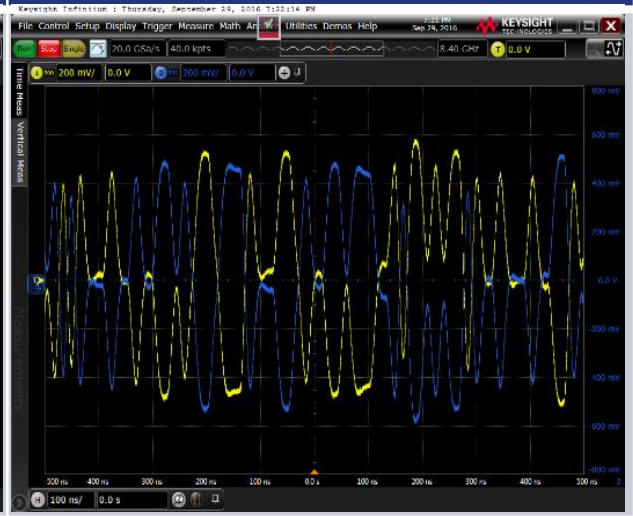
Category	Test mode	Test Items		Measurement Equipment	Keysight model
Transmitter 1000Base-T1 IEEE Std 802.3bp-2016	Test mode 6	97.5.3.1	Transmitter output positive droop	Oscilloscope (2.5GHz or better, 20Mpoints)	DSOS254A or better
	Test mode 1	97.5.3.1	Transmitter output negative droop	Oscilloscope	
	Test mode 4	97.5.3.2	Transmitter distortion	Oscilloscope + AWG	81150A AWG 2 channel
	Test mode 1	97.5.3.3	Transmitter master and slave timing jitter	Oscilloscope	
	Test mode 2	97.5.3.3	Transmitter MDI jitter	Oscilloscope	
	Test mode 5	97.5.3.4	Transmitter Power Spectral Density (PSD) with spectral analyzer	Oscilloscope + Spectrum Analyzer (1GHz)	N9010A (3.6GHz)
	Test mode 5	97.5.3.4	Transmitter Power Spectral Density (PSD) with oscilloscope	Oscilloscope	
	Test mode 4	97.7.2.1	MDI Return Loss	Oscilloscope + Network Analyzer	E5071C ENA Series
	Test mode 5	97.5.3.5	Transmitter Peak Differential Output	Oscilloscope	
	Test mode 1	97.5.3.6	Transmit clock (TX_TCLK125) frequency	Oscilloscope	

Overview of Transmitter Tests – N6467A/B

Category	Test mode	Test Items		Measurement Equipment	Keysight model
Transmitter 100Base-T1 IEEE Std 802.3bw-2015	Test mode 1	5.4.1	Transmitter Output Droop	Oscilloscope (1GHz or better, 20Mpoints)	DSOS254A or better
	Test mode 2	5.2	Transmit Clock Jitter	Oscilloscope	
	Test mode 2 and 3	5.4.3	Transmitter Timing Jitter Master TxOut Jitter (test mode 2) Slave TX-TCLK Jitter (test mode 3)	Oscilloscope + AWG	+81150A AWG 2 channel
	Test mode 4	5.4.2	Transmitter Distortion	Oscilloscope	
	Test mode 4	8.2.2	MDI Return Loss	+Vector Network Analyzer	+ E5071C ENA Series
	Test mode 5	5.4.4	PSD (Power Spectral Density)	Oscilloscope + Spectrum Analyzer (1GHz)	+N9010A (3.6GHz)
	Test mode 5	96.5.6 (NEW)	Transmitter Peak Differential Output	Oscilloscope	

NOTE: Basic test setup includes an oscilloscope 1 GHz or better. Additional instrumentation is required as indicated.

Test Signals

Test Mode 1	Test Mode 2	Test Mode 4	Test Mode 5
			
• Maximum Transmitter Output Droop	• Transmitter Timing Jitter • Transmit Clock Frequency	• Transmitter Distortion	• Transmitter Power Spectral Density • MDI Return Loss • MDI Mode Conversion Loss

- Test signals are mandatory for transmitter test (Test Mode 1, 2, 4, 5)
- Test signals can be transmitted by setting register

5.4.3 Transmitter Timing Jitter (Master)

- Spec

  J_{TXOUT} < 50ps

- Test Pattern

  Test Mode 2

- Test Procedure

- Measuring Jitter (RMS) between Test Mode 2 and unjittered reference.
- Scope Setting
  - ✓ Sampling Rate : 20GSa/s, Memory : 20M points
- Acquisition time is at least1ms. Repeat test 3 times for accuracy

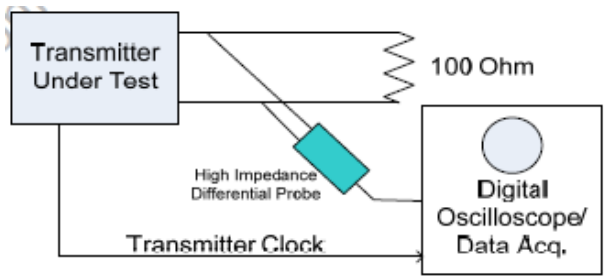
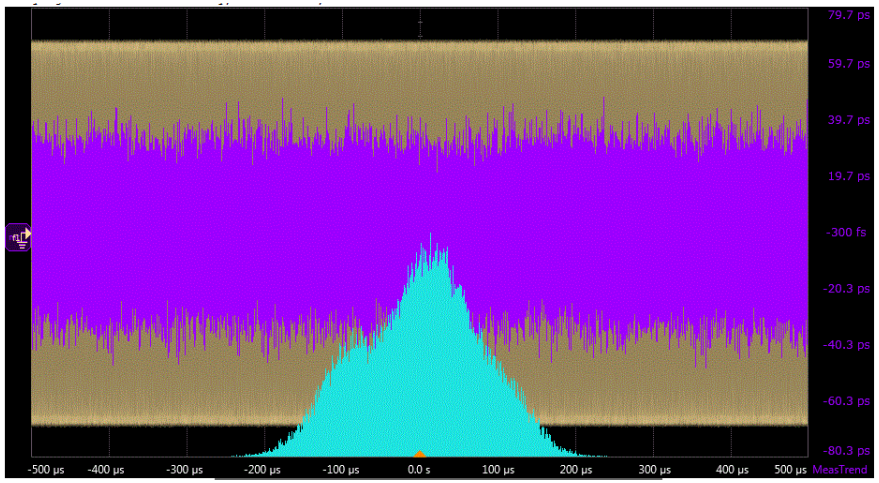


Figure 5.1 Transmitter Test Fixture 1: Droop, Jitter



5.4.3 Transmitter Timing Jitter (Slave)

- Spec

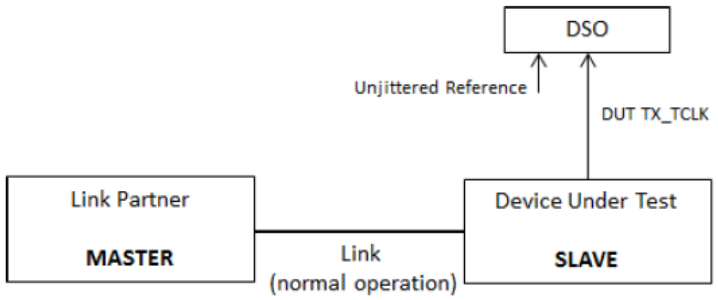
  J_{TXOUT} < 0.01UI (Unit Interval) (equivalent to 150ps)

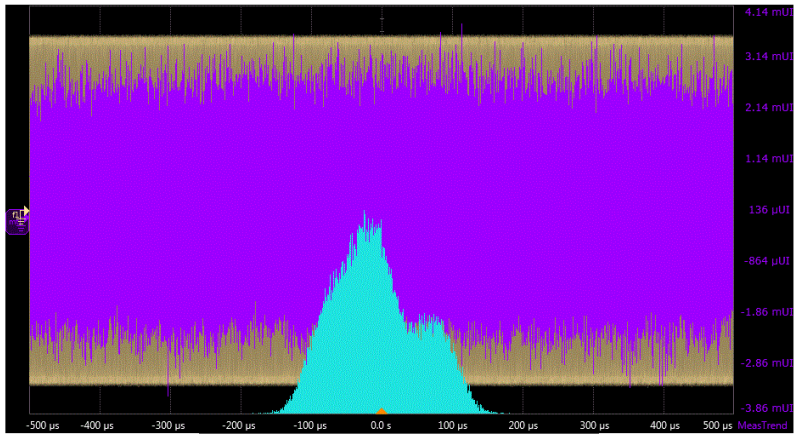
- Test Pattern

  Test Mode 3

- Test Procedure

- Measuring Jitter (RMS) between Test Mode 2 and unjittered reference.
- Scope Setting
  - ✓ Sampling Rate : 20GSa/s, Memory : 20M points
- Acquisition time is at least 1ms. Repeat test 4 times for accuracy.
- If DUT does not provide access to TX_CLK, testing cannot be performed.





5.4.2 Transmitter Distortion

- Spec
  Peak Distortion < 15mV

- Test Pattern
  Test Mode 4

- Test Procedure

- Calculating the least mean squared error for the peak error between the ideal reference and observed symbols.
- Using Matlab to process the 2ms captured waveform.
- Calculate the peak distortion at 10 uniformly spaced phase offset over 1 symbol perio

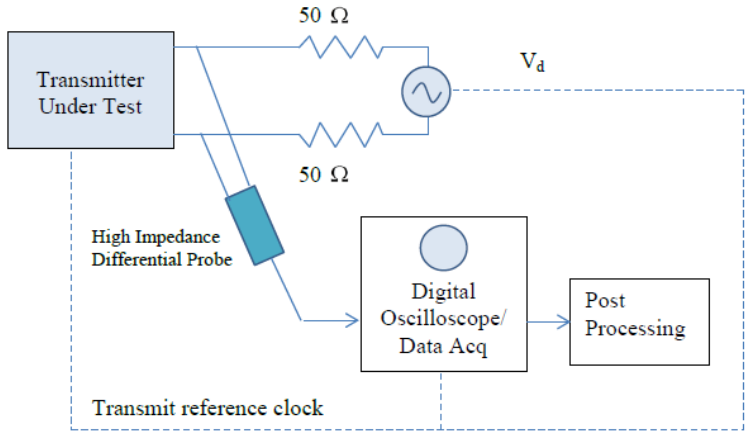
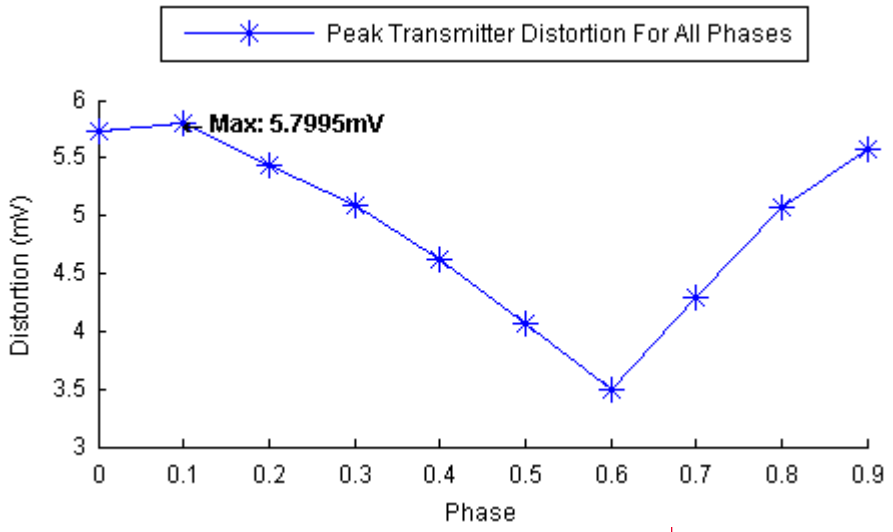
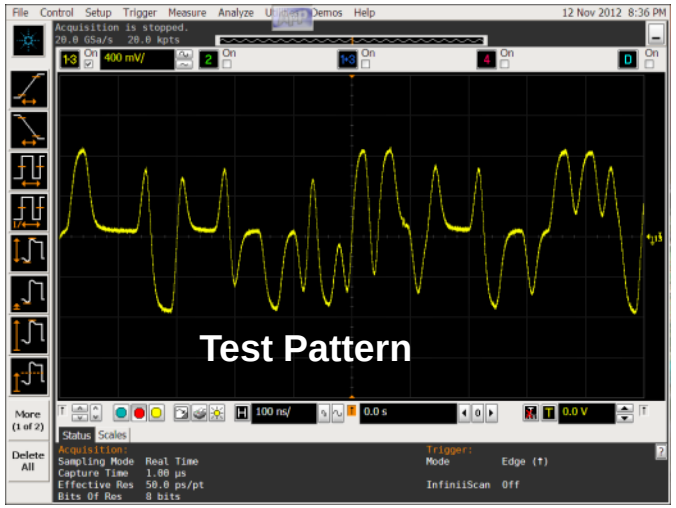


Figure 5-2 Transmitter Test Fixture 2: Distortion



5.4.2 Transmitter Distortion (cont)

- This test requires the test equipment (disturber and oscilloscope) to be synchronized with DUT's TX_CLK to guarantee internal sampling clock shares a common clock source and is phased locked
- If TX_CLK is not accessible, distortion testing will be tested without test equipment synchronization



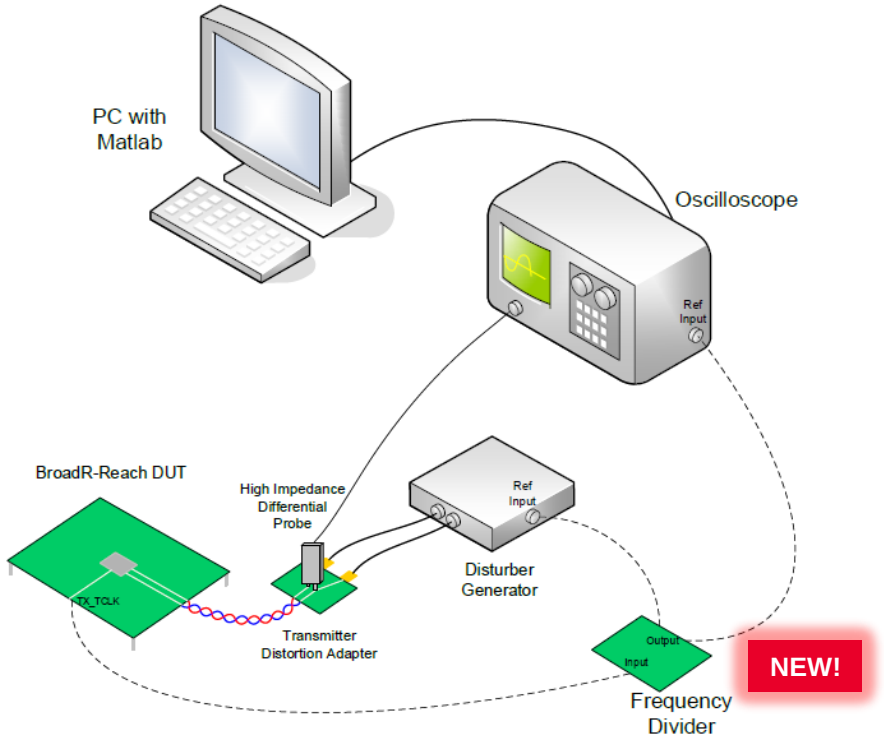
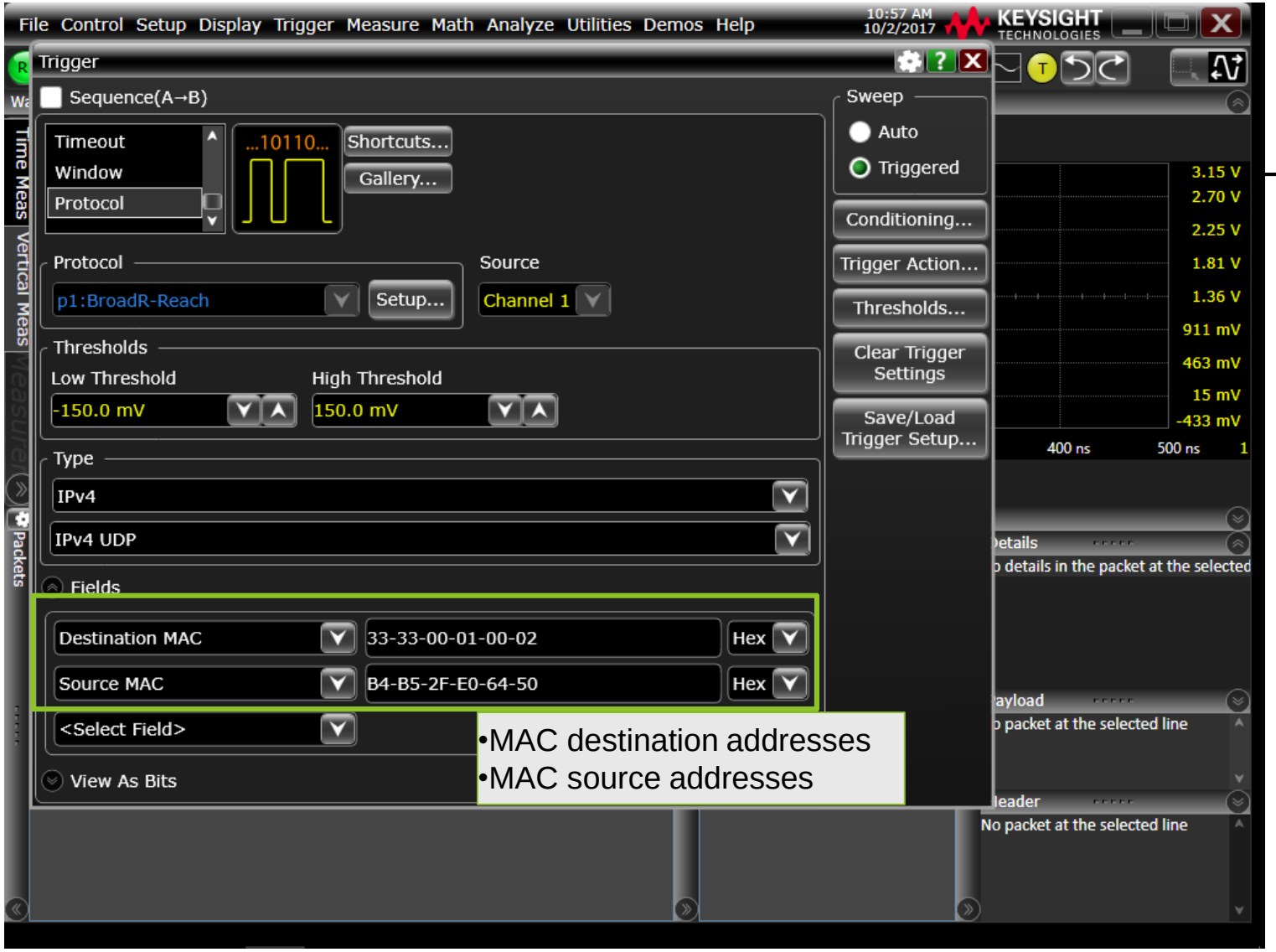
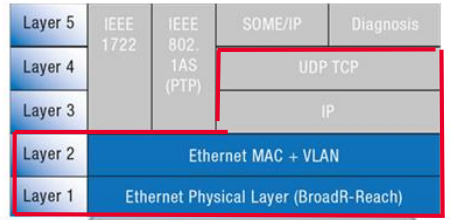


Figure A.5: Distortion Test Setup (Test Fixture 2)

N8847A can Trigger on a specific event

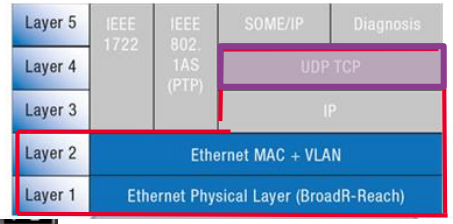




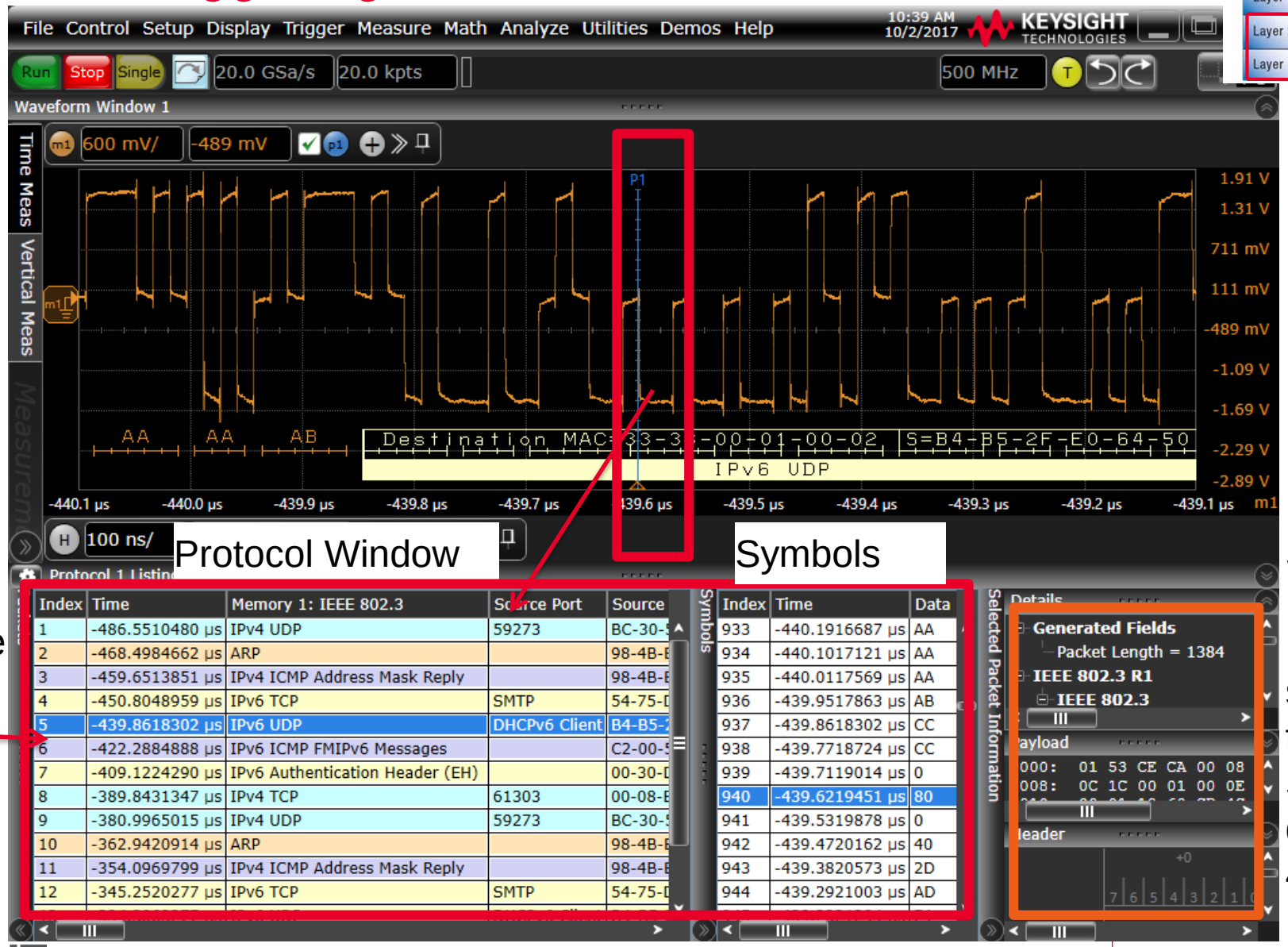
N8847A can Decode, Trigger and Search

- 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

N8847A Protocol Triggering & Decode



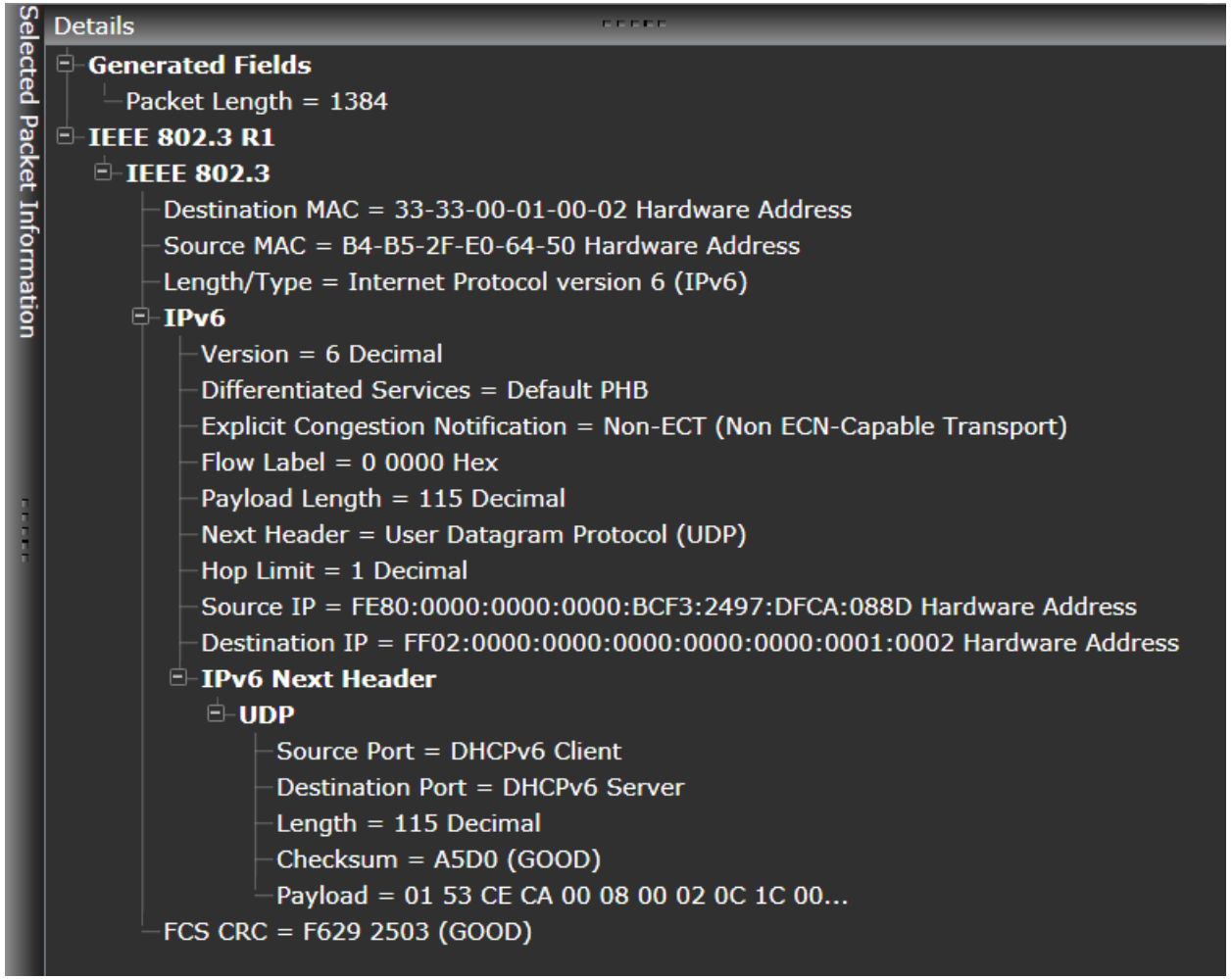
Blue marker in the Waveform window that time correlates the waveform with the Packets and Symbols Listing

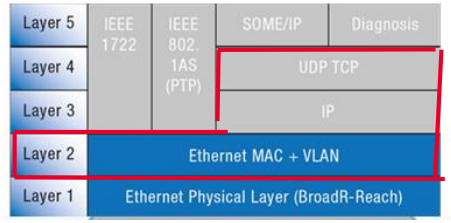


Selected Packet Details Payload/Header - showing layer 4 in the PHY stack
Symbols are 3B4B data
4B data is

Packet Details

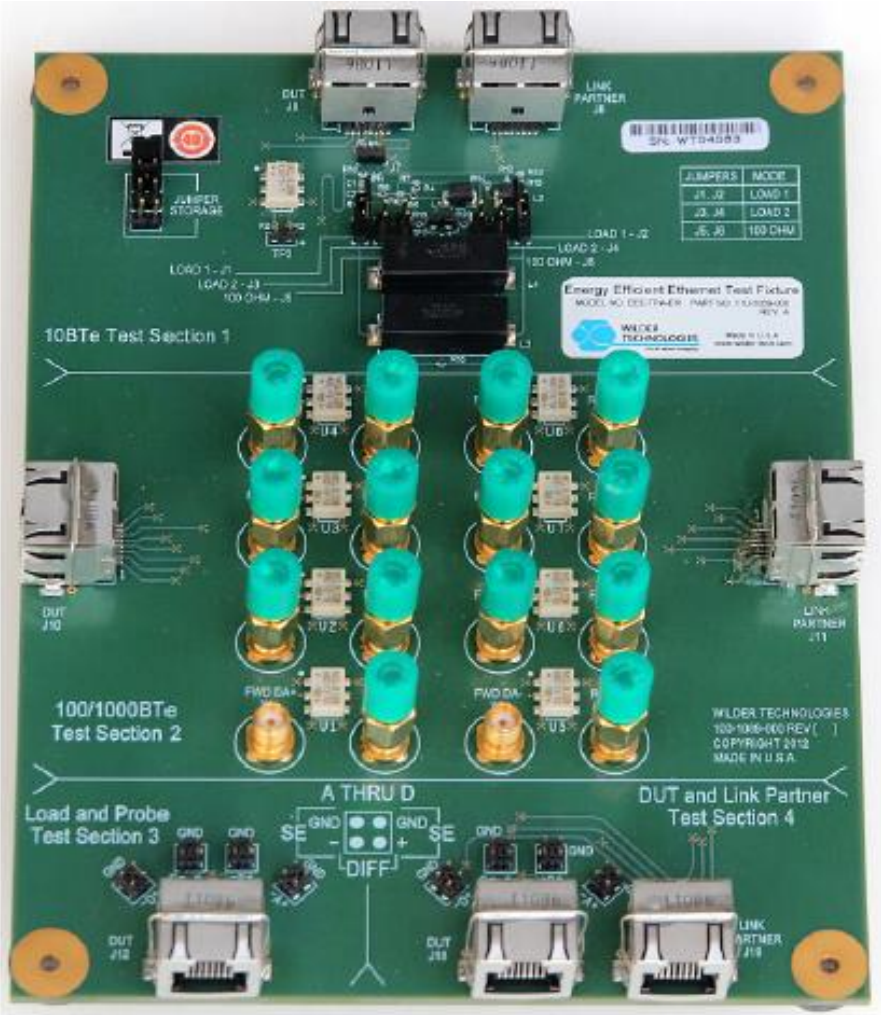
Details of OSI layers 2, 3, and 4

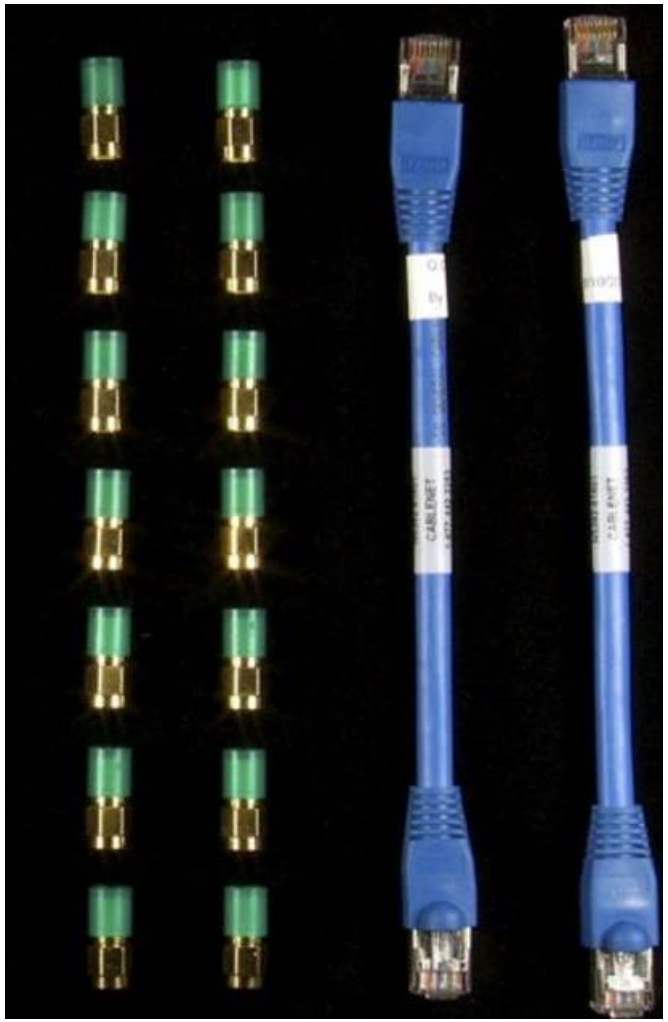




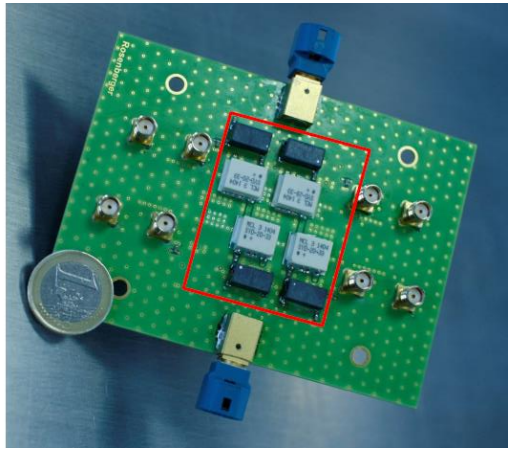
Protocol Triggering & Decode

Must decode one direction at a time





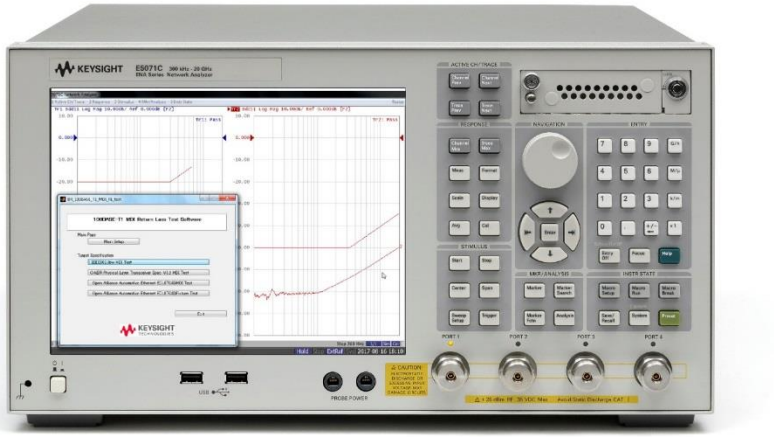
Wilder Technologies 110-1089-000 EEE Electrical Compliance Test Fixture used to breakout the bidirectional signals



Other methods of breakout are also acceptable ie Rosenberger cable adapter

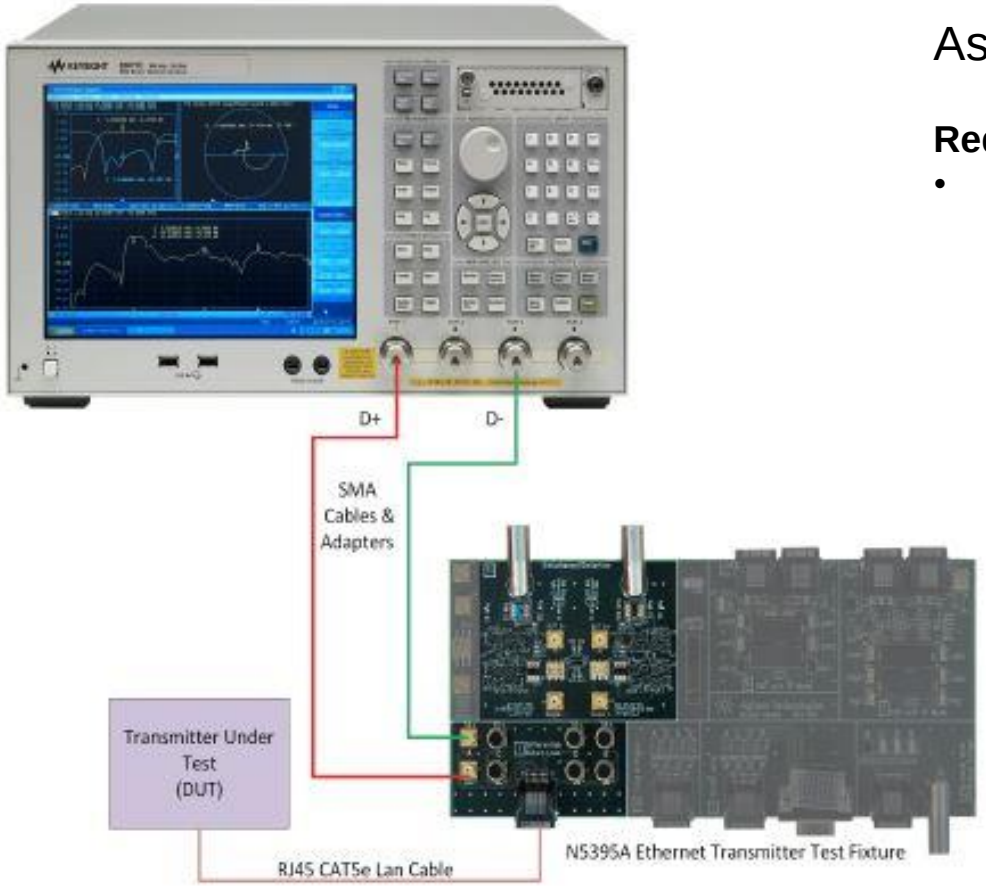
Overview of MDI S-parameter Test – E6964A

Target Specification	Parameter	Measurement Equipment	Keysight model
IEEE802.3bw MDI Test	96.8.2.1, 96.8.2.2	Vector Network Analyzer	E5071C ENA Series
OABR Physical Layer Transceiver Spec. V3.2 MDI Test	8.2.2		
Open Alliance Automotive Ethernet ECU(TC8)	OABR_PMA_TX_05, OABR_PMA_TX_06		



E6964A MDI S-parameter test

Typical test setup



As described in 100Base-T1 MDI transceiver tests.

Required Equipment

- E5071C ENA Series Network Analyzer
  - Option 480 or 485 (8.5 GHz) / 4D5 (14 GHz) / 4K5 (20 GHz)
  - ENA Firmware Revision B.13.30 or later

Accessories

- N5395C Ethernet Test Fixture for use with RJ45 connectors

(*For custom connectors, the user needs to provide fixtures.)*

- 2-port or 4-port ECal Module
  - N4431B, N4691B (for E5071C-480/485)
  - N4433A, 85093C (for E5071C-4D5/4K5)
- Coaxial Adapters and RF cables (2/ea.)

E6964A MDI S-parameter test

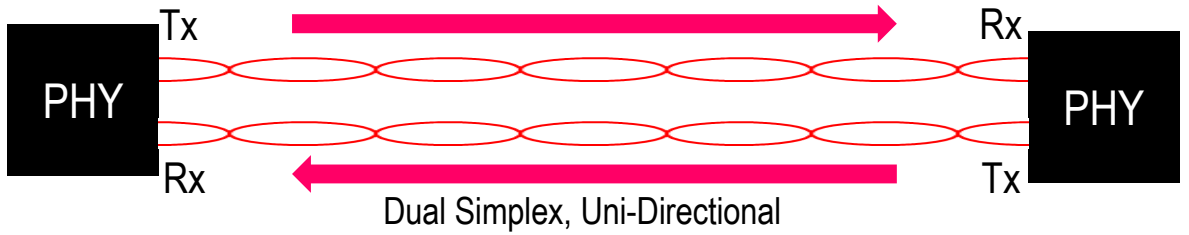
Typical test result

What the ENA display shows

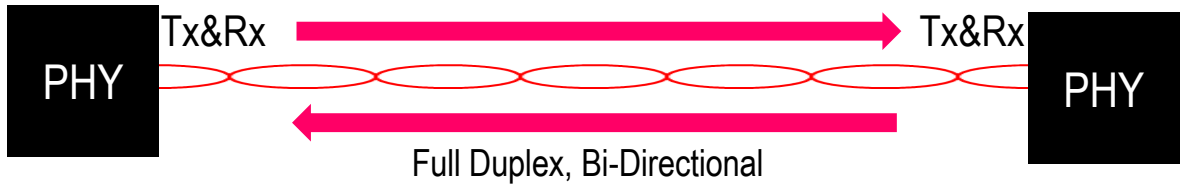
Sdd11 and Sdc11 test result example

Automotive Ethernet Waveform Separation Solution

Normal Ethernet 100BASE-TX

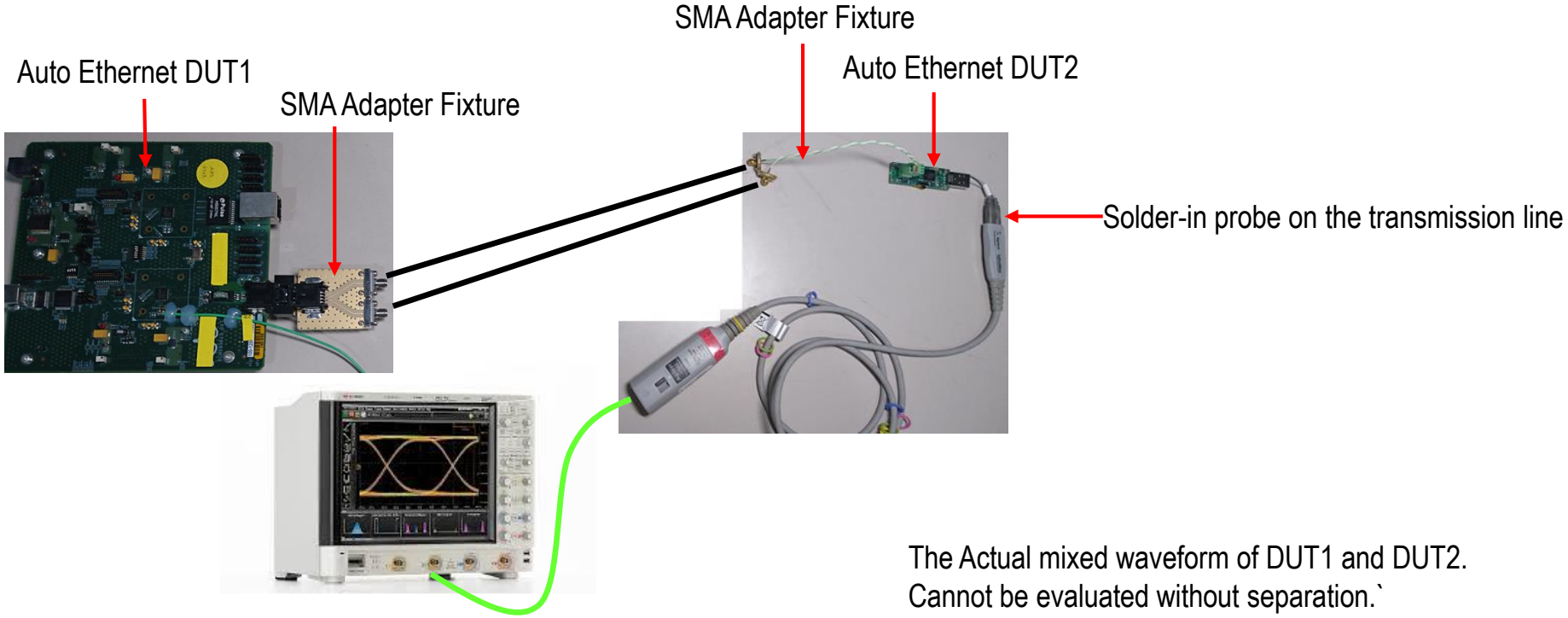


Automotive Ethernet 100BASE-T1

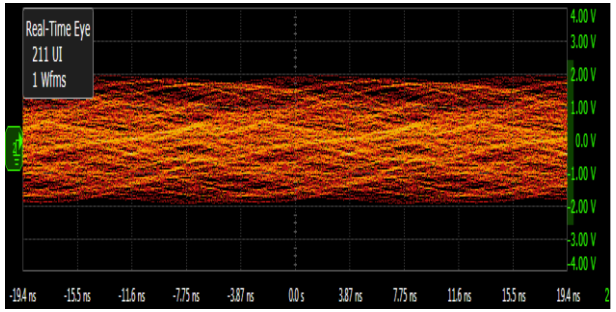


Automotive Ethernet signals are transmitted in both directions simultaneously on a single-pair cable. That's why the Automotive Ethernet waveform observed on the scope is chaotic.

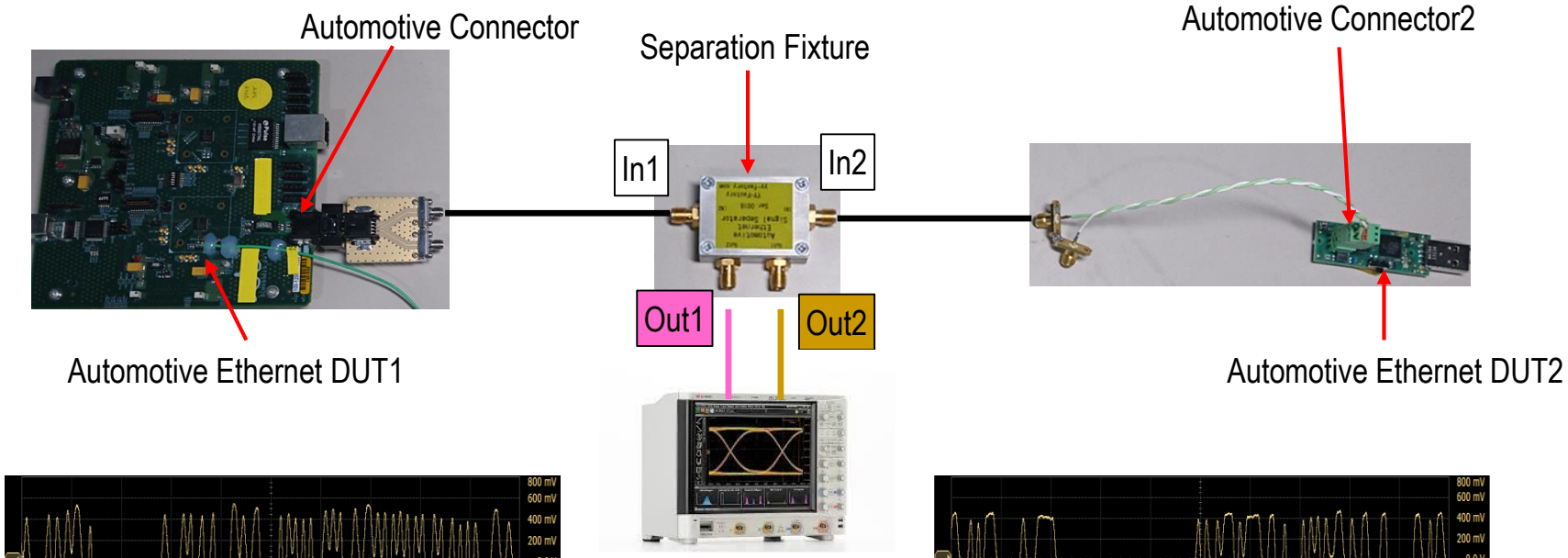
Automotive Ethernet Waveform Separation Solution – Cont.

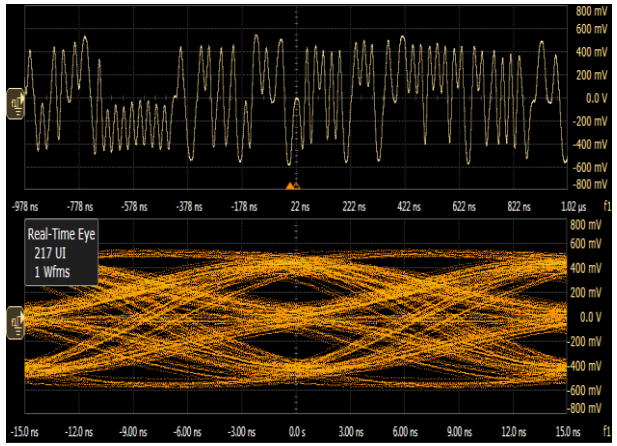


The Actual mixed waveform of DUT1 and DUT2.
Cannot be evaluated without separation.`

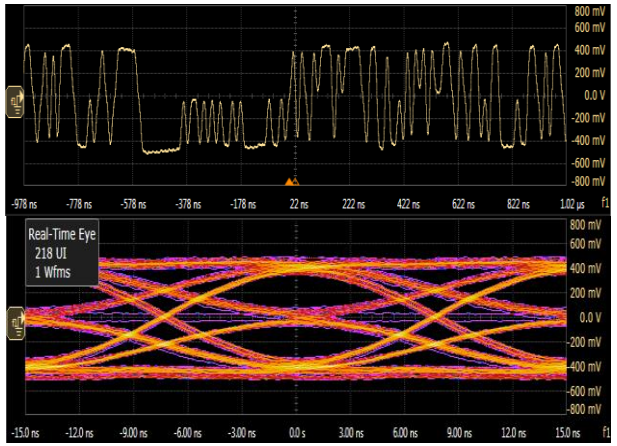


Automotive Ethernet Waveform Separation Solution – Cont.





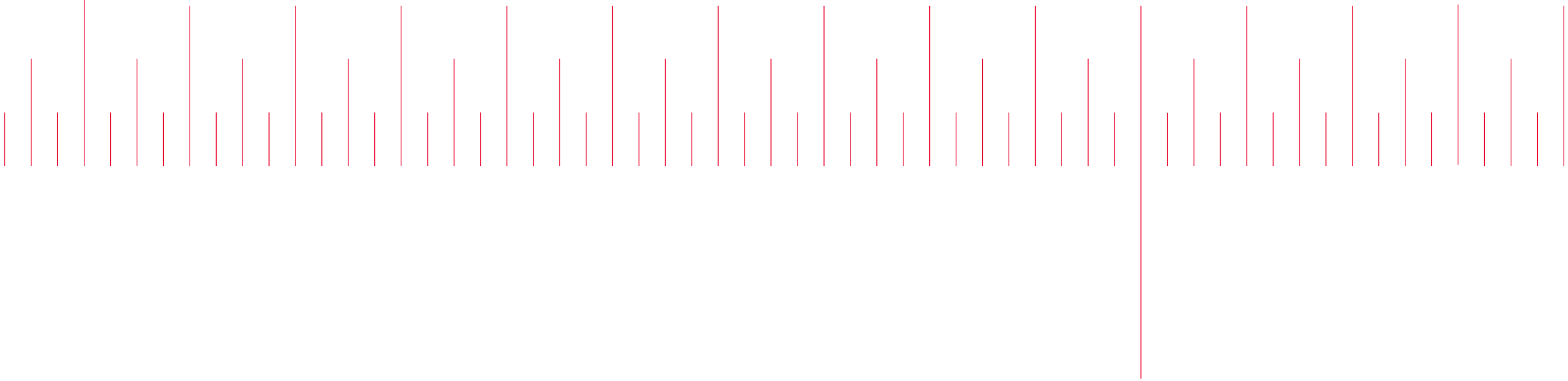
Waveform and Eye Pattern of DUT1



Waveform and Eye Pattern of DUT2

DUT1 and DUT2 waveforms successfully separated

E6962A Automotive Ethernet Rx Compliance Solution

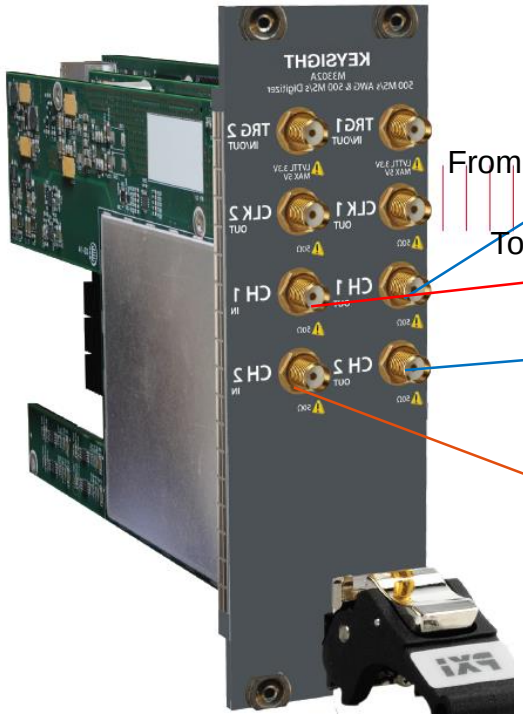


KEYSIGHT TECHNOLOGIES

Receiver Test – E6962A Bit Error Rate Verification

Target Specification	Parameter	Keysight model
IEEE802.3bw 2015	96.5.5.1	PXIe chassis, controller and M3302A AWG and digitizer
Open Alliance BroadR-Reach Physical Layer Transceiver Specification for Automotive Application V3.2 June 24, 2014	5.5.1	
Open Alliance Automotive Ethernet ECU Test Specification (TC8 ECU and Network Test) January 15, 2016	OABR_PMA_RX_01	

E6962A Receiver Test Setup



M3302A Combo Module

11636B Power Splitter

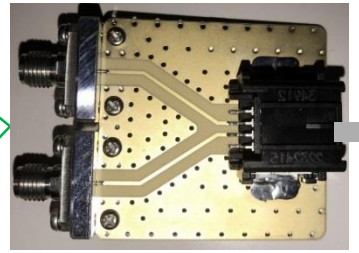
From AWG D+

To DIG D+

From AWG D-

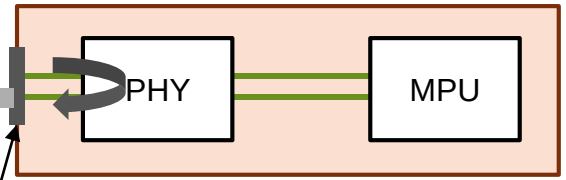
To DIG D-

11636B Power Splitter



Example of Custom Test Fixture

Wire Harness (15m)



Custom Test Fixture

DUT

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

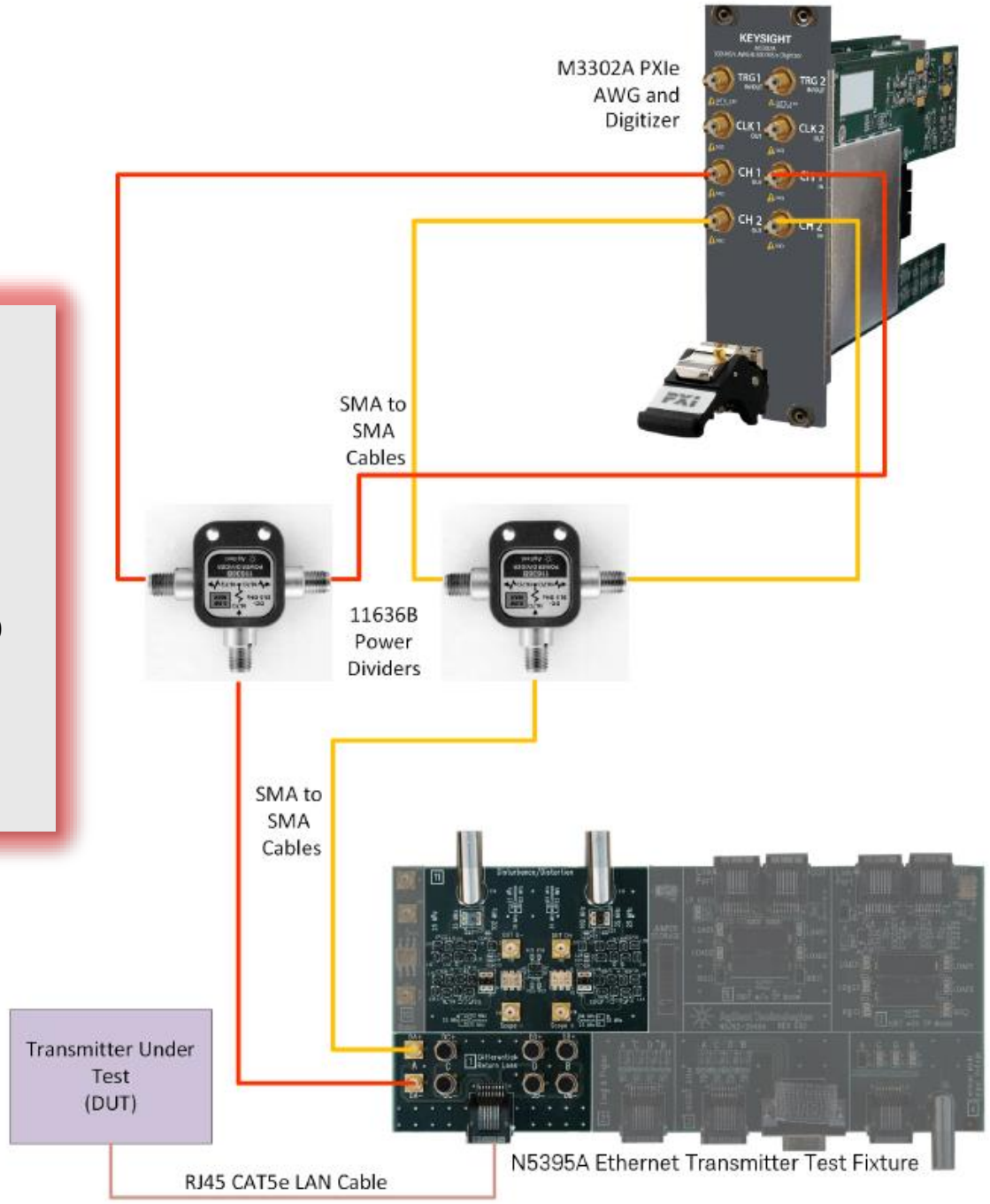
E6962A Receiver Test

Typical test setup and Benefit

Benefits:

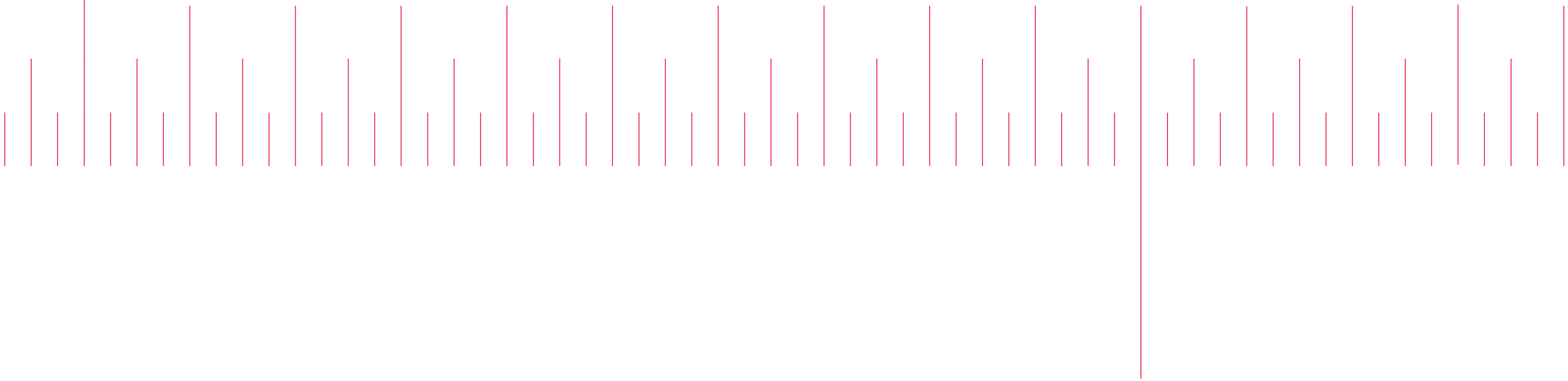
- Simplifies receiver compliance testing.
- Automatically configures all of the required test equipment reducing the overall test time.
- Diagrams to show you how to make connections to the device under test.
- Creates a printable pass/fail HTML report with margin analysis

E6962A can make ‘true’ BER test



KEYSIGHT TECHNOLOGIES

E6963A Automotive Ethernet Link Segment Compliance Solution

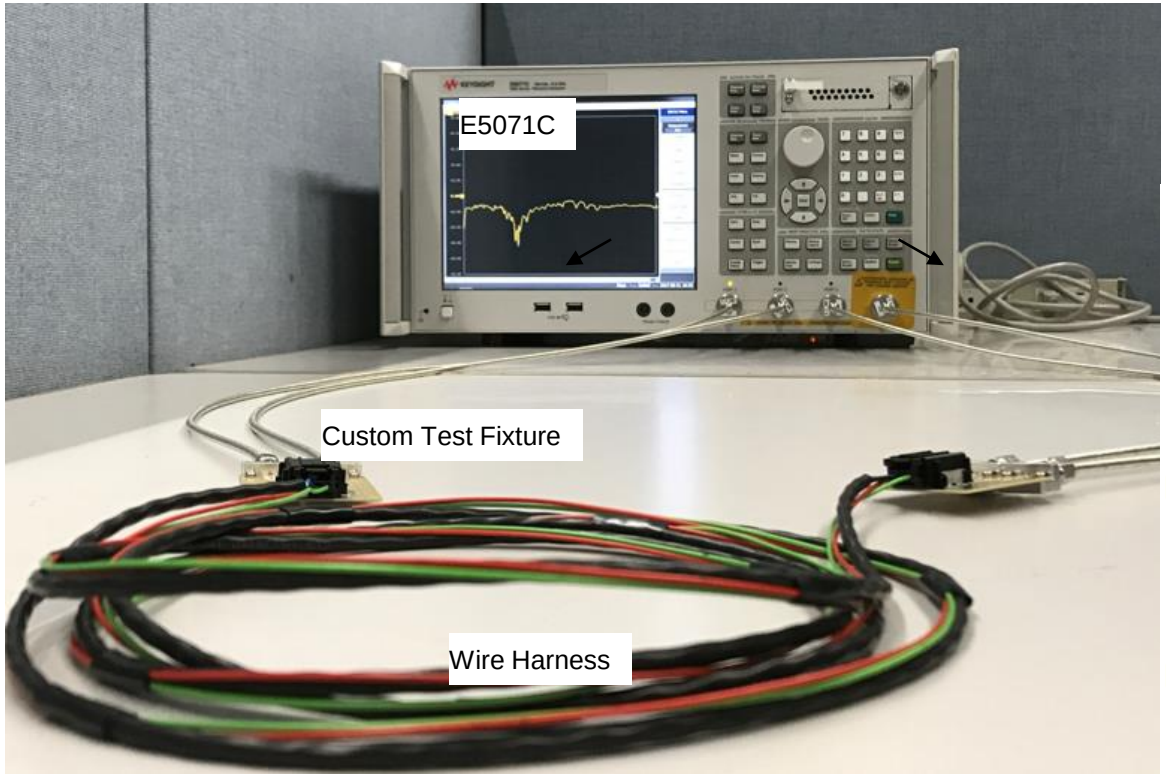


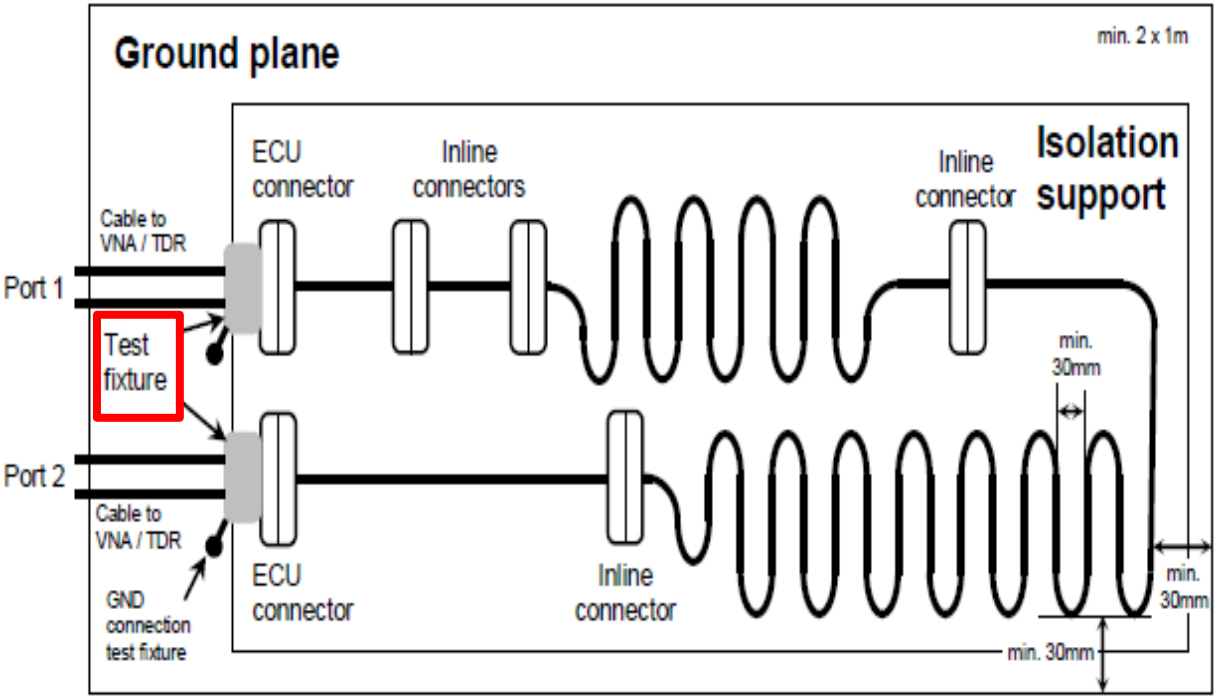
KEYSIGHT TECHNOLOGIES

Overview of BroadR-Reach Link Segment Software – E6963A

Target Specification	Parameter	Measurement Equipment	Keysight model
BroadR Reach 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*	E5071C ENA Series opt TDR
	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		

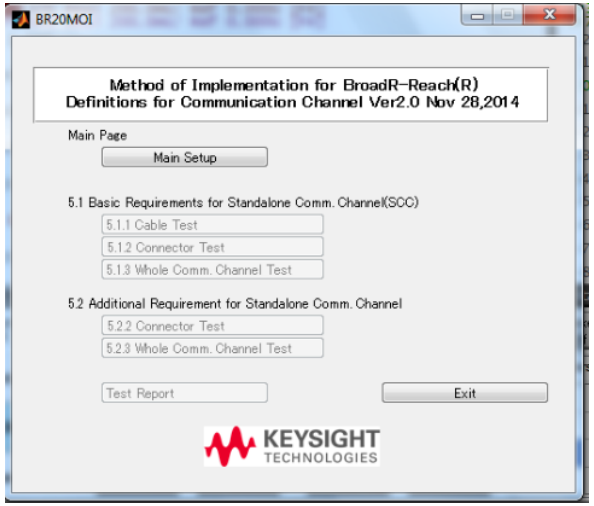
Test Setup for Harness Connector Test



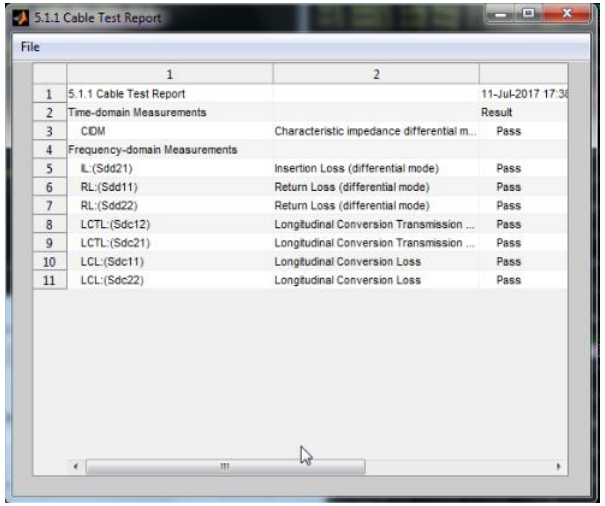


Compliant Test Configuration

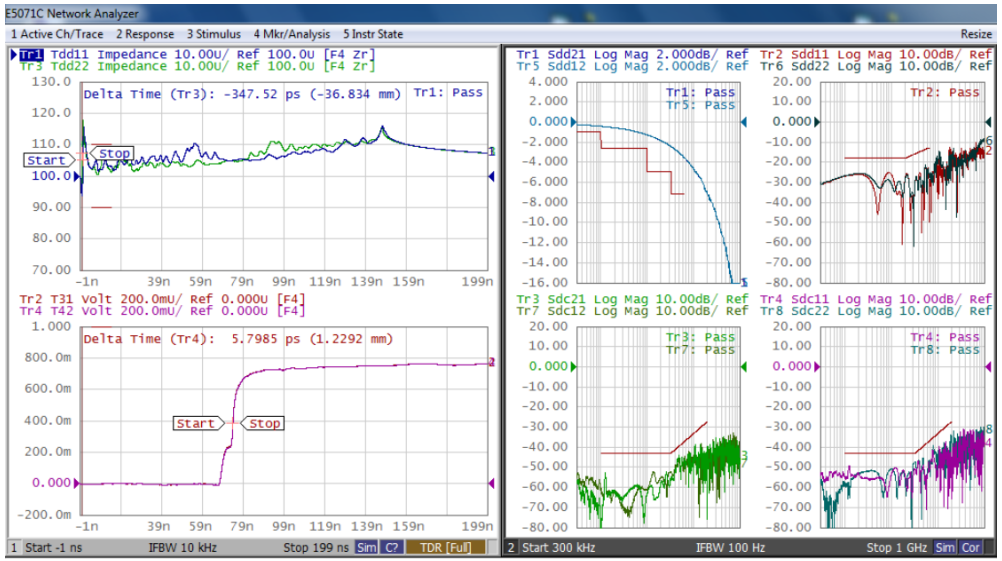
GUI and Report Sample



Main Control Window



Test Report Example – Pass/Fail List



Test Result Example – E5071C screenshot of limit test

- 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 file
  - ✓ Csv file
  - ✓ Screenshot
- Automated VNA setting

KEYSIGHT TECHNOLOGIES

Back up slides

E6961A ordering information

BroadR-Reach Tx Solution (100Base-T1 compliant)

1 Order Software

			Used for what tests			
	Option name	**Description**	**N6467B BroadR-Reach compliance**	**E6960A 1000Base-T1 compliance**	**N8847A Protocol**	**E6964A MDI S-parameter**
Required must order one of	E6960A-1FP	1000BaseT1 Transmitter Compliance Application fixed perpetual license		x		
	N6467B-1FP	BroadR-Reach compliance software, fixed perpetual license	x			
Optional Apply only to N6467B	N8847A-1FP	BroadR-Reach Protocol Triggering & Decode Software fixed perpetual license			x	
	E6964A-1FP	BroadR-Reach MDI S parameter software fixed perpetual license				x

E6961A ordering information - continued

BroadR-Reach Tx Solution (100Base-T1 compliant)

2 Order Accessories

	Option name	Description	Used for what tests			
			N6467B	E6960A	N8847A	E6964A
Required	E6961A-AEB (bundle of fixtures and cables)	SMA Cable - SMA(m) -SMA(m) x 2 Adapter, N-Type (M) to SMA (F) 1250-1250 x 2 Ethernet test fixture N5395C	x	x		
		Frequency Divider Board PCB E6960-26600	x	x		
			Transmitter distortion test			
Optional	E6961A-EEE	Energy efficient Ethernet test fixture EEE-TPA-ERK			x	
			Used to remove one direction of the bidirectional signal			
Required	E6961A-MDI	Bundle accessories for MDI S-parameter testing includes; SMA cable x2, adapter coaxial straight to APC x4				x
			A total of 4 SMA cables is needed for E6964A, also order E6961A-AEB			
Required	E6961A-PRO	Oscilloscope probe and probe head, 1131B InfiniiMax Probe 3.5 GHz E2678B probe head	x	x		
Optional	E6961A-ECL	RF Electronic calibration module, 4 ports (Ecal) N4431B (ECal), 9 kHz to 13.5 GHz, 4-port with N4431-010	x	x		x
			Used to calibrate the network analyzer			
Optional	E6961A-USB	82357B USB/GPIB Interface High-Speed USB 2.0	x	x		
			Used for MDI S-parameter to control ENA from Oscilloscope			

E6961A ordering information - continued

BroadR-Reach Tx Solution (100Base-T1 compliant)

3 Order Hardware ***Note**: it is optional to order the hardware through the E6962A however it is necessary to have this equipment to fully test compliance*

	Option name	Description	Used for what tests			
			N6467B	E6960A	N8847A	E6964A
Optional	E6961A-AWG	81150A Pulse Function Arbitrary Noise Generator, 2 channel	X	X		
			Transmitter distortion test			
	E6961A-ENA	E5071C ENA Vector Network Analyzer, options 440,810, 820	X	X		X
			MDI S-parameter			
	E6961A-OSC	DSOS254A Oscilloscope: 2.5 GHz, 4 analog channels	X	X	X	
	E6961A-EXA	N9010A EXA Signal analyzer , 10 Hz to 44 GHz with option 503 and FSA	X	X		
			Power spectral density test			

E6962A ordering information

BroadR-Reach Rx Solution (100Base-T1 compliant)

1 Order Software

Option name	Description
E6962A-1FP	BroadR-Reach Receiver Compliance Application fixed perpetual license
E6962A-1TP	BroadR-Reach receiver compliance software, transportable license

2 Order Accessories

Option name	Description
E6962A-PWD	Power Divider, 3.5 mm (f), DC to 26.5 GHz
E6962A-SMA	Cable , SMA(m) -SMA(m) x 4

3 Order Hardware

***Note**: it is optional to order the hardware through the E6962A however it is necessary to have this equipment to fully test compliance*

Option name	Description
E6961A-AWG	PXIe chassis and filler panels, M9010A, Y1212Ax2, Y1213Ax2
E6962A-PXC	M9037A PXIe High Performance Embedded Controller, Memory, 16GB, Windows Embedded Standard 7 (64 bit) M9037A, M9037A-M16, M9037A-WE6
E6962A-PXD	M3302A PXIe AWG and Digitizer Combination with sampling clock, FPGA and HVI programming memory and FPGA M3302A, M3302-C22, M3302-CLV, M3302-FP1, M3302-HV1, M3302-K41, M3302-M20
E6962A-CBL	Cables for the monitor
E6962A-KYM	Keyboard and mouse

E6963A ordering information

BroadR-Reach Link Segment Solution (100Base-T1 compliant)

1 Order Software

Option name	Description
E6963A-1TP	BroadR-Reach Link Segment Application transportable license
E6963A-1FP	BroadR-Reach Link Segment Application fixed perpetual license

2 Order Accessories

Option name	Description
E6963A-APC	Adapter, Straight APC (M)- APC(F) x 4
E6962A-SMA	Cable , SMA(m) -SMA(m) x 4

3 Order Hardware

Option name	Description
E6963A-ENA	E5071C ENA Vector Network Analyzer with option TDR, 440, 820 and 810

***Note**: it is optional to order the hardware through the E6963A however it is necessary to have this equipment to fully test compliance*

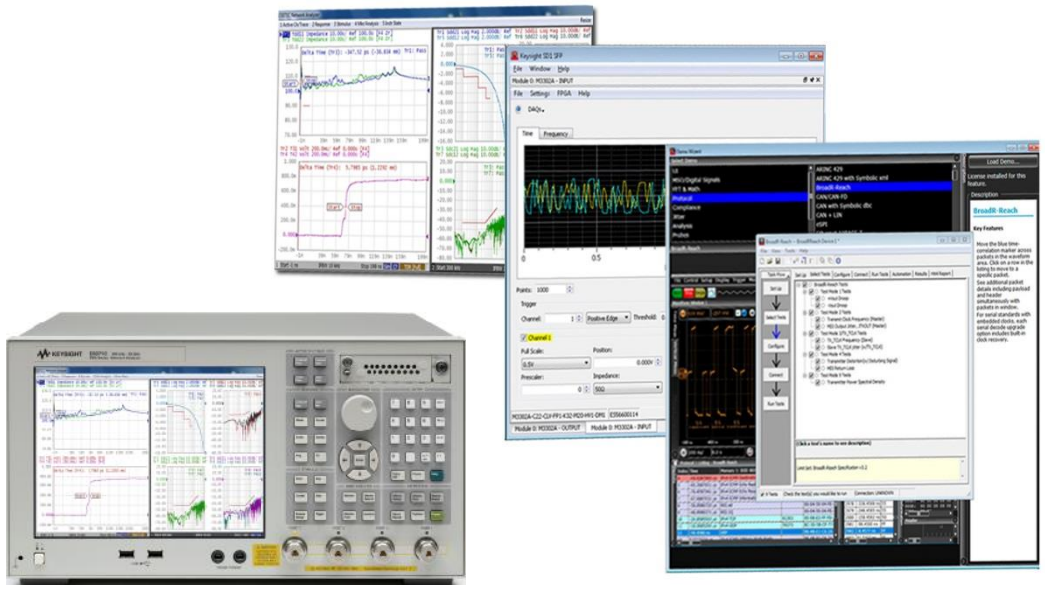
Automotive Ethernet Standards: 100Base-T1 vs. 1000Base-T1

	BroadR-Reach	100BASE-T1	1000BASE-T1
IEEE Standard	n/a	802.3bw-2015	802.3bp-2016
Transmissions Speeds	100 Mb/s	100 Mb/s	1000 Mb/s
Cable	Single unshielded twisted pair , full duplex	Single Balanced Unshielded Twisted Pair, full duplex 15m	Single Balanced Unshielded Twisted Pair Cable
Cable Type	CAT 5	CAT 5	CAT 5e
Disturbing Signal (TM4)	5.4 Vpp @ 11.11 MHz	5.4 Vpp @ 11.11 MHz	3.6 Vpp @ 125 MHz
PHY Signal	PAM3 @ 33.3 MHz	PAM3 @ 66.667 Mb/s	PAM3 @ 750 Mb/s

Background to Solution Launch

Nov. 2011	OPEN (One Pair EtherNet) Alliance is formed to encourage Ethernet-based networks as the standard in automotive networking applications
Dec. 2011	BroadR-Reach, invented by Broadcom, is officially released
…in the meantime…	OABR (OPEN Alliance of BroadR-Reach) encourages adoption of automotive Ethernet using the BroadR-Reach technology
Oct. 2015	100 Mbit/s Ethernet for automotive applications is standardized as IEEE 802.3bw with the terminology 100Base-T1*, a little more strict than BroadR-Reach specs*
…in the meantime…	OPEN Alliance, no longer specific to Broadcom's BroadR-Reach, continues to promote automotive Ethernet and to work with IEEE to complete new standards for even greater capability
Jun. 2016	1000 Mbit/s Ethernet for automotive & industrial applications is standardized as IEEE 802.3bp with the terminology 1000Base-T1

Automotive Ethernet



Kyu-Il, Kim

KEYSIGHT TECHNOLOGIES

Agenda – what you can expect

What Are We Launching?	Keysight offerings, Product Highlights

Product Overview

What Are We Launching?

Existing BroadR-Reach (100Mb/s) N6467B

Transmitter output droop +/-
Transmit clock frequency (master), master TxOut jitter
Transmit clock frequency (slave), slave TxClk jitter
Transmitter distortion, MDI return loss
Transmit power spectral density

New Solutions

100Mb/s

Transmitter test N6467B – update to included additional test for Full coverage for 100Mb/s
MDI S-parameter E6964A
Protocol trigger & decode N8847A

Receiver test E6962A – BER test

Link Segment test E6963A– Full coverage

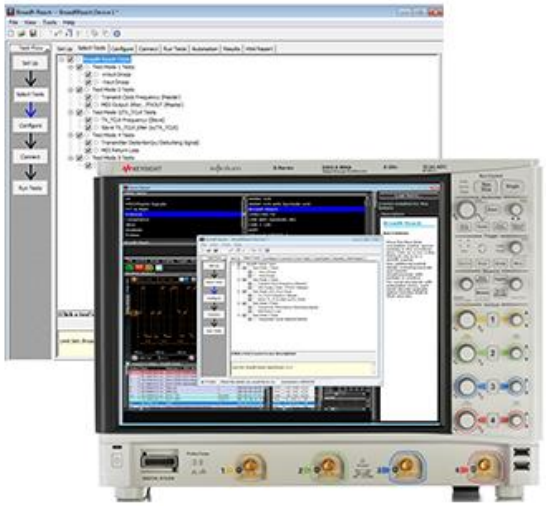
1000Mb/s

Transmitter test E6960A – Full coverage NOT including protocol trigger & decode

Keysight Automotive Ethernet Solutions

Unique test coverage across 100Base-T1 Tx, Rx and Link Segment, as well as 1000Base-T1 Tx tests

Transmitter



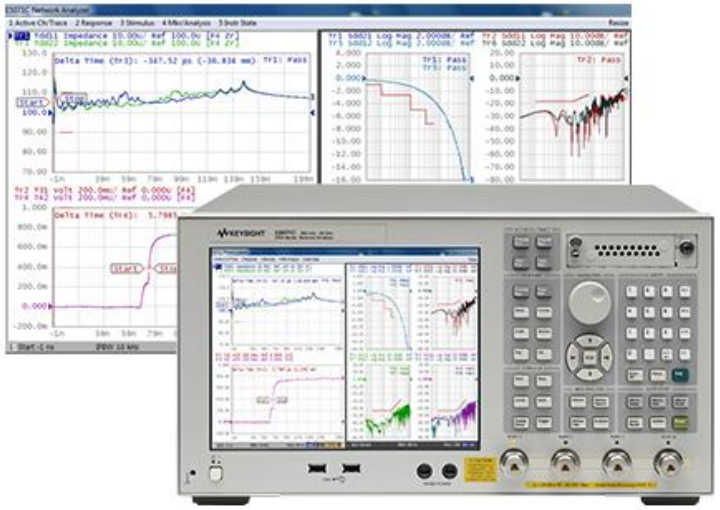
E6961A Automotive Ethernet Transmit

- **Complete 1000Base-T1 & 100Base-T1 compliance**
- **Industry-first Protocol trigger & decode**
- **Industry-first MDI S-parameter test** *Medium Dependent Interface*

Solution components (orderable under one number)

- 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 (orderable under one part number)

- 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**

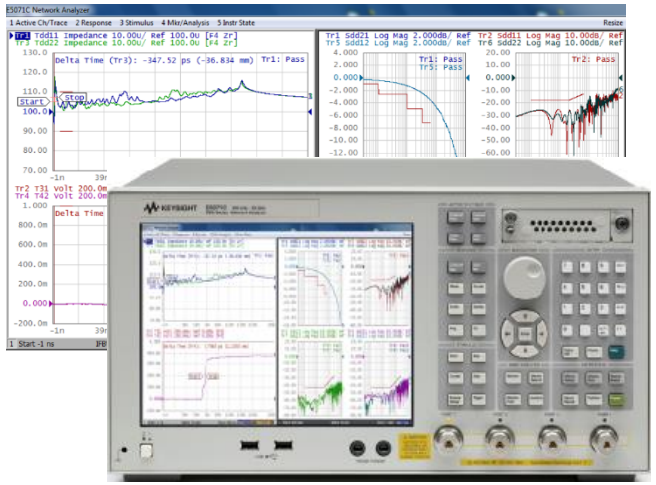
Solution Components (orderable under one part number)

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

Keysight Automotive Ethernet Link Segment Solution

What is it? Why Buy?

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 (orderable under one part number)

- ENA Vector Network Analyzer
- Cables and adapters
- Software

What is it?

- ❖ **Compliance software for 100Base-T1 Link segment**
- ❖ **All software, accessories and necessary hardware are structured under one model number.** (NOTE: both accessories and hw are optional)

Hardware configurations

- Software runs on an ENA – E5071C

Why Buy?

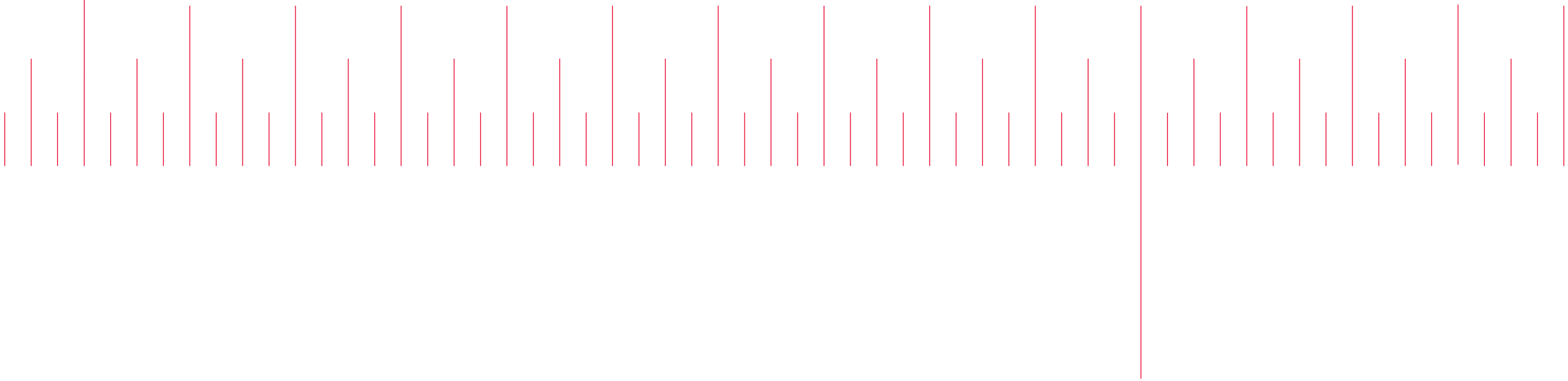
- ❖ **To ensure compliance to 100Base-T1 Link segment tests**
- ❖ **Save time from the manual calculation and extra work , configuration and testing up to 20 ports**
- ❖ **Easy to follow test setup and configuration directions**
- ❖ **Pass/Fail report with margin analysis - taking the manual error out**

Agenda – what you can expect

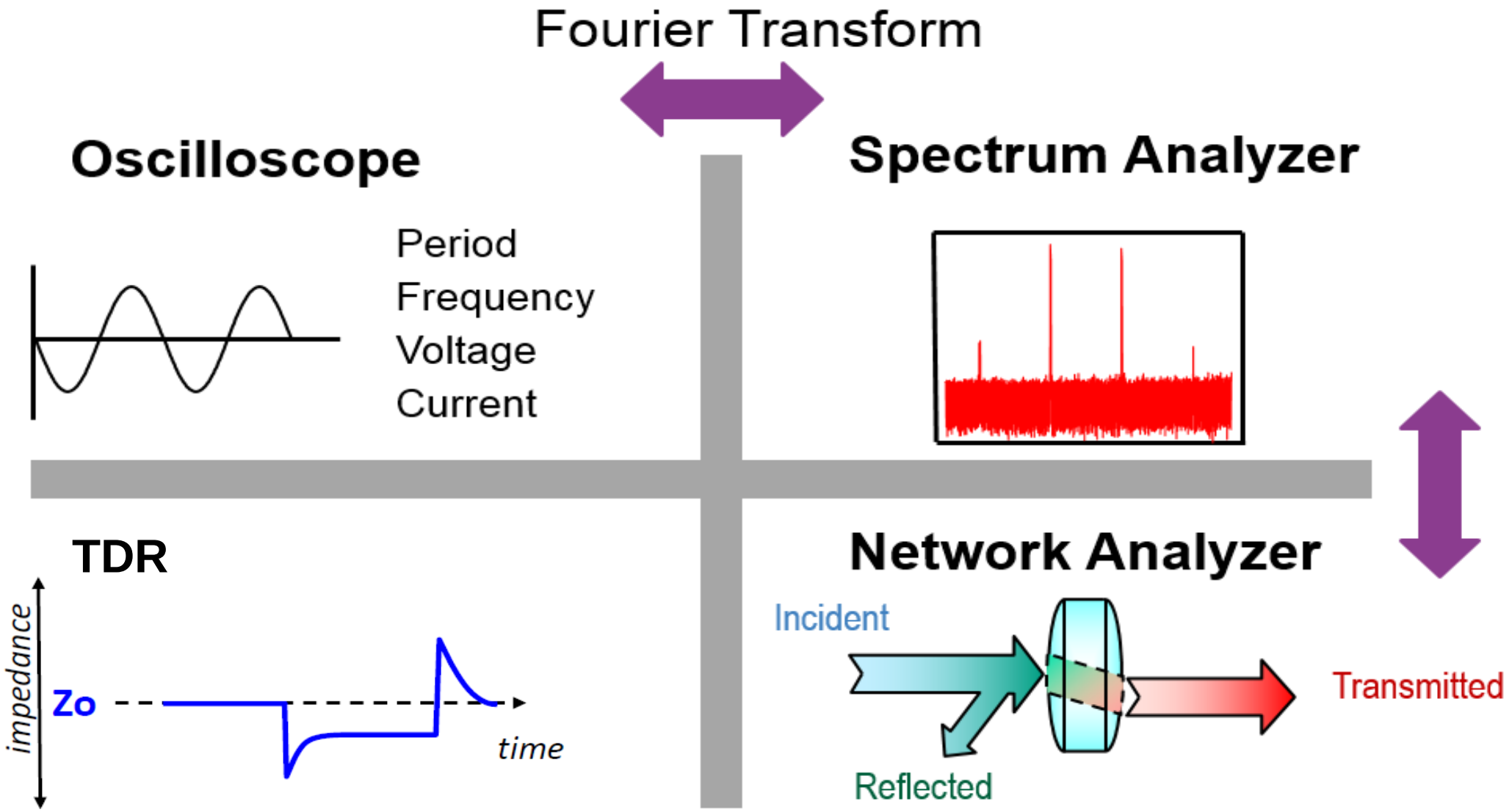
What Are We Launching?

Product Overview

Network Analyzer Overview

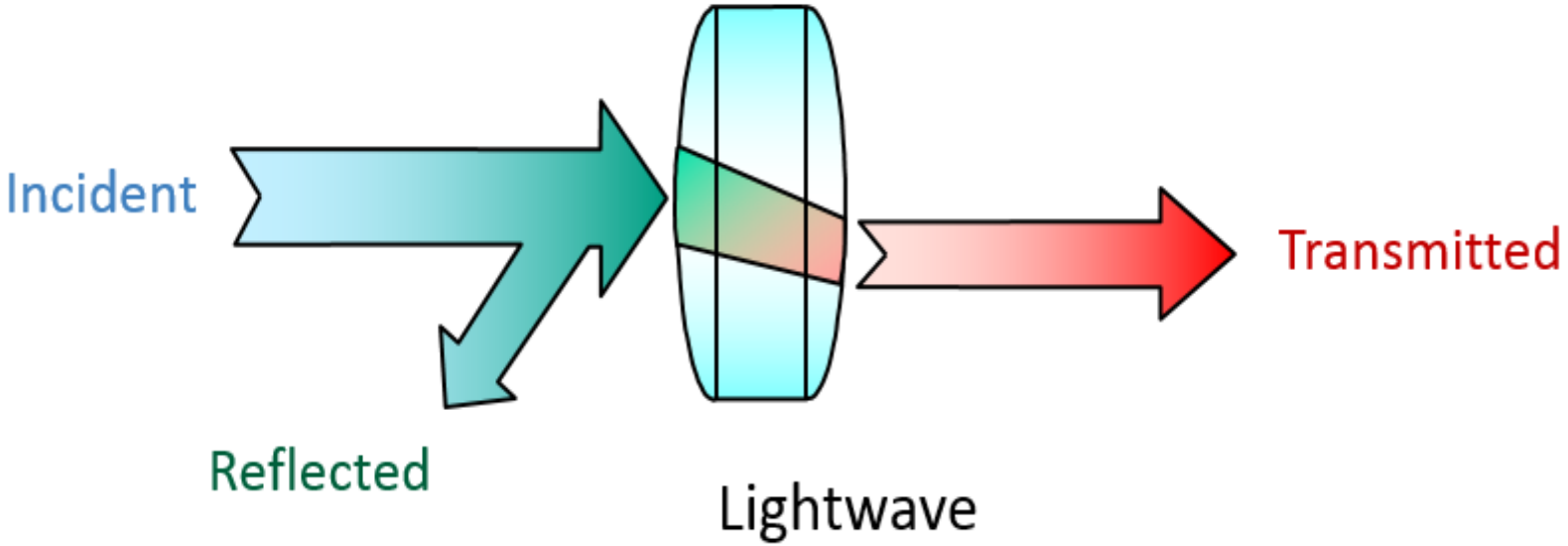


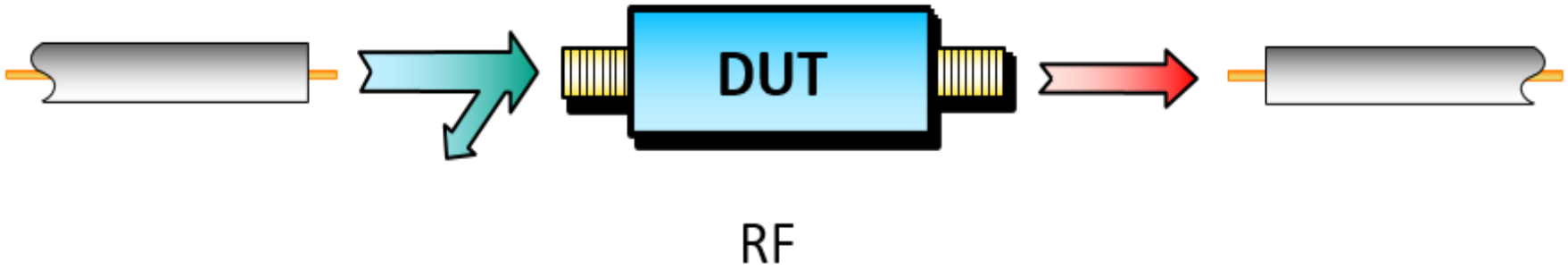
Comparison of 3 measurement instruments



Basic Concept of Analysis – Stimulus & Response test system

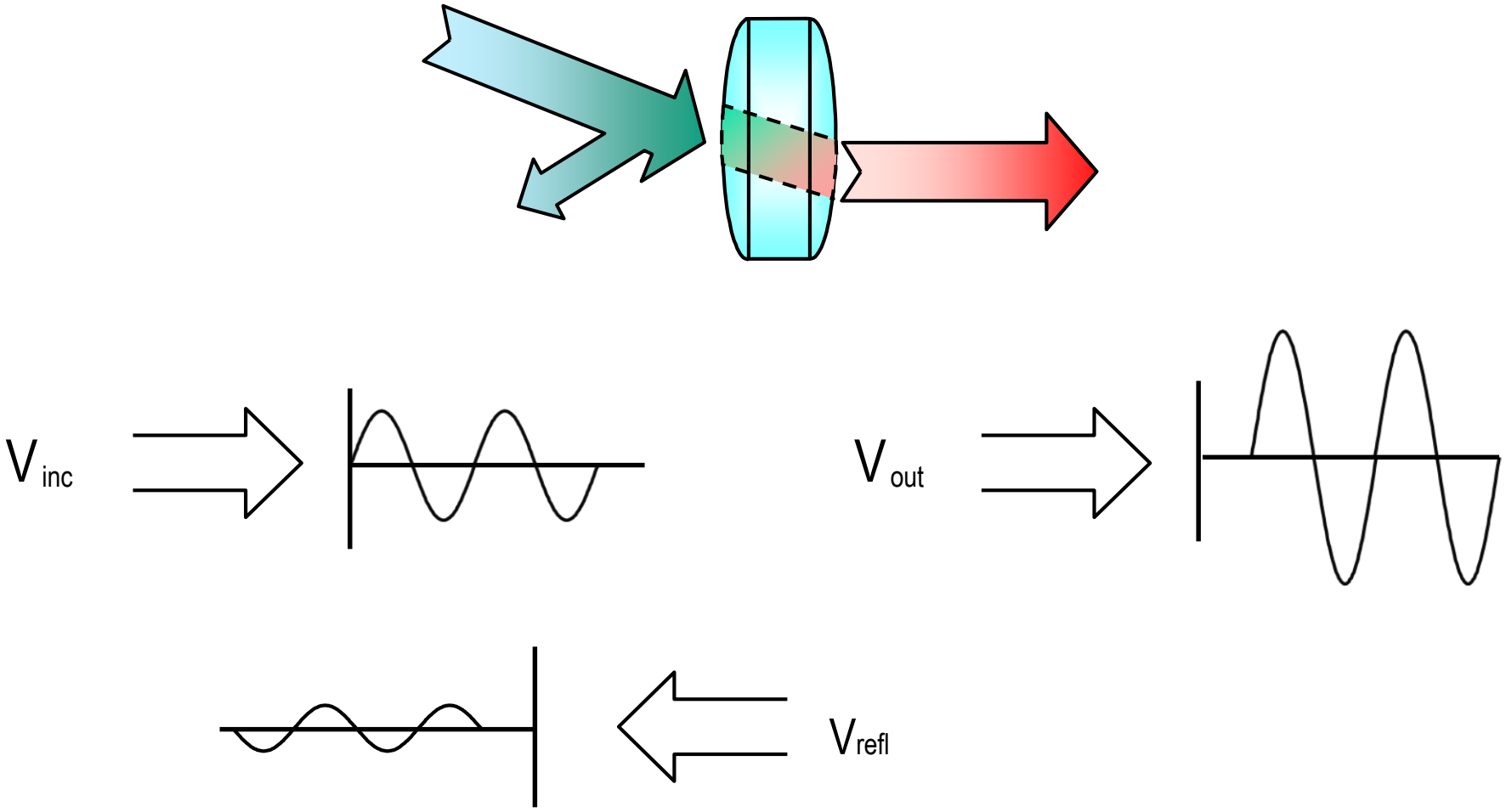
Lightwave Analogy to RF Energy



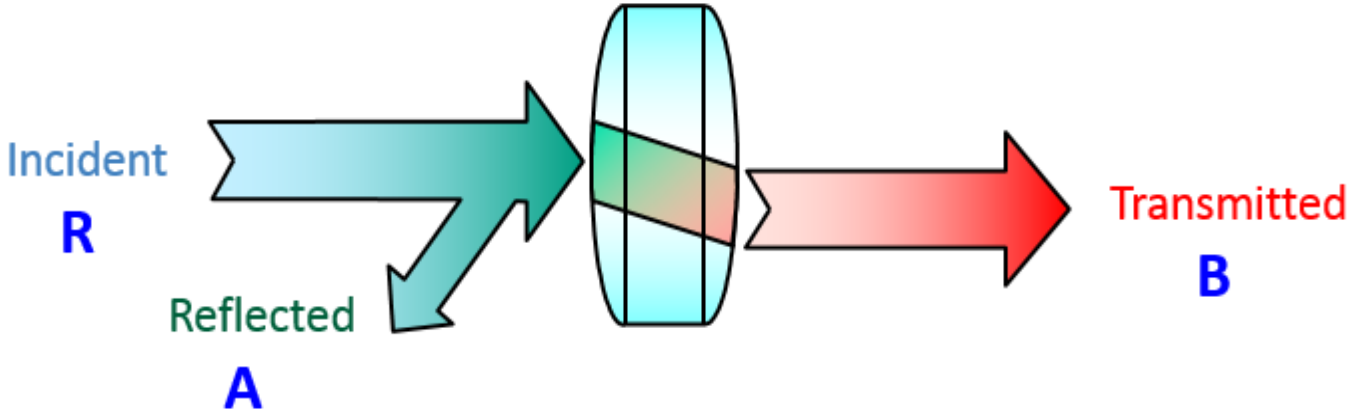


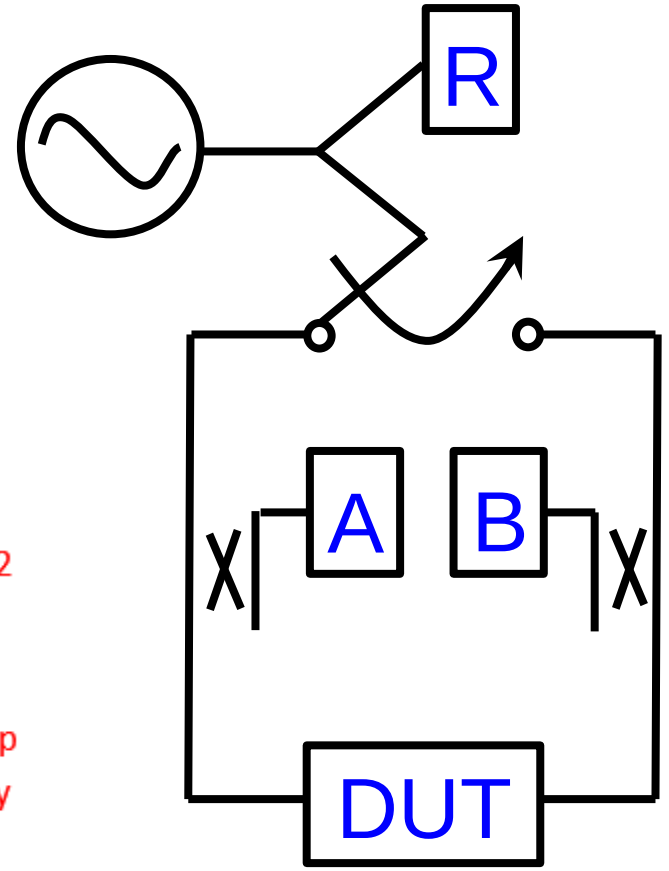
Basic Concept of Analysis – Vector Measurement

Measures both Magnitude & Phase



Basic Concept of Analysis





REFLECTION

$$\frac{\text{Reflected}}{\text{Incident}} = \frac{A}{R}$$

S_{11}, S_{22}

- SWR
- Reflection Coefficient Γ, ρ
- Impedance, Admittance R+jX, G+jB
- Return Loss

TRANSMISSION

$$\frac{\text{Transmitted}}{\text{Incident}} = \frac{B}{R}$$

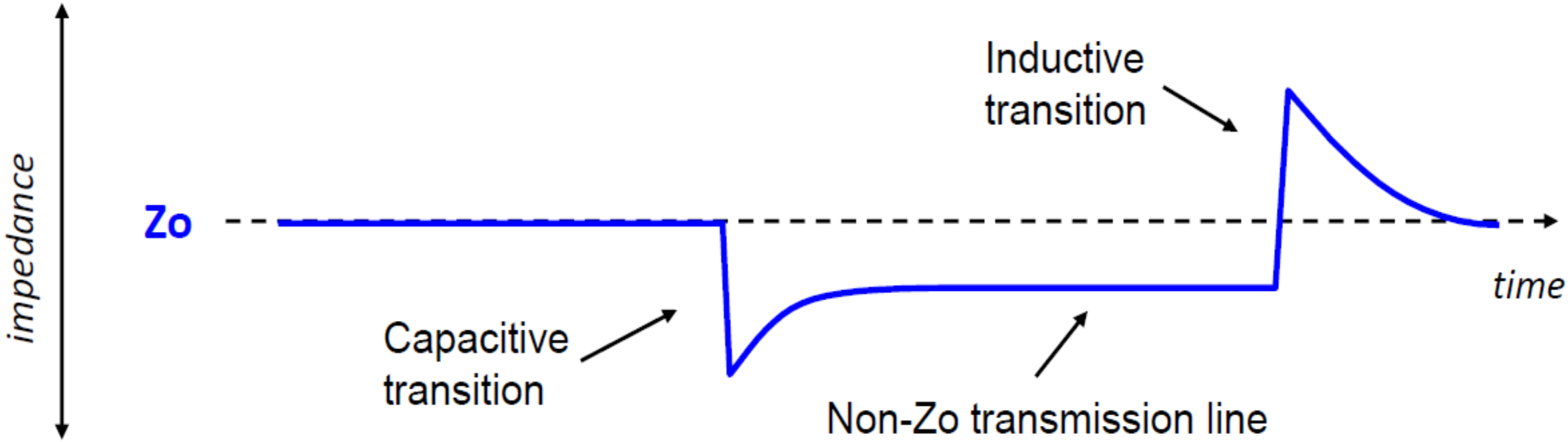
S_{21}, S_{12}

- Gain / Loss
- Transmission Coefficient T, τ
- Insertion Phase
- Group Delay

Time-Domain Reflectometry (TDR)

What is TDR?

- Time-domain reflectometry
- Analyze Characteristic impedance versus time
- Measures in Frequency domain and converts it to Time domain using IFT(Inverse Fourier Transform)



Time-Domain Reflectometry (TDR)

Requirements for both Time domain and Frequency domain measurement

Frequency Domain
- Insertion Loss (Sdd21)
- Return Loss (Sdd11)
- Crosstalk (NEXT)

Time Domain
- Characteristic Impedance (TDR)

Traditional Solution

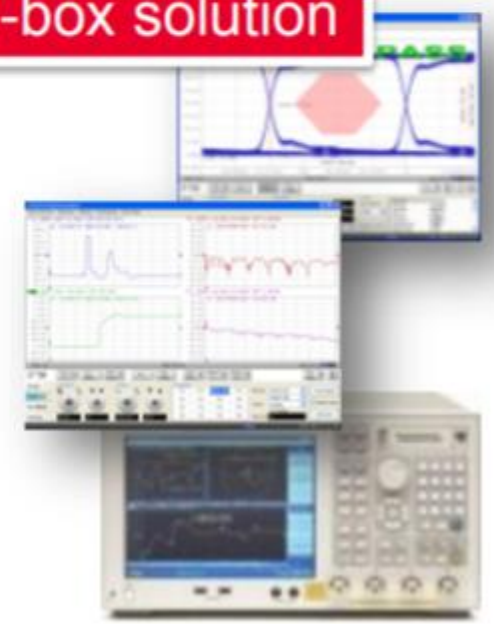
Vector Network Analyzer (VNA)

TDR Scope

New Solution

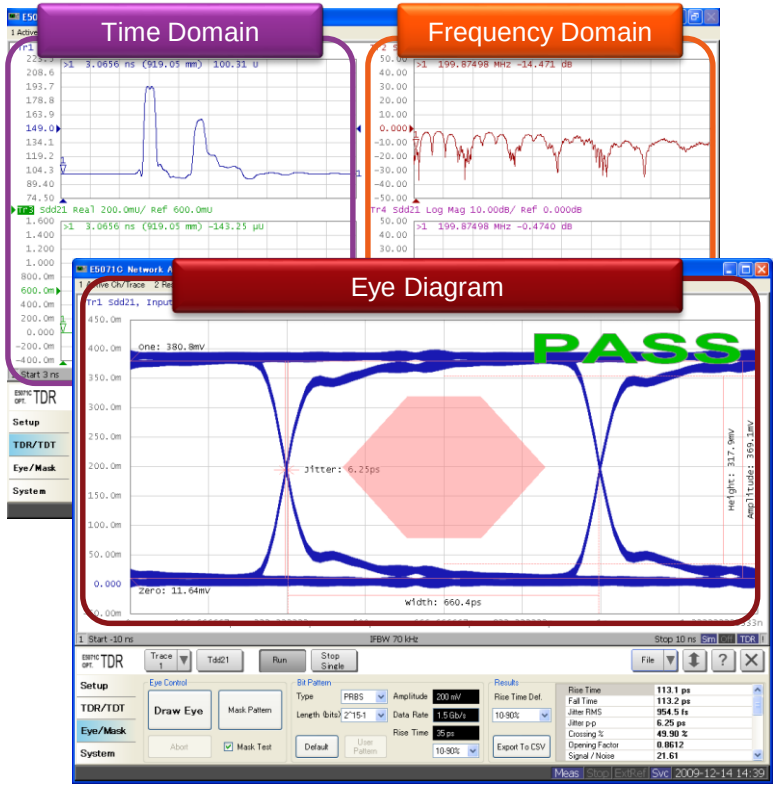
ALL parameters can be measured with ENA Option TDR

One-box solution



What is ENA-TDR?

The ENA Option TDR is an application software embedded on the ENA, which provides an **one-box solution** for high speed serial interconnect analysis.



3 Breakthroughs

for Signal Integrity Design and Verification

Simple and Intuitive Operation

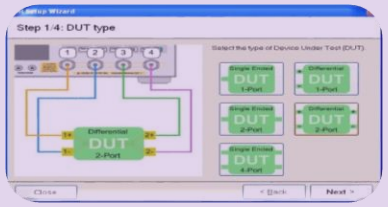
Fast and Accurate Measurements

ESD Robustness

What is ENA-TDR?

Three Breakthroughs

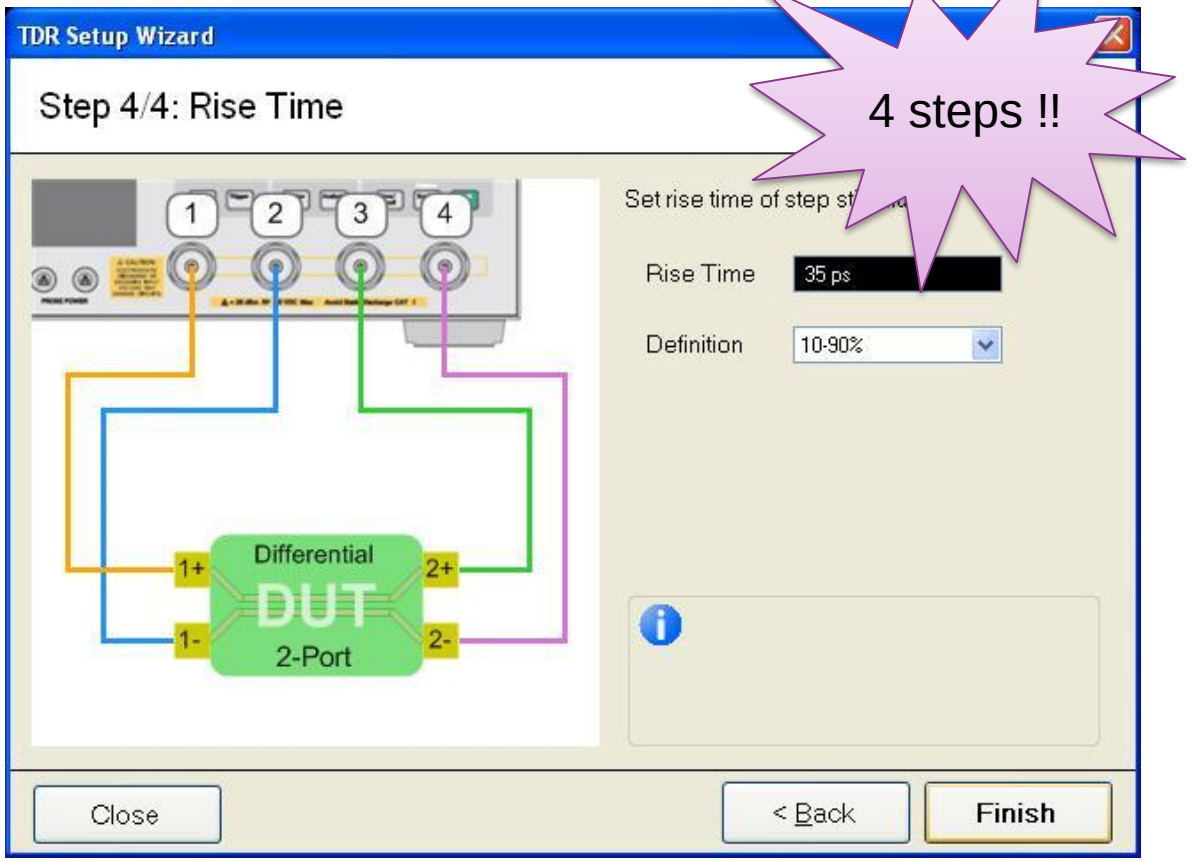
Simple & Intuitive



Fast & Accurate

ESD Robustness

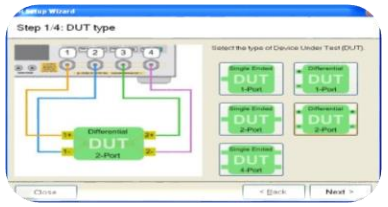
TDR Setup Wizard



What is ENA-TDR?

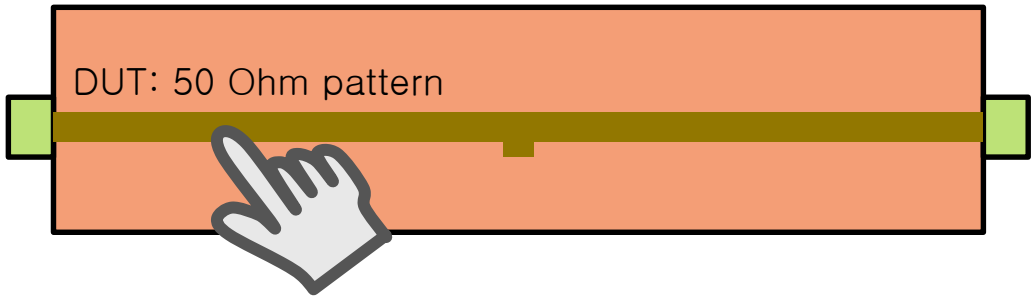
Three Breakthroughs

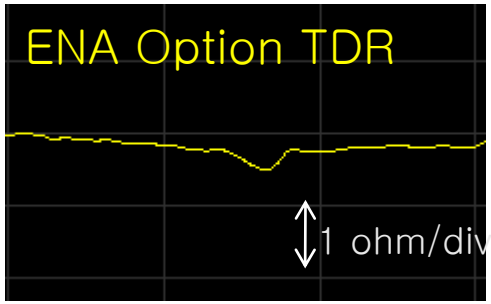
Simple & Intuitive

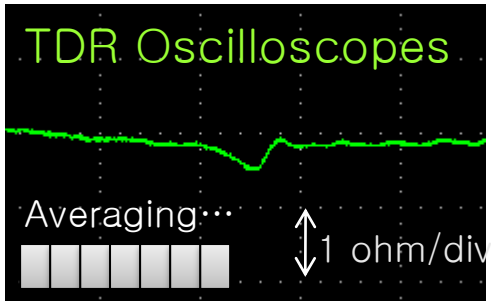


Fast & Accurate

ESD Robustness





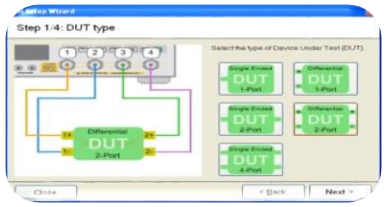


Real-Time Analysis

What is ENA-TDR?

Three Breakthroughs

Simple & Intuitive



Fast & Accurate

ESD Robustness

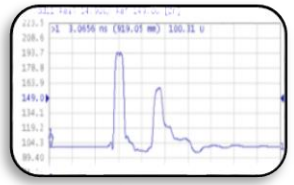
TDR oscilloscope is sensitive to ESD

ESD Robustness

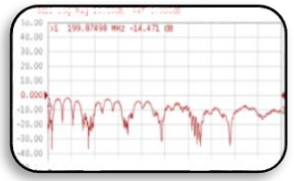
One-Box Solution

For High Speed Serial Interconnect Analysis

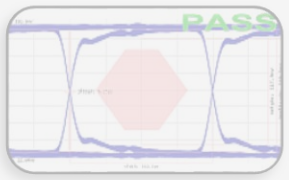
Time domain

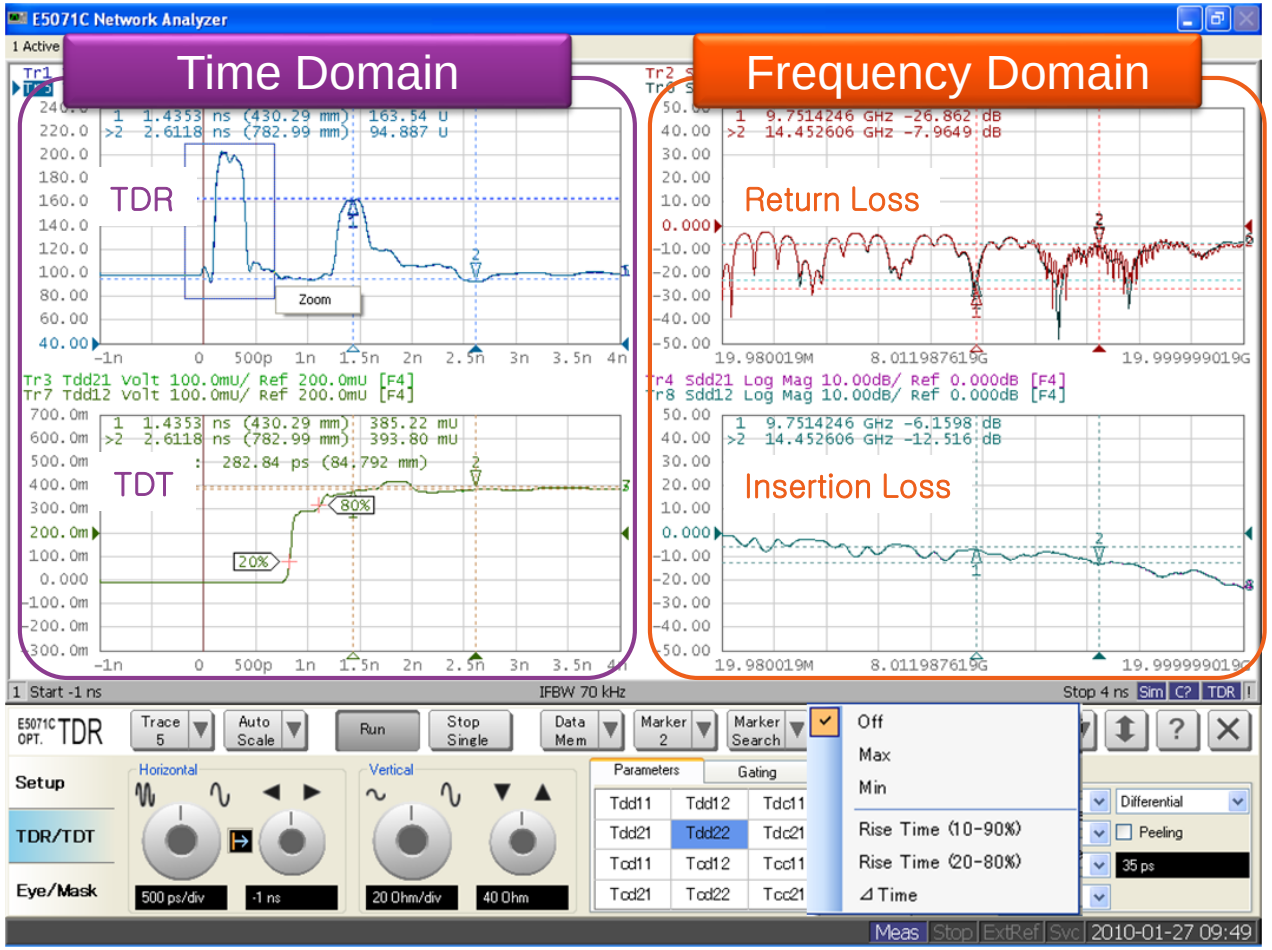


Frequency domain



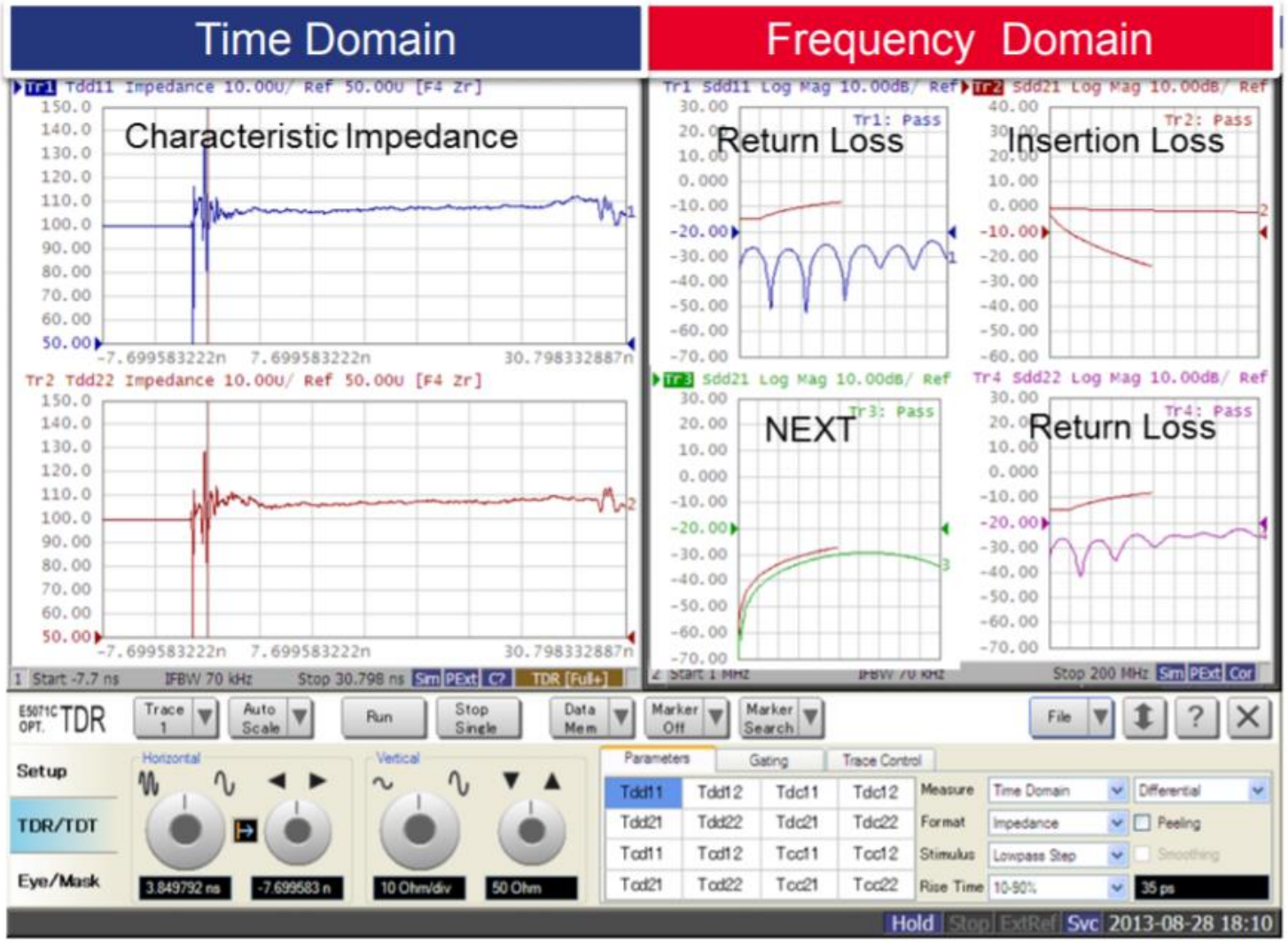
Eye diagram





Time-Domain Reflectometry (TDR) – One Box Solution

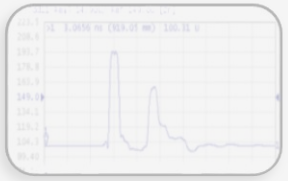
Measurement Parameters



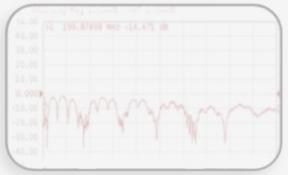
Time-Domain Reflectometry (TDR) – One Box Solution

Measurement Parameters

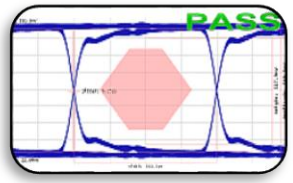
Time domain

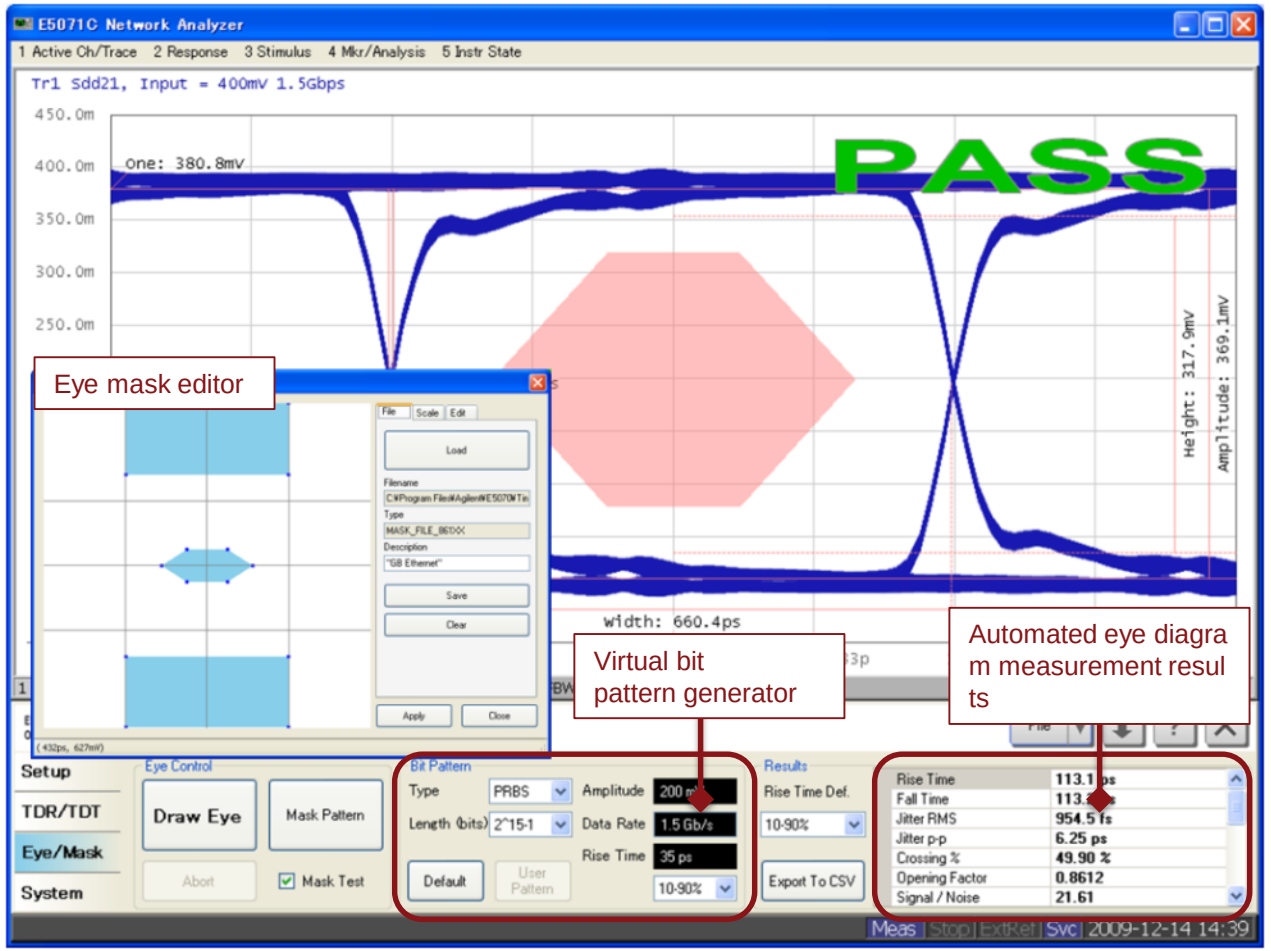


Frequency domain



Eye diagram





Time-Domain Reflectometry (TDR)

Cable Compliance Test Solution

Provides MOI(Method Of Implementation) for Cable Compliance Test

- USB(2.0, 3.0, 3.1, Type-C)
- HDMI(1.4, 2.0, 2.1)
- SATA
- MIPI(D-PHY, M-PHY)
- Ethernet(100Base-TX, 10GBase-T)
- BroadR-Reach
- PCIe

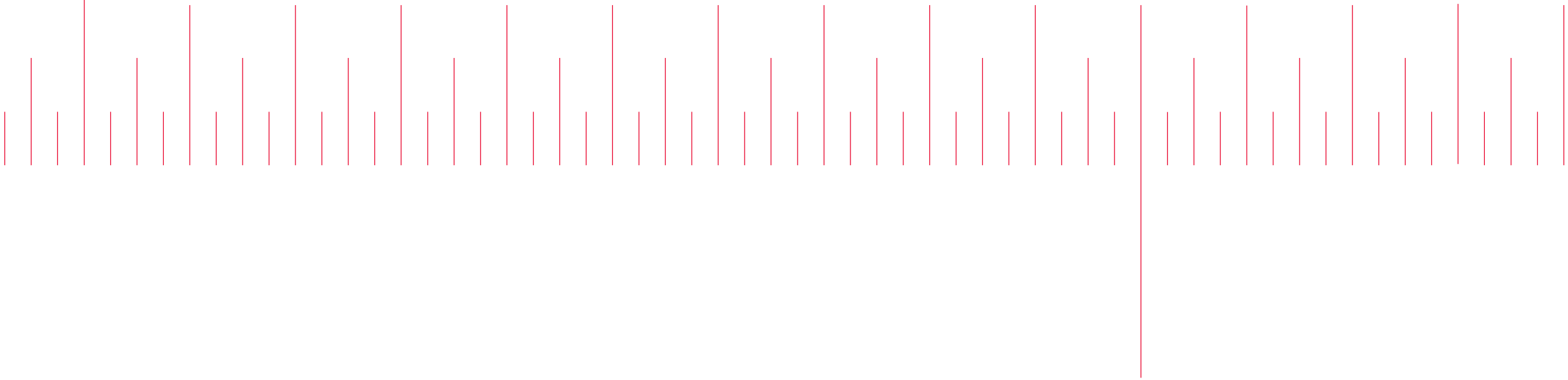
E6961A Automotive Ethernet Tx Compliance Solution

E6960A 1000Base-T1 Tx Compliance Application

N6467B BroadR-Reach Compliance Application (100Base-T1 compliant)

N8847A BroadR-Reach Protocol Trigger & Decoder (100Base-T1 compliant)

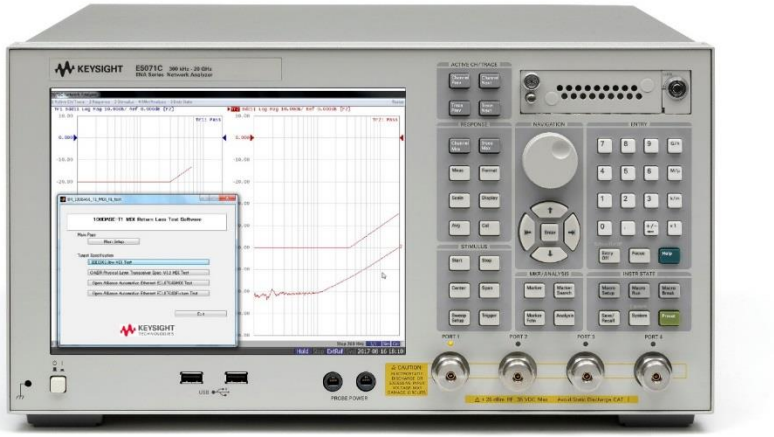
E6964A BroadR-Reach MDI S-parameter software (100Base-T1 compliant)



KEYSIGHT TECHNOLOGIES

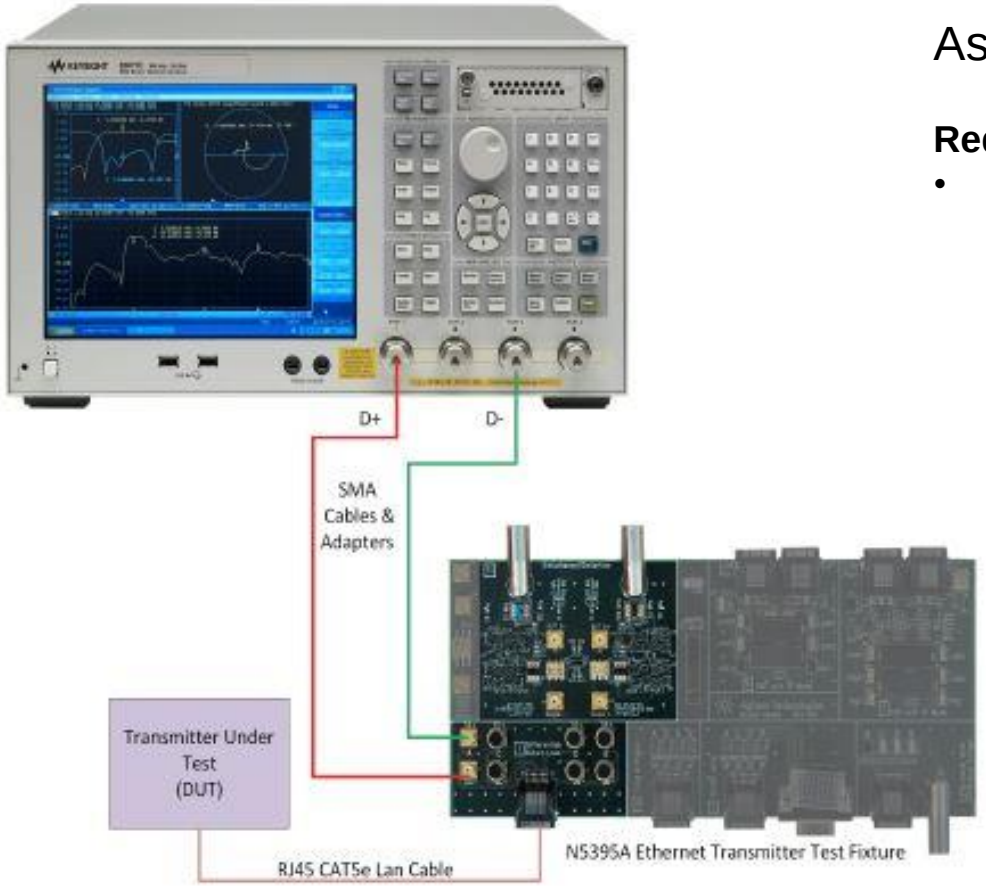
Overview of MDI S-parameter Test – E6964A

Target Specification	Parameter	Measurement Equipment	Keysight model
IEEE802.3bw MDI Test	96.8.2.1, 96.8.2.2	Vector Network Analyzer	E5071C ENA Series
OABR Physical Layer Transceiver Spec. V3.2 MDI Test	8.2.2		
Open Alliance Automotive Ethernet ECU(TC8)	OABR_PMA_TX_05, OABR_PMA_TX_06		



E6964A MDI S-parameter test

Typical test setup



As described in 100Base-T1 MDI transceiver tests.

Required Equipment

- E5071C ENA Series Network Analyzer
  - Option 480 or 485 (8.5 GHz) / 4D5 (14 GHz) / 4K5 (20 GHz) what is the min?
  - ENA Firmware Revision B.13.30 or later

Accessories

- N5395C Ethernet Test Fixture for use with RJ45 connectors

(*For custom connectors, the user needs to provide fixtures.)*

- 2-port or 4-port ECal Module
  - N4431B, N4433A (for E5071C-480/485)
  - N4691B, 85093C (for E5071C-4D5/4K5)
- Coaxial Adapters and RF cables (2/ea.)

E6964A MDI S-parameter test

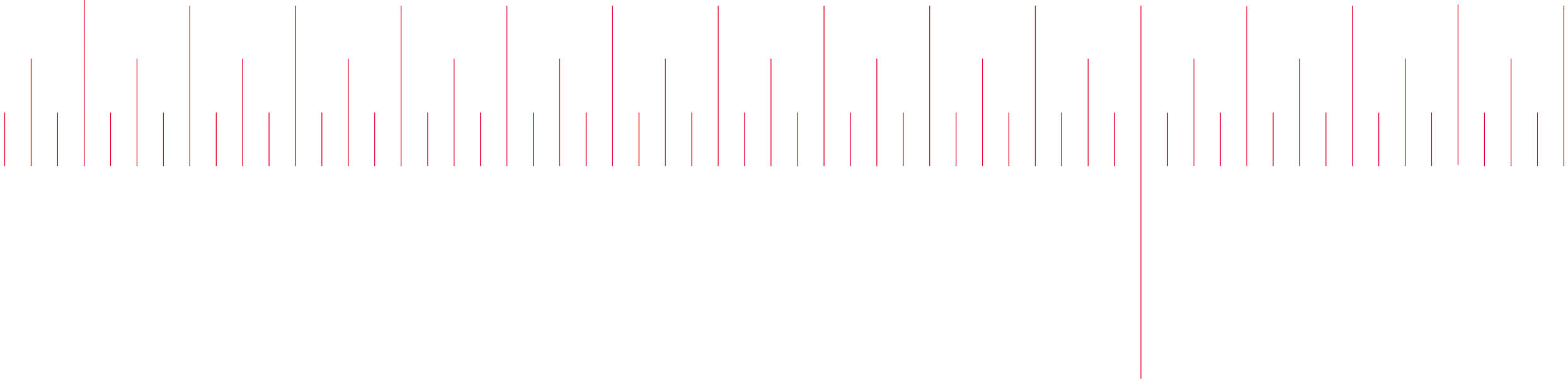
Typical test result

Any additional information to add here?

What the ENA display shows

Sdd11 and Sdc11 test result example

E6963A Automotive Ethernet Link Segment Compliance Solution

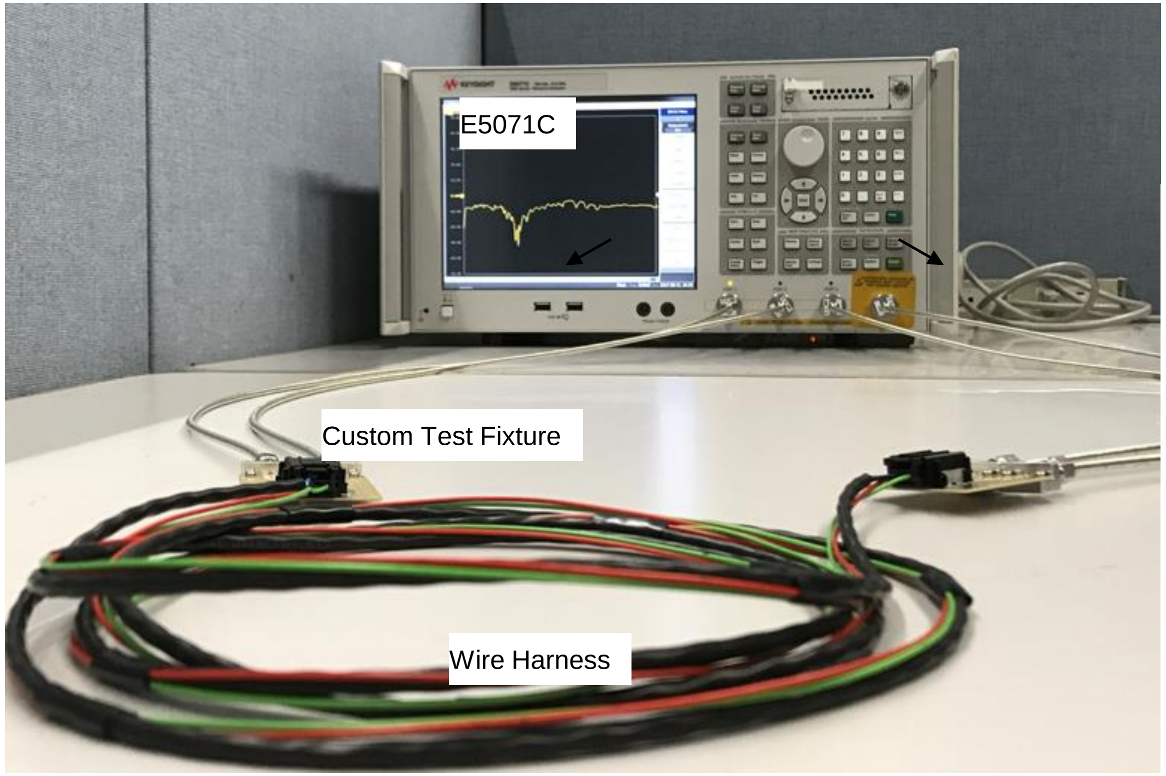


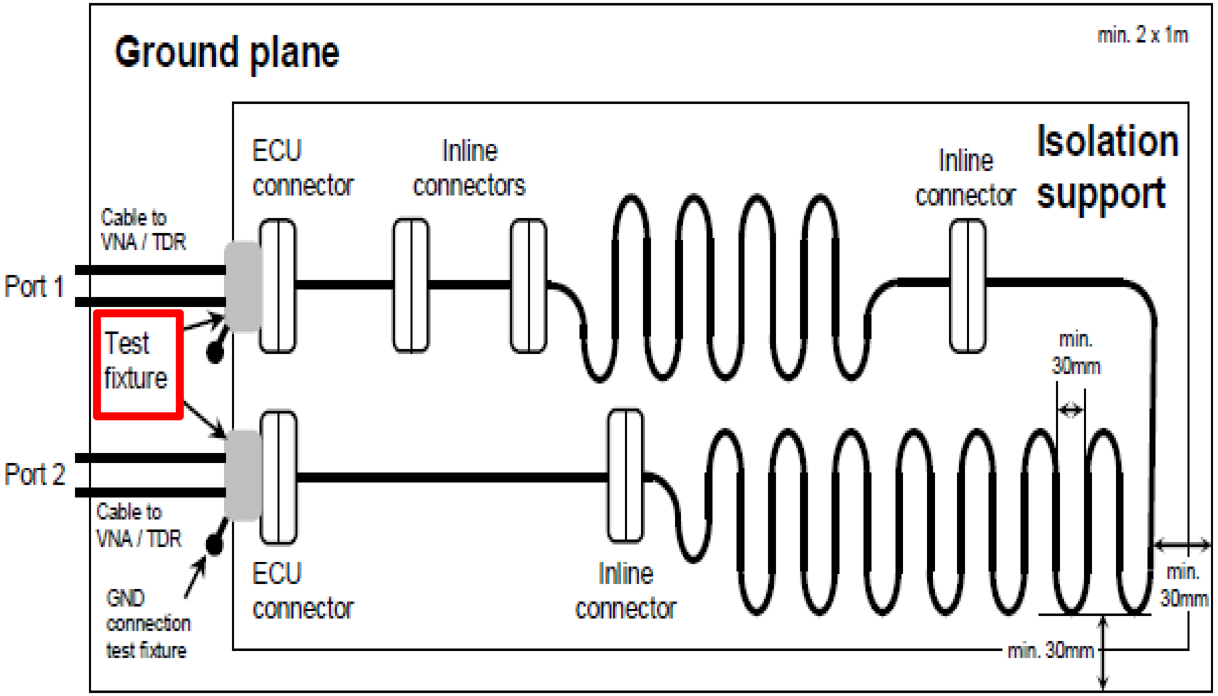
KEYSIGHT TECHNOLOGIES

Overview of BroadR-Reach Link Segment Software– E6963A

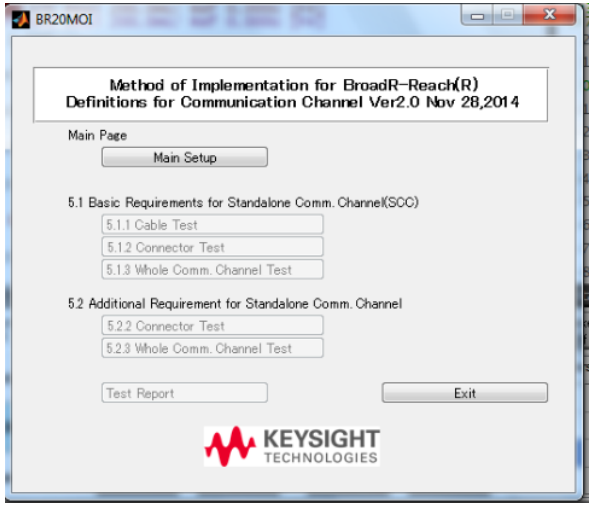
Target Specification	Parameter	Measurement Equipment	Keysight model
BroadR Reach Definition for Communication Channel ver 2.0	**5.1.1 Cable Test** CIDM, IL, RL, LCL, LCTL	4port Vector Network Analyzer with opt TDR is required. *Both differential reflection and transmission have to be measured*	E5071C ENA Series opt TDR
	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

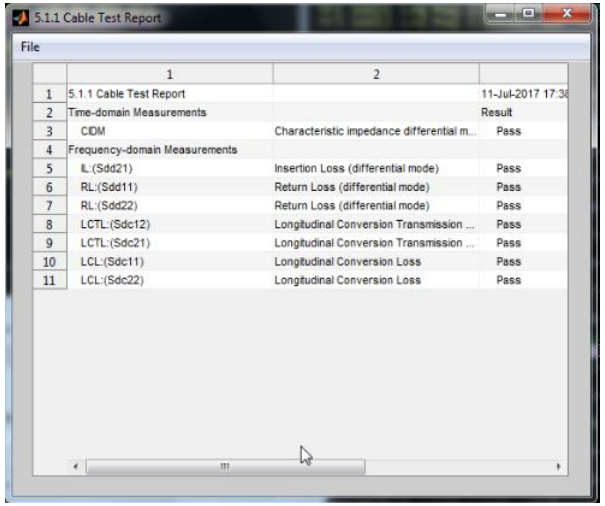




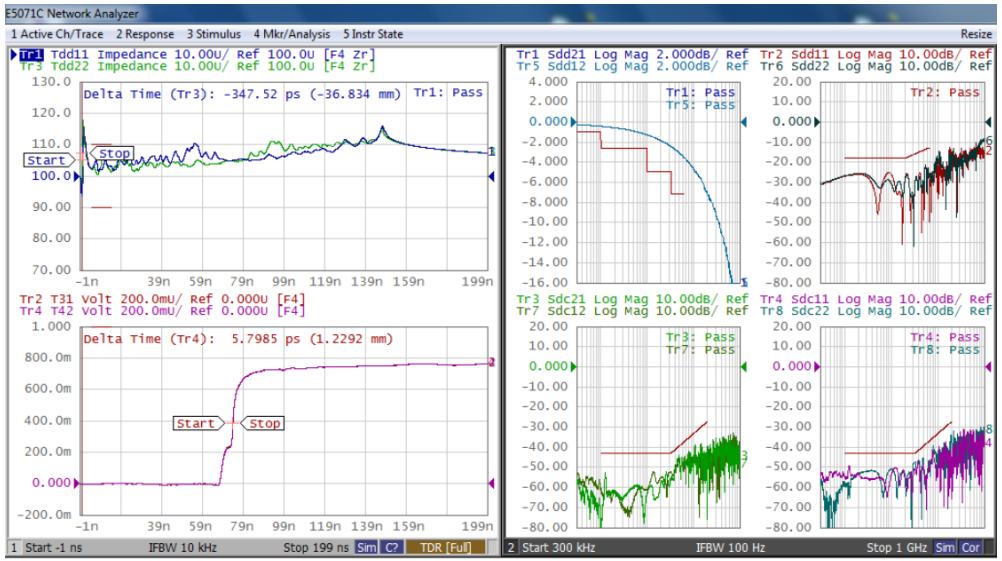
GUI and Report Sample



Main Control Window



Test Report Example – Pass/Fail List



Test Result Example – E5071C screenshot of limit test

- 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 file
  - ✓ Csv file
  - ✓ Screenshot
- Automated VNA setting

KEYSIGHT TECHNOLOGIES

E6963A ordering information

BroadR-Reach Link Segment Solution (100Base-T1 compliant)

1 Order Software

Option name	Description
E6963A-1TP	BroadR-Reach Link Segment Application transportable license
E6963A-1FP	BroadR-Reach Link Segment Application fixed perpetual license

2 Order Accessories

Option name	Description
E6963A-APC	Adapter, Straight APC (M)- APC(F) x 4
E6962A-SMA	Cable , SMA(m) -SMA(m) x 4

3 Order Hardware

Option name	Description
E6963A-ENA	E5071C ENA Vector Network Analyzer with option TDR, 440, 820 and 810

***Note**: it is optional to order the hardware through the E6963A however it is necessary to have this equipment to fully test compliance*