

# Automotive Ethernet Test Solutions

1000Base-T1  
100Base-T1  
10Base-T1S



## Key Features

### Supports 1 Gb/s, 100 Mb/s, and 10 Mb/s

- 1000Base-T1 (IEEE 802.3bp)
- 100Base-T1 (IEEE 802.3bw)
- 10Base-T1S (IEEE 802.cg)
- TC8 (ECU Specification)

### Comprehensive compliance testing

- Supports all PMA transmitter tests including MDI s-parameters
- Report generation with pass/fail results and annotated screenshots
- Software clock recovery algorithm for the distortion test

### Dedicated debug tools

- Debug link startup handshaking
- Characterize system performance with 12 eye diagram measurement parameters
- Separate bi-directional traffic with superior signal fidelity

**Cover all aspects of physical layer Automotive Ethernet compliance testing and debug for 10Base-T1S, 100Base-T1, and 1000Base-T1. The best next generation Automotive Ethernet solutions include debug tools for Link Startup, a dedicated PAM3 debug toolkit, and enhanced signal separation.**

## Automated Compliance Testing

QualiPHY performs electrical compliance testing of the Physical Media Attachment (PMA) according to the 1000Base-T1, 100Base-T1, BroadR-Reach, 10Base-T1S, and TC8 specifications. Detailed connection diagrams ensure the proper setup and provide information about the required test pattern for each test. Upon completion of the test session, pass/fail results are automatically compiled into a report including screenshots.

## Debug Tools for Link Startup

Trigger on and decode the link startup handshaking between the Master and Slave. Track where the devices are in the handshaking sequence to determine the cause of a proper link not being established. Identify link startup and packet errors by descrambling Data Packets.

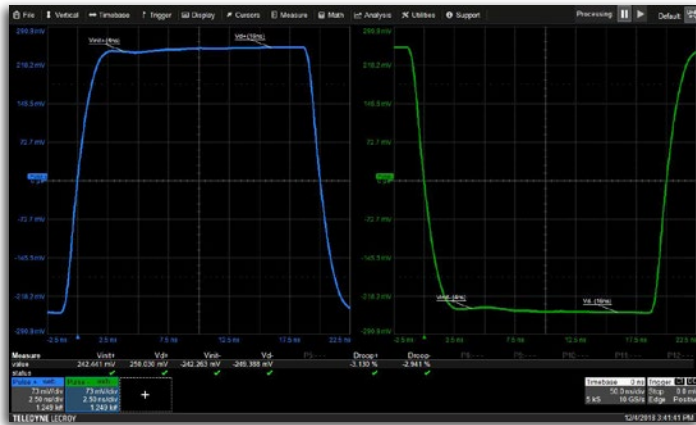
## Beyond Compliance Testing

The Automotive Ethernet Debug Toolkit provides a dedicated PAM3 debug environment specifically designed to detect and debug signal quality link communication issues that would not be identified during compliance testing. Fully characterize and quantify system performance with a suite of 12 eye diagram parameters, and enable equalization to visualize how the signal appears at the receiver.

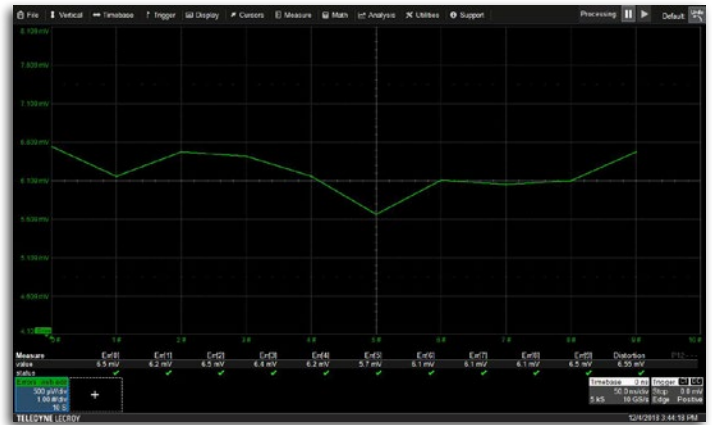
## Enhanced Signal Separation

The TF-AUTO-ENET separates bi-directional link traffic to independently view signals from the Master and Slave. The software enhances the directivity of the directional couplers in real time, providing superior signal fidelity compared to other directional coupler approaches. Use the same fixture for debug and compliance testing.

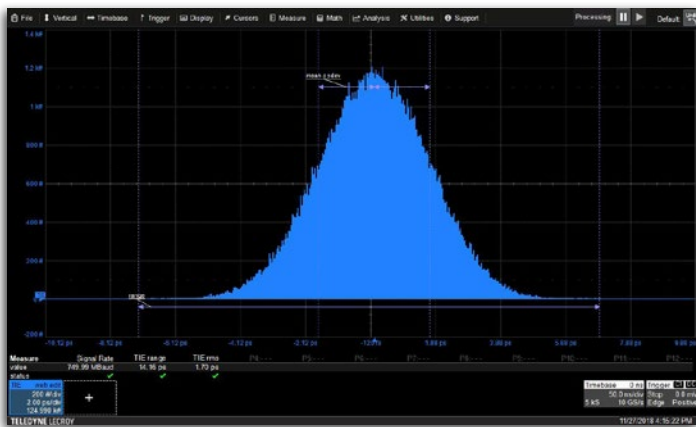
# COMPREHENSIVE COMPLIANCE TESTING



**Maximum Transmitter Output Droop** — The output droop is calculated on both the “+1” and “-1” symbols. The magnitude of the droop is measured with respect to an initial peak value after the zero crossing (Vinit) and the value a defined amount of time after the initial peak value (Vdelay).



**Transmitter Distortion** — The peak distortion is determined by capturing output from the DUT while it is in Test Mode 4. The disturbing sine wave is removed and peak distortion is measured at equally spaced phases of the symbol period. To pass, the script must report less than 15 mV distortion for 10 records.



**Transmitter Timing Jitter & Transmit Clock Frequency** — The transmitter timing jitter and transmit clock frequency are tested while the DUT is in Test Mode 1 or 2. For some tests, the jitter is measured by directly probing the DUT’s TX\_TCLK.



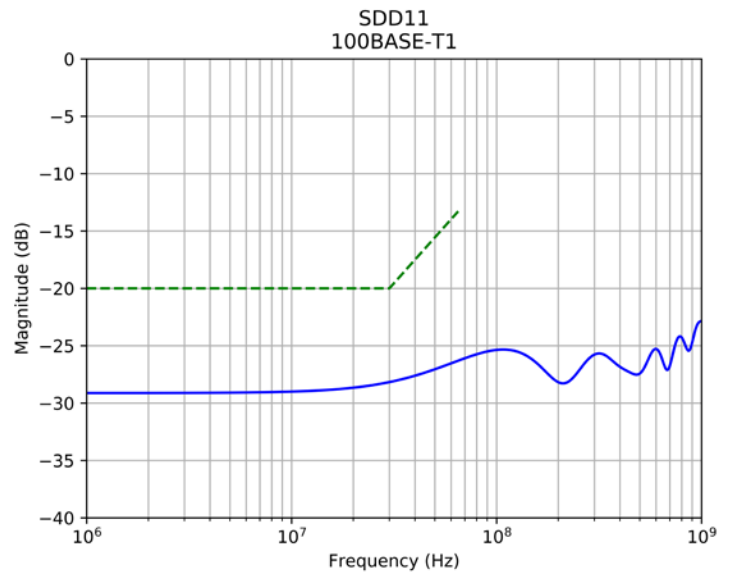
**Transmitter PSD & Peak Differential Output** — The Power Spectrum Density (PSD) of the transmitter is tested against the specified limits defined by the mask while the DUT is transmitting Test Mode 3 or 5. Using the oscilloscope for the PSD test removes the need to purchase a spectrum analyzer. The Test Mode 5 waveform is also used to test the peak differential output.

# COMPREHENSIVE COMPLIANCE TESTING

## MDI Return Loss (Sdd11)

The return loss is measured at the medium dependent interface (MDI), which is the ratio between the power of the differential signal that is reflected due to impedance mismatch and the power of the differential incident signal (differential to differential).

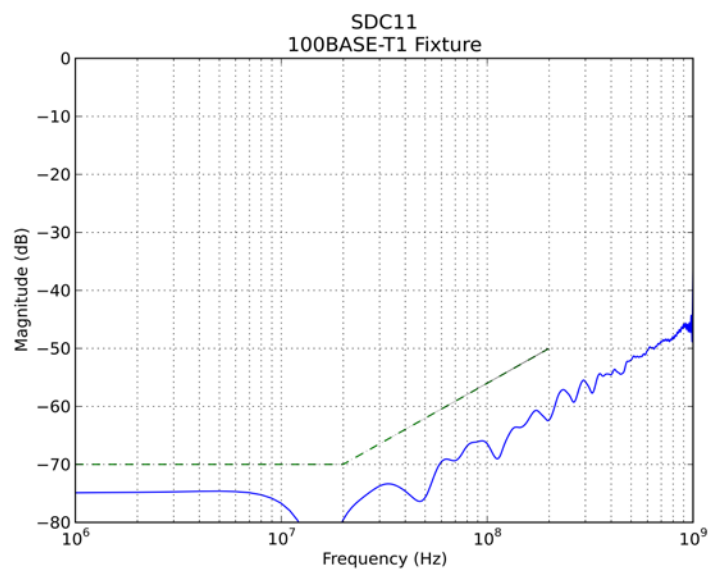
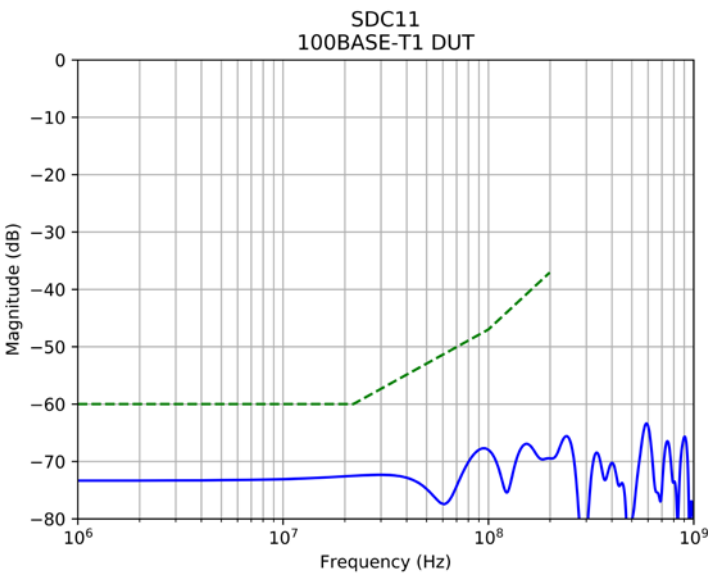
Additionally, the differential characteristic impedance is measured, which for a 10Base-T1S, 100Base-T1, and 1000Base-T1 compliant device will ideally be 100  $\Omega$ .



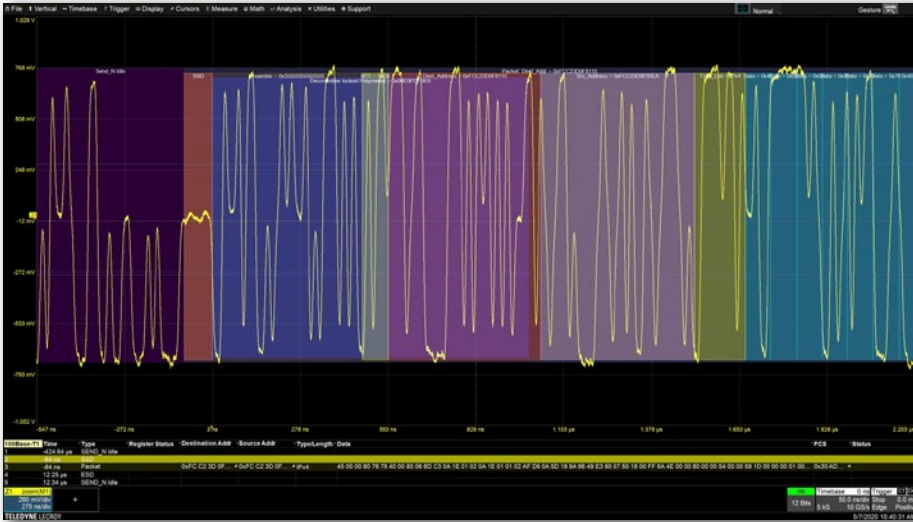
## MDI Mode Conversion Loss (Sdc11)

The mode conversion loss is measured at the MDI, which is the ratio between the power of the differential signal that is reflected due to impedance mismatch and the power of the incident common mode signal (common to differential) for both the DUT as well as the test fixture alone

Additionally, the differential and common mode characteristic impedance is measured, which for a 100Base-T1 and 1000Base-T1 compliant device will ideally be 100  $\Omega$  and 25  $\Omega$  respectively.

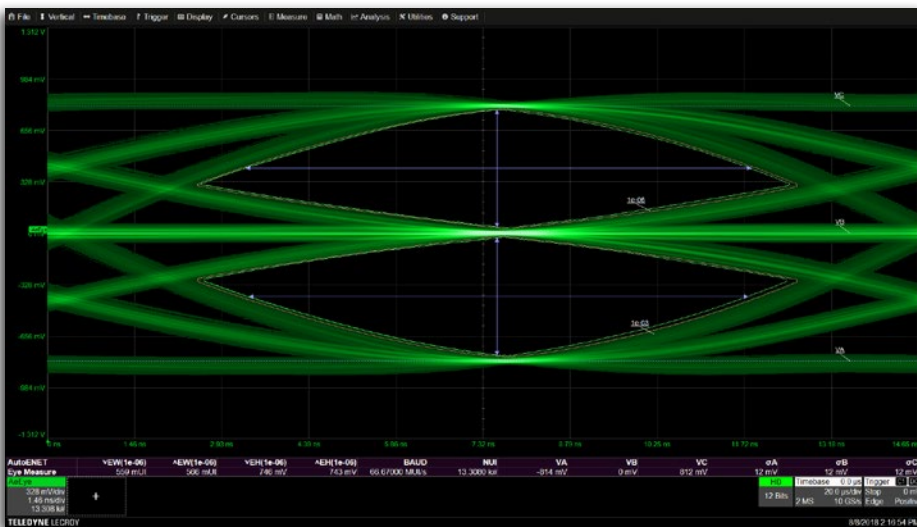
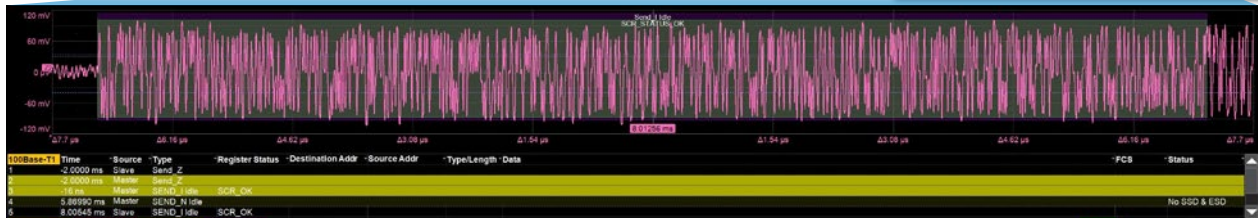


# DEBUG AND CHARACTERIZE SYSTEM PERFORMANCE



## Debug Tools for Link Startup

Trigger on and decode the link startup handshaking between the Master and Slave. Track where the devices are in the handshaking sequence to determine the cause of a proper link not being established.



## Beyond Compliance Testing

The Automotive Ethernet Debug Toolkit is designed to detect signal quality communication issues between a Master and Slave that are not identifiable during compliance testing.

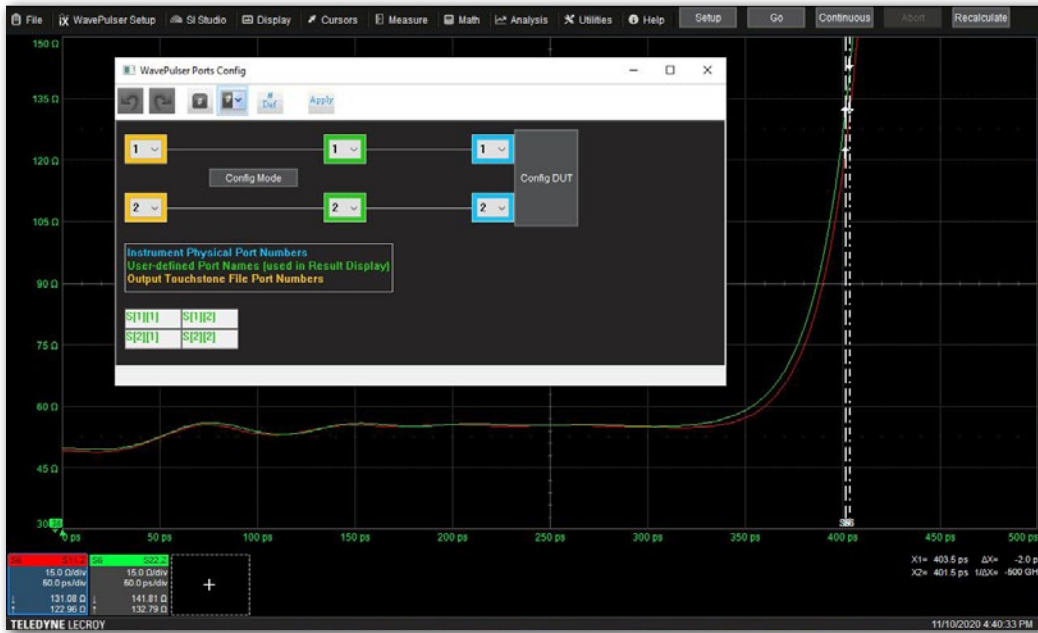
## Quantify System Performance

Fully characterize and quantify a link's performance using 12 parameters, including eye height and eye width of both the upper and lower eyes. Visually observe system failure rates with customizable BER contours.

## Integrated FF Equalization

Enable the FF Equalization to see exactly how the signal appears at the receiver or determine which equalization scheme will be best for opening the eye. Define the number of taps and specific tap weights, or train the equalizer on acquired data.

# DEBUG AND CHARACTERIZE SYSTEM PERFORMANCE



The WavePulser uses impedance profiles to measure the difference in the electrical length of the two signals,  $D+$  and  $D-$ , of the differential signal, including the test fixture.

## Reliable Test Fixture Characterization

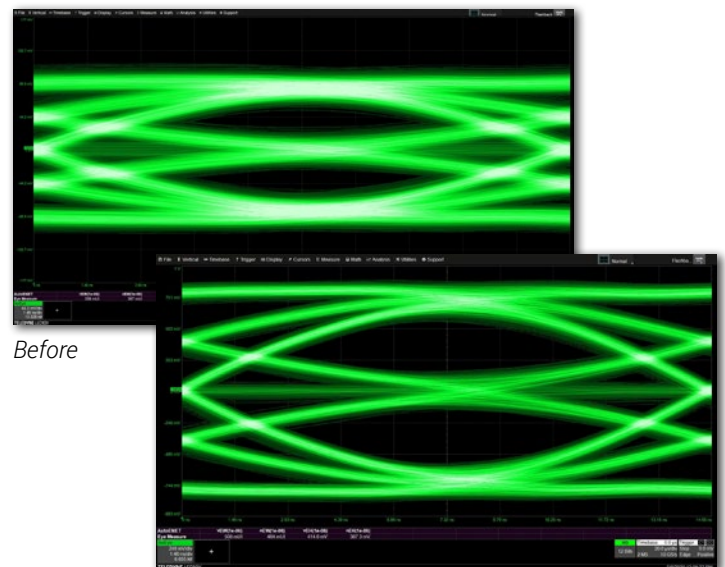
The impedance balance of the cabling and test fixtures in the test setup is critical when measuring the MDI S-parameters and mode conversion loss.

WavePulser 40iX measures the impedance profile of cables and test devices to ensure that the paths of the two signals  $D+$  and  $D-$  are identical so that there is no mode conversion generated from a difference in electrical length.

The precise characterization of the test fixtures used to connect the DUT MDI to the test equipment provides confidence that the fixtures in use have enough mode conversion loss margin compared to the MDI requirement.

## Enhanced Signal Separation

The TF-AUTO-ENET separates bi-directional link traffic to independently view signals from the Master and Slave. The Automotive Ethernet Debug Toolkit enhances the directivity of the directional couplers in real time, providing superior signal fidelity compared to other directional coupler approaches.



After software enhancement to improve the directivity.

# COMPLIANCE TEST COVERAGE

100Base-T1	Test Mode	PMA	TC8	IEEE	Oscilloscope	TDR	Test Fixture	Function/ Arbitrary Generator	Differential Probe
Maximum Transmitter Output Droop	Mode 1	✓	✓	✓	✓		✓		
Transmitter Timing Master Jitter	Mode 2	✓	✓	✓	✓				✓
Transmitter Timing Slave Jitter	Slave's TX_TCLK or Mode 3	✓		✓	✓				✓
Transmitter Clock Frequency	Mode 2	✓	✓	✓	✓		✓		
Transmitter Distortion	Mode 4	✓	✓	✓	✓		✓	✓	
Transmitter Power Spectral Density	Mode 5	✓	✓	✓	✓		✓		
Transmitter Peak Differential Output*	Mode 5	✓		✓	✓		✓		
MDI Return Loss	Mode 4	✓	✓	✓		✓	✓**		
MDI Mode Conversion	Mode 4	✓	✓			✓	✓**		
MDI Common Mode Emission	Mode 5		✓		✓		✓		

\* No test for BroadR-Reach, only for 100Base-T1

\*\* Requires SMA connector boards (Qty.2)

1000Base-T1	Test Mode	PMA	TC8	IEEE	Oscilloscope	TDR	Test Fixture	Function/ Arbitrary Generator	Differential Probe
Maximum Transmitter Output Droop	Mode 6	✓	✓	✓	✓		✓		
Transmitter Timing Master Jitter	Mode 1	✓	✓	✓	✓		✓		
Transmitter Timing Slave Jitter	Mode 1	✓		✓	✓				✓
MDI Jitter	Mode 2	✓		✓	✓		✓		
Transmitter Clock Frequency	Mode 2	✓	✓	✓	✓		✓		
Transmitter Distortion	Mode 4	✓	✓	✓	✓		✓	✓	
Transmitter Power Spectral Density	Mode 5	✓	✓	✓	✓		✓		
Transmitter Peak Differential Output	Mode 5	✓	✓	✓	✓		✓		
MDI Return Loss	Mode 4	✓	✓	✓		✓	✓**		
MDI Mode Conversion	Mode 4	✓	✓	✓		✓	✓**		

\*\* Requires SMA connector boards (Qty.2)

10Base-T1S	Test Mode	PMA	IEEE	Oscilloscope	TDR	Test Fixture
Transmitter Output Voltage	Mode 1	✓	✓	✓		✓
Transmitter Output Droop	Mode 2	✓	✓	✓		✓
Transmitter Timing Jitter	Mode 1	✓	✓	✓		✓
Transmitter Power Spectral Density	Mode 3	✓	✓	✓		✓
MDI Return Loss	Mode 4	✓	✓		✓	✓**

\*\* Requires SMA connector boards (Qty.2)

## Automotive Ethernet Debug Toolkit Specs

**Supported Protocols** – 10Base-T1S, 100Base-T1/BroadR-Reach, and 1000Base-T1

**Eye Parameters** – Eye Height (upper/lower), Eye Width (upper/lower), Symbol Rate, # of Symbols, Mean Levels (+1, 0, -1), RMS at Levels (+1, 0, -1)

**Eye Contours** – Two customizable BER levels displayed on the eye diagram

**FF Equalization** – Define up to 20 tap weights or automatically train on acquired signal

# ORDERING INFORMATION

## Product Description

## Product Code

### Compliance Test Software

#### Oscilloscope

1000Base-T1 Compliance Software	QPHY-1000Base-T1
100Base-T1/BroadR-Reach Compliance Software	QPHY-100Base-T1
10Base-T1S Compliance Software	QPHY-10Base-T1S

#### WavePulser 40iX - Time Domain Reflectometer (TDR)

1000Base-T1 MDI S-parameter Compliance Software	QPHY-1000Base-T1-TDR
100Base-T1/BroadR-Reach MDI S-parameter Compliance Software	QPHY-100Base-T1-TDR
10Base-T1-TDR MDI S-parameter Compliance Software	QPHY-10BASE-T1-TDR

### Test Fixture

Test Fixture for 10Base-T1S, 100Base-T1, and 1000Base-T1 Debug and Compliance Testing	TF-AUTO-ENET*
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\*Includes 3-foot SMA-SMA cables (Qty 4), 3-foot SMA-BNC cables (Qty 4) and SMA Connector Boards (Qty 2)

4 Pack of SMA Connector Boards for TF-AUTO-ENET	TF-AUTO-ENET-SMA
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### Trigger, Decode, Measure/Graph and Eye

#### 100Base-T1 TDME Options

For a complete list of part numbers and oscilloscope compatibility, see the [Low-speed TDME datasheet](#).

### Debug Toolkit Software

#### Support for 100Base-T1 and 1000Base-T1

Debug Toolkit for WaveRunner 8000HD	WR8KHD-AUTO-ENET-TOOLKIT
Debug Toolkit for WaveRunner 9000	WR9K-AUTO-ENET-TOOLKIT
Debug Toolkit for WavePro HD	WPHD-AUTO-ENET-TOOLKIT
Debug Toolkit for WaveMaster 8 Zi	WM8Zi-AUTO-ENET-TOOLKIT
Debug Toolkit for LabMaster 10 Zi	LM10Zi-AUTO-ENET-TOOLKIT

### Recommended 1000Base-T1 Equipment

2.5 GHz, 20 GS/s, 4 Ch, 100 Mpts/Ch High Definition Oscilloscope with 15.6" 1920x1080 capacitive touch screen	WavePro 254HD
4 GHz, 5 Vp-p ProBus2 Differential Probe	D420-A-PB2
Function/Arbitrary Waveform Generator, 2 Ch, 250 MHz, 16 bit, 128 Mpts/Ch, 6 Vpp output	T3AWG3252
High-speed Interconnect Analyzer (TDR), 4-port, mixed-mode S-parameters DC-40 GHz, <1 mm spatial resolution, internal calibration, OSLT calibration kit, torque wrench, 4 phase matched cables	WavePulser-40iX-BUNDLE

## Product Description

## Product Code

### Recommended 100Base-T1/BroadR-Reach Equipment

1 GHz, 20 GS/s, 4 Ch, 16 Mpts/Ch DSO with 12.1" WXGA Color Display	WaveRunner 9104
1 GHz, 1.0 pF Active Differential Probe, ±8 V	ZD1000
40 MHz, 1.2 GS/s, 8 Mpts, 2 Ch, 20 Vpp Function/Arbitrary Waveform Generator	T3AFG40
High-speed Interconnect Analyzer (TDR), 4-port, mixed-mode S-parameters DC-40 GHz, <1 mm spatial resolution, internal calibration, OSLT calibration kit, torque wrench, 4 phase matched cables	WavePulser-40iX-BUNDLE

### Recommended 10Base-T1S Equipment

350 MHz, 4 Ch, 12 Bits, 10 GS/s, 50 Mpts/Ch High Definition Oscilloscope with 15.6" 1920x1080 capacitive touch screen	HDO6034B
High-speed Interconnect Analyzer (TDR), 4-port, mixed-mode S-parameters DC-40 GHz, <1 mm spatial resolution, internal calibration, OSLT calibration kit, torque wrench, 4 phase matched cables	WavePulser-40iX-BUNDLE



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