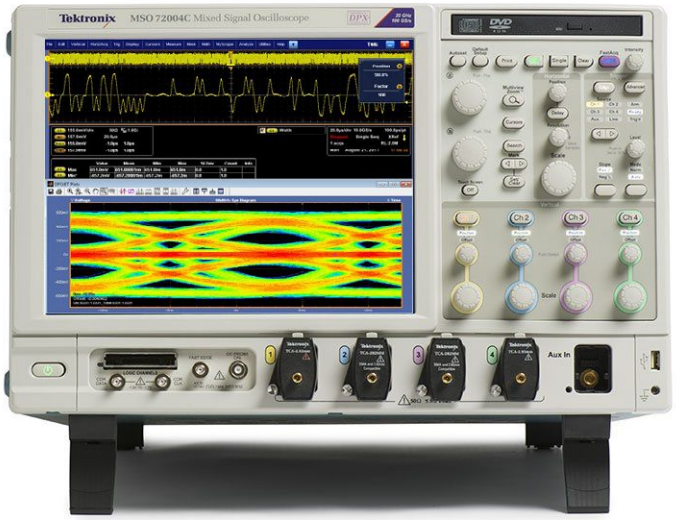
Tektronix®

Automotive Ethernet Test Solution

1000BASE-T1/100BASE-T1 (Option BRR) Datasheet



The Tektronix BRR Automotive Ethernet Solution is a fully automated compliance test software application for 1000BASE-T1 and 100BASE-T1 standards. The test suite runs on the DPO/MSO5000B, DPO7000C, DPO/MSO70000C series, letting you take full advantage of validation and debug capabilities in the oscilloscope in addition to compliance testing. The integration of automotive ethernet is placing greater demands on technology and is placing even greater demands on comprehensive design validation to ensure interoperability between multiple ECUs and reliability in demanding environments. A complete testing solution enables passing strict compliance tests and provides greater confidence in design margins under real-world conditions.

Key features

- **Test Time**: Fully automated with setup wizard, to perform compliance testing as per the Automotive Ethernet 1000BASE-T1 (802.3bp™) and 100BASE-T1 (802.3bw™) standards. The software automatically configures equipments as per test requirement which reduces overall test time.
- **Test Coverage:** Automotive Ethernet solution for 100BASE-T1 and 1000BASE-T1 is designed as per IEEE and Open Alliance specification. The test coverage is as per OPEN Alliance TC8 ECU test.
- **Validation and Debug**: Supporting tools, such as advanced jitter analysis, help to catch problems before compliance testing, or in the event of a failure.
- **Signal Qualification**: In addition to compliance testing, automated tests and advanced jitter analysis tools are provided for testing your DUT under different environmental conditions.
- **Comprehensive Report**: Automated reporting with Pass/Fail screenshot of the waveform.
- **Return Loss Measurements**: The 100/1000BASE-T1 specification defines Return Loss measurement that requires a Vector Network Analyzer (VNA). A patented measurement approach in the Tektronix Automotive Ethernet Test Solution software allows the designer to perform return loss measurement using an oscilloscope, reducing the need for additional test equipment.
- **ECU Clock Access**: The Distortion test requires to access ECU clock which is not possible most of the time. Tektronix unique algorithm software correction method (patent pending) allows user to perform Distortion measurement without connecting clock from ECU. This method is available for 100BASE-T1 and 1000BASE-T1.
- **Performance Verification**: Automotive Ethernet application allows user to run Selected test for multiple times. The report shows pass/fail result of each run to study ECU performance over different run.

Automated Automotive Ethernet compliance testing

Physical layer compliance tests have been defined to ensure interoperability between different designs and hardware vendors. These requirements to perform these tests have been expanded and now cover Automotive Ethernet 1000BASE-T1 (802.3bp™) and 100BASE-T1 (802.3bw™). For electrical signaling, there are specific tests defined for the Physical Media Attachment (PMA), and as part of Group 1, focuses primarily on the transmitter. 1000BASE-T1 Automotive Ethernet testing requires an oscilloscope with a minimum of 2 GHz bandwidth.

Supported tests for 1000BASE-T1

Test Items	Test Name	Test Mode	Instrument
97.5.3.1	Transmitter Output Droop	6	2 GHz oscilloscope
97.5.3.2	Transmitter Distortion	4	2 GHz oscilloscope and AWG
97.5.3.3	Transmitter Timing Jitter (Master/Slave)	1	2 GHz oscilloscope
97.5.3.4	Transmitter Power Spectral Density (PSD)	5	2 GHz oscilloscope
97.5.3.6	Transmitter Clock Frequency	1	2 GHz oscilloscope

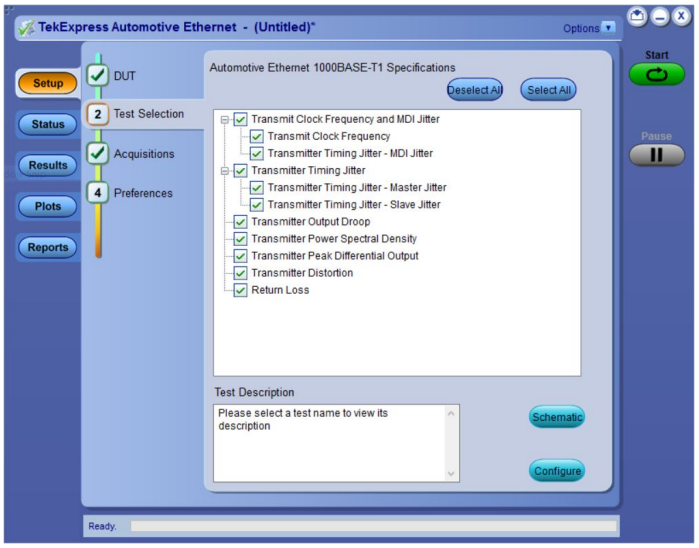
Test Items	Test Name	Test Mode	Instrument
97.5.3.5	Transmitter Peak Differential Output	5	2 GHz oscilloscope
97.7.2.1	MDI Return Loss	4	2 GHz oscilloscope and AWG or Tektronix VNA
97.5.3.3	MDI Jitter	2	2 GHz oscilloscope

Supported tests for 100BASE-T1

Test ID	Test Name	Test Mode	Instrument
5.1.1	Transmitter Output Droop	1	1 GHz oscilloscope
5.1.2	Transmitter Distortion	4	1 GHz oscilloscope and AWG/AFG
5.1.3	Transmitter Timing Jitter	2	1 GHz oscilloscope
5.1.4	Transmitter Power Spectral Density (PSD)	5	1 GHz oscilloscope
5.1.5	Transmitter Clock Frequency	2	1 GHz oscilloscope
5.1.6	MDI Return Loss	4	1 GHz oscilloscope and AWG or Tektronix VNA
5.1.6	Peak Differential Output	5	1 GHz oscilloscope

The Tektronix Automotive Ethernet test solution provides automated compliance testing for 100BASE-T1 (IEEE 802.3bw™) and 1000BASE-T1 (IEEE 802.3bp™). The automated compliance solution includes test software that runs on a 1 GHz or greater oscilloscope to perform all physical layer (PHY) transmitter compliance tests.

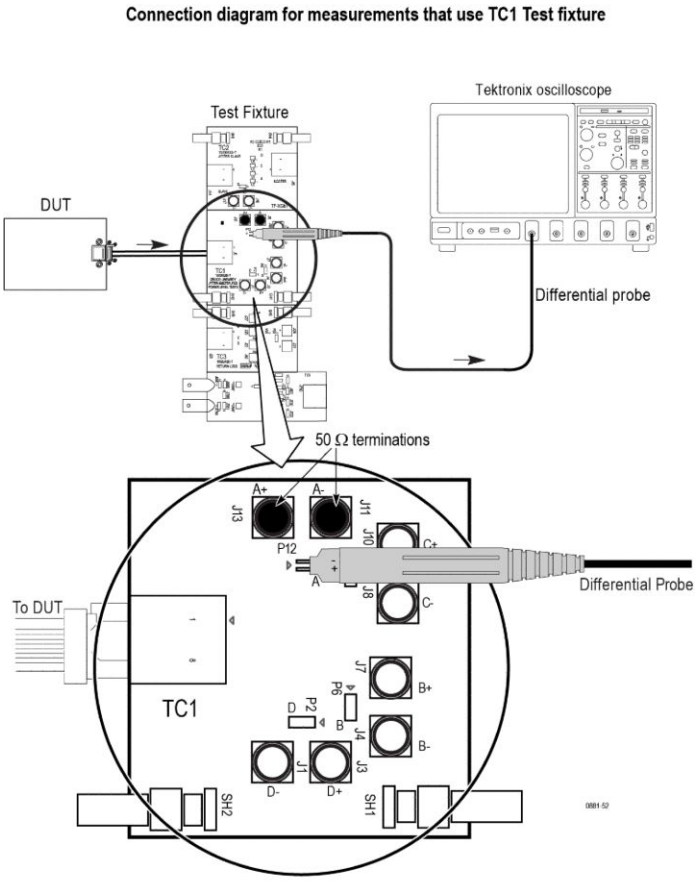
The compliance software allows for complete or selective testing of any of the transmitter electrical specifications, including complete oscilloscope control of the required setups. Software setup flexibility allows you to perform design validation, margin analysis, and repeatable compliance testing while reducing instrument setup difficulties. Additionally, the software can generate a comprehensive date-stamped test report with pass/fail results, and display waveforms and data plots.



The TekExpress Automotive Ethernet setup menu - 1000BASE-T1

The Automotive Ethernet compliance software allows selection of all or any of the specific tests through a simple Setup menu. Software navigation follows a logical workflow for quick test setups, changes, and review of test results.

Test setup configurations vary greatly from connections to the device under test, probing, test fixtures, calibration, and use of the oscilloscope and signal generator. To help testers correctly set up for a measurement, the Automotive Ethernet software provides setup instructions for each test, with images and reference illustrations, to ensure the correct setup.



Setup configuration

The Automotive Ethernet compliance software requires a Tektronix DPO5K, 7K, and 70K oscilloscope with Windows 7 or Windows 10. Since it operates as a Windows application, the software shares the oscilloscope display. For convenience, the recommended configuration is to add a PC display monitor to display the compliance software and test reports separately from the oscilloscope screen.

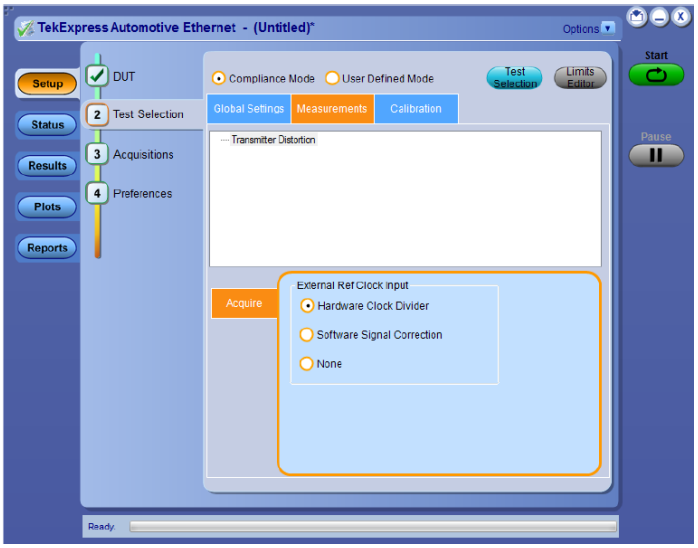
Displaying the compliance software on a separate monitor for easier results analysis

Conducting each test requires configuring the transmitter for specific operating modes using specialized software from the device supplier. Once the transmitter is correctly configured, along with the proper test fixtures and probing, configure the Automotive Ethernet software setup to match the specific test of interest. After test selection, the software guides you to perform all the necessary instrument setups. For the Distortion and Return Loss tests, this can include setup of the signal generator required to conduct these tests.

Distortion (with and without TX_TCLK access):

Distortion test requires the disturber signal and the data acquisition clock of the oscilloscope are frequency locked to the DUT TX_TCLK. Tektronix supports this method using Hardware clock Divider method.

Most ECUs do not have access to TX_TCLK signal. Tektronix has developed unique algorithm for 100BASE-T1 and 1000BASE-T1 which performs software Clock recovery on signal with Disturbance. This method does not need access to DUT clock or hardware locking or Clock divider unit.



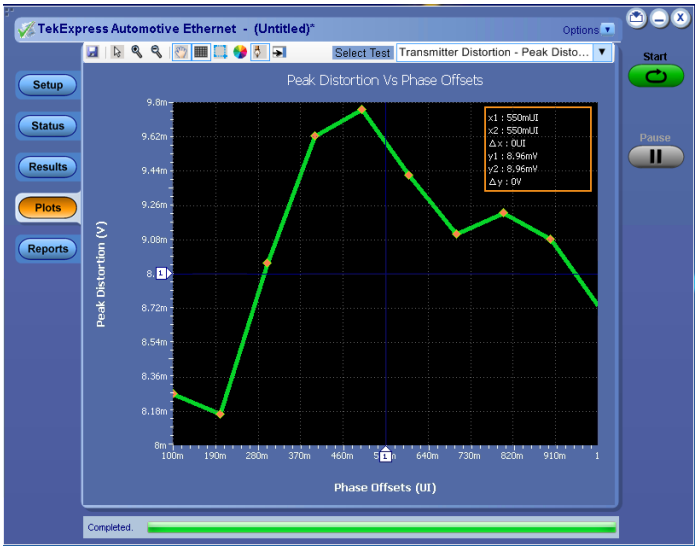
TekExpress Automotive Ethernet provides external reference clock input sources - 1000BASE-T1

Industry defined testing

In order to ensure hardware interoperability, the test software follows the test methods and test limits defined by the OPEN (One-Pair-Ethernet) Alliance Special Interest Group (SIG). The OPEN Alliance test suite documents are strictly followed to ensure that the instrument setups, algorithms, and test outcomes are fully supported.

Distortion test

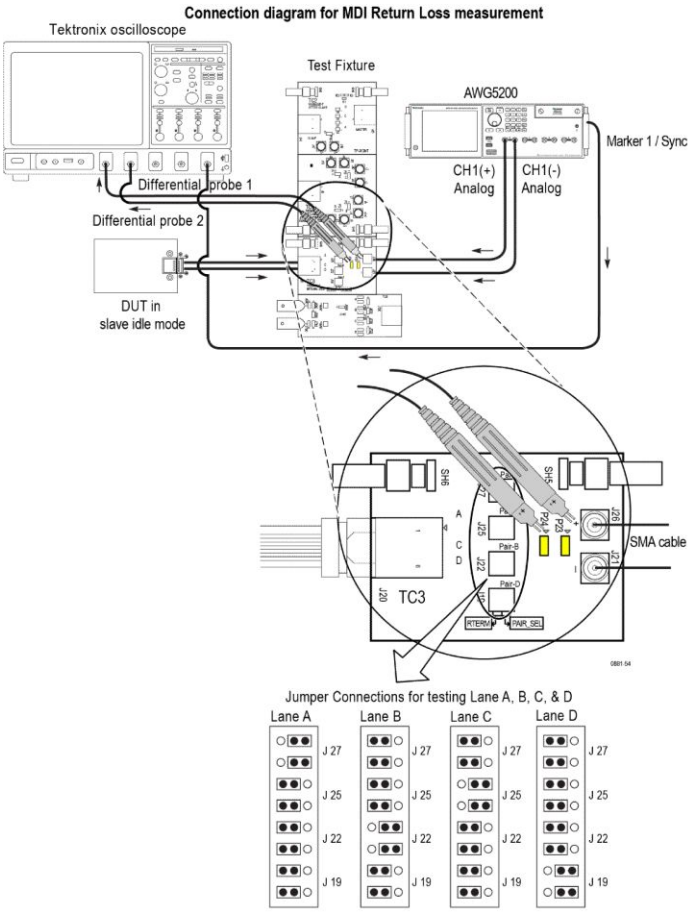
Configured for Test Mode (as referred in the table Supported tests for 1000BASE-T1/100BASE-T1), the distortion test measures the maximum allowable transmitter distortion. This test requires the use of a disturbing sine wave signal that is added to the PHY output signal. The peak transmitter distortion is calculated, and the measured values are compared against the compliance test specification.



Distortion measurement

Return Loss measurement

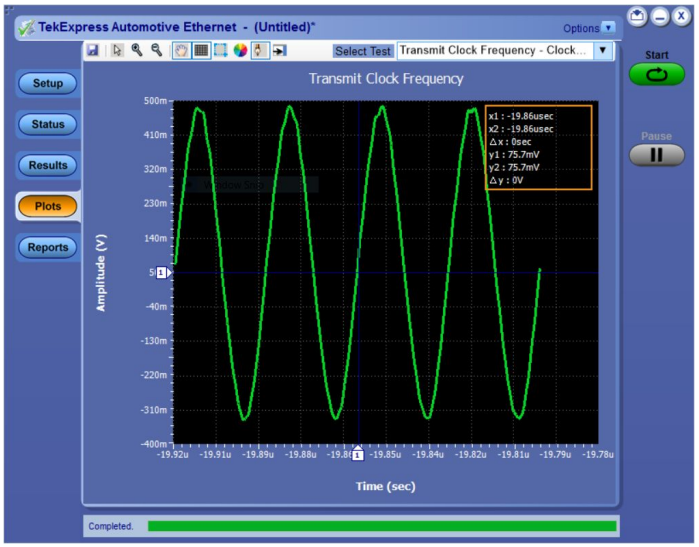
The MDI return loss test determines the impedance mismatch from the differential impedance specification of 100 Ω, which will affect hardware interoperability. This test can be performed using a Tektronix VNA, but the Tektronix BRR solution can perform this test with an oscilloscope using a patented measurement approach that eliminates the need for additional test instruments.



Setup configuration for Return Loss measurement

Jitter and transmit clock frequency tests

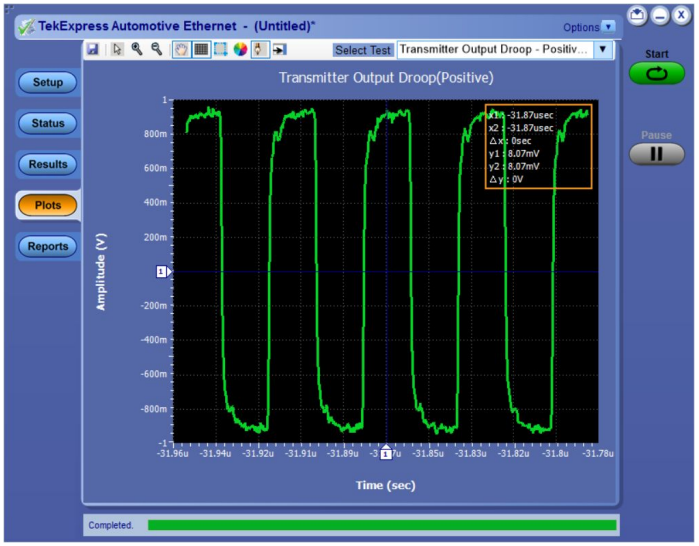
The PHY has a symbol clock that is the output using Test Mode (as referred in the table Supported tests for 1000BASE-T1/100BASE-T1). Separate tests are run to measure the Master (Slave) RMS jitter and the TX clock frequency.



Jitter and Transmit Clock Frequency measurements

Droop measurement

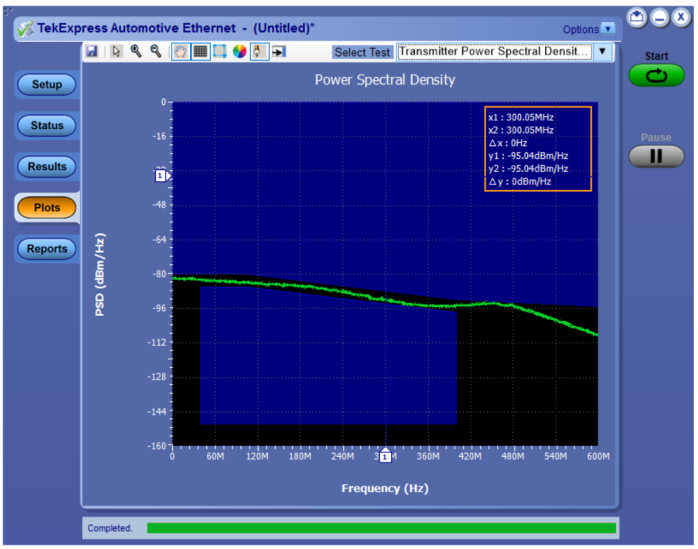
The PHY is configured using Test Mode (as referred in the table Supported tests for 1000BASE-T1/100BASE-T1). The droop measurements are performed by determining the positive and negative waveform peak voltages.



Droop measurement - Positive and Negative peak of waveform

Power Spectral Density (PSD) measurement

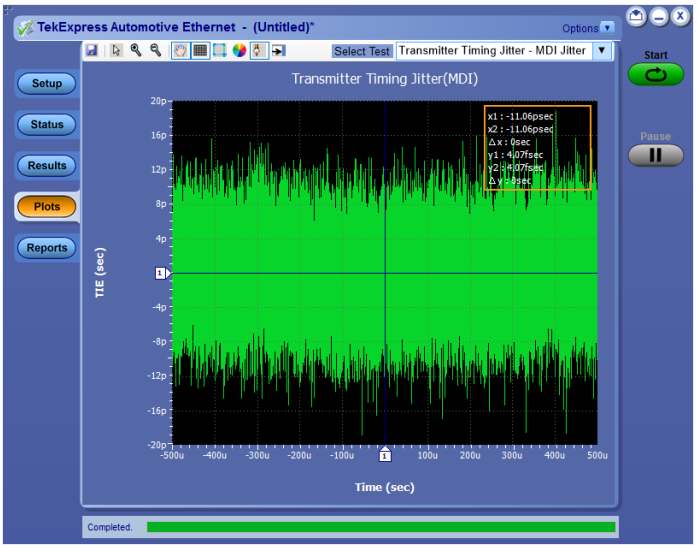
The spectral of an input signal (set to Test Mode as referred in the table Supported tests for 1000BASE-T1/100BASE-T1), is computed using built-in oscilloscope MATH functions. Post processing is done on the signal to arrive at the PSD. The computed PSD is then compared with the specification by using lower and upper masks to arrive at the final result.



Power Spectral Density (PSD) measurement

MDI Jitter Measurement

Configure for Test Mode (as referred in the table Supported tests for 1000BASE-T1/100BASE-T1), and transmit three {+1} symbols followed by three {-1} symbols continually. Measure jitter of the Data signals.



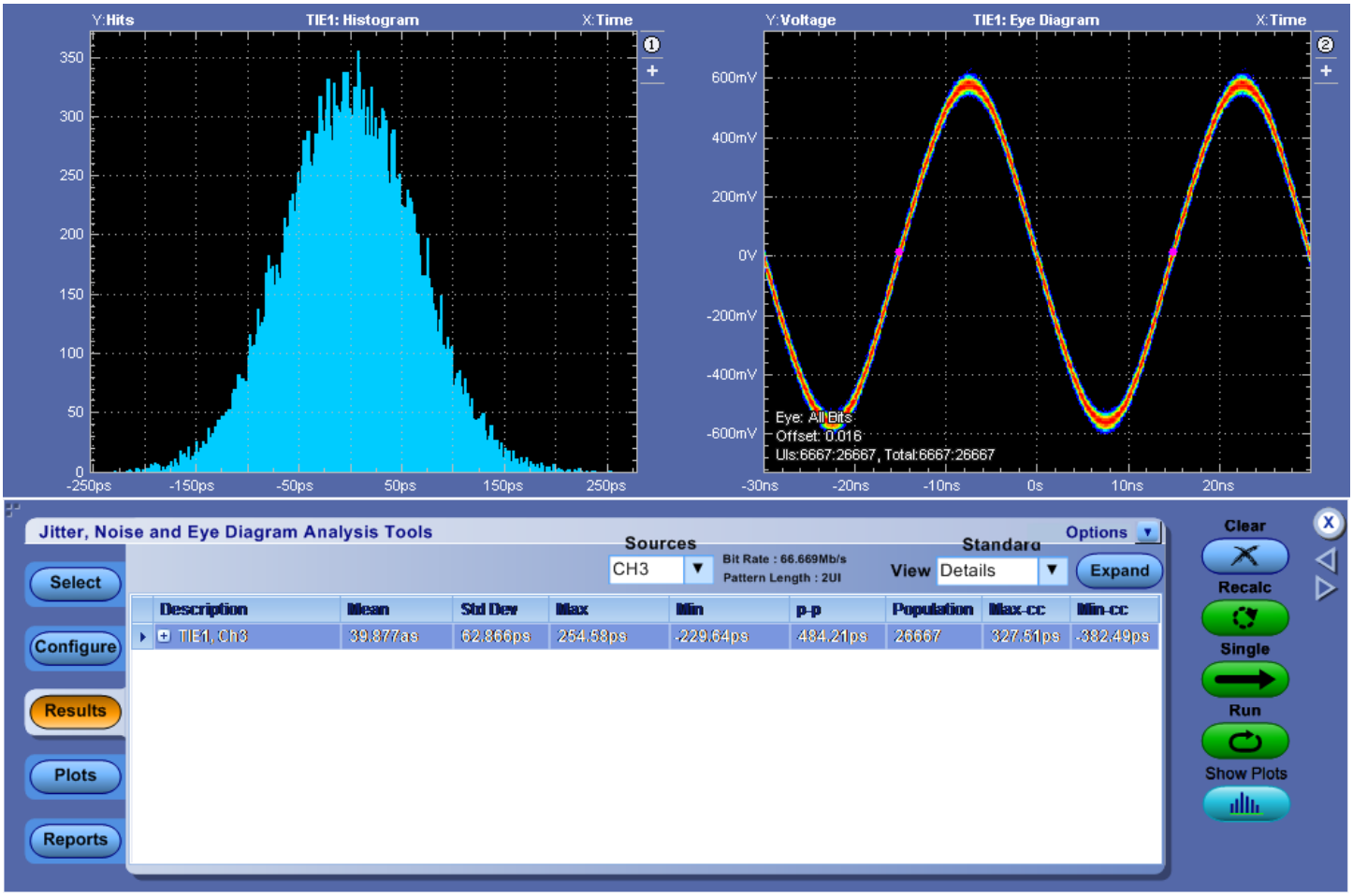
MDI jitter measurement

Validation and debug

Validation and debugging can easily be accomplished early in the design process and ahead of final compliance testing by using the DPO5K/7K/70K oscilloscope. The oscilloscope's standard measurement set, along with the optional DPOJET Advanced Jitter and Timing Analysis software, supports several of the key compliance tests including:

- Clock frequency and transmitter amplitude with histogram and trend analysis
- Positive and negative droop measurements
- Full characterization of jitter performance including TIE and histogram profiles
- Eye diagram analysis of PAM3 signals

This type of early testing increases the likelihood of passing compliance tests, while allowing more complete characterization and determination of design margins. Master and slave jitter measurements can be particularly challenging given the tight compliance limits and the need to eliminate any possible sources of random or deterministic jitter.



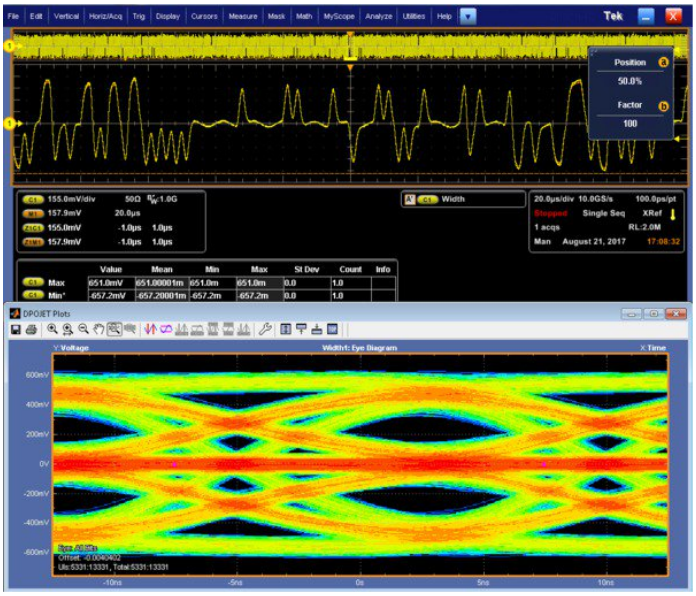
Transmitter Master Jitter analysis showing Time Interval Error (TIE) using DPO5K/7K/70K measurements and DPOJET measurements

Susceptibility to various sources of interference is a concern for reliable network communication between master and slave devices. Confirmation of reliable operation and identification of possible sources of interference or error conditions can be difficult to distinguish in PAM3 signaling.

Eye pattern analysis is a proven technique to evaluate long data streams of complex communication signals. Configuring the oscilloscope with the Advanced Jitter and Eye Analysis software provides capabilities to debug and execute measurements of jitter, timing, and eye diagrams completely.

Signal Qualification

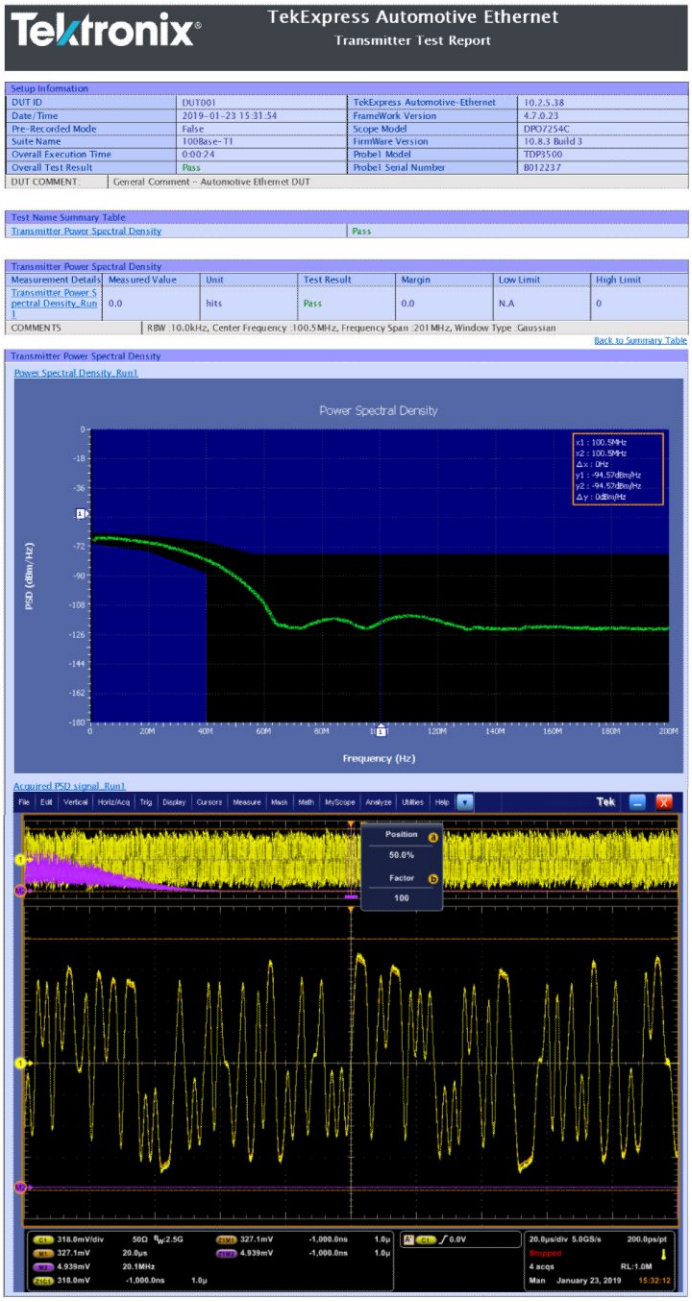
Automotive designers need to qualify their circuit designs under various conditions such as temperature, voltage, and vibration. Apart from compliance, designers need to qualify the design under various conditions. The DPOJET Advance Jitter and Timing Analysis software allows designers to configure 1000BASE-T1/100BASE-T1 measurements and run them under different environmental conditions. Designers can integrate the measurement in their automation environment to run the measurement in a continuous mode.



PHY jitter / timing analysis

Pass/Fail report

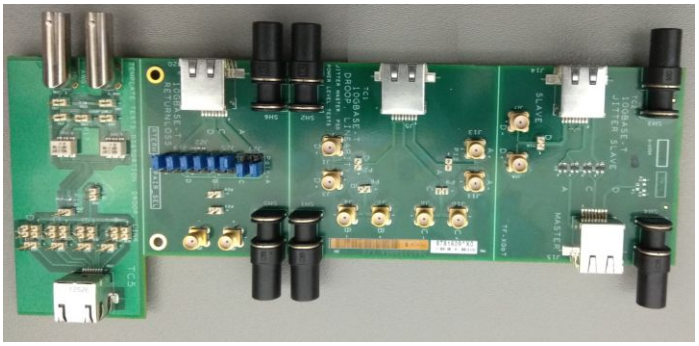
Creating compliance test documentation is quick and easy in BRR with a summary report in MHL or PDF format. The software automatically generates a report after tests are completed, and includes Pass/Fail status to quickly analyze the test results. The report also includes test configuration details, waveform plots, oscilloscope displays, and margin analysis, to provide more insights into your design.



Detailed test report showing PSD mask test plot

Test fixtures

Accurate and repeatable compliance testing requires access to the PHY transmitter output and reference clock, and must support calibration and use of disturbing signals. The recommended approach is to use the Tektronix TF-XGbT Ethernet fixture and the TF-BRR-CFD clock divider fixtures. These fixtures can support all test setups while providing convenient test points for probing.



TF-XGbT Ethernet fixture

For direct probing of a DUT, use a differential probe with a bandwidth of ≥2 GHz. The Tektronix TDP3500 is the recommend differential probe for 1000BASE-T1 testing.

Ordering information

Measurement names and hardware

Measurements	Required hardware
Transmitter output droop Transmitter timing Jitter Transmitter clock frequency MDI Jitter Differential Output Transmitter power spectral density	DPO70K with one probe
Transmitter distortion	AFG3152C or AWG5200
Return Loss	100BASE-T1: AFG3152C and two probes or TTR503 1000BASE-T1: AWG5200 and two probes or TTR503

1000BASE-T1/100BASE-T1 ordering information

Required software	Option BRR or DPO-UP BRR (TekExpress Automotive Ethernet compliance)
Required hardware	1000BASE-T1 DPO/MSO5000B, DPO7000C, DPO/MSO70000C (2GHz and above)
	100BASE-T1 DPO/MSO5000B, DPO7000C, DPO/MSO70000C (1GHz and above)
Recommended options	Option DJA or DPO-UP DJA (adds Advanced Jitter and Eye Analysis measurements)
	Option SR-AUTO or DPO-UPSR-AUTO (adds CAN, LIN, FlexRay serial bus trigger and decode)
	Option SR-EMBD or DPO-UP SR-EMBD (adds I^2C, SPI serial bus trigger and decode)
Probing	**Recommended (two required)**: 1000BASE-T1 TDP3500 differential probes and 100BASE-T1 TDP1500 or TDP3500 differential probes (require TCA-VPI50 adapter)
	Supported: TDP7704/7706/7708 probe with P77C292MM adapter (not supported for Return loss and Distortion test), P6247 or P6248 (requires use of TPA-BNC adapter)
Signal sources (AWG)	**Recommended**: Tektronix AFG3152C signal source
	Supported: Tektronix AWG5200 with high amplitude DC coupled with output option or AWG70000 signal source
Recommended test fixtures	TF-XGbT Test Fixture
	TF-BRR-CFD clock frequency divider (Required for Hardware clock for Distortion measurement)
Recommended extras	External PC monitor
	Two pairs of 50 Ω high-quality SMA or coaxial cables (four cables total) for use with AFG or AWG signal sources; all cables must be the same length
	Two 50 Ω high-quality coaxial cables for use with clock divider outputs; both cables must be the same length
	One 50 Ω high-quality SMA cable for the clock divider input
	One 50 Ω high-quality coaxial cable for the AFG or AWG signal source, for marker output

Tektronix is registered to ISO 9001 and ISO 14001 by SRI Quality System Registrar.

Product(s) complies with IEEE Standard 488.1-1987, RS-232-C, and with Tektronix Standard Codes and Formats.

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