

10BASE-T1L Industrial Ethernet Compliance Test Solution

Option 5-CMINDUEN10 and 6-CMINDUEN10 Datasheet

Get more visibility into your 10BASE-T1L designs



Get more visibility into your Ethernet designs with the 10BASE-T1L Industrial Ethernet Compliance Test Solution for the 5 Series and 6 Series B MSOs. The combination of the oscilloscope, analysis software, and a wide range of available analog probes enables you to perform detailed and accurate amplitude and timing measurements on your designs.

Key features

- **Test Time:** Fully automated with a setup wizard to perform compliance testing as per the 10BASE-T1L (IEEE 802.3cg™) standard. Highly optimized and intuitive user interface for quick test configuration and validation of electrical signals. The software automatically configures equipment per the test requirements which reduces overall test execution time.
- **Test Coverage:** The TekExpress Industrial Ethernet solution for 10BASE-T1L is designed to comply with the IEEE 802.3cg specification covering transmitter test.
- **Validation and Debug:** Tools such as Advanced Jitter Analysis (DJA) let you identify problems before compliance testing or in the event of failure.
- **Comprehensive Report:** Automated reporting with Pass/Fail status and screenshots of the waveforms.
- **Measurement Accuracy:** Tektronix 5 series and 6 series B Mixed Signal Oscilloscopes offer analog bandwidth up to 8 GHz, sample rates up to 25 GS/s and 12-bit analog-to-digital converters (ADC), delivering the performance needed to capture waveforms with high signal fidelity and resolution. Tektronix' patented measurement approach in the TekExpress Industrial Ethernet Test Solution enables designers to perform return loss measurements using an oscilloscope, reducing the need for additional test equipment.
- **Domain measurements:** Time domain and frequency domain measurements (Return Loss and Power Spectral Density) can be made with a single instrument.
- **Performance Verification:** The Industrial Ethernet application enables you to easily run tests multiple times. The statistics in the reports display Pass/Fail status for each run, to help study device performance over different runs.

Fully automated compliance testing

The Tektronix Industrial Ethernet Solution is a fully automated compliance test application for the 10BASE-T1L (802.3cg) standard. Executing all the measurements manually is extremely time-consuming. The TekExpress Industrial Ethernet application provides an automation framework, that enables you to execute all the measurements with less intervention, only when you need to change connections.

The physical layer compliance tests are defined to ensure interoperability between different designs and hardware vendors. The requirements to perform these tests have been expanded and now cover Industrial Ethernet 10BASE-T1L (802.3cg) standards.

The test suite runs on 5 Series and 6 Series B MSOs, and lets you to take full advantage of the oscilloscope validation and debug capabilities

in addition to compliance testing. The integration of Industrial Ethernet is placing greater demands on technology and comprehensive design validation to ensure interoperability. The Tektronix Industrial Ethernet Solution provides greater confidence in design margins under real world conditions by ensuring that your designs pass the strict 10BASE-T1L compliance tests.

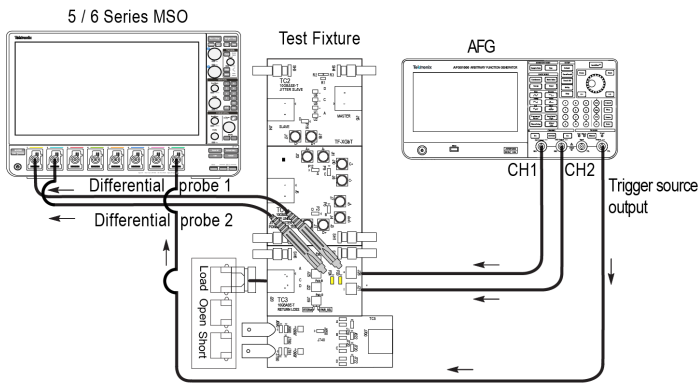
Table 1: Supported 10BASE-T1L tests

Test Name	Test Mode	Instrument
Transmitter Output Droop	2	350 MHz Oscilloscope
Transmitter Timing Jitter	1	
Transmitter Power Spectral Density (PSD)	3	
Transmitter Clock Frequency	1	
Peak Differential Output	1	
MDI Return Loss	Slave	350 MHz Oscilloscope and AFG or Tektronix VNA

TekExpress Industrial Ethernet software allows for complete or selective testing of any of the transmitter electrical specifications. Tests are configured by following a step-by-step process. Software navigation follows a logical workflow for quick test setups, configurations, and review of test results. The software sets up the oscilloscope and automates the tests, guiding you to accurate and repeatable results.

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

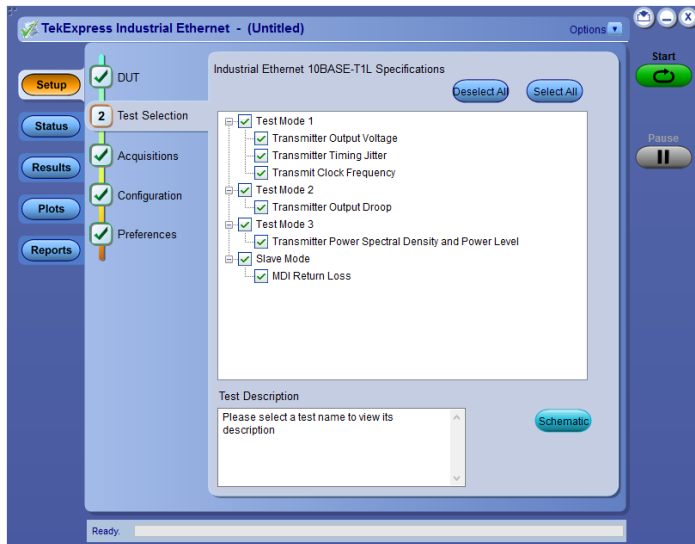
Connection diagram for Return Loss Calibration



Note: For best results, connect the Oscilloscope, DUT, and test fixture to a common ground.

Figure 1: Return loss

The application generates a comprehensive, date-stamped test report with pass/fail results, waveforms, and data plots.



The TekExpress Industrial Ethernet compliance software requires a Tektronix 5 Series or 6 Series B MSOs with Option 5-WIN/6-WIN or SUP5-WIN/SUP6-WIN (Microsoft Windows 10). Since it operates as a Windows application, the software shares the oscilloscope display. For convenience, we recommend that you add an external monitor to display the compliance software and test reports separately from the oscilloscope screen.

Return loss measurement

The MDI return loss test determines the impedance mismatch between PHY and reference MDI Connector from the differential impedance specification of 100 Ω, which will affect hardware interoperability. Return Loss is a frequency domain measurement and generally requires an additional frequency domain test instrument to run the measurement. The Tektronix 5-CMINCEN10/6-CMINDUEN10 solution can perform

this test with an oscilloscope using a patented measurement approach that eliminates the need for additional test instruments.

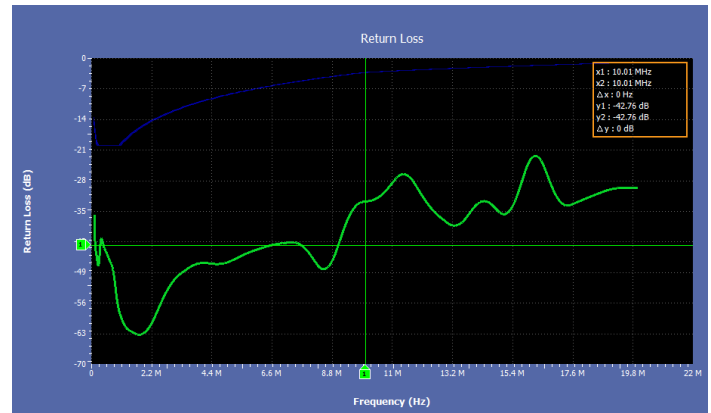


Figure 2: Return loss plot generated using the oscilloscope and AFG

Transmitter clock frequency and jitter measurements

Jitter tests quantify the timing variations of the edges of the signal, using specified test patterns. These jitter measurements include contributions from duty cycle distortion and baseline wander. Jitter is determined by accumulating waveforms and measuring the width of the accumulated points at the eye crossing. The jitter peak-to-peak measurement is determined by the minimum and maximum values in the tails of the histogram. The PHY has a symbol clock output, configured at Test Mode1.

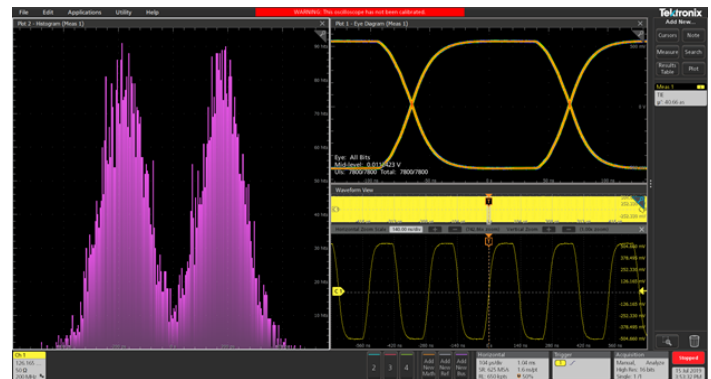


Figure 3: Jitter measurement

Droop measurement

The droop measurements are performed by determining the positive and negative waveform peak voltages. The PHY has a symbol clock output, configured at Test Mode2.

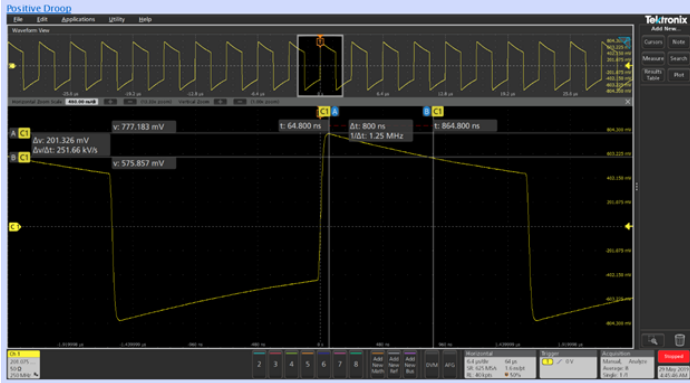


Figure 4: Droop measurement

Power spectral density (PSD) measurement

Power spectral density is a frequency domain measurement that may require a spectrum analyzer. The Tektronix 5 Series and 6 Series B MSOs, with 12-bit analog-to-digital converters (ADC) and outstanding noise performance, provides accuracy similar to a spectrum analyzer. The spectrum of an input signal in test mode is computed using built-in oscilloscope math functions. The post-processing is done on the signal to determine the PSD. The computed PSD is then compared with the specification by using lower and upper masks to arrive at the final result.

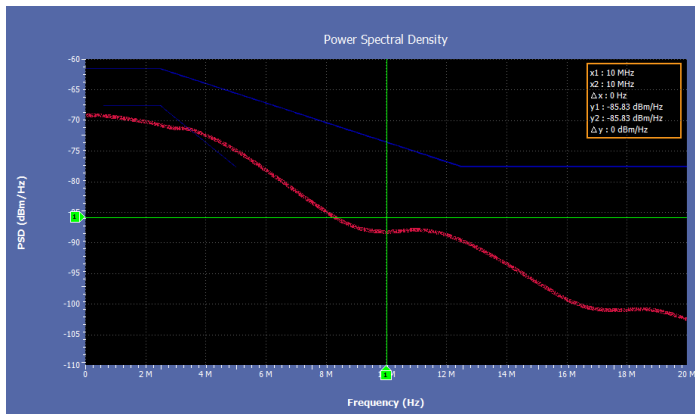


Figure 5: Power Spectral Density measurement

Limits

10BASE-T1L Ethernet operates at 1 Vpp or 2.4 Vpp levels and the limits are defined accordingly. The TekExpress Industrial Ethernet Application allows you to configure operating voltage and selects the limit accordingly. The application can work in Compliance mode, where limits are defined as per compliance specification, or in User Defined mode, which allows you to edit the limits to perform characterization of the Device under Test (DUT).

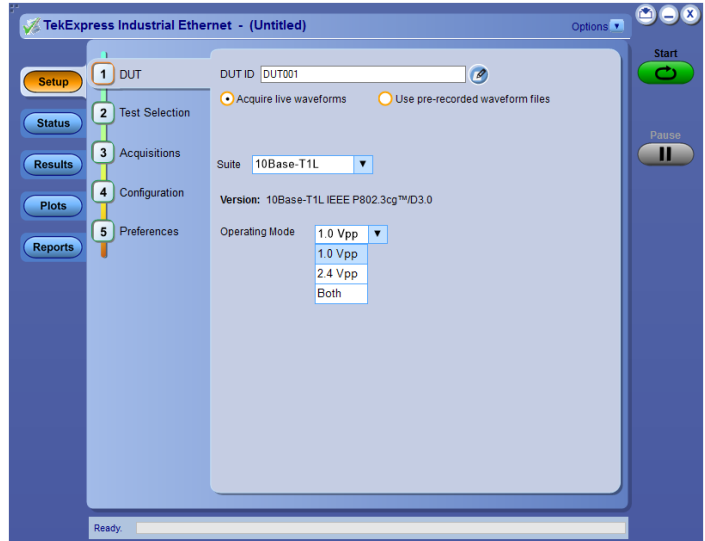


Figure 6:

Validation and debug

Validation and debugging are easily accomplished early in the design process and ahead of final compliance testing with the 5 Series and 6 Series B MSOs. The oscilloscope's standard measurement set, along with the optional 5-DJA/6-DJA (Advanced Jitter and Timing Analysis) software supports several of the key compliance tests including:

- Clock Frequency
- Transmitter Amplitude with Histogram
- Trend Analysis Positive
- Negative Droop measurements
- Full characterization of Jitter performance including TIE
- 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.

Pass/fail reports

The TekExpress Industrial Ethernet application creates compliance test documentation quickly with a summary report in MHL or PDF format. The software automatically generates a report after test execution is complete, and includes Pass/Fail status to help you quickly analyze the test results. The report also includes test configuration details, waveform plots, oscilloscope display screenshots, and margin analysis to provide more insights into your design.

Setup Information			
DUT ID	DUT001	TekExpress Industrial Ethernet	1.0.0.1
Date/Time	2019-07-21 22:10:16	Framework Version	4.10.0.35
Pre-Recorded Mode	False	Scope Model	MSOS8
Compliance Mode	True	Firmware Version	1.16.6.6557
Suite Name	10Base-T1L	Probe1 Model	P6248
Overall Execution Time	0:00:23	Probe1 Serial Number	8021607
Overall Test Result	Pass		
DUT COMMENT	General Comment - Industrial Ethernet DUT		

Test Name Summary Table	
Transmitter Output Droop	Pass

Statistics						
Measurement Details	Run Count	Min	Max	Average	Units	Standard Deviation
Positive Output Droop_1.0Vpp	1	2.365	2.365	2.365	%	0
Negative Output Droop_1.0Vpp	1	2.261	2.261	2.261	%	0

Transmitter Output Droop								
Measurement Details	Test Result	Low Limit	Measured Value	High Limit	Units	Margin	Run#	
Positive Output Droop_1.0Vpp	Pass	NA	2.365	10	%	LL: N.A., HL: 7.635	1	
Negative Output Droop_1.0Vpp	Pass	NA	2.261	10	%	LL: N.A., HL: 7.739	1	

COMMENTS: Signal Validation : Pass.
 1.0Vpp mode: Positive droop: Max value = 3.1%, Min value = 1.45%, Count = 599
 1.0Vpp mode: Negative droop: Max value = 2.88%, Min value = 1.57%, Count = 599

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Figure 7: Measurement report in MHT format

6 Series B MSO Oscilloscope

With up to 10 GHz analog bandwidth, 50 GS/s sample rates, lowest noise and highest resolution, the 6 Series B MSO oscilloscope has the performance you need to capture waveforms with the best possible signal fidelity.

At the heart of the 6 Series B MSO oscilloscope are 12-bit analog-to-digital converters (ADCs) that provide 16 times the vertical resolution of traditional 8-bit ADCs. This resolution, combined with an extremely low-noise front end, allows you capture small signal details even on relatively large signals.

*More Bandwidth. More Channels.
Less Noise.*



Test fixtures and probing test points

Accurate and repeatable compliance testing requires access to the PHY transmitter output. The recommended approach is to use the Tektronix TF-XGbT Ethernet fixture. These fixtures can support all test setups while providing convenient test points for probing.

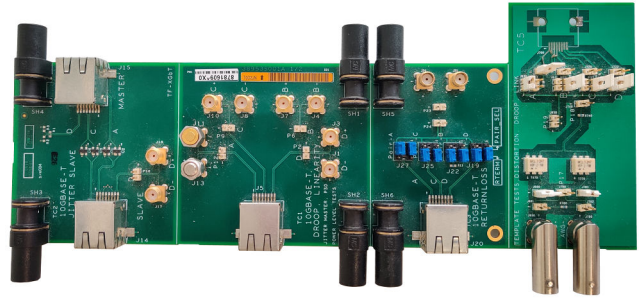


Figure 8: TF-XGbT test fixture

Ordering information

Measurement names and required hardware

Measurements	Required hardware
Transmitter Output Droop Transmitter Timing Jitter Transmitter Clock Frequency Differential Output Transmitter Power Spectral Density	5 Series or 6 Series B MSOs with a probe (TDP1500, P6247 or P6248)
Return Loss	5 Series or 6 Series B MSOs AFG31052 Two TDP1500, P6247 or P6248 probes

Required hardware 5 Series MSO with minimum bandwidth of 350 MHz (Option 5-BW-350, 5-BW-500, 5-BW-1000, 5-BW-2000) or 6 Series B MSO oscilloscope with minimum bandwidth of 1 GHz (Option 6-BW-1000 6-BW-2500, 6-BW-4000, 6-BW-6000, 6-BW-8000, 6-BW-10000)
Option 5-WIN/6-WIN or SUP5-WIN/SUP6-WIN (removable SSD with Microsoft Windows 10 operating system)

Required software

TekExpress Industrial Ethernet Compliance Analysis Solution Option 5-CMINDUEN10/6-CMINDUEN10 or SUP5-CMINDUEN10/SUP6-CMINDUEN10
Advanced Jitter and Eye Analysis Option 5-DJA/6-DJA or SUP5-DJA/SUP6-DJA
125 M Record Length Option 5-RL-125M/6-RL-1/6-RL-2 or SUP5-RL-125M/SUP6-RL-1/SUP6-RL-2

Required signal generators

Signal source Tektronix AFG31052 (50 MHz and above)

Recommended probes

Probes TDP1500, P6247 or P6248 (requires use of TPA-BNC adapter)

Recommended accessories

Test fixture TF-XGbT

External PC monitor

Cables Two pairs of 50 Ω high-quality SMA or coaxial cables for AFG signal sources; all cables must be of same length



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.



Product Area Assessed: The planning, design/development and manufacture of electronic Test and Measurement instruments.

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