# Ethernet Electrical Testing Software for 5/6 SeriesMSO

Option 5-CMENET/6-CMENET and 5-CMENETML/6-CMENETML Application Datasheet

## *Get more visibility into your Ethernet designs*

Get more visibility into your Ethernet designs with 1000BASE-T/100BASE-TX/10BASE-T PHY Measurement and Analysis on the 5 Series, 6 Series, and 6 Series B MSO. The combination of the oscilloscope, analysis software – Option 5-CMENET/6-CMENET, and a wide range of available analog probes enables you to perform detailed and accurate amplitude and timing measurements on your designs. The 12-bit analog-to-digital converters in the 5/6/6B Series MSO deliver precise measurement data.

Option 5-CMENET/6-CMENET is a standard specific application for Tektronix 5/6 Series and 6 Series B MSO oscilloscopes. This application includes compliance measurements that enable you to achieve new levels of debugging, efficiency, and accuracy. Option 5-CMENET/6-CMENET adds a long list of IEEE 802.3 and ANSI X3.263 specific measurements for different Ethernet standards to the standard jitter, timing, and signal quality measurements in the 5/6 Series MSO oscilloscopes.

## Key features

- Comprehensive Ethernet PHY test coverage supporting multiple speeds.
- Highly optimized and intuitive user interface for quick test configuration and validation of electrical signals.
- Compliance and margin testing for accurate analysis and improved interoperability.
- Time-domain and frequency-domain measurements made with a single instrument.
- Jitter and timing measurements with and without filters.
- Amplitude and droop testing for transmitter performance.
- Detailed test reports with results, pass/fail info, test margin, and test specific waveform images.
- Configure test parameters and limits for debug and characterization.
- Configure multiple test runs and analyze the results.
- Preview the test mode waveform before running the tests.
- Additional *Peak Distortion Vs Phase Offset* and *Error Values Vs Symbol Number* plots for 1000BASE-T distortion tests.

Ethernet compliance testing has some unique measurement challenges:

- Generating the disturbing signals requires you to generate pattern data and noise to create real-world noise for some measurements.
- You must test amplitude, timing, return loss, and template measurements for the ethernet standards:
    - The 100BASE-TX standard outlines 12 tests per port plus CMRR and more
    - The 1000BASE-T standard calls for 80 tests per port plus BER, CMRR, and more
    - The 10BASE-T standard specifies 22 tests per port plus fault tolerance and CMRR
- Because of the large number of individual tests, compliance testing takes a lot of setup and measurement time, and makes repeatable measurement results difficult to achieve.

## Automated Ethernet physical layer compliance testing

Automated TekExpress Ethernet electrical testing with option 5-CMENET/6-CMENET requires an oscilloscope with minimum bandwidth of 1 GHz. This application provides automated compliance testing for Ethernet verification.

Executing all of the measurements manually is extremely time-consuming. TekExpress Ethernet software provides you an automation framework, enabling you to execute all of the measurements with less user intervention, such as when you need to change the connections.

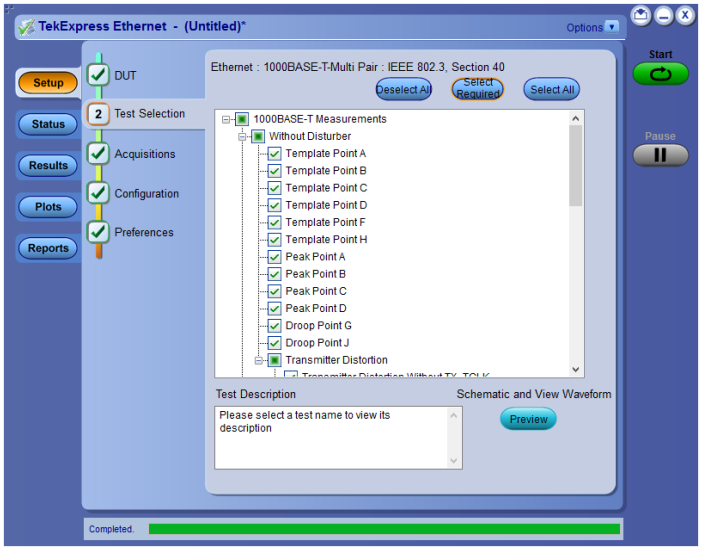



*Figure 1: TekExpress Ethernet test selection panel*

TekExpress Ethernet software allows you to choose complete or selective testing of any of the transmitter electrical specifications. Tests are configured by following a step-by-step process. The software sets up the oscilloscope and automates the testing, guiding you to accurate and repeatable results. It generates a comprehensive, date-stamped test report with pass/fail results, waveforms, and data plots.

Software navigation follows a logical workflow for quick test setups, changes and review of test results. Valid testing requires proper cabling, probes, and connections between fixtures, instruments, and the device under test (DUT). The software provides setup instructions for each test, with images and reference illustrations showing correct configurations.

TekExpress Ethernet software requires a Tektronix 5/6/6B Series MSO oscilloscope with Option 5-WIN/6-WIN or SUP5-WIN/SUP6-WIN (Microsoft Windows 10). This is a Windows application and the software displays TekExpress Ethernet software and test reports on the oscilloscope display. However, for convenience an external monitor may be connected to the 5/6/6B Series MSO so test controls and reports can be viewed on the external display, while signal acquisition is observed on the primary oscilloscope display.

*Figure 2: TekExpress Ethernet results panel displaying tests results*

## 1000Base-T-Multi Pair testing

The 1000Base-T consists of four pairs of full duplex signals namely, Pair A, Pair B, Pair C, and Pair D. The compliance testing of the Ethernet testing requires all the four pairs/lanes of signals to be tested for all the parameters listed below the disturbing and non-disturbing options.

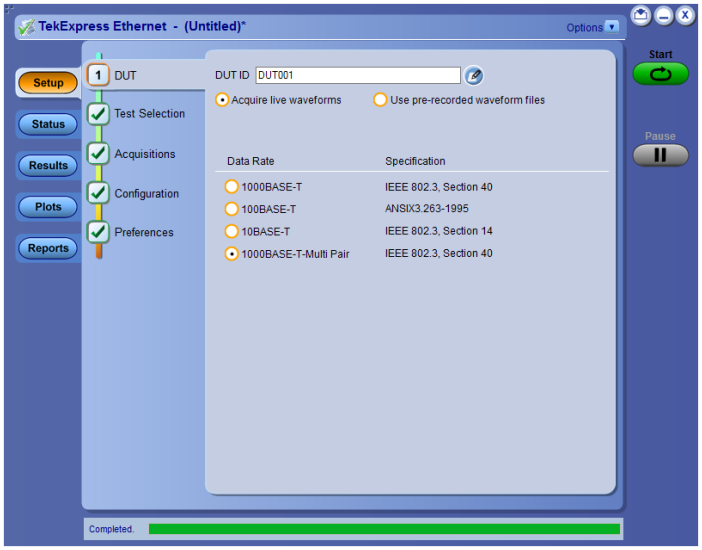



*Figure 3: 1000Base-T-Multi Pair testing setup*

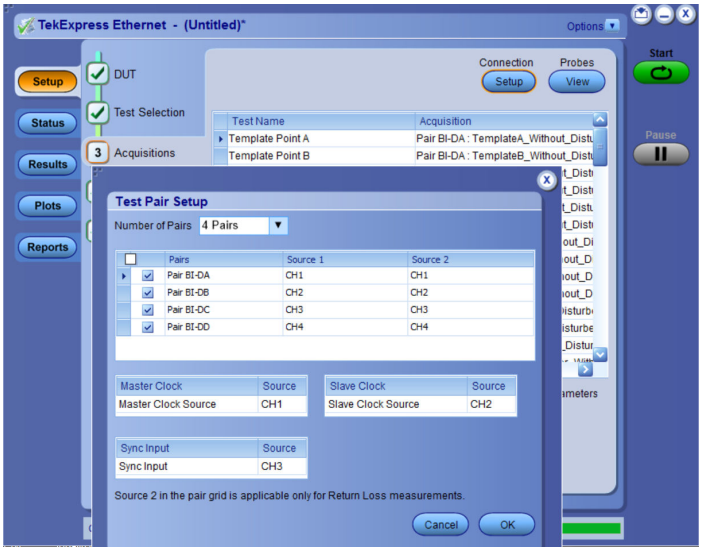



*Figure 4: Test pair setup for four pairs*

The traditional approach is testing of each pair sequentially. Most systems come with multiple ports. Testing four pairs of signals on each port sequentially can lead to very long test times and subsequently a longer time to market. The new approach tests all four pairs of signals at the same time in the non-disturbing signal mode testing. Parallel testing for pairs in non-disturbing signal mode leads to saving 30 minutes of test time as compared to running a single pair test four times. This leads to saving days of test time in characterization labs and hence, a faster time to market.

The multi-pair top up on 5-CMENET/6-CMENET enables both two pair and four pair parallel testing for non-disturbing signal mode. The two pair testing requires two probes and the four pair option requires four probes. The TC2 section of the TF-GBE-BTP provides parallel access to all the four pairs. The TekExpress application allows both options: Traditional approach of single lane testing and optionally, multi pair.

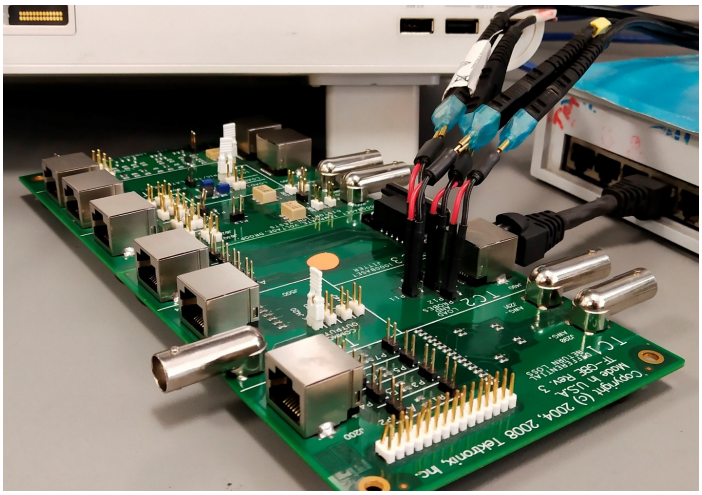


*Figure 5: Multi Pair testing*

## Amplitude tests

The industry standards require the signals to have amplitudes within specified ranges to assure interoperability between devices. The amplitude tests vary with the signal speeds but include such parameters as peak or peak-to-peak amplitude, overshoot, common mode voltage, and positive/ negative pulse symmetry.

## Timing tests

Timing parameters of the signals are also specified by the standards. These tests include timing measurements such as rise time, fall time, and difference or symmetry between rise and fall times.

## Jitter tests

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

## Template tests

Template mask tests are often used to quickly verify that the transmitted signal meets industry-standard requirements. These template masks are defined so that signal distortions such as overshoot, jitter, incorrect rise and fall times, etc., will cause the mask test to fail.

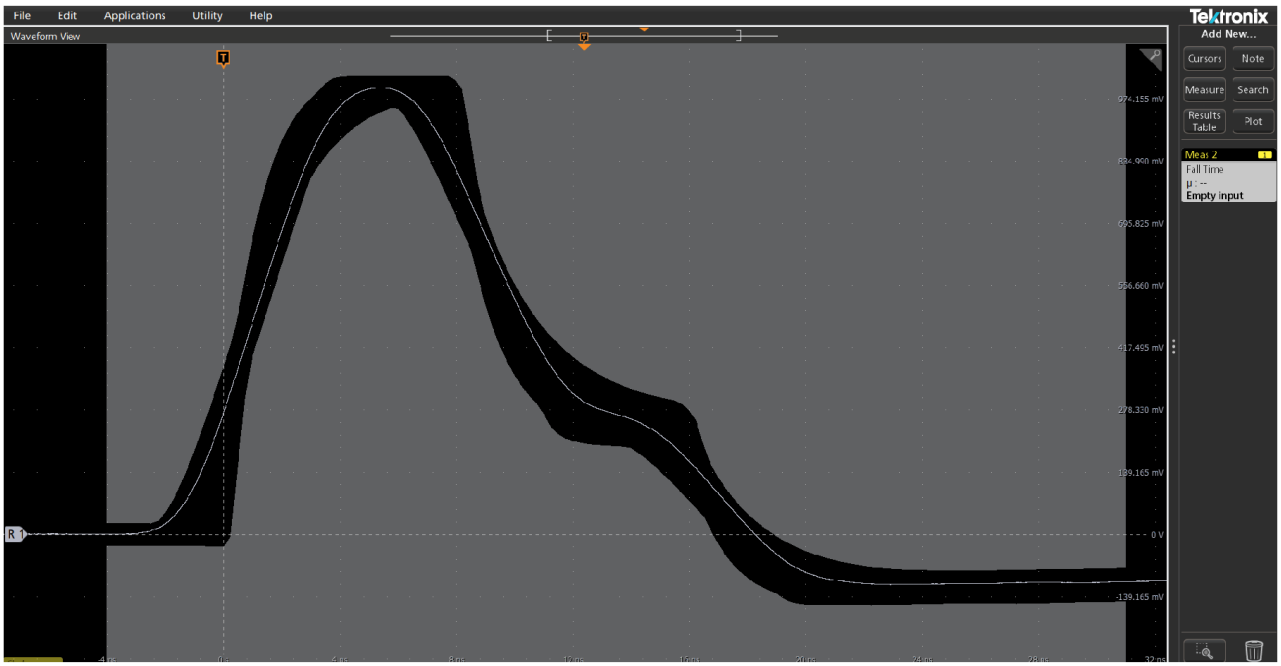



*Figure 6: TekExpress Ethernet running 1000BASE-T template measurement*

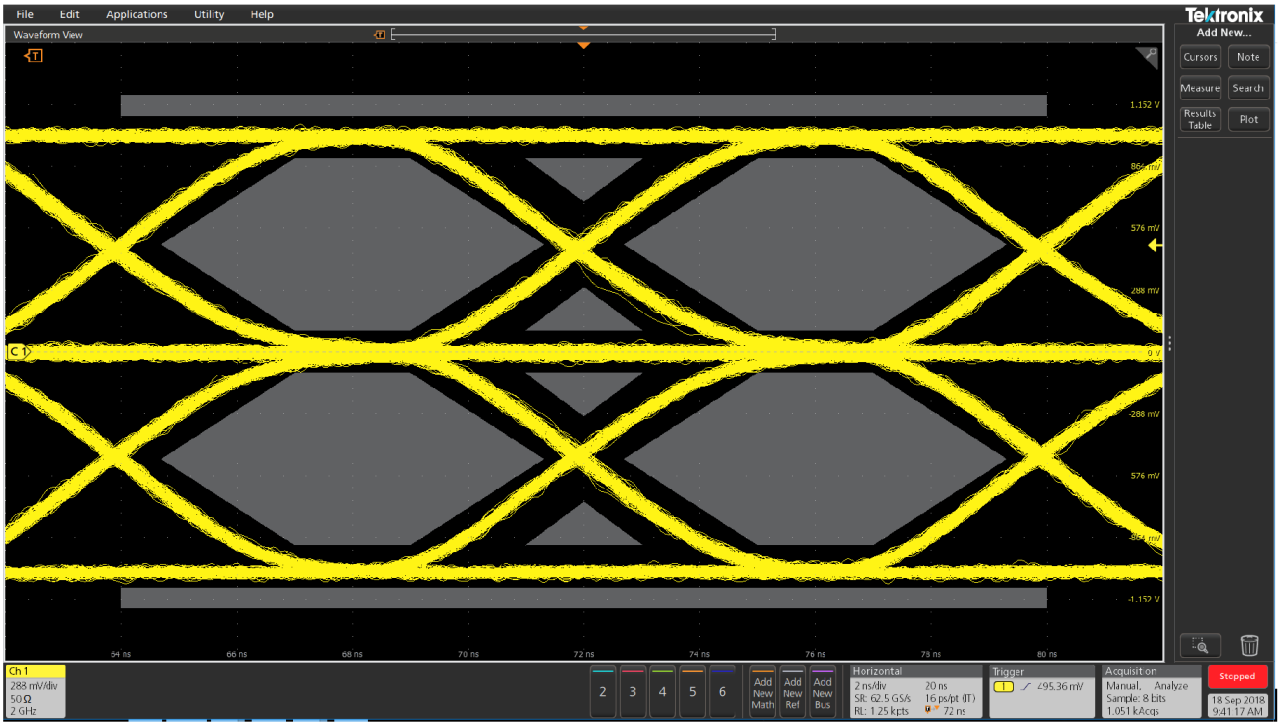



*Figure 7: TekExpress Ethernet running 100BASE-T AOI template*

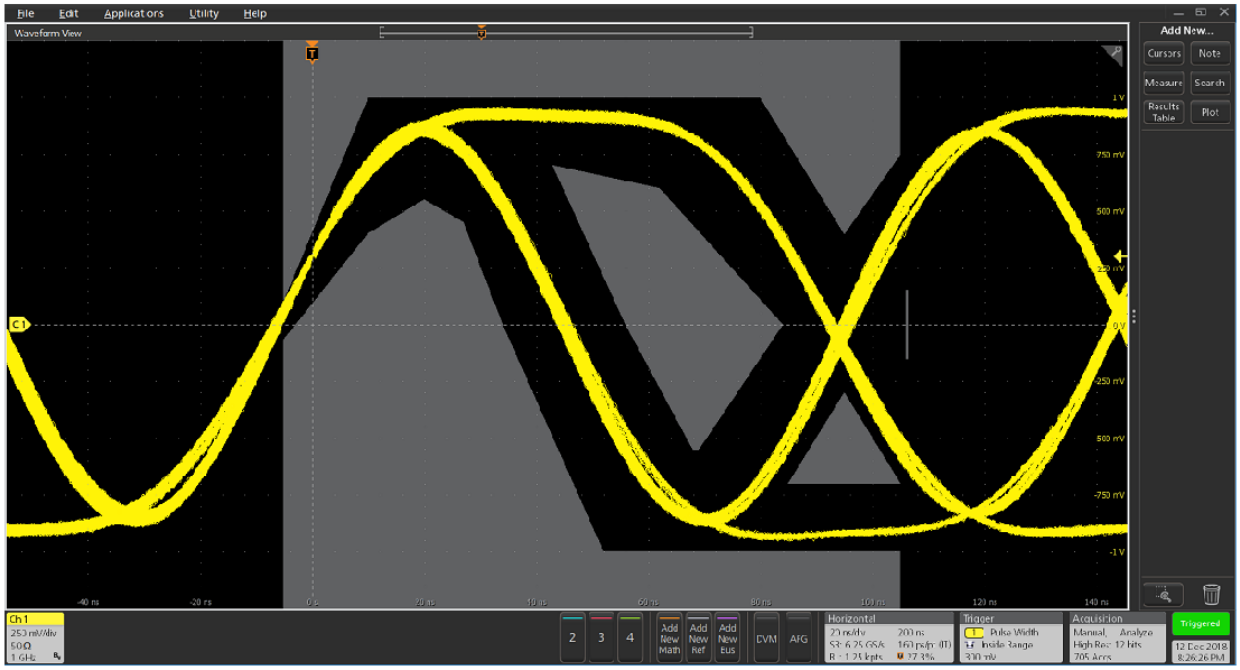



*Figure 8: TekExpress Ethernet running 10BASE-T MAU temple test*

## Return Loss test

The return loss of the cabling system can affect interoperability of the system. The Ethernet standard defines the minimum amount of attenuation the reflected signal should have relative to the incident signal. The Return Loss test measures the impedance, typically over the range of 100 Ω ±15%. The TekExpress Ethernet ingeniously performs the Return Loss test for 85, 100, and 115 Ω (111 Ω for 10BASE-T) impedances as prescribed by the standard, using the 5/6/6B Series MSO and AFG/AWG series used for other tests, enabling efficient usage of resources.

The TekExpress application enables two ways of testing. One where the AFG/AWG can be used in automated solution and the other where the S-parameter files from a TTR500 can be used for report generation. In the case of AFG/AWG, the application supports return loss testing on upto two pairs at a time. This helps reduce test time by half and thus, saving considerable amount of time.

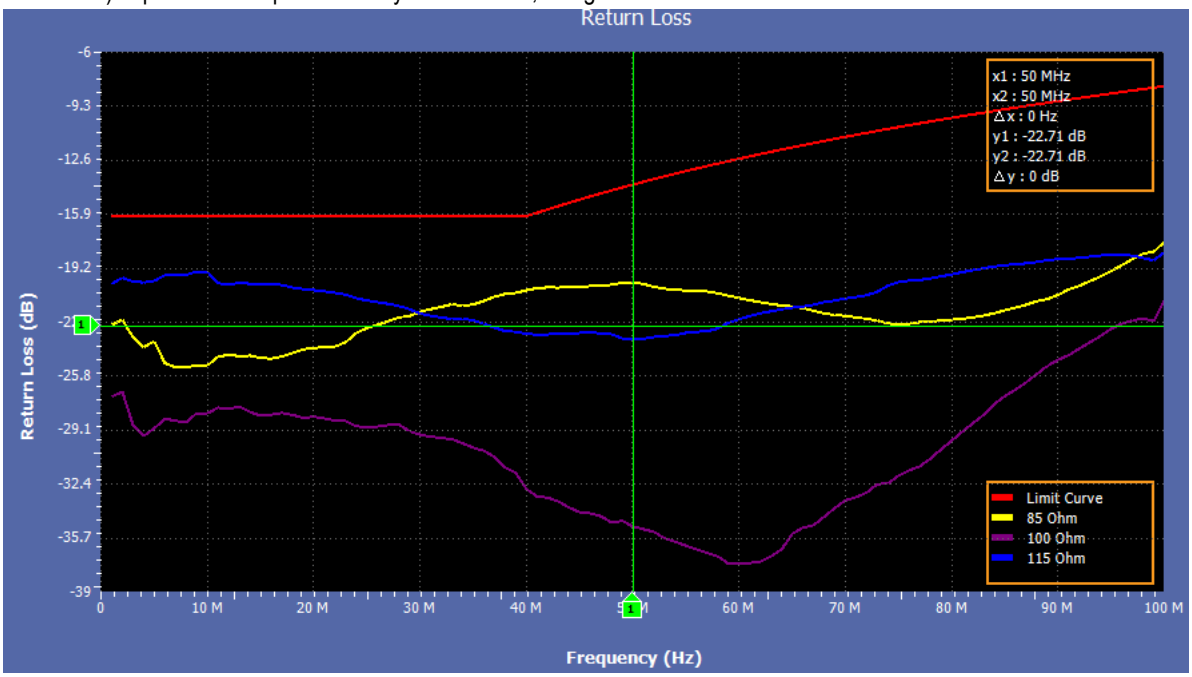
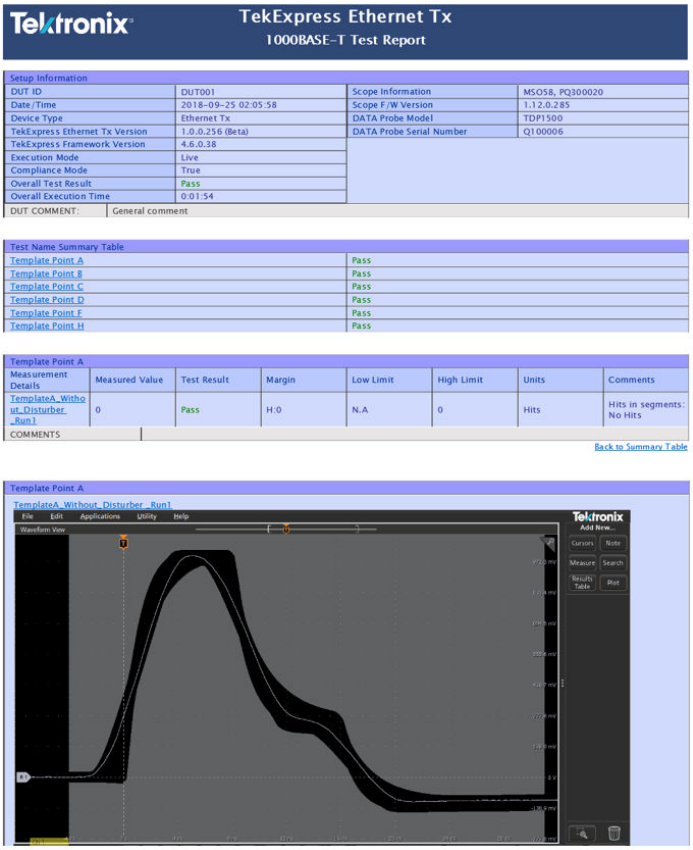



*Figure 9: 1000BASE-T Return Loss plot*

## Test report generation

TekExpress Ethernet allows you to quickly validate and generate detailed reports with images and setup details at the end of every execution.



Tektronix

TekExpress Ethernet Tx
1000BASE-T Test Report

| Setup Information | | | |
|---|---|---|---|
| DUT ID | DUT001 | Scope Information | MSO58, PQ300020 |
| Date/Time | 2018-09-25 02:05:58 | Scope F/W Version | 1.12.0.285 |
| Device Type | Ethernet Tx | DATA Probe Model | TDP1500 |
| TekExpress Ethernet Tx Version | 1.0.0.256 (Beta) | DATA Probe Serial Number | Q100006 |
| TekExpress Framework Version | 4.6.0.38 | | |
| Execution Mode | Live | | |
| Compliance Mode | True | | |
| Overall Test Result | Pass | | |
| Overall Execution Time | 0:01:54 | | |
| DUT COMMENT: | General comment | | |

| Test Name Summary Table | |
|---|---|
| Template Point A | Pass |
| Template Point B | Pass |
| Template Point C | Pass |
| Template Point D | Pass |
| Template Point F | Pass |
| Template Point H | Pass |

Template Point A

| Measurement Details | Measured Value | Test Result | Margin | Low Limit | High Limit | Units | Comments |
|---|---|---|---|---|---|---|---|
| TemplateA_Without_Disturber_Run1 | 0 | Pass | H:0 | N.A | 0 | Hits | Hits in segments: No Hits |

COMMENTS

Back to Summary Table

Template Point A

TemplateA_Without_Disturber_Run1



*Figure 10:*

## Test fixtures

The TF-GBE Series of test fixtures supports many of the Ethernet compliance tests, providing convenient signal access, test points for accurate removal of disturbing signals, return loss calibration, and cross-connect circuits to connect to traffic generators and link partners. The TF-GBE-BTP is the basic test fixture package for 10/100/1000BASE-T tests. The TF-GBE-ATP is the advanced test fixture package which also includes a 1000BASE-T jitter test channel cable.

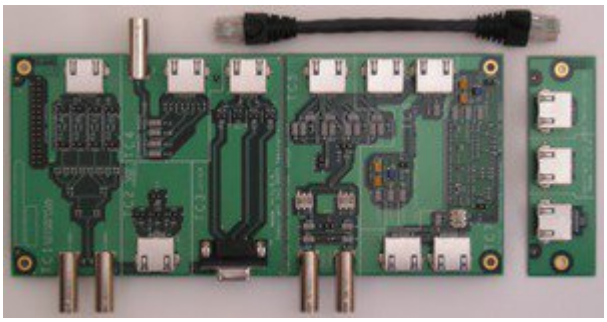


*Figure 11: TF-GBE-BTP Basic Ethernet Test Fixture.*

## Key measurements

TekExpress Ethernet Electrical Testing Software provides the following key measurements:

1000BASE-T (available with and without disturbing signal test option)

- With and without disturber
  - Template A
  - Template B
  - Template C
  - Template D
  - Template F
  - Template H
  - Peak A
  - Peak B
  - Peak C
  - Peak D
  - Droop G
  - Droop J
  - Distortion (with and without clock)
- Master Jitter - Filtered and unfiltered (with and without clock)
- Slave Jitter - Filtered and Unfiltered (with and without clock)
- Common Mode Voltage
- Return Loss

100BASE-TX

- AOI Template
- Rise Time
- Fall Time
- Rise/Fall Time Symmetry
- Differential Output Voltage
- Amplitude Symmetry
- Waveform Overshoot
- Duty Cycle Distortion
- Jitter
- Return Loss

10BASE-T

- Link Pulse (With and without TPM)
- TP_IDL (With and without TPM)
- MAU Template
- Harmonics
- Common Mode Voltage
- Differential Voltage
- Jitter
- Return Loss

# Ordering information

## Required hardware

| | |
|---|---|
| Oscilloscope | 6 Series or 6 Series B MSO oscilloscope with minimum bandwidth of 1 GHz (option 5-BW-1000 or 6-BW-1000)<br>5-WIN or 6-WIN (Removable SSD with Microsoft Windows 10 operating system) |
| Supported instruments | MSO54, MSO56, MSO58, MSO64, MSO64B, MSO66B, and MSO68B. |

## Required software

| Application | Options | License type |
|---|---|---|
| TekExpress Ethernet (1000BASE-T, 100BASE-TX, 10BASE-T) automated compliance test solution | 5-CMENET<br>6-CMENET | New instrument license |
| | SUP5-CMENET<br>SUP6-CMENET | Upgrade license |
| | SUP5-CMENET-FL<br>SUP6-CMENET-FL | Floating license |
| Multilane Ethernet (1000BASE-T, 100BASE-TX, 10BASE-T) automated compliance test solution | 5-CMENETML[1]<br>6-CMENETML[1] | New Instrument license<br>Requires 5/6-CMENET |
| | SUP5-CMENETML[1]<br>SUP6-CMENETML[1] | Upgrade license<br>Requires 5/6-CMENET |
| | SUP5-CMENETML-FL[1]<br>SUP6-CMENETML-FL[1] | Floating license<br>Requires 5/6-CMENET-FL |

## Recommended probes and accessories

| Recommended Probes | 5/6-CMNET | 5/6-CMENETML |
|---|---|---|
| TDP 3500 | 2[2] | Maximum 8 Probes are required for complete automation of 4 pairs. 6 probes are required for 4 pair jitter tests ifTX_TCLK is available. 5/6-CMENETML needs a minimum of 2 probes |
| TDP 1500 | 2[2] | |
| P6247[3] | 2[2] | |
| P6248[3] | 2[2] | |

[1] 5/6-CMENET is mandatory for all options 5/6-CMENETML.

## Recommended test fixtures

| Test Fixtures | Vendor |
|---|---|
| TF-GBE-BTP | Basic Ethernet Test Fixture |
| TF-GBE-ATP | Advanced Ethernet Test Fixture with Jitter Channel |
| TF-GBE-JTC | 103 meter 1000BASE-T Jitter Test Channel Cable |
| TF-GBE-SIC | Short (4 inch or 0.1 meter) RJ-45 Interconnect Cable |

## Supported signal sources (for Disturbing signal and Return Loss testing)

| Instrument | Models |
|---|---|
| Arbitrary Function Generator | AFG31000[2] (recommended), AFG3000 Series |
| Arbitrary Waveform Generator | AWG5200, AWG5000C, AWG7000C, AWG7000C Series |

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.

2 Supported models - AFG31252, AFG31152, and AFG31102

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