Ethernet Package

For LeCroy Oscilloscopes

Operator's Manual

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Introduction

What is Ethernet?

Etherent, is the most dominant local area network (LAN) technology. The most familiar version of Ethernet supports a data transmission rate of 10 Mbps. More advanced versions of Ethernet called "Fast Ethernet" and "Gigabit Ethernet" support data rates of 100 Mbps and (1000 Mbps). An Ethernet LAN may use coaxial cable, special grades of twisted pair wiring, or fiber optic cable. "Bus" and "Star" wiring configurations are supported. Ethernet devices compete for access to the network using a protocol called Carrier Sense Multiple Access with Collision Detection (CSMA/CD).

The History of Ethernet

The first experimental Ethernet system was developed in the early 1970s by Dr. Robert Metcalfe and David Boggs of the Xerox Palo Alto Research Center (PARC). It interconnected Xerox Palo Alto computers and printers at a data transmission rate of 2.94 Mbps. This data rate was chosen because it was derived from the local system clock (of the Alto computer). In July 1976, Metcalfe and Boggs published their landmark paper entitled "Ethernet: Distributed Packet Switching for Local Computer Networks" in the *Communications* of the Association for Computing Machinery (ACM). US Patent number 4,063,220, "Multiunit data communications system with collision detection," was issued to Xerox Corporation on December 13, 1977.

In 1979, Digital Equipment Corporation (DEC), Intel, and Xerox joined for the purpose of standardizing an Ethernet system that any company could use. In September 1980 the three companies released Version 1.0 of the first Ethernet specification called the "Ethernet Blue Book," or "DIX standard" (after the initials of the three companies). It defined the "thick" Ethernet system (10Base5), based on a 10 Mbps CSMA/CD (Carrier Sense Multiple Access with Collision Detection) protocol. It is known as "thick" Ethernet because of the thick coaxial cable used to connect devices on the network. The first Ethernet controller boards based on the DIX standard became available about 1982. The second and final version of the DIX standard, Version 2.0, was released in November 1982.

In 1983, the Institute of Electrical and Electronic Engineers (IEEE) released the first IEEE standard for Ethernet technology. It was developed by the 802.3 Working Group of the IEEE 802 Committee. The formal title of the standard was *IEEE 802.3 Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications*. IEEE reworked some portions of the DIX standard, especially in the area of the frame format definition. However the 802.3 standard was defined in a manner that permitted hardware based on the two standards to interoperate on the same Ethernet LAN.

In 1985, IEEE 802.3a defined a second version of Ethernet called "thin" Ethernet, "cheapernet," or 10Base2. It used a thinner, cheaper coaxial cable that simplified the cabling of the network. Although both the thick and thin systems provided a network with excellent performance, they utilized a bus topology, which made implementing changes in the network difficult, and also left much to be desired in regard to reliability. Also released in 1985 was the IEEE 802.3b 10Broad36 standard that defined transmission of 10 Mbps Ethernet over a "broadband" cable system.

In 1987, two more standards were released. The IEEE 802.3d standard defined the Fiber Optic Inter-Repeater Link (FOIRL) that used two fiber optic cables to extend the maximum distance between 10 Mbps Ethernet repeaters to 1000 meters. IEEE 802.3e defined a "1 Mbps" Ethernet standard based on twisted pair wiring. This 1 Mbps standard was never widely used.

In 1990, a major advance in Ethernet standards came with introduction of the IEEE 802.3i 10Base-T standard. It permitted 10 Mbps Ethernet to operate over simple Category 3 Unshielded Twisted Pair (UTP) cable. The widespread use of UTP cabling in existing buildings created a high demand for 10Base-T technology. 10Base-T also permitted the network to be wired in a "star" topology that made it much easier to install, manage, and troubleshoot. These advantages led to a vast expansion in the use of Ethernet.

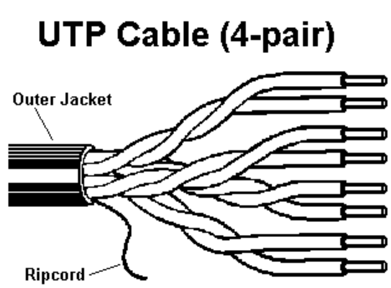
In 1993, the IEEE 802.3j standard for 10Base-F (FP, FB, & FL) was released which permitted attachment over longer distances (2000 meters) via two fiber optic cables. This standard updated and expanded the earlier FOIRL standard.

In 1995, IEEE improved the performance of Ethernet technology by a factor of 10 when it released the 100 Mbps 802.3u 100Base-T standard. This version of Ethernet is commonly known as "Fast Ethernet." Three media types were supported: 1) 100Base-TX operates over two pair of category 5 twisted pair cable; 2) 100Base-T4 operates over four pairs of category 3 twisted pair cable; and 3) 100Base-FX operates over two multi-mode fibers.

In 1997, the IEEE 802.3x standard became available, which marked a departure from the traditional approach by defining a "full-duplex" Ethernet operation for the first time. Full-Duplex Ethernet bypasses the normal CSMA/CD protocol to allow two stations to communicate over a point to point link. It effectively doubles the transfer rate by allowing each station to concurrently transmit and receive separate data streams. For example, a 10 Mbps full-duplex Ethernet station can transmit one 10 Mbps stream at the same time it receives a separate 10 Mbps stream. This provides an overall data transfer rate of 20 Mbps. The full-duplex protocol extends to 100 Mbps Ethernet and beyond. Also released in 1997 was the IEEE 802.3y 100Base-T2 standard for 100 Mbps operation over two pairs of Category 3 balanced cabling.

In 1998, IEEE once again improved the performance of Ethernet technology by a factor of 10 when it released the 1 Gb/s 802.3z 1000Base-X standard. This version of Ethernet is commonly known as "Gigabit Ethernet." Three media types are supported: 1) 1000Base-SX operates with a 850 nm laser over multi-mode fiber; 2) 1000Base-LX operates with a 1300 nm laser over single and multi-mode fiber; and 3) 1000Base-CX operates over short-haul copper "twinax" shielded twisted pair (STP) cable. Also released in 1998 was the IEEE 802.3ac standard that defines extensions to support Virtual LAN (VLAN) tagging on Ethernet networks.

In 1999, the release of the 802.3ab 1000Base-T standard defined 1 Gb/s operation over four pairs of category 5 UTP cabling:

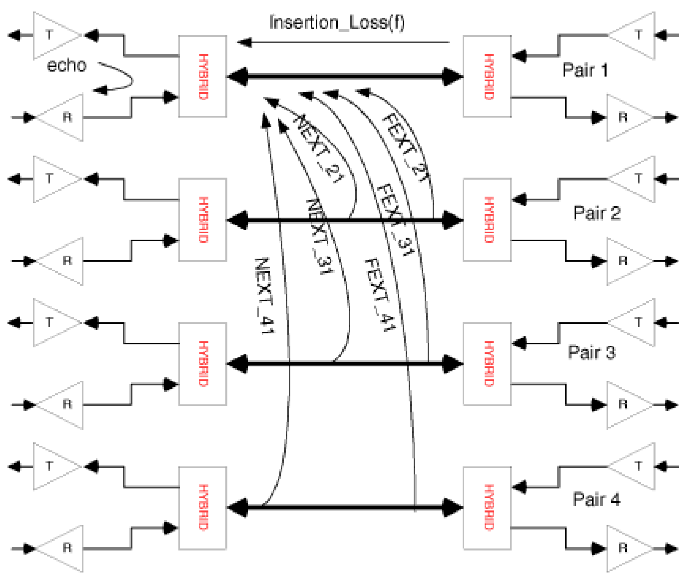


1000Base-T Theory of Operation

When working on the 1000Base-T standard, the 802.3ab committee was faced with a big challenge. Transmitting and receiving 1000 Mbps at dual (full) duplex over the popular CAT 5-cable infrastructure is not an easy task. (Operation is over four-pair, 100 ohm Category 5 balanced copper cabling, as defined by ANSI/TIA/EIA-568-A).

The problems were many:

- Signal attenuation
- Echo
- Return loss
- Crosstalk (NEXT, FEXT)
- Electromagnetic emissions and susceptibility (See figure below.)



The principles of the solution proposed by the committee were:

? Use existing 4-pair Category 5 cable. To ensure proper operation at full link lengths, the cable must conform to the requirements of ANSI/TIA/EIA-568-A (1995).

? Use all four pairs in the cable to keep symbol rate at 125 Mbaud (same as 100Base-TX).

? Use PAM-5 coding to increase the amount of information sent with each symbol.

? Use 4D 8-state Trellis Forward Error Correction coding to offset the impact of noise and crosstalk.

? Use pulse-shaping techniques to condition the transmitted spectrum.

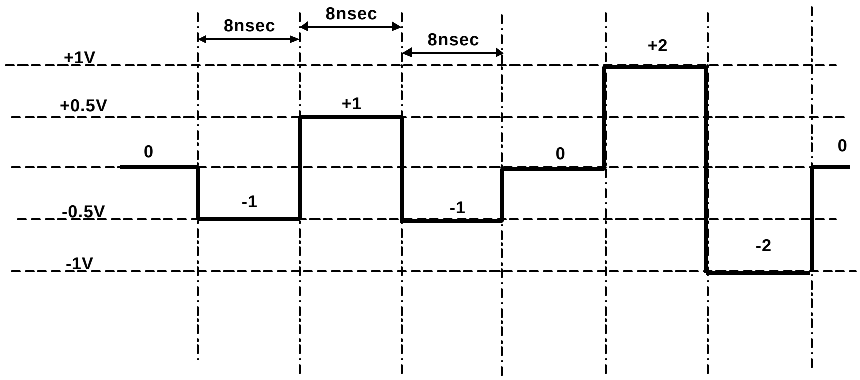
? Use state-of-the-art DSP signal equalization techniques to manage the problems of noise, echo, and crosstalk; and to ensure a bit error rate of at least $10^{-10.}$

These principles were based on experience with the well-proven 100Base-TX, 100Base-T4, and 100Base-T2 technologies:

? 100Base-TX demonstrates that it is possible to send a symbol stream over Category 5 cable at 125 Mbaud.

? 100Base-T4 demonstrates techniques for sending multi-level coded symbols over four pairs.

? 100Base-T2 demonstrates the use of digital signal processing (DSP), five-level coding, and simultaneous two-way data streams while dealing with alien signals in adjacent pairs.



Example of the 4D-PAM5 signal, used in 1000Base-T. This diagram simplifies the signal and shows it only on one pair. The transmission is done on four pairs in parallel.

The solution, though meeting the above criteria, is relatively complicated. The PHY element is a DSP-based complex device.

The testing of the Physical Layer signals is also far from simple and requires several steps.

The standard describes the testing process in detail.

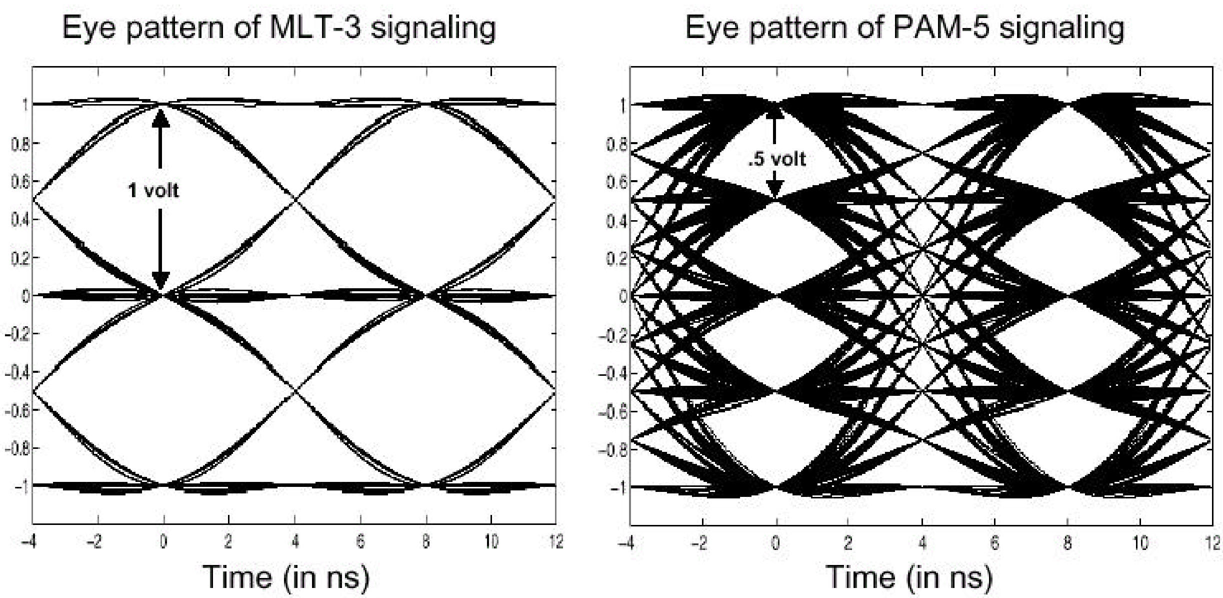
Introduction to LeCroy's Ethernet Package

As the Ethernet connection evolved over the years from one stage to another, it kept some characteristics unchanged, such as frame formats. Other parts, however, kept changing constantly. Among these are the Physical Layer specifications. 10Base-T, for example, uses 2 level Manchester encoding; 100Base-T uses 3 level MLT-3 signaling, while Gigabit (1000Base-T) uses 4D-PAM5, based on 5 level signals. Therefore, while the evolution seemed natural and easily implemented by the network manager, hardware designers and manufacturers alike found it more complicated. Actually, much more complicated, as in the case of 1000Base-T

LeCroy's Ethernet package bridges the gap between the different testing methods for 100 and 1000 Mbps. It is based on a software package that can be installed on DSOs with 1 GHz bandwidth or higher. The result is a user-friendly solution that dramatically reduces testing times and simplifies the testing process. Tests and calculations are performed inside the DSO, bypassing the need for external programs (such as MATLAB) and making the use of analog filters unnecessary.

You can select between 100Base-TX and 1000Base-T. Each standard has a specific array of tests to be performed. After selecting a test, waveforms are displayed on the DSO grid(s) while the measurement results are listed below. Some measurements include statistics.

The package can be easily customized, by adding new masks (PolyMasks). The DSO can perform other tasks in parallel, and unused channels may be used for more testing.



Ethernet Standards

Two Ethernet connections are addressed with LeCroy Ethernet Package:

- ? 100Base-TX
- ? 1000Base-T

They are included in the IEEE 802.3 - 2000 standard.

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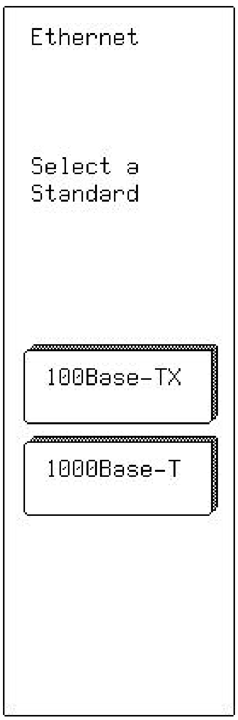
Operation

Getting Started



Access the Ethernet Package by pressing the **ANALYSIS PACKAGES** button (**MATH** on LC scopes). A menu showing all the packages installed on the DSO is displayed.

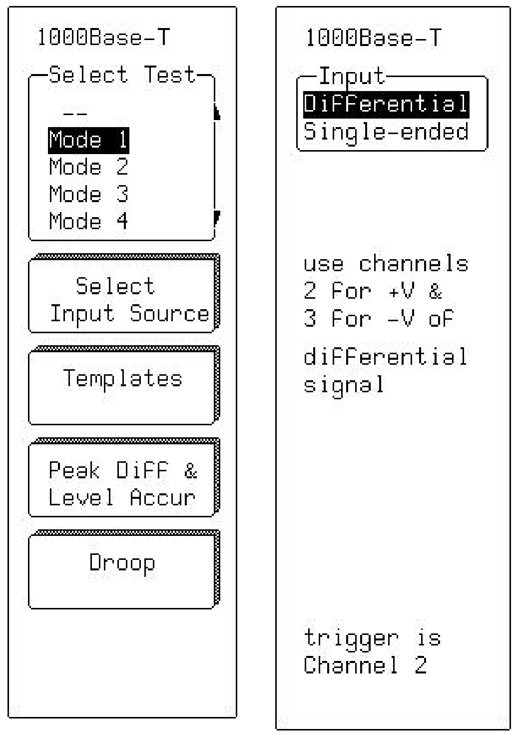
Select **Ethernet Analysis**. The menu at left is displayed:

(If only the Ethernet Package is installed, this menu will be displayed instantly when you press the **ANALYSIS PACKAGES** button).

Select the standard by pressing the corresponding soft key.

The following tests and measurements are available for 1000Base-T:

Test Mode	Test or measurement to be performed	Use Test Fixture
1	Peak differential output voltage and level accuracy	1
	Maximum output voltage droop	2
	Differential output templates	1
2	Jitter in master mode	4
3	Jitter in slave mode	4
4	Transmitter distortion measurement	3



The above menu selects one of the four test modes. In this example, Test Mode 1 was selected.

The same menu allows the selection of input source: either a differential probe such as AP034 (or equivalent, with 1 GHz bandwidth minimum), or two single-ended probes with 1 GHz minimum bandwidth (HFP1000 for example).

If probing is performed directly with two cables (using scope channels 2 and 3) they should be coupled to 50 ? DC.

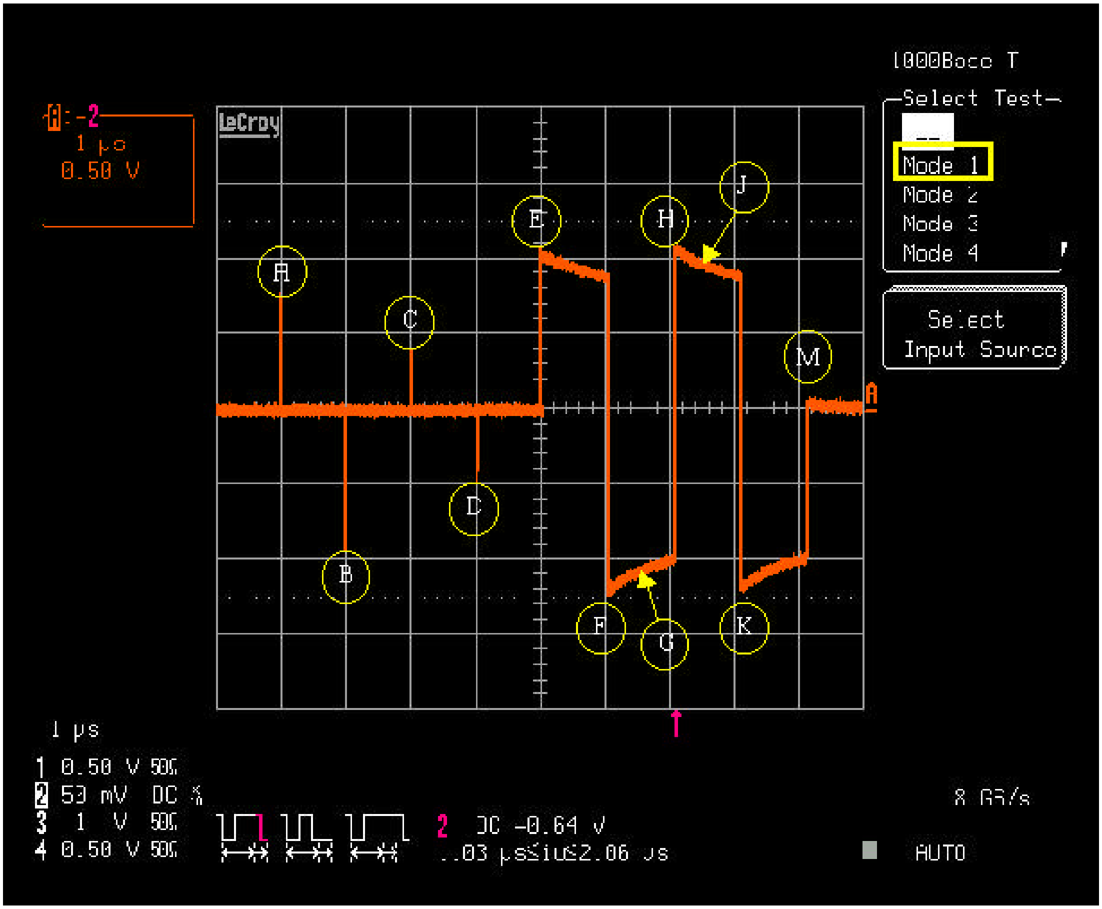
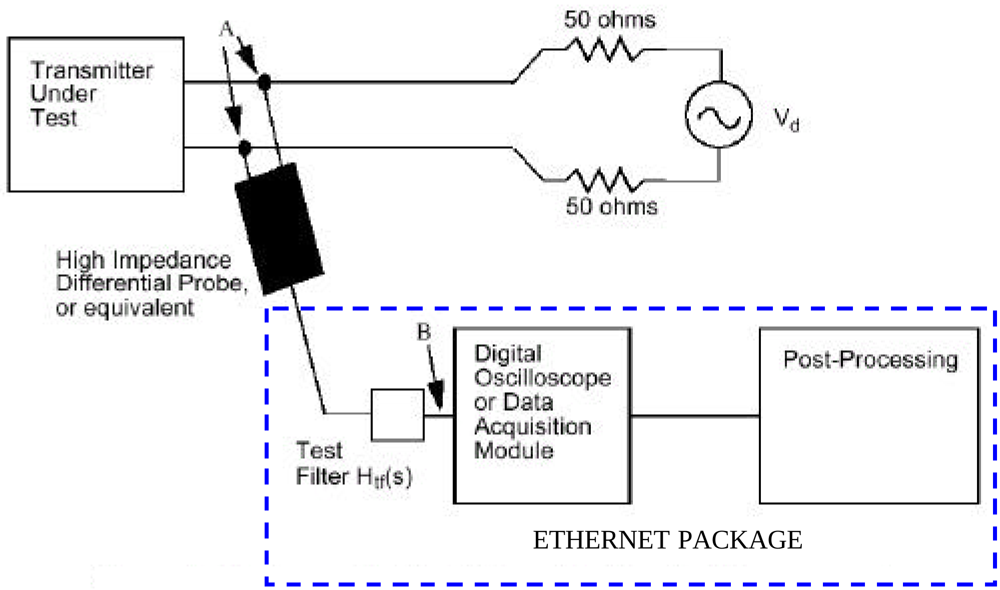


Figure 1. Waveform generated by the DUT in Test Mode 1. The circled letters are for reference only and are not displayed on the screen.

Three tests, based on the above waveform are performed. The standard specifies a disturbing signal (V_d), which has to be added to the waveform. The setup is shown in Figure 2.

Differential Output Templates

In these tests, points A, B, C, D, F and H are compared against two mask templates. The point to be tested can be selected from the menu. This test is performed with test fixture 1 setup. The disturbing signal is automatically removed from the composite signal inside the



oscilloscope.

Figure 2. Transmitter Test Fixture 1 for Template Measurement per Section 40.6.1.1.3 of 802.3-2000 Standard

Note: The Ethernet package combines the functionality of the Test Filter, Digital Oscilloscope, and Post Processing Block.

Disturbing signal (V_d) characteristics (as specified in section 40.6.1.1.3 of the standard)

Characteristic	Test Fixture 1	Test Fixture 2	Test Fixture 3
Waveform	Sine Wave		
Amplitude	2.8 V pk-pk	2.8 V pk-pk	5.4 V pk-pk
Frequency	31.25 MHz	31.25 MHz	20.833 MHz
Purity	Harmonics should be at least -40 dB below fundamental		

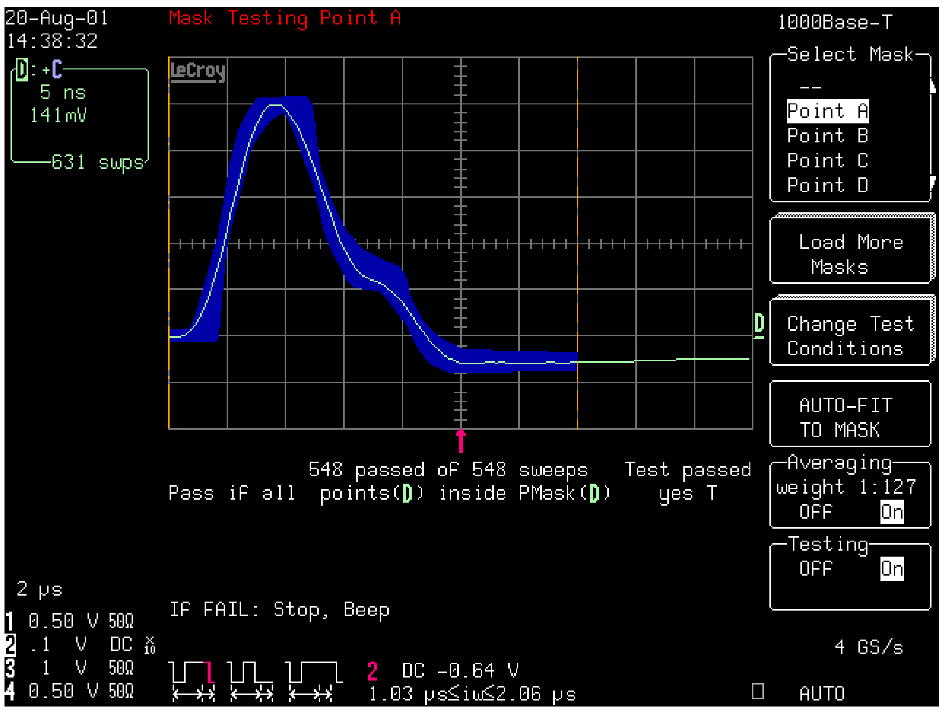
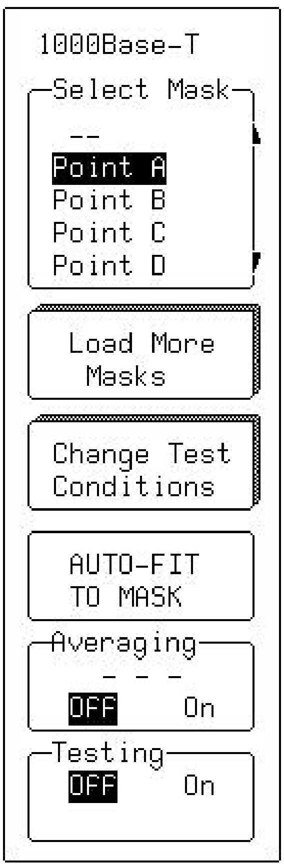


Figure 3. Example of Mask Testing Point A (Test Mode 1)

Select a Point To Be Tested



When a point to be tested is selected

? The corresponding mask template is displayed.

? The signal is automatically triggered and aligned to the template.

? The signal is normalized to the template, as recommended by the standard.

? The signal can be averaged with continuos averaging.

? The operator can set averaging factor between 1:1 to 1:127 or bypass averaging.

? Failure points are highlighted with red circles.

? The Pass/Fail testing result is displayed under the display grid.

The Mask Testing operation is similar to LeCroy PolyMask option. (See also the PolyMask addendum for WavePro or Waverunner oscilloscopes.)

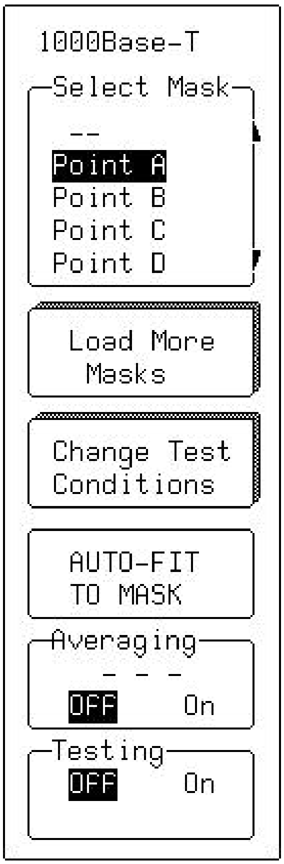
Test errors are counted under the display grid, on line one, and highlighted with red circles.

"Load More Masks" allows testing a specific peak against new or modified masks (which can be created with the MaskMaker utility). These templates can be loaded from a memory card, hard drive, or floppy disk.

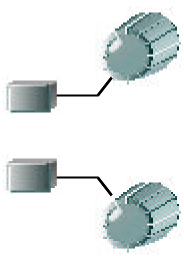
Suggested Application: the two default templates can be modified and masks with different tolerances can be created.

Another possibility is to create mask templates, which will test only a portion of the signal, allowing the user to focus only on that portion.

"Change Test Conditions" You may choose a specific action in case the signal passes (or fails the test). As with other LeCroy tolerance mask testing programs, a specific action may be taken if the signal fails or passes the test. You may choose to stop the test, store the results, dump the image to an external printer or drive, emit a loud "beep," or output a 10 µs pulse at the CAL BNC.



"AUTO-FIT TO MASK" This soft key will align the signal to the mask. It is recommended to do so before you start testing.



"Averaging" The default operation is testing without averaging. However, averaging can be turned on and set between 1:1 and 1:127. with the knob.

"Testing" Turns the mask testing on and off.

Note: It is possible to fine tune the signal's position relative to the mask template by adjusting the horizontal and vertical positioning knobs. (ANALYSIS CONTROL box)

Peak Differential Output Voltage and Level Accuracy

Peak differential output voltage and level accuracy is measured using the Test Fixture 1 setup (Figure 2). The signal is first filtered (with a digital filter), then the disturbing signal is removed from the composite waveform in the oscilloscope prior to post-processing.

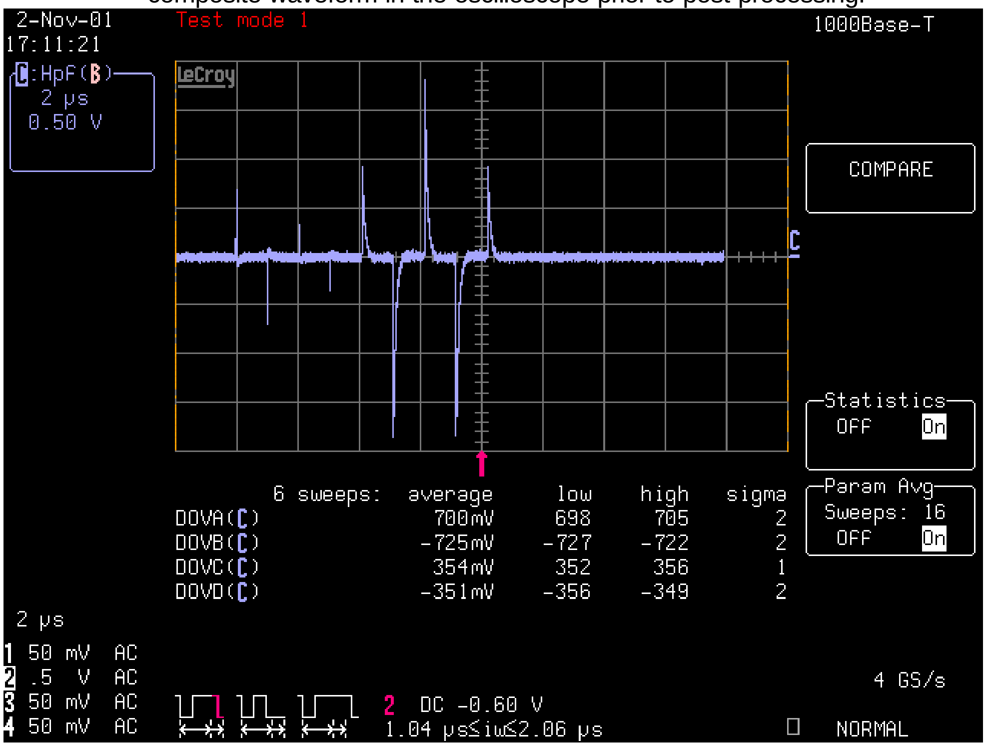


Figure 4. The filtered test mode 1 waveform is displayed on trace C. The measurement results for each point are reported underneath, on the parameter line. If required, the measurements can be averaged over several sweeps by setting Parameter Averaging between 2 and 50. The default averaging factor is 16.

The following measurements are performed for the peak differential output voltage and level accuracy test:

? DOVA – Amplitude of Peak A

? DOVB – Amplitude of Peak B. The standard limits the amplitudes of Points A and B between 0.67 V and 0.82 V

? DOVC – Amplitude of Peak C

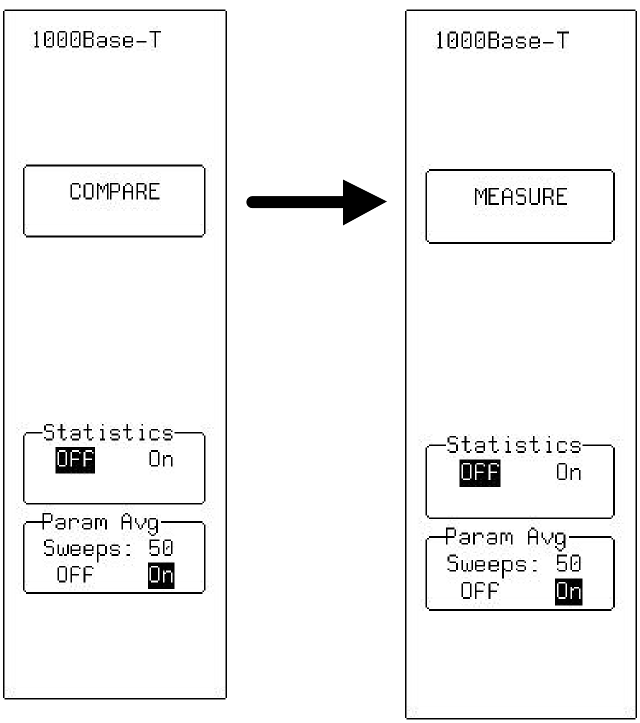
? DOVD – Amplitude of Peak D. The absolute value of Peaks C and D shall differ by less than 2% from 0.5 times the average of Peaks A and B.

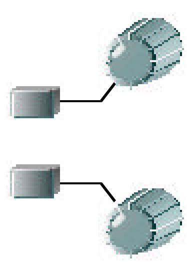
? accAB – accuracy comparison between the absolute values of Peaks A and B. The difference should be less than 1%

? accC – accuracy comparison between Peaks C and A

? accD – accuracy comparison between Peaks D and B

This soft key permits toggling between amplitude measurements of peaks A, B, C, and D; and amplitude comparisons such as peak A vs. peak B.





Statistics: As with regular parameter measurements in LeCroy oscilloscopes, statistics can be turned on and off with the corresponding soft key.

Parameter Averaging: can be turned on and off; 16 is the default averaging factor.

Maximum Output Droop

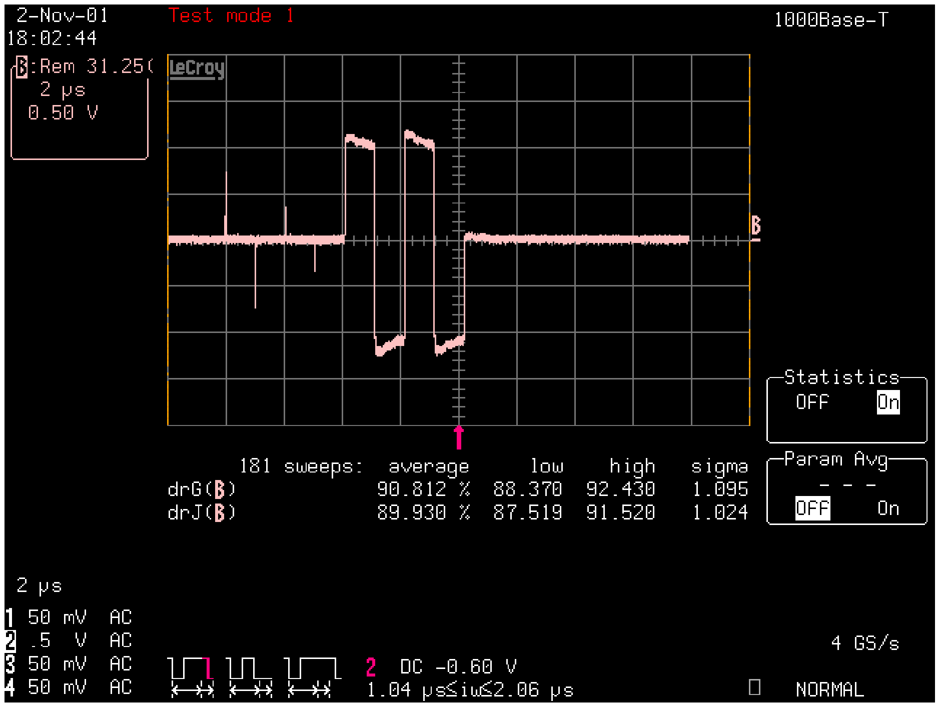


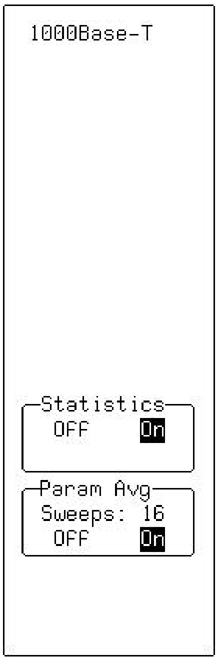
Figure 5. Test mode 1 waveform is also used for the maximum output droop measurement; however, the test fixture is changed to Test Fixture 2 (Figure 6).

As before, the grid displays the test mode 1 waveform. Points G and J are evaluated. Under the display grid, the amplitude values of these points are listed.

? drG – Voltage droop at point G relative to point F

? drJ – Voltage droop at point J relative to point H

(The maximum droop permitted by the IEEE 802.3 -2000 standard in section 40.6.1.2.2 is 73.1%)



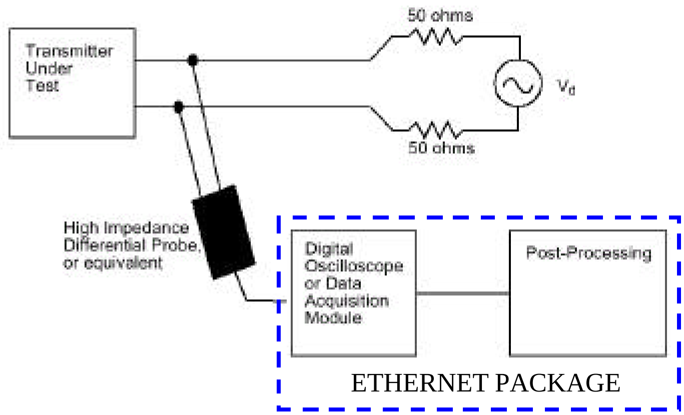


Figure 6. Transmitter Test Fixture 2 for Droop Measurement per Section 40.6.1.1.3 of 802.3-2000 Standard

Test Fixture 2 is identical to test fixture 1, except for the test filter. Now, the waveform remains unfiltered prior to processing.

Statistics and Parameter Averaging of the voltage droop meaurement are identical to “Peak differential voltage and level accuracy test.”

Test Modes 2 and 3

These test modes are used for the measurement of transmitter timing jitter.

Test mode 2 is used in combination with Test Fixture 4 (Figure 8) to measure jitter in master mode (for more details, including the use of "test channel," see section 40.6.1.1.1 of the standard)

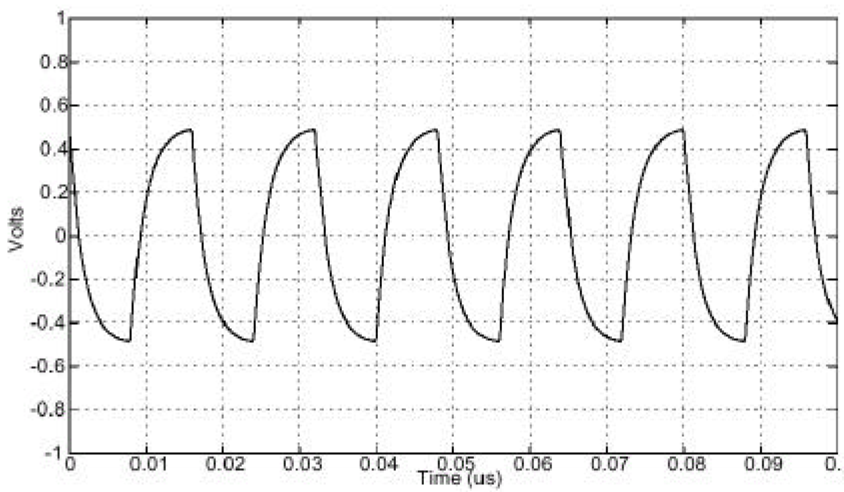


Figure 7. Example of Transmitter Test Modes 2 and 3 Waveform

Section 40.6.1.2.5 of the 802.3-2000 standard describes the transmitter timing jitter measurements. This section is divided into two parts. The first part specifies the measurement of jitter in Master Mode; the second part in Slave Mode.

In Master Mode, the transmitter works independently, clocked by the master TX_TCLK.

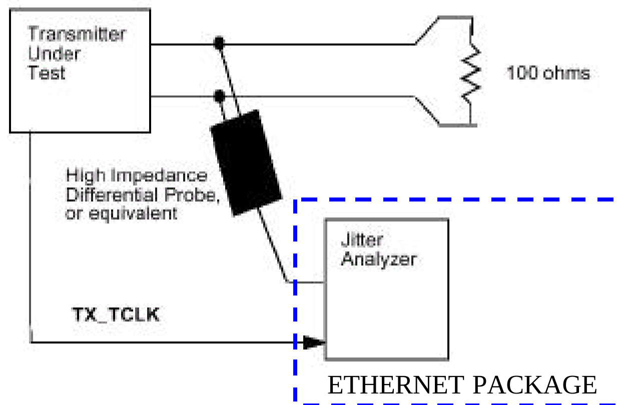


Figure 8. Transmitter Test Fixture 4 for Transmitter Jitter Measurement per Section 40.6.1.1.3 of 802.3-2000 Standard

The test Mode 2 waveform has to be generated and the measurements performed with the Test Fixture 4 setup. Test Fixture 4 is used to measure jitter in both master and slave modes.

Operation Mode

Jitter Measurements in Master and Slave Modes

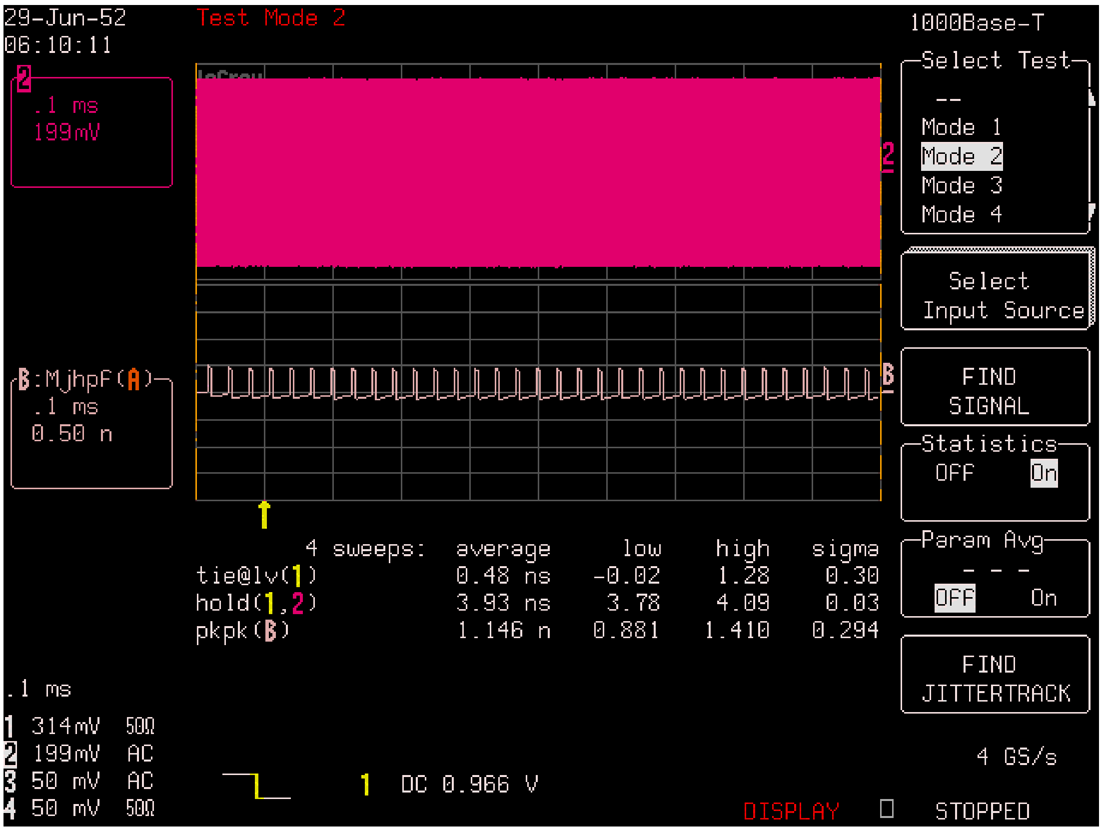


Figure 9. ***Example of Jitter Measurement in Master Mode. The upper grid displays an acquisition of the differential data for 1 ms. The lower grid shows the JitterTrack (or waveform) on TX_TCLK, filtered by the high-pass filter.***

The measurement results are reported on lines 1-3, with statistics turned on. See below for more details.

Setup

After setting up Test Fixture 4, connect the TX_TCLK signal to Channel 1 of the oscilloscope.

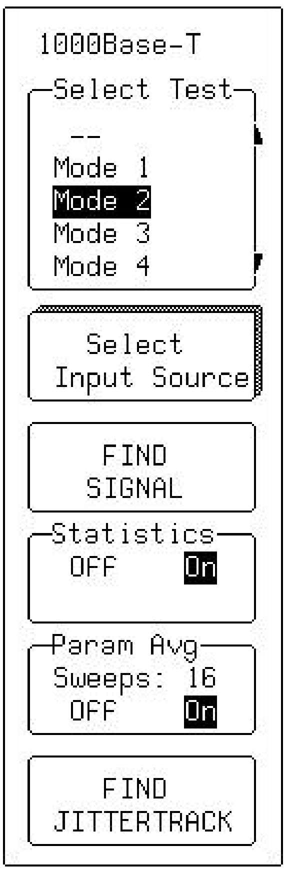
The differential data signal can be probed in two ways. (Use the "**Select Input Source**" button):

? with a differential probe (such as AP034 or equivalent) connected to channel 2.

? with two single-ended probes connected to channels 2 and 3.

Note: The trigger is always on channel 2.

Jitter in Master Mode



If probing is performed directly with two cables (on channels 2 and 3) they should be coupled to 50 ? DC

When Test Mode 2 (Jitter in Master Mode) is selected, the following menu is displayed: **"Find Signal**" will place the differential data signal (Channel 2-3) on the upper grid. The acquisition length is 1ms. "Find Signal" sets the voltage range to the maximum to ensure that the Jitter measurements will not be compromised by a low level amplitude.

Statistics and **Parameter Averaging** are identical to the "Peak differental voltage and level accuracy test."

"FIND JITTERTRACK" centers the JitterTrack (or jitter waveform) on the lower grid signal if the trace is not displayed instantly. This is a Jittertrack of the TX_TCLK signal, filtered by the high-pass filter, H_{jf1}. (For more details on JitterTrack, see the *Jitter and Timing Analysis Operator's Manual*).

The following parameters are reported on lines 1 to 3 under the lower grid:

Line 1 lists the accumulated jitter on TX_TCLK (tie@lv). The standard specifies that the jitter level should be less than 1.4 ns. That is the pk-pk accumulated jitter over the specified acquisition, relative to an ideal clock.

Line 2 displays the measured jitter (hold) between TX_TCLK and the corresponding zero crossing of the differential data (J_{txout}).

Line 3 shows the pk-pk jitter value of the measurement result on line 1, when the jitter waveform (track) is filtered by a high-pass filter with the following transfer function:

$$H_{jf1}(f) ? \frac{jf}{jf ? 5000}$$

where *f* is specified in Hz. (section 40.6.1.1.2 of IEEE 802.3-2000)

Notes:

1. The standard requires summing the results on lines 2 and 3. That means that the pk-pk jitter on the filtered JitterTrack should be added to the J_{txout} value. The total amount should be less than 0.3 ns
2. Over the 1 ms acquisition, a slow deviation (drift) in the TX_TCLK signal may be noticed (Trace A). In such cases, it's advisable to synchronize between the system's clock and the DSO's 10 MHz reference input clock. In any case, the high-pass filter will remove all low frequency components from the JitterTrack. (Trace B).

Jitter in Slave Mode

Test Fixture 4 (Figure 8) is used again, this time in conjunction with the Test Mode 3 waveform. The difference (from the previous measurement) is that now, the port is in configured in slave mode, driven by TX_TCLK of the master port. The master port is connected to the slave via the test channel defined in section 40.6.1.1.1.

The measurement result displayed on line 1, is the jitter between the master and slave TX_TCLK signals (hold). The standard limits it to less than 1.4 ns.

Line 2 shows the pk-pk jitter value on the Slave TX_TCLK, with TX_TCLK jitter waveform (track), filtered by the high-pass filter with the following transfer function (as specified in section 40.6.1.2.5 of IEEE 802.3-2000):

$$H_{jf2}(f) \, ? \, \frac{jf}{jf \; ? \; 32000}$$

Line 3 displays the measured jitter between the slave TX_TCLK and the corresponding zero crossing of the differential data (J_{txout}). This measurement is similar to the measurement performed in master mode (hold).

Line 4 shows the pk-pk jitter value on filtered Master TX_TCLK, which is essential for the jitter calculation on line 2.

Note: The standard requires summing the results on lines 2 and 3. That means that the pk-pk jitter of the filtered JitterTrack should be added to J_{txout} value. The total amount should be no more than 0.4 ns greater than the pk-pk jitter on line 4.

Transmitter Distortion Measurement

Select Test Mode 4 from the menu:

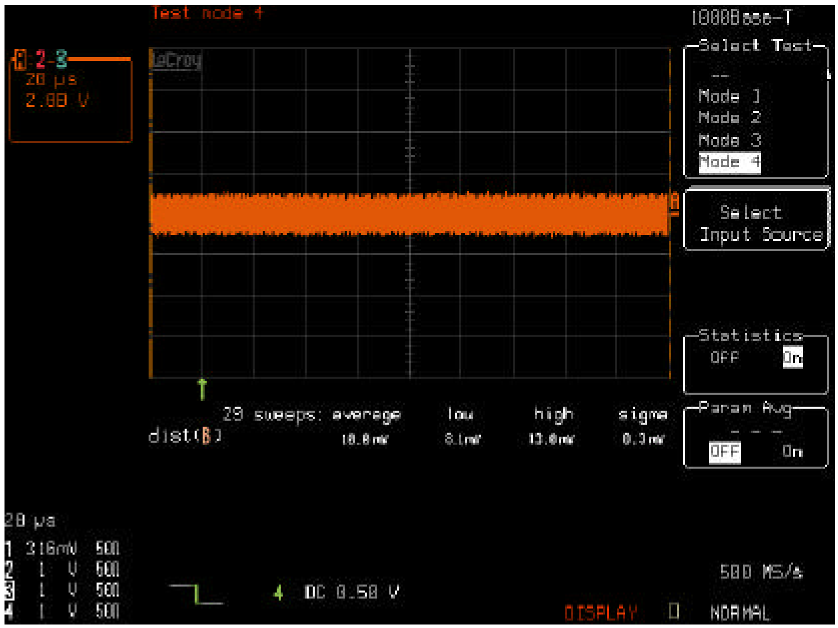


Figure 10. As can be seen in this example, the input signal is displayed on the grid. Below the grid, the result of the peak distortion measurement is reported on the parameter line. Averaging and statistics are identical to Test Mode 1 measurements.

Note: The peak distortion measurement is calculated by following the MATLAB code example from section 40.6.1.2.4

The peak distortion measurement is performed using Test Fixture 3 (Figure 11). As before, filtering, data acquisition, and removal of the disturbing signal from the composite waveform are performed in the oscilloscope.

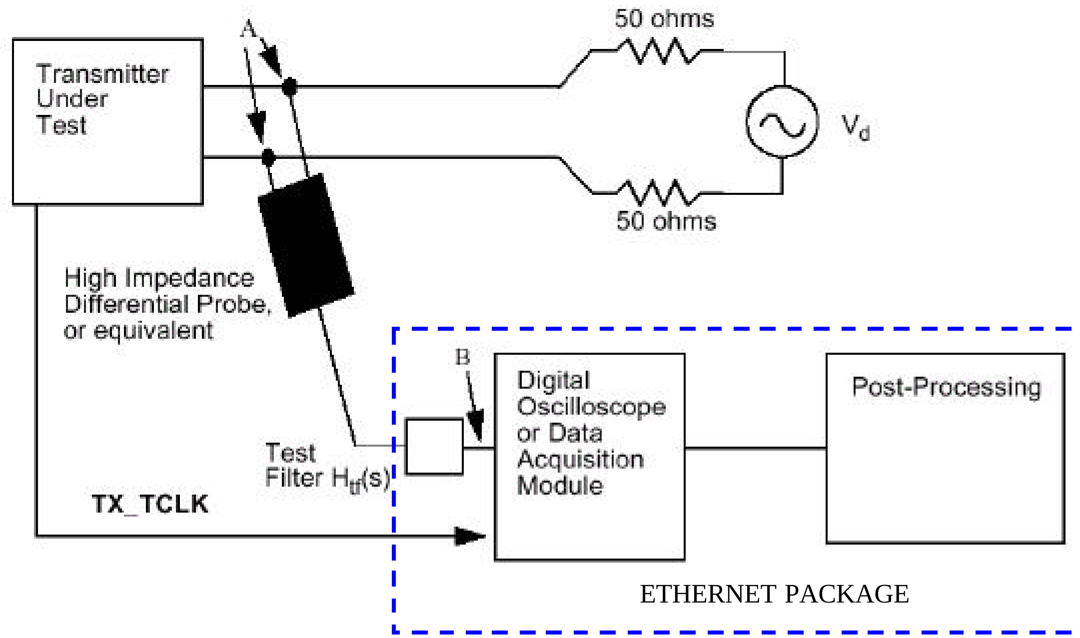


Figure 11. Transmitter Test Fixture 3 for Distortion Measurement per Section 40.6.1.1.3 of 802.3-2000 Standard

The peak distortion is determined by sampling the differential data (A) with TX_TCLK and processing 2047 consecutive samples. The differential data signal has to be filtered (B) prior to processing, with the following filter:

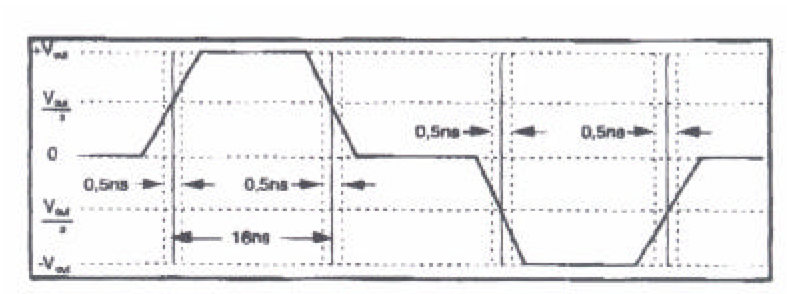
$$H_{tf}(f) \, ? \, \frac{jf}{jf \, ? \, 2*10^{6}}$$

where f is specified in Hz.

Note: The standard limits the distortion to less than 10 mV peak.(see section 40.6.1.2.4)

100Base-TX

The 100Base-TX standard uses the MLT-3 signaling code:



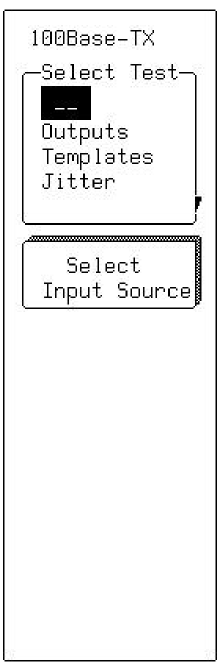
See section 9.1.8 of ANSI X3.263-1995 standard.

The LeCroy Ethernet Package provides three test types for this standard:

? Mask testing

? Signal measurements

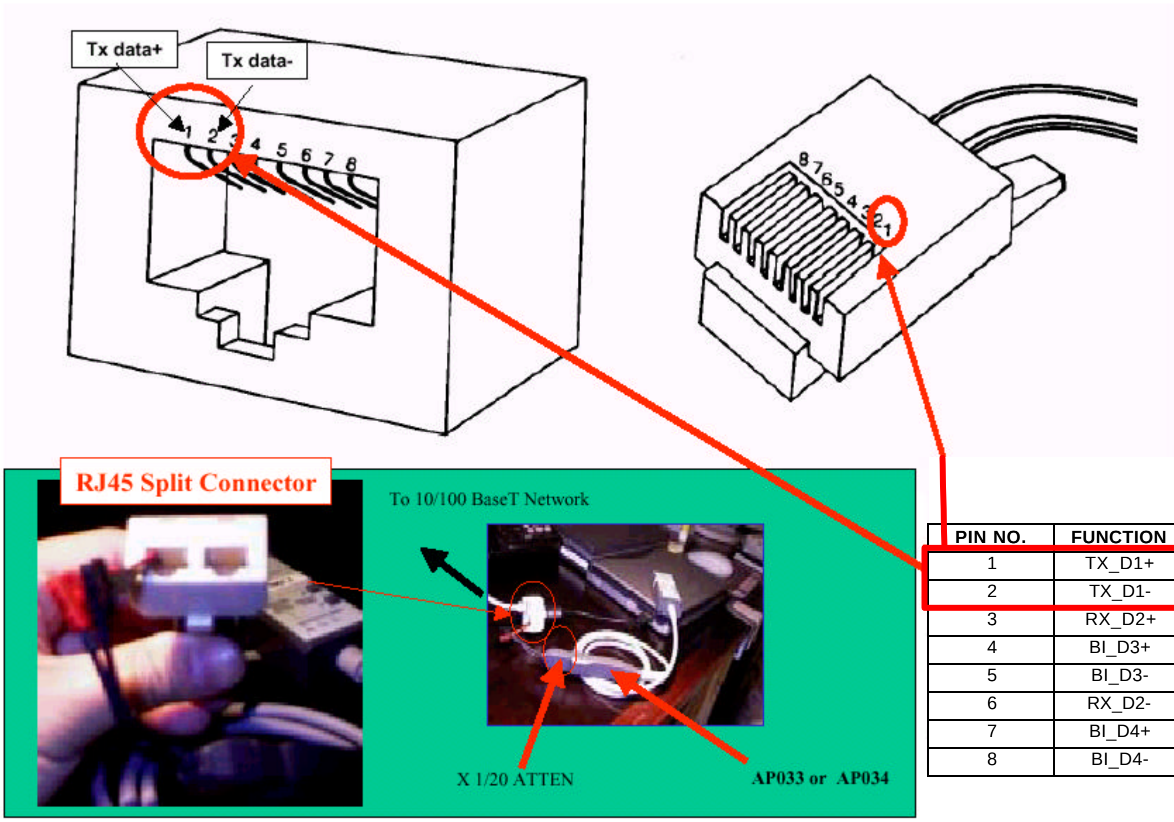
? Jitter measurement



After the 100Base-TX is selected from the start menu, the menu at left is displayed.

Select Test: Selects between Outputs (signal measurements), Templates (mask testing) and Jitter measurements.

Note: An idle transmission between two 100Base-TX stations can be used for probing 100Base-TX signals, after the auto negotiation process is over and a stable 100Base-TX link is established. Notice that some measurements are performed on 96 ns wide pulses, some on 80 ns pulses, and some on 16 ns pulses. For signal parameter measurements, the DSO is triggered to capture data following a 96 ns positive pulse.



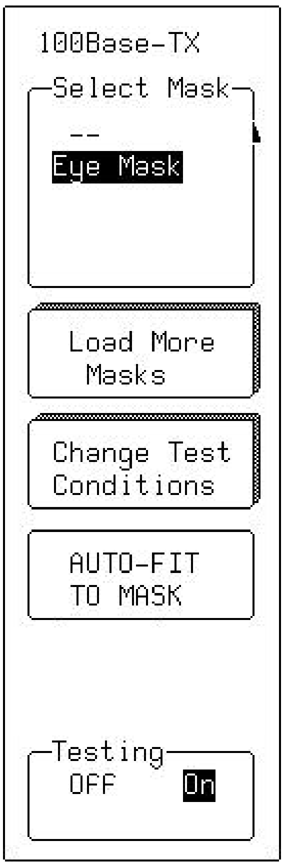
PIN NO.	FUNCTION
1	TX_D1+
2	TX_D1-
3	RX_D2+
4	BI_D3+
5	BI_D3-
6	RX_D2-
7	BI_D4+
8	BI_D4-

Figure 12. Example of probing 100Base-TX signals with an AP034 differential probe

Mask Testing

Figure 13. ***An example of 100Base-TX mask testing. When this test is selected, the mask template is displayed, with the signal triggered and automatically aligned with the template. Red circles indicate the points of failure. The Pass/Fail test results are shown below the grid, on the parameter line.***

The Mask Testing feature is similar to the LeCroy PolyMask option.



"Load More Masks" allows testing against new or modified masks created with the MaskMaker utility. Mask templates can be loaded from a memory card, hard drive, or floppy disk.

Suggested applications: The default template can be modified, and new masks with different tolerances can be created.

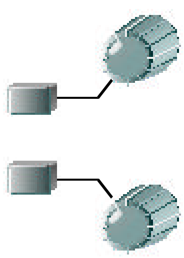
Another possibility is to create mask templates that will test only a portion of the signal, allowing you to focus on a specific point only.

"**Change Test Conditions"** As with other LeCroy tolerance mask testing programs, a specific action can be taken if the signal fails or passes the test. You can choose to stop the test, store the results, dump the image to an external printer or drive, emit a loud "beep," or output a 10 µs pulse at the CAL BNC.

"AUTO-FIT TO MASK" This soft key will align the signal with the mask. It is recommended to do so before the start of testing.

Notes:

1. It is possible to fine tune the signal's position relative to the mask template by adjusting the horizontal, vertical and zoom positioning knobs (ANALYSIS CONTROL box).
2. If an eye pattern is desired, press the **ANALOG PERSISTENCE** button.



"Testing" Turns the mask testing on or off.

Signal Measurements

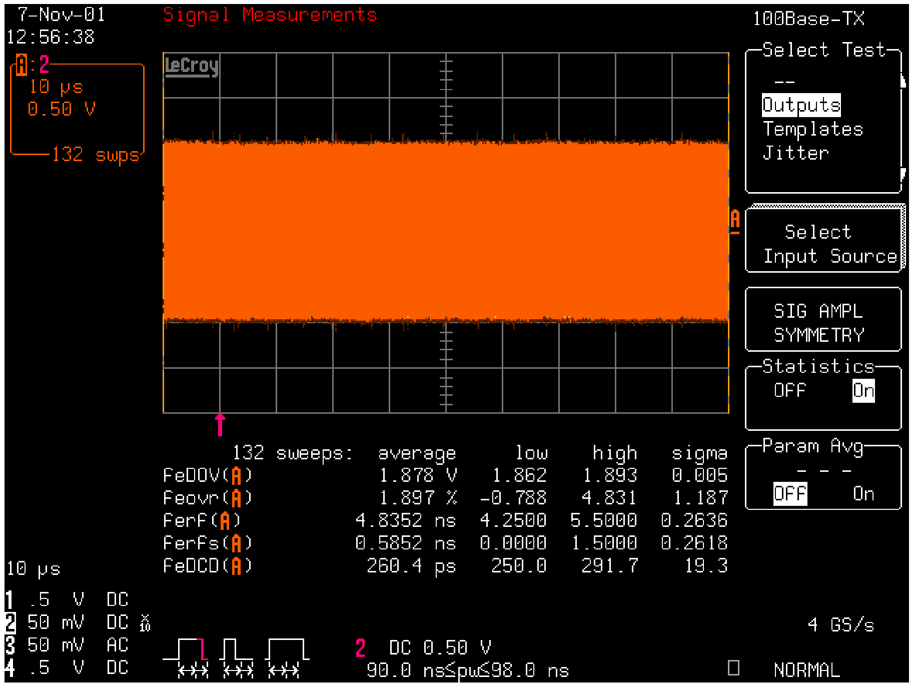


Figure 14. Example of 100Base-TX Signal Measurements

Trace A is a 100 µs acquisition of the MLT-3 input signal. Below the grid, five measurement results are reported:

- feDOV – Differential Output Voltage: 1.9 V - 2.1 V. This is the total signal (positive plus negative) pk-pk value
- feSAS – Signal Amplitude Symmetry:

$$0.98 \; ? \; \frac{\left| ? \, Vout \right|}{\left| ? \, Vout \right|} \; ? \; 1.02$$

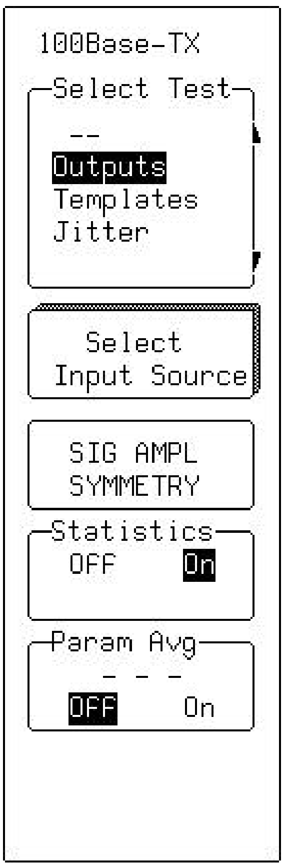
- ferf – Rise/Fall times: 3 ns -5 ns
- ferfs – Rise/Fall symmetry : ? 0.5 ns
- feDCD – Duty Cycle Distortion +/-0.25 ns

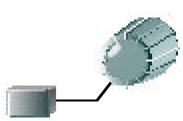
? feovr – Signal Overshoot maximum allowed is 5% above steady state voltage

The feDOV and feSAS measurements are closely related. Only one of them is displayed at a time. You can select between showing feDOV or feSAS with a soft key. (See Figure 14.)

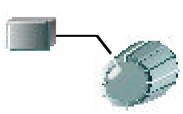
Notes:

1. The feDOV, feSAS, and feover measurements are performed on a 96 ns positive reference pulse. The DSO acquisition will be triggered by this pulse (Channel 2).
2. ferf and ferfs measurements are performed on an 80 ns positive reference pulse.
3. feDCD measurement is performed on 16 ns wide pulses.





Statistics: As with regular parameter measurements in LeCroy oscilloscopes, statistics can be turned on and off with the corresponding soft key.



Parameter Averaging: A global averaging factor for all measurements can be set with another soft key. The default averaging factor is 16, but it can be set from 2 to 50.

Jitter Measurement

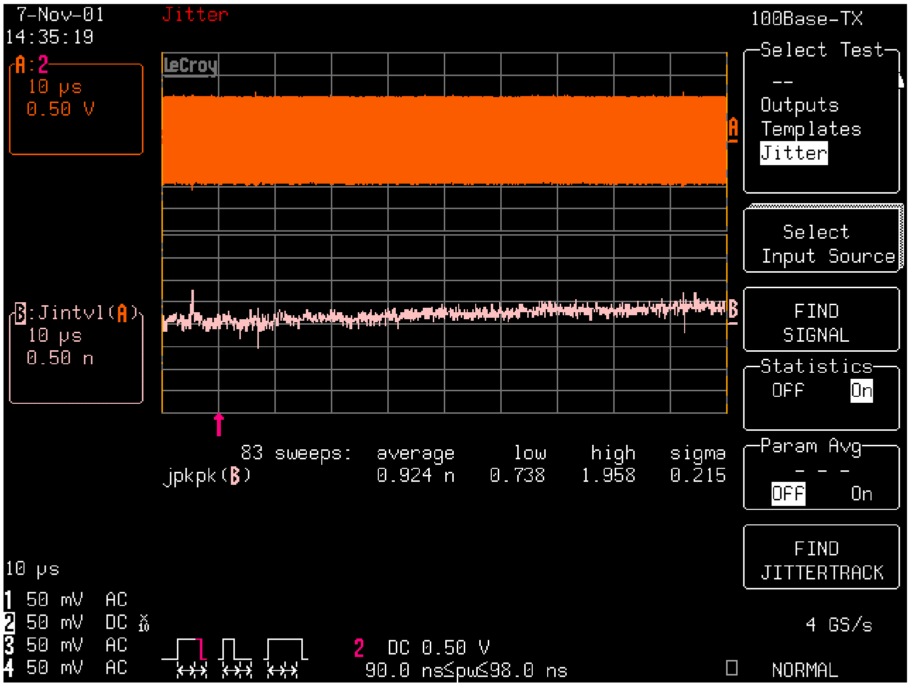


Figure 15. The upper grid displays the MLT-3 signal. The JitterTrack of the signal is displayed on the lower grid. The peak-to-peak jitter value is reported below the grid

The jitter pk-pk measurement is a tie@lv measurement, i.e., the total jitter over 100 µs, relative to an ideal clock. The ideal clock is calculated from the data stream. (See the *Jitter and Timing Analysis Operator's Manual*).

"Find Signal" will place the differential data signal (Channel 2-3) on the upper grid. The acquisition length is 100 µs. "Find Signal" sets the voltage range to the maximum to ensure that the Jitter measurements will not be compromised by a low-level amplitude.

Averaging and Statistics are similar to Signal Measurements.

"FIND JITTERTRACK" centers the JitterTrack (or jitter waveform) on the lower grid signal if the trace is not displayed instantly. (For more details on JitterTrack, see the *Jitter and Timing Analysis Operator's Manual*).

Over the 100 µs acquisition, a slow deviation (drift) in the TX_TCLK signal may sometimes be noticed (Trace A). In such cases, it's advisable to synchronize between the system's clock and the DSO's 10 MHz reference input clock. In any case, a high-pass filter will remove all low frequency components from the JitterTrack.

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3 Remote Commands

FUNCTION — DEFINE, DEF

DESCRIPTION

In addition to the parameters listed in your scope's *Remote Control Manual,* there is another parameter for the DEF EQN command for the Ethernet package: ETHERNET (Tx).

COMMAND SYNTAX

Tx:DEF EQN, "ETHERNET <source>",PROC,<value>

Tx =: {T1,T2,T3,T4}

<source> =: {TA,TB,TC,TD,M1,M2,M3,M4,C1,C2,C3,C4}

processing <value> =:

NOOP	no operation
REM_3125	remove 31.25 MHz disturbing signal
HPF	apply test high-pass filter
MJHPF	apply master mode jitter signal HPF),
SJHPF	apply slave mode jitter signal HPF
GBMSK	premask processing for gigabit mask testing, remove 31.25 MHz disturbing signal, apply test high-pass filter, position signal to a stable point, perform 1-bit ERES on the signal
FENET	do basic Fast Ethernet calculations and perform 1-bit ERES for mask testing)

FUNCTION ENET_AVG, ENAV

DESCRIPTION

In the Ethernet package, this command controls how many measurements are averaged before being returned as a single result of a parameter. This helps the value appear stable and readable on the parameter display. If statistics are enabled, it reduces sigma and the range between low and high results. (Outside of the Ethernet package, parameters do not average internally. They return each measurement as a result; statistics, therefore, are for individual measurements.) If this internal averaging is enabled, the parameter display will show "- - -" until the required number of measurements has been made so that one result can be returned. After that the display will change each time the required number of measurements has been made to produce a new result.

COMMAND SYNTAX

ENAV {ON,OFF}

FUNCTION ENET_AVG_COUNT, ENCT

DESCRIPTION

In the Ethernet package, this command controls how many measurements are averaged before being returned as a single result of a parameter. This helps the value appear stable and readable on the parameter display. If statistics are enabled, it reduces sigma and the range between low and high results. (Outside of the Ethernet package, parameters do not average internally. They return each measurement as a result; statistics, therefore, are for individual measurements.) If this internal averaging is enabled, the parameter display will show "- - -" until the required number of measurements has been made so that one result can be returned. After that the display will change each time the required number of measurements has been made to produce a new result.

COMMAND SYNTAX

ENCT <value>

<value> =: 2 through 50; the default is 16

FUNCTION PARAMETER_CUSTOM, PACU

DESCRIPTION

The PARAMETER_CUSTOM command controls the parameters that have customizable qualifiers, and can also be used to assign any parameter for histograms. The parameters for the Ethernet option take only a trace or channel for input.

COMMAND SYNTAX

<source>:PACU,<value>

<source> =: {TA,TB,TC,TD,M1,M2,M3,M4,C1,C2,C3,C4}

<value> =:

DOVA	gigabit Ethernet voltage at point A
DOVB	gigabit Ethernet voltage at point B
DOVC	gigabit Ethernet voltage at point C
DOVD	gigabit Ethernet voltage at point D
ACCAB	gigabit Ethernet voltage accuracy between points A and B
ACCC	gigabit Ethernet voltage accuracy at point C
ACCD	gigabit Ethernet voltage accuracy at point D
DRG	gigabit Ethernet droop at point G relative to point F
DRJ	gigabit Ethernet droop at point J relative to point H
DIST	gigabit Ethernet distortion calculation
FEDOV	fast Ethernet differential output voltage
FEDSAS	fast Ethernet signal amplitude symmetry
FEOVR	fast Ethernet overshoot
FERF	fast Ethernet rise/fall time
FERFS	fast Ethernet rise/fall time symmetry
FEDCD	fast Ethernet duty cycle distortion
JPKPK	peak-to-peak jitter measurement

# # #

Specifications

The Ethernet Package evaluates the following:

<u>1000Base-T</u>

Test	Where / What	The standard specifies
Peak Differential Output Voltage and Level Accuracy	DOVA, DOVB, Amplitude measurement of peaks A, B	Between 0.67 V and 0.82 V
	DOVC, DOVD Amplitude measurement of peaks C, D	1/2 of absolute averaged A, B amplitude values
	ACCAB Amplitude comparison: peak A vs. B	< 1%
	ACCC Amplitude comparison: peak C vs. A	< 2%
	ACCD Amplitude comparison: peak B vs. D	< 2%
Mask Test	Peaks A, B, C, D, F and H	2 template boundaries
Maximum Voltage Droop	DRG, DRJ, Voltage droop at peaks G and J	G > 0.731F; J > 0.731H
Jitter in Master Mode	tie@lv on TX_TCLK	See section 40.6.1.2.5 in clause 40 of 802.3-2000 standard.
	hold, J_{txout}	
	jpkpk, the Pk-Pk Jitter on TX_TCLK (filtered)	
Jitter in Slave Mode	hold, Slave TX_TCLK relative to Master TX_TCLK	
	jpkpk jitter value on the Slave TX_TCLK (filtered)	
	hold, between Slave TX_TCLK and corresponding diff data zero crossing	
	jpk-pk jitter value on Master TX_TCLK (filtered)	
Transmitter Distortion	At least 2047 samples	T_{ds} < 10 mV

100Base-TX

Test	Where / What	The standard specifies
Mask Test	One mask template	Eye diagram template boundaries
Jitter Measurement	tie@lv on the MLT-3 signal	< 1.4 ns
Signal Measurements	feDOV	0.95 V ? DOV ? 1.05 V
	feSAS	0.98 – 1.02
	ferf Rise/Fall Times	3 ns ? V_{rs} ? 5 ns
	ferfs Rise/Fall Symmetry	? 0.5 ns
	feDCD	+/-0.25 ns
	feovr Overshoot	+5% steady state voltage

# # #