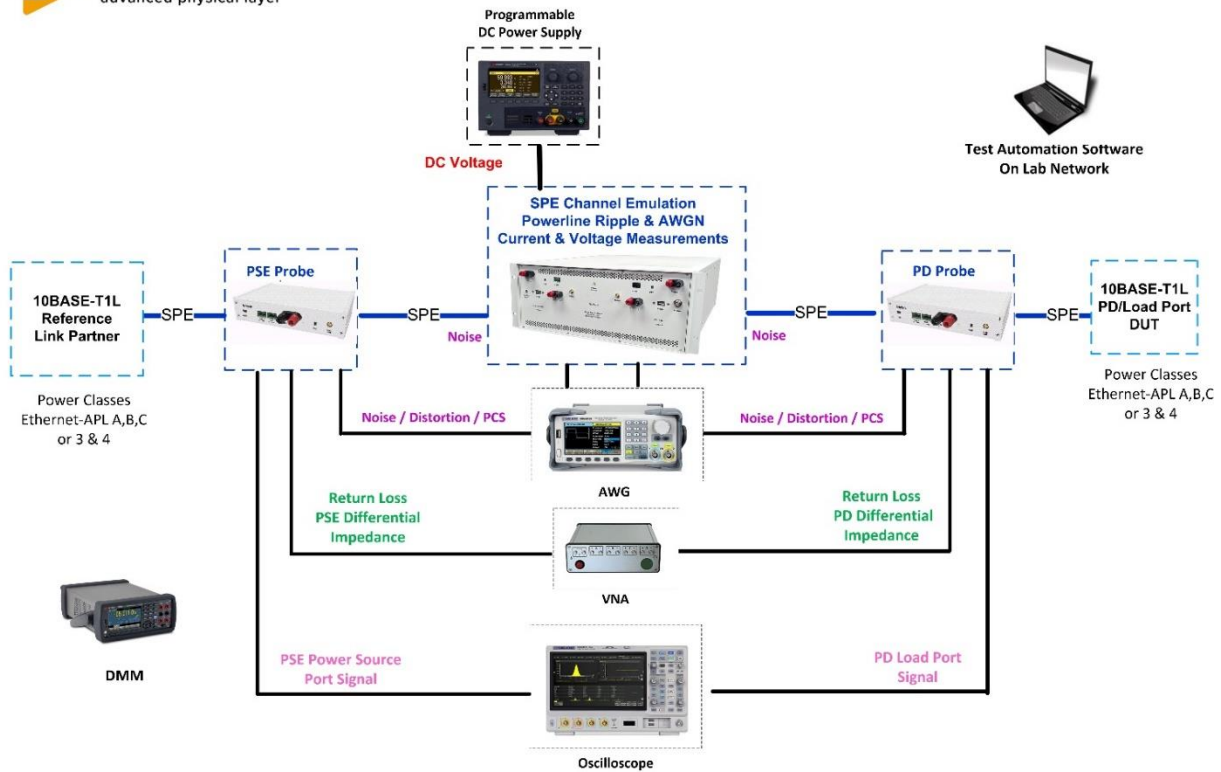


APPLICATION NOTE

Automated Ethernet-APL Power & Data Conformance Testing (Budget Version for Load/Sensor)



Telebyte's Ethernet-APL Universal Test Setup supports PD Load ports with one setup for Ethernet-APL Conformance and Interoperability Data and Power testing. The small footprint saves valuable laboratory test space while the fully automated approach saves time and money and provides repeatable test results. The solution is easy to use, allowing tests to be performed by technicians with minimal training. There is no need to plug/unplug different instruments and fixtures in the test setup. Additional features include automated software for controlling DUTs and all test equipment. The software generates Pass / Fail Reports for Ethernet-APL Conformance Power and Data tests. A customer's PC with a serial and network connection is used to transfer data to the PC for post processing the captured Ethernet signal with Telebyte's Test Automation Software. Customers may purchase all integrated test setup instruments from Telebyte. Please note this same setup (with the addition of a DC programmable load) can be used for testing PSE switches. An optional switch matrix is available for switching in of multiple DUTs in a test bed.

Required equipment:

Telebyte 4950 10BASE-T1L Channel Emulator
Telebyte SPE Test Automation Software
Telebyte 4950-P01 Probe
10BASE-T1L Reference Link Partner
AEM MMVNA 8-Channel Vectored Network Analyzer

Keysight E36232A Programmable Power Supply
Keysight EL33133A DC Electronic Load
Siglent SDS2104X Digital Storage Oscilloscope
Siglent SDG6022X Arbitrary Waveform Generator (AWG)
Keysight KT-34465A Truevolt Digital Multimeter



**Telebyte 4950 10BASE-T1L
Channel Emulator**

Telebyte's Model 4950 offers the world's first standard-based channel / cable emulator designed for testing Single Pair Ethernet (SPE) and supports a universal test setup with two Model 4950-P01 Multifunction Probes at the Power Source Port and Powered Device or Load Port.

This full duplex link supports power and communications over the same data line connected to devices at the edge of the "smart factory" network. The cost-effective technology provides data and analytics for industrial automation including control systems and cloud applications for remote operation as well as monitoring and management of the entire "intelligent building." Elevators, HVAC, power, security access, wireless access points, sensors, industrial controls, cameras, robotics, railway and transportation as well as lighting may all be integrated on the enterprise network.



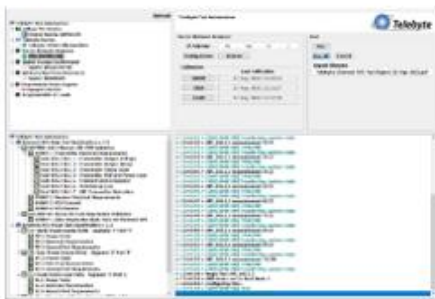
**Model 4950-P01 SPE
Multifunction Probe**

Single Pair Ethernet Testing Solution
For use with the Model 4950 Channel
Emulator

The Telebyte 4950-P01 SPE Multifunction Probe test instrument is designed specifically for testing Single Pair Ethernet (SPE) 10BASE-T1L with Power over Dataline (PoDL) as defined in the Ethernet-APL Data Test Specification v1.5, Power Test Specification v1.2 and the IEEE 802.3-2022 standard.

This specialized instrument is used with the Model 4950 Channel Emulator to test a wide range of Power Source Ports (PSE) and Powered Device (PD or Load) ports in applications such as Auto-Negotiation Tests, Transmitter Tests, BER Receiver Test, Power coupling and decoupling, noise generation (including background and impulsive noise), noise capture to replicate field environments in the lab, Power Spectral Density (PSD) and power level measurements, Transmitter clock frequency, distortion and jitter measurements, Voltage Droop, MDI Return Loss, PoDL / SPoE measurements and more.

This physical layer compliance test solution ensures interoperability between different designs and applications offered by hardware vendors. It features a variety of functions designed to enable and simplify automation of a universal test setup with no manual changes of patch cables or test fixtures (e.g., jigs, baluns) in the test setup.



Telebyte SPE Test Automation Software

Automation of SPE
Standards-Based Testing

The Telebyte SPE Test Automation Software provides easy control and configuration of the devices in the test bed as well as data storage and reporting. This automates, unifies, standardizes and simplifies the testing process, thereby enabling repeatability across implementations, saving time and lowering costs. Designed for automated testing following the standards:

Ethernet-APL

- Ethernet-APL Port Profile Specification (FCG TS10186) Rev 1.2
- Ethernet-APL Data Test Specification (FCG TT10188) Rev 1.5.4
- Ethernet-APL Power Test Specification (FCG TT10189) Rev 1.3

IEEE 802.3 – 2022 / IEEE 802.3dd (Coming soon)

Ethernet-APL Data Test Specification v1.5.6

Group 1: Transmitter Electrical Measurements

- Test APL.146.1.1 – Transmitter Output Voltage (Test Mode 1)
- Test APL.146.1.2 – Transmitter Output Droop (Test Mode 2)
- Test APL.146.1.3 – Transmitter Timing Jitter (Test Mode 1)
- Test APL.146.1.4 – Transmitter Power Spectral Density (PSD) and Power Level (Test Mode 3)
- Test APL.146.1.5 – Transmit Clock Frequency (Test Mode 1)
- Test APL.146.1.6 – MDI Return Loss (Part A: Tx disabled: DUT in Slave, high Z state)
- Test APL.146.1.6 – MDI Return Loss (Part B: Test Mode 3 VNA with narrowband IF of 100Hz)
- Test APL.146.1.7 – Transmitter Distortion (Test Mode 2) with 1MHz Sinusoidal Disturber at 1.0Vpp and/or 2.4Vpp

Group 2: Receiver Electrical Measurements

- Test APL.146.2.1 – Receiver Packet Error Rate Stress Test
 - Noise includes
 - AWGN @ -106dBm/Hz
 - Power-line Ripple Noise components
 - 100mV at 1kHz and 10kHz, 10mV at 100kHz and 1MHz, and
 - 100mV at 10kHz falling 20dB per decade to 10mV at 100kHz swept
 - Ethernet-APL Appendix F – 1.0Vpp Spur & 2.4Vpp Trunk Worst-Case Whole Communication Channel Traffic Testing – Link Quality SNR better than 20dB, DUT Passing BER < 10⁻⁹

Group 3: Transmit Packet Formation

- Test APL.146.3.1 – Transmit Signaling

Group 4: Receive Error Handling

- Test APL.146.4.1 – Automatic Polarity Detection and Correction
- Test APL.146.4.2 – Handling of Received ESD_ERR4
- Test APL.146.4.3 – Handling of Received CRC Errors

Section 98: Ethernet-APL Clause 98 Auto-Negotiation Validation

Group 1: Auto –Negotiation Basic Tests for Ethernet-APL

- Test APL.98.1.1 – Advertisement and Auto-Negotiation Verification
 - Part A: DUT advertises valid capabilities
 - Part B: DUT links with compatible link partner
 - Part C: DUT spur port when LP advertises but does not request increased transmit level
 - Part D: DUT behavior with incompatible link partner (spur to trunk, trunk to spur)
 - Part E: DUT behaves properly with incompatible link partner (spur to trunk, trunk to spur)
 - Part F: DUT behavior when link partner prefers master or slave port role (M/S is always 0).
 - Part G: DUT behavior when link partner forces master or slave port role (M/S is always 1).
- Test APL.98.1.2 – Management Restart of Auto-Negotiation
- Test APL.98.1.3 – Link Status Fail
- Test APL.98.1.4 – DME Voltage Envelope Test
- Test APL.98.1.5 – Auto-Negotiated Link-Up Time

Ethernet-APL Power Test Specification v1.3

TL.1 Power Tests

TL.1.1 Minimum Current Draw Minimum Supply Voltage 28.8 V

TL.1.1 Minimum Current Draw Maximum Supply Voltage 50V

TL.1.2 Inrush Current

TL.2 Electrical Characteristics

TL.2.1 Differential In-Band Ripple and Noise

TL.2.2 Differential Out-Band Ripple and Noise

TL.2.3 Current Derivatives

TL.2.4 Current Events Maximum Supply Voltage 50V

TL.2.5 Under Voltage Current

TL.3 General Port Requirements

TL.3.1 Terminal and Connectors

TL.3.2 Shielding Options*

TL.3.3 Polarity Sensitivity Mode A + / –

TL.3.3 Polarity Sensitivity Mode B – / +

SL: Spur Power Load Ports – Segment ‘S’; Port ‘L’

SL.1 Power Tests

SL.1.1 Minimum Current Draw Minimum Supply Voltage UPL(min) Class A=9V ClassC =10.6V

SL.1.1 Minimum Current Draw Maximum Supply Voltage UPL(min) Class A and C = 15V

SL.1.2 Inrush Current

SL.2 Electrical Characteristics

SL.2.1 Differential In-Band Ripple and Noise Maximum Supply Voltage UPS(max) Class A and C = 15V

SL.2.1 Differential In-Band Ripple and Noise Minimum Load Voltage UPL(min) Class A=9V ClassC =10.6V

SL.2.2 Differential Out-Band Ripple and Noise Maximum Supply Voltage UPS(max) Class A and C = 15V

SL.2.2 Differential Out-Band Ripple and Noise Minimum Load Voltage UPL(min) Class A=9V ClassC =10.6V

SL.2.3 Current Derivatives Maximum Supply Voltage UPS(max) Class A and C = 15V

SL.2.3 Current Derivatives Minimum Load Voltage UPL(min) Class A=9V ClassC =10.6V

SL.2.4 Current Events Minimum Load Voltage UPL(min) Class A=9V ClassC =10.6V

SL.2.4 Current Events Maximum Supply Voltage UPS(max) Class A and C = 15V

SL.2.5 Under Voltage Current

SL.3 General Port Requirements

SL.3.1 Terminal and Connectors

SL.3.2 Shielding Options*

SL.3.3 Polarity Sensitivity Mode A + / –

SL.3.3 Polarity Sensitivity Mode B – / +

* External DMM required (KT-34465A direct measurement)