



"Your Trusted Partner in SPE Testing"

**Model 4950
10BASE-T1L Cable Emulator with
Integrated SCCP Protocol Analyzer**

Single Pair Ethernet (SPE) Testing Solution



**Lab Test
Instrument**

**Repeatable
Testing**

World's First Standard-Based Cable Emulator for Testing SPE 10BASE-T1L and PoDL

Telebyte's Model 4950 offers the world's first standard-based cable emulator designed for testing Single Pair Ethernet (SPE).

This full duplex link will support 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.

Suitable for Compliance, Safety, and Interoperability Testing.



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Features Include:

- Simulation of Single Balanced Pair of Conductors of various cable types and lengths as defined in section 146.7.1 of IEEE 802.3cg-2019; APL Port Profile Specification v1.0, subclause 7.5; IEC 61156-13 ED1 section 6.3; and TIA 568.5 section 6.

Simulation includes:
 - Attenuation supports two PHY operational modes (1.0 Vpp or 2.4 Vpp)
 - Differential Return Loss
 - Link Delay
 - DC Resistance
- Low Noise Floor of < -165 dBm/Hz
- Bandwidth DC to 20 MHz
- Integrated Current Monitor, 0 to +/-2.5A
- Integrated Voltage Monitor at each end of the link, 0 to +/-60 VDC
- Data logging of current and voltage with timestamps every 500ms or 1s
- Serial Communication Classification Protocol (SCCP) Analyzer to view register data and logic analyzer view of pulses with timing
- Fault Tolerance and Safety Testing with Short Circuits on the differential pair or on signal wires to the Shield (Ground) from 5ms to 100ms in 1ms steps (Short Current not to exceed ~3.5A)
- Integrated Differential Mode Noise Injection at each end of the cable emulator
- Wide Dynamic Range of Noise output when integrating with Telebyte's Universal Noise Generator: -70dBm/Hz to -155dBm/Hz
- Micro-Interrupts from 5ms to 500ms in 1ms increments to simulate intermittent connections at wire joints (terminal box). Tests Power Over Data Line stability and Signal integrity path with reflections.
- Compliance Testing for Timers to test Maintain Full Voltage Signature for PoDL stability
- Supports PoDL Type E Power Class Devices w/ 60V DC, 2A, 90Watts and Ethernet-APL Class A, C and 3
- 1 to 80.5 ohm variable Cable DC resistance emulation in 0.5-ohm increments
- Symmetric and Bi-directional emulation
- Integrated electronic circuit breaker and ground fault current condition (GFI)
- Repeatable, configurable, realistic
- Remote Control via telnet or SSH with a command line interface (CLI)
- Linux SBC with built-in web server for browser user interface
- Made in the USA



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Current/Voltage Monitor

The Model 4950 includes an integrated current and voltage monitor at the PSE and PD. In addition, the user may enable data logging to monitor current and voltage over the link for long term thermal or stability testing of Power over Data Line. For safety, the unit will open the cable emulator in the event of over-current error conditions (electronic circuit breaker or ground fault current conditions [GFI]). Log data for Ethernet-APL intrinsically safe devices to ensure limits are maintained for Class A, C and 3.

SCCP Protocol Analyzer

This innovative product includes a Protocol Analyzer for the Serial Communication Classification Protocol (SCCP) to monitor or troubleshoot the half-duplex bi-directional serial data bus for communication between the Master PSE and Slave PD devices. The initialization sequence of reset, presence, write, and read pulses are presented with time stamped information in a tabular or graphical view similar to a logic analyzer. This information is available to the user via a web interface and/or remote commands. The CRC pass/fail criteria, Volt Info, Power Info, Power Assign and Class Type Info register values may be checked as well.

Cable Faults

The Model 4950 can verify fault tolerance performance with short circuits on the Single Pair Ethernet link from 5ms to 100ms in 1ms increments to determine when the PSE shuts down the output power should a short circuit be detected between the differential pair or a signal wire to ground. The short condition can be placed at the PSE or PD end of the link with normal operation expected after the short circuit is removed.

Spurs may have up to four inline connections and Trunks may have up to ten inline cable connections. To emulate faulty connections at these terminal points, this product supports mechanical faults called Micro-Interrupts. These may be inserted from 1ms to 500ms onto the twisted pair link to open a single wire or both wires to emulate a bad wire joint connection.

If these cable faults are subject to vibration from heavy equipment or HVAC, they may experience impedance discontinuities which affects the signal path with reflections and the DC power to the Powered Device which may cause the link to drop or underperform.

Noise Testing

It is vital to test link performance in noisy conditions such as those found in factory environments with harsh EMI radiated noise. The Model 4950 features integrated differential mode noise injection at each end of the cable emulator and is designed to be used with Telebyte's 4975 SPE Noise Generator and Analyzer (see separate datasheet) to inject a mixture of noise in the frequency and/or time domain on the data line. This reduces the signal-to-noise margin and validates the data rate and stability of the DUT in the presence of noise.

The Ethernet-APL Data Test Specification v1.0 Receive Packet Error Rate Stress Test is supported by supplying the AWGN and power line ripple voltage to see if the DUT maintains a BER of less than 10^{-9} .



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Noise Capture

Telebyte's Model 4975 (see separate datasheet) also supports the signal capture of real-world noise environments on the twisted pair including alien crosstalk, impulse noise, RFI, inductive noise, and the background noise floor. The captured noise can be recorded and played back on the Telebyte noise generator to replicate different noise environments or installations during lab testing.

Cable Emulation

The 4950 simulates variable insertion loss, DC resistance, impedance and delay. There are various cable types existing in different environments and Telebyte supports multiple standards for single twisted pair cable.

Telebyte's repeatable test solution provides a variety of cable lengths and cable types for both the 1.0 Vpp and 2.4 Vpp transmit amplitude PHY operational modes, each with the applicable low and high insertion loss (attenuation) curves. The 1.0 Vpp (low voltage) is optimal for intrinsically safe applications or relatively low noise environments. For more severe noise environments with older and longer twisted pair cables (with high attenuation), a higher transmit level using 2.4 Vpp is beneficial. Testing both transmit amplitude conditions ensures devices are interoperable in multiple cable plant and EMC environments.

Standards Based Cable Models, Each with an Allowable Cable Length

802.3cg section 146.7.1 (1.0 Vpp) 100m, 250m, 500m, 600m, 850m, 1000m

OR

802.3cg section 146.7.1 (2.4 Vpp)

Lengths: 50m, 150m, 250m, 350m, 500m, 600m, 750m, 850m, 1000m, 1100m, 1600m*, 2000m*

OR

Ethernet-APL Spur Worst Case Cable Model (1.0 Vpp) 200m

OR

Ethernet-APL Trunk Worst Case Cable Model (2.4 Vpp) 1000m

OR

61156-13 ED1 section 6.3

Lengths: 100m (A-100), 250m (A-250), 400m (A-400), 1000m (A-1000)

OR

TIA 568.5 section 6

Lengths: 100m (SP-1-100), 250m (SP-1-250), 400m (SP-1-400), 1000m (SP-1-1000)

*optional



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Specifications

Cable Emulator Specification									
Simulation	Single Balanced Pair of Conductors as defined in: IEEE 802.3cg section 146.7.1 (1.0 Vpp): 100m, 250m, 500m, 600m, 850m, 1000m IEEE 802.3cg section 146.7.1 (2.4 Vpp): 50m, 150m, 250m, 350m, 500m, 600m, 750m, 850m, 1000m, 1100m, 1600m*, 2000m* Ethernet-APL Spur Worst Case Cable Model (1.0 Vpp): 200m Ethernet-APL Trunk Worst Case Cable Model (2.4 Vpp): 1000m IEC 61156-13 ED1 section 6.3: 100m (A-100), 250m (A-250), 400m (A-400), 1000m (A-1000) TIA 568.5 section 6: 100m (SP-1-100), 250m (SP-1-250), 400m (SP-1-400), 1000m (SP-1-1000) * Optional								
Bandwidth	DC to 20 MHz								
Average Noise Floor	< -165 dBm/Hz								
Attenuation (Insertion Loss)	Mean Absolute Error (MAE) <0.75dB (0.1MHz to 20MHz)								
Maximum Attenuation	Theoretical attenuation of cable as defined by the applicable standard at 20MHz or 70db, whichever is less								
Return Loss	Better than 19 dB								
DC Loop Resistance	Variable from 1 Ohm to 80.5 Ohms in 0.5 Ohm increments (+/- 0.2 ohms)								
Delay	Various between 0.1MHz to 20MHz								
Maximum Current	<table style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th style="text-align: center;">DC Loop Resistance (ohms)</th> <th style="text-align: center;">Maximum Current (Amps)</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">< 9.5</td> <td style="text-align: center;">1.579</td> </tr> <tr> <td style="text-align: center;">< 25</td> <td style="text-align: center;">0.600</td> </tr> <tr> <td style="text-align: center;">< 65</td> <td style="text-align: center;">0.231</td> </tr> </tbody> </table>	DC Loop Resistance (ohms)	Maximum Current (Amps)	< 9.5	1.579	< 25	0.600	< 65	0.231
DC Loop Resistance (ohms)	Maximum Current (Amps)								
< 9.5	1.579								
< 25	0.600								
< 65	0.231								
Maximum voltage	60 VDC								
Current Monitor	0 to +/-2.5A, 75 uA resolution, +/- 1%								
Voltage Monitor	0 to +/-60 VDC, 4 mV resolution at PD and/or PSE side of link, +/- 1%								
Data Logging	Current and voltage every 0.5 seconds with timestamping								
Serial Communication Classification Protocol (SCCP) Analyzer	CRC pass/fail criteria, Volt Info, Power Info, Power Assign and Class Type Info register data. Reset, initialization, presence, write, and read pulses with timing information. Logic analyzer functionality showing Bit timing and register contents.								
Short	Short the BI_DA+ and BI_DA- from 5ms to 100ms in 1ms increments at the PD or PSE end of link for Fault Tolerance and Safety Testing (Short current not to exceed ~3.5 A)								
Micro Interrupts	Short term millisecond opening of the BI_DA+(PI+) or BI_DA-(PI-) signals from 5ms to 500ms in 1ms steps. Interrupt can be placed midspan of cable emulator.								
Data Connectors	2, 3-position Terminal Blocks for BI_DA+, BI_DA- & Shield								
Control Connector	1 Female CAT6A RJ45								
Control	802.3 Ethernet, including high-level command set for remote control, OR a web-based Graphic User Interface (GUI)								
Power Supply	88 to 264 VAC, 50 or 60 Hz								
Dimensions	[4U] W 19 in x H 7 in x D 25 in (W 482 mm x H 178 mm x D 635 mm)								
Mounting options	Mountable in 19" rack								



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Specifications (continued)

Integrated Noise Injector(s) Specification	
Bandwidth	100 kHz to 30 MHz
Input Impedance	50Ω unbalanced SMA Connector
Injection Type	Differential Mode, balanced, high impedance
Crest Factor	Greater than 5
Maximum RMS Output	+5 dBm into 50Ω
Dynamic Range of noise output when integrated with Telebyte's Universal Noise Generator	-70dBm/Hz to -155dBm/Hz
Connectors	4 SMA Female for connection to Telebyte's Model 4975 Noise Generator

Specifications are subject to change without notice. Made in USA.

Ordering Options

Model Number	Description
4950-001	10BASE-T1L Cable Emulator with Integrated SCCP Protocol Analyzer IEEE 802.3cg section 146.7.1 (1.0 Vpp): 100m, 250m, 500m, 600m, 850m, 1000m IEEE 802.3cg section 146.7.1 (2.4 Vpp): 50m, 150m, 250m, 350m, 500m, 600m, 750m, 850m, 1000m, 1100m Ethernet-APL Spur Worst Case Cable Model (1.0 Vpp): 200m Ethernet-APL Trunk Worst Case Cable Model (2.4 Vpp): 1000m IEC 61156-13 ED1 section 6.3: 100m (A-100), 250m (A-250), 400m (A-400), 1000m (A-1000) TIA 568.5 section 6: 100m (SP-1-100), 250m (SP-1-250), 400m (SP-1-400), 1000m (SP-1-1000)
4950-002	10BASE-T1L Cable Emulator (extended reach) with Integrated SCCP Protocol Analyzer IEEE 802.3cg section 146.7.1 (1.0 Vpp): 100m, 250m, 500m, 600m, 850m, 1000m IEEE 802.3cg section 146.7.1 (2.4 Vpp): 50m, 150m, 250m, 350m, 500m, 600m, 750m, 850m, 1000m, 1100m, 1600m, 2000m Ethernet-APL Spur Worst Case Cable Model (1.0 Vpp): 200m Ethernet-APL Trunk Worst Case Cable Model (2.4 Vpp): 1000m IEC 61156-13 ED1 section 6.3: 100m (A-100), 250m (A-250), 400m (A-400), 1000m (A-1000) TIA 568.5 section 6: 100m (SP-1-100), 250m (SP-1-250), 400m (SP-1-400), 1000m (SP-1-1000)
4975	Optional SPE Noise Generator & 802.3cg / Ethernet-APL Conformance Tester (see separate datasheet for ordering options)