AEM Networks

WHITE PAPER

Power over Ethernet & Signal-to-Noise Ratio Performance

on Extended Reach Copper Cabling

from 100m to 1700m: Measurements, Analysis, and Deployment Guidance

Arvind C. Patel
Director of Engineering, AEM Networks
June 2026

https://aemnetworks.com | arvind.patel@aem.com.sg

© 2025 AEM Networks. Confidential.

Executive Summary

The proliferation of IoT endpoints, IP surveillance systems, Wi-Fi 6/6E/7 access points, and building automation controllers has created strong industry demand for Ethernet connectivity that extends well beyond the traditional 100-meter structured cabling limit. Simultaneously, the widespread deployment of Power over Ethernet (PoE) means that cable signal quality and DC resistance are no longer merely data-link concerns — they directly determine whether powered devices can operate at all.

This white paper presents comprehensive field-measurement data collected by AEM Networks using the TESTPRO Cable Certification Platform across five distinct cable channel configurations:

- TIA Cat5e 24AWG, 4-pair, 100m — 1 Gbps / 79.1W PoE delivered
- CatxL 22AWG, 4-pair, 200m — 1 Gbps / 77.7W PoE delivered
- CatxL 22AWG, 4-pair, 250m — 100 Mbps / 72.1W PoE delivered
- CatxL 22AWG, 4-pair, 300m — 10 Mbps / 66.5W PoE delivered
- Single Pair Ethernet (SPE), 23AWG, 1700m — 10 Mbps (data only)

Measurements confirm that: (1) SNR margins remain positive at all tested distances with appropriately rated cable; (2) PoE delivery degrades gracefully with distance, governed by DC loop resistance; and (3) 22AWG CatxL conductors are remarkably effective at preserving both data throughput and power delivery at 2–3× the standard channel length.

Key Finding

22AWG CatxL extended reach cabling delivers simultaneous Gigabit Ethernet and >77W PoE at 200m — within 2% of the power available at 100m. At 300m, PoE delivery exceeds 66W at 10 Mbps data rates. Single Pair Ethernet achieves data connectivity at 1700m over 23AWG cable.

1. Introduction and Market Context

1.1 The Extended Reach Imperative

Modern enterprise, industrial, and smart-building networks increasingly require Ethernet beyond the 100-meter channel limit first codified in TIA-568 and ISO/IEC 11801 in the early 1990s. Key application drivers include:

- Campus and outdoor Wi-Fi: Wireless access points in parking structures, athletic fields, and building perimeters often cannot be reached within 100m from an equipment room.

© 2025 AEM Networks. Confidential.

- IP video surveillance: Long perimeter runs, large parking decks, and multi-building campuses routinely require 150–300m channel lengths.
- Building automation (BAS/BMS): HVAC sensors, access control panels, and lighting controllers are distributed throughout a building's mechanical infrastructure, often far from IT closets.
- Industrial IoT: Process control sensors, motor monitoring systems, and conveyor PLCs in factory environments require long reaches without conduit-to-conduit fiber splicing.
- Single Pair Ethernet: Replacing legacy 4–20 mA analog and HART fieldbus loops with IP-based Single Pair Ethernet enables sub-1GHz Ethernet to 1000m+ for critical infrastructure monitoring.

IEEE 802.3 standards address these needs through both enhanced 4-pair variants (CatxL, 10BASE-T, 100BASE-TX at extended distances) and the newer Single Pair Ethernet PHY family (10BASE-T1L, 100BASE-T1, up to 10GBASE-T1 for automotive). TIA and ISO/IEC cabling standards provide the complementary channel specifications that define what cable performance is needed to support each PHY.

1.2 Power over Ethernet: The Distance Problem

Power over Ethernet (PoE), standardized in IEEE 802.3af/at/bt, delivers DC power over the same copper conductors used for data. The physical constraint is straightforward: every meter of cable adds resistance, and that resistance consumes power as I^2R heat before the electricity reaches the Powered Device (PD).

The governing equations are:

$$V_{PD} = V_{PSE} - (I \times R_{loop}) \quad | \quad P_{lost} = I^2 \times R_{loop} \quad | \quad P_{PD} = V_{PD} \times I$$

Where V_{PSE} is the Power Sourcing Equipment (switch) output voltage, I is the load current, and R_{loop} is the total DC loop resistance of the two conductors in the powered pair. For IEEE 802.3bt Type 3 (60W at PSE, 51W minimum at PD), a PSE may output up to 57V. At 37m of 22AWG cable (R_{loop} = 4.7 Ω) with 1.77A current draw, the voltage drop alone is 4.7 Ω ×1.77A = 8.32V, leaving 48.7–49V at the PD end (from a 57V PSE).

This makes DC loop resistance the primary engineering constraint for PoE at extended reach — not the data signal integrity limits, which are generally more forgiving at lower data rates. Conductor AWG (cross-sectional area) is the most impactful design variable: 22AWG has approximately 57 Ω/km loop resistance versus 94 Ω/km for standard 24AWG.

1.3 SNR and Transmission Quality Fundamentals

Signal-to-Noise Ratio margin quantifies the headroom between what the cable delivers and what the Ethernet PHY requires for reliable operation. The primary measurements contributing to SNR assessment in field certification are:

- Insertion Loss (IL): Attenuation of the signal across the channel. This increases with frequency and length. It is the dominant limit for extended-reach links.

© 2025 AEM Networks. Confidential.

- NEXT (Near-End Crosstalk): Interference induced in adjacent pairs at the transmitting end. Governed by pair-to-pair balance and connector quality.
- Return Loss (RL): Signal reflections from impedance discontinuities (connectors, cable changes, kinks). Degrades SNR and causes inter-symbol interference.
- ELFEXT / PSELFEXT: Far-end crosstalk. Critical for 1000BASE-T and higher, which use all four pairs bidirectionally.
- Delay and Skew: Propagation time and timing differences between pairs. Relevant for pair-bonding PHYs such as 1000BASE-T.

AEM's TESTPRO reports each parameter as a margin (dB above the applicable standard limit). Positive margins confirm channel compliance; the magnitude of the margin indicates operational robustness. A margin of 3 dB means any individual parameter could degrade by 3 dB before the link fails certification — a useful design safety target for extended-reach channels subject to environmental variation.

2. Applicable Standards

2.1 Four-Pair Cabling Standards

Standard	Scope	Extended Reach Relevance
ANSI/TIA-568.2-E	4-Pair Cabling & Components	CatxL provisions; extended-reach channel specs
ISO/IEC 11801-1	Generic Premises Cabling	Class D– Class I; aligns with TIA Cat5e–Cat8
TIA TSB-184-A	PoE over Twisted Pair	PoE power delivery guidance; thermal derating for bundles
TIA TSB-5073	Extended Distance Copper	Guidelines for channels >100m; 10M–1G data rates
IEEE 802.3bt	PoE Type 3 & 4	60W/90W PSE; 4-pair power delivery; class signatures
IEEE 802.3cg	10BASE-T1L / 10BASE-T1S	SPE to 1000m; SPoE power standard

The TIA CAT-XL designation specifically targets cables engineered for extended reach by using larger conductors (22AWG or 20AWG) combined with tighter electrical tolerances. These cables are backward compatible with standard Cat5e/Cat6 equipment but are certified to vendor-specific limit curves rather than the standard TIA-568 channel limits.

2.2 Single Pair Ethernet Standards

© 2025 AEM Networks. Confidential.

IEEE Standard	PHY	Data Rate	Max Distance	Application Domain
802.3bw	100BASE-T1	100 Mb/s	15m	Automotive, Sensors
802.3bp	1000BASE-T1	1 Gb/s	15m / 40m	Automotive, High-speed Sensors
802.3cg	10BASE-T1L	10 Mb/s	1000m	Building Automation, Long-haul IoT
802.3cg	10BASE-T1S	10 Mb/s	15m (multidrop)	Industrial Short Links, Multidrop
802.3ch	5GBASE-T1	5 Gb/s	15m	Automotive
802.3dg (draft)	100BASE-T1	100 Mb/s	500m	Industrial Extended Reach
802.3da (draft)	10BASE-T1S	10 Mb/s	50m, 16 nodes	Multidrop Industrial

ANSI/TIA-568.5 defines two SPE cabling categories: SP-1000 (to 1000m, DC loop resistance ≤49.4 Ω, 18AWG minimum) and SP-400 (to 400m, DC loop resistance ≤62.9 Ω, 23AWG minimum). Connector standardization is provided by the IEC 63171 series, defining seven connector types for diverse industrial environments including M8/M12, LC-style, and rectangular forms.

2.3 PoE Power Standards

IEEE Standard	Type	PSE Max Output	Min PD Power	Typical Applications
802.3af	Type 1	15.4W	12.95W	VoIP phones, basic IP cameras
802.3at	Type 2	30W	25.5W	PTZ cameras, dual-band APs
802.3bt	Type 3	60W	51W	High-power APs, video conferencing
802.3bt	Type 4	90W	71.3W	Laptops, digital signage
802.3bu PoDL	PoDL	Up to 50W	Up to 40W	Automotive data lines
SPoE (IEC/TIA)	Single Pair PoE	Up to 52W	~40W	Industrial SPE devices

3. Test Methodology

3.1 AEM TESTPRO Test Platform

© 2025 AEM Networks. Confidential.

All measurements were conducted using the AEM TESTPRO Cable Certification System with CAT8.1 channel, CAT 8.1 Permanent Link, M12 D-coded or M12 X-coded industrial Ethernet, or AD-NET-CABLE adapter(4-pair testing, 1 MHz to 3 GHz) and SPE adapters (single pair, 0.1 MHz to 20 MHz). For more information on the wide range of adapters available please refer to Your Ultimate Guide to TestPro CV100 Kits & Adapters.

The TESTPRO platform provides:

- Full IEEE 802.3 limit set storage and automated margin calculation
- Integrated PoE load tester — presents 802.3bt PD class signature to the PSE and measures actual voltage, current, and power under load
- Frequency resolution down to 20 kHz (vs. 150 kHz for standard 4-pair testers) enabling finer fault localization on long links
- Extended lower frequency range to 0.1 MHz for SPE certification per ANSI/TIA-568.5

The TESTPRO platform supports both standard-limit certification (TIA-568, ISO/IEC 11801) and vendor-specific extended-reach limit sets. For extended reach CAT-XL and SPE channels, vendor-specific limits were loaded into the tester to provide meaningful margin results against the actual performance targets of the cable under test.

3.2 Test Channel Configurations

Test	Configuration	Conductor	Speed	Max Length	DC Loop R
1	TIA Cat5e Channel	24AWG / 4-pair	1 Gbps	100m	21.7 Ω
2	CatxL Extended Reach	22AWG / 4-pair	1 Gbps	200m	24.2 Ω
3	CatxL Extended Reach	22AWG / 4-pair	100 Mbps	250m	30.7 Ω
4	CatxL Extended Reach	22AWG / 4-pair	10 Mbps	300m	38.2 Ω
5	SPE (Single Pair)	23AWG / 1-pair	10 Mbps	1700m	269.5 Ω

3.3 PoE and SNR Test Sequence

For each configuration the following sequence was performed:

- Step 1: Autotest — full RF certification including IL, RL, NEXT, ELFEXT, delay, and skew against IEEE 802.3 limits for the target speed tier
- Step 2: SNR margin extraction — minimum margin across all frequency points for each parameter
- Step 3: PoE load test — TESTPRO simulates PD at IEEE 802.3bt Type 3, measuring V_PD, I_PD, and P_PD
- Step 4: Results documentation — saved with equipment serial number, firmware version, channel ID, and timestamp

© 2025 AEM Networks. Confidential.

4. Measurement Results and Analysis

4.1 Test 1: TIA Cat5e, 100m — Baseline Reference

The standard Cat5e 100m channel establishes the performance baseline. All SNR margins are comfortable, and PoE power delivery well exceeds IEEE 802.3bt Type 3 requirements.

Parameter	Measured	Limit / Target	Margin
Length	100m	≤100m	At limit
DC Loop Resistance	21.7 Ω	≤25 Ω (TIA)	+3.3 Ω
Insertion Loss @ 100 MHz	23.2 dB	≤24.0 dB	+0.8 dB
PoE Voltage at PD	44.64V	≥42.5V	+2.14V
PoE Current	1.77A	—	—
PoE Power Delivered	79.1W	≥51W (Type 3)	+28.1W

The 79.1W delivered PoE power comfortably exceeds the Type 3 (51W) and approaches Type 4 (71.3W) levels, supporting the most power-hungry devices including 802.11be Wi-Fi 7 access points and high-resolution PTZ cameras. This baseline demonstrates the performance target that extended-reach configurations seek to preserve as distance increases.

4.2 Test 2: CAT-XL 22AWG, 200m — 1 Gbps with Full PoE

Doubling channel length to 200m using 22AWG CAT-XL cabling delivers the most striking result in this study: both Gigabit Ethernet capability and near-baseline PoE power delivery are maintained.

Parameter	Measured	vs. 100m	Status
Length	200m	+100m / +100%	Extended reach
DC Loop Resistance	24.2 Ω	+2.5 Ω / +11.5%	Within CAT-XL spec
Insertion Loss @ 100 MHz	38.1 dB	+14.9 dB	Within 1G limit
PoE Voltage at PD	43.44V	−1.20V	Above 42.5V minimum
PoE Current	1.79A	+0.02A	Stable
PoE Power Delivered	77.7W	−1.4W / −1.8%	Exceeds Type 3

© 2025 AEM Networks. Confidential.

The near-identical DC loop resistance between 100m of 24AWG (21.7 Ω) and 200m of 22AWG (24.2 Ω) explains this remarkable result. The lower resistance-per-meter of 22AWG (~57 vs. ~94 Ω/km) effectively compensates for the doubled cable length. PoE power loss over the additional 100m of 22AWG is less than 1.5W — negligible for most applications.

Insertion loss at 200m (38.1 dB @ 100 MHz) approaches but remains within the 1000BASE-T channel limit. SNR margins for NEXT, RL, and ELFEXT are positive across all tested pairs, confirming Gigabit Ethernet link capability. This configuration is particularly well-suited for dense campus Wi-Fi deployments where Gigabit uplinks and high PoE power must be delivered beyond IDF room reach.

Design Highlight

200m of 22AWG CatxL delivers 77.7W PoE — within 2% of the 79.1W available at 100m on standard Cat5e. The cable physics of AWG advantage nearly exactly compensates for the doubled distance.

4.3 Test 3: CAT-XL 22AWG, 250m — 100 Mbps

At 250m, insertion loss exceeds the 1000BASE-T limit, requiring fallback to 100BASE-TX (100 Mbps) operation. This represents an important design crossover point.

Parameter	Measured	Notes
Length	250m	2.5× standard 100m limit
DC Loop Resistance	30.7 Ω	Within CAT-XL 100M spec; above Cat5e 25 Ω limit
Insertion Loss @ 100 MHz	46.6 dB	Exceeds 1G limit; within 100M limit
Return Loss Margin	5.9 dB (vendor data)	Positive; 100M capable
NEXT Margin	6.2 dB (vendor data)	Positive; adequate headroom
PoE Voltage at PD	41.14V	Slightly below 42.5V (see note)
PoE Power Delivered	72.1W	Exceeds Type 3 (51W minimum)

The 72.1W PoE delivery at 250m, despite the step down to 100 Mbps data rate, makes this configuration practical for outdoor access points and IP cameras where 100 Mbps throughput is sufficient, but PoE power is critical. Note that the 41.14V PD voltage is slightly below the IEEE 802.3bt standard's 42.5V minimum specification; PSE output voltage settings and PD minimum voltage specifications should be confirmed for 250m deployments.

4.4 Test 4: CAT-XL 22AWG, 300m — 10 Mbps

© 2025 AEM Networks. Confidential.

At 300 meters, the channel operates at 10 Mbps (10BASE-T using vendor-specific extended reach limits) while still delivering substantial PoE power.

Parameter	Measured	Notes
Length	300m	3× standard limit
DC Loop Resistance	38.2 Ω	Within CAT-XL 10BASE-T spec
Insertion Loss @ 16 MHz	20.9 dB	Within 10BASE-T vendor limit
SNR Margin (NEXT)	> 0 dB	10M capable; thin margins
PoE Voltage at PD	37.66V	Below 42.5V IEEE minimum
PoE Current	1.77A	Near standard levels
PoE Power Delivered	66.5W	Substantially exceeds Type 3

The 66.5W delivered at 300m is a striking result but comes with an important caveat: the PD-side voltage of 37.66V is below the IEEE 802.3bt Type 3 standard minimum of 42.5V. While many PDs can operate at lower input voltages (some specify as low as 35V), IEEE 802.3bt-compliant PDs may enter a reduced-power class mode or disconnect at this voltage level. Deployment at 300m requires explicit confirmation that target devices accept 37–38V input.

> **300m Deployment Warning**
>
> PD-side voltage at 300m is 37.66V — below the IEEE 802.3bt minimum of 42.5V. Verify that all target Powered Devices are rated to operate at voltages as low as 37–38V DC before deploying at 300m distances. Some PSE products offer a high-power mode with 57V output that can compensate for this voltage drop.

4.5 Test 5: SPE 23AWG, 1700m — 10 Mbps Data

The 1700m Single Pair Ethernet result is the most technically remarkable in this study. The IEEE 802.3cg standard specifies 10BASE-T1L operation to 1000m, yet AEM Networks' TESTPRO measures channel at 1700m — 70% beyond specification — demonstrating thetester's capability.

Parameter	Measured	IEEE 802.3cg Limit	Notes
Length	1700m	1000m (standard)	70% beyond spec
Propagation Delay	8350 ns	≤8834 ns	Within limit
DC Loop Resistance	269.5 Ω	~350 Ω (18AWG ref)	Within range
Insertion Loss @ 1 MHz	36.7 dB	Within 10BASE-T1L limit	Passes

© 2025 AEM Networks. Confidential.

Parameter	Measured	IEEE 802.3cg Limit	Notes
Return Loss Margin	2.0 dB	> 0 dB required	Marginally passes
TCL (Unshielded)	0.5 dB margin	> 0 dB required	Marginally passes
SPoE Power Delivery	Not applicable	N/A at this resistance	Power not viable at 1700m

10BASE-T1L employs PAM3 modulation with low-frequency spectral content (centered at ~1 MHz), extensive adaptive equalization, and robust forward error correction — allowing it to exploit available SNR headroom well beyond the standardized distance. At 1700m, all margins are positive but thin (0.5–2.0 dB), indicating that this is near the functional limit of the 23AWG cable.

At 269.5 Ω DC loop resistance, SPoE (Single Pair Power over Ethernet) delivery is not viable at 1700m. For comparison, 18AWG SPE cable at 1000m reaches 49.4 Ω loop resistance and can deliver up to 20W at 451m. For 1700m deployments, powered devices must be locally powered — but data connectivity over a single copper pair at this distance represents significant cost savings versus fiber installation.

4.6 Vendor-Specific Field Measurements (BICSI Japan 2025)

Complementary field measurements from a BICSI Japan presentation (November 2025) using vendor-specific extended reach cable products validate AEM's laboratory results with real-world installation data:

Parameter	SPE (1000m)	10BASE-T (~278m)	100BASE-T (~218m)	1000BASE-T (~170m)
Propagation Delay	5559 ns	1532 ns	1201 ns	747 ns
DC Loop Resistance	49.4 Ω	28.7 Ω	22.3 Ω	15.3 Ω
Insertion Loss Margin	—	0.2 dB	0.6 dB	2.8 dB
Return Loss Margin	7.0 dB	—	5.9 dB	7.0 dB
NEXT Margin	6.2 dB	—	5.9 dB	4.8 dB

The BICSI field data confirms positive SNR margins across all speed tiers at their respective maximum distances. The 1000BASE-T result at 155–185m shows a 2.8 dB insertion loss margin — adequate for reliable link operation with meaningful design headroom. The SPE result at 1000m shows strong return loss (7.0 dB) and NEXT (6.2 dB) margins, consistent with operation well within the PHY's adaptive equalization range.

5. Analysis: Distance, PoE, and SNR Trade-offs

5.1 Power Delivery vs. Distance Summary

© 2025 AEM Networks. Confidential.

Config	Length	AWG	R_loop (Ω)	V_PD (V)	P_PD (W)	PoE Type
Cat5e	100m	24	21.7	44.64	79.1	Type 3+4 ✓
CAT-XL	200m	22	24.2	43.44	77.7	Type 3+4 ✓
CAT-XL	250m	22	30.7	41.14	72.1	Type 3 ✓
CAT-XL	300m	22	38.2	37.66	66.5	Type 3* ⚠

*PoE power is technically delivered at 300m but PD voltage is below the 42.5V IEEE 802.3bt standard minimum. Device compatibility must be confirmed.

The data reveals a profoundly important insight for network designers: the choice of cable AWG has a multiplicative effect on extended-reach performance. By selecting 22AWG CatxL over standard 24AWG, the channel can double its physical length while maintaining performance comparable to the 24AWG baseline — for both data rate and PoE power delivery.

5.2 Speed Tier Selection by Distance

Insertion loss at the highest frequency of the target speed tier determines which data rate a channel can support. The crossover distances measured in this study align precisely with the theoretical IL-vs.-distance profiles:

Speed Tier	Frequency Range	Max IL at Limit	Effective Max Distance (22AWG CatxL)
1000BASE-T	1–100 MHz	~40.1 dB @ 100 MHz	~200m
100BASE-TX	1–100 MHz	~46.8 dB @ 100 MHz	~250m
10BASE-T	5–16 MHz	~25 dB @ 16 MHz	~300–350m
10BASE-T1L (SPE)	0.1–1 MHz	Per 802.3cg mask	~1000–1700m

Network designers should use these crossover distances as planning guides, applying a safety margin of 10–15% below the maximum (i.e., design to 180m for 1G rather than 200m) to account for connector resistance, temperature variation, and installation quality variability.

5.3 Thermal and Environmental Derating

The test results reported here represent controlled conditions with individual cable runs at ambient temperature. In production deployments, several derating factors apply:

- Temperature: DC resistance increases ~0.4% per °C above 20°C. A cable at 40°C (common in overhead cable trays) exhibits ~8% higher resistance than at 20°C.

© 2025 AEM Networks. Confidential.

- Bundling: IEEE 802.3bt and TIA TSB-184-A specify thermal derating for PoE in bundled cables. A 24-cable bundle may derate PoE current by up to 50%.
- Connector quality: Poor punch down terminations can add 0.1–1.0 Ω per connection, cumulatively significant at extended reach.
- Patch cord inclusion: The channel includes up to 10m of patch cord; if patch cord AWG is smaller than the horizontal cable, this contributes disproportionate resistance.

6. Deployment Guidance

6.1 Cable Selection

- Standard deployments ≤100m: Cat5e or Cat6, 24AWG. Standard TIA-568 certification sufficient.
- 100–200m at 1 Gbps + PoE: 22AWG CAT-XL is the clear choice. Verify that switches support extended-reach link training and PoE delivery to remote load.
- 200–300m at 100Mbps or 10Mbps + PoE: 22AWG CAT-XL; certify against vendor-specific extended reach limits. Plan for Type 3 PoE with PD voltage confirmation.
- IoT/BAS to 1000m: SPE 18AWG (SP-1000 category) for combined data + SPoE up to 20W at 451m or 52W at 187m.
- Data-only runs to 1700m: SPE 23AWG (SP-400 or higher) with 10BASE-T1L PHY. No PoE at distances >~400m.

6.2 PoE Power Budget Planning

Use this checklist for PoE planning at extended distances:

- 1. Determine target PD power requirement including local PD efficiency (typically 85–92%)
- 2. Calculate DC loop resistance: $R_{loop} = 2 \times L_{meters} \times \rho_{AWG}$ (Ohms/meter)
- 3. Select PSE output voltage: standard 48V or boosted 57V (IEEE 802.3bt)
- 4. Calculate PD voltage: $V_{PD} = V_{PSE} - (I \times R_{loop})$; verify V_{PD} > device minimum
- 5. Apply thermal derating for bundled installations (per TIA TSB-184-A)
- 6. Apply 10–15% safety margin for connector resistance and temperature variation
- 7. Document the calculation; retain for system warranty compliance

6.3 Field Test and Documentation

Extended reach installations require more rigorous verification than standard 100m channels:

- Certify against applicable extended-reach limits (vendor-specific or IEEE 802.3 for SPE), not standard TIA-568 Cat5e/Cat6 limits
- Include PoE load testing in the certification workflow — RF pass does not guarantee PoE viability
- Report SNR margins, not just pass/fail: margins below 3 dB at extended reach indicate risk
- Use test equipment supporting extended frequency ranges (down to 0.1 MHz) for SPE certification

© 2025 AEM Networks. Confidential.

- Test after final installation and termination, not during rough-in, to capture real channel performance
- Retain test reports with model, firmware version, limit set used, and adapter module serial number for warranty documentation

7. Industry Context and Standards Evolution

7.1 IEEE 802.3 Working Group Activities

The IEEE 802.3 standards body continues expanding the extended reach ecosystem. Key active work items as of 2025:

- P802.3dg: 100BASE-T1 at 500m over single pair — extending SPE mid-range reach substantially beyond current 100BASE-T1 15m spec
- P802.3dm: 10GBASE-T1 for automotive camera applications at 15m
- P802.3da: 10BASE-T1S multi-drop extension to 50m / 16 nodes for industrial multi-device topologies
- P802.3dd: SPoE (Single Pair Power over Ethernet) standardization — formal IEEE standard for power delivery over SPE cables

These activities signal sustained industry investment in both high-speed short-reach (automotive) and low-speed long-reach (industrial/building) SPE applications. Backward compatibility with existing SPE infrastructure is a design priority throughout.

7.2 TIA and BICSI Practitioner Guidance

TIA and BICSI provide installation-level guidance that complements IEEE and TIA cabling standards:

- BICSI TDMM (15th Ed.): Now includes extended-reach copper guidelines consistent with AEM's measured results; recommends minimum 3 dB SNR margin for extended-reach installations
- TIA TSB-184-A: Comprehensive thermal and PoE interaction analysis; mandates derating calculations for bundled installations; widely referenced by AHJs (Authorities Having Jurisdiction)
- TIA TSB-5073 (draft): Updated guidance supporting 4-pair extended-reach channels from 100Mbps to 1Gbps at distances from 100m to 300m
- ANSI/TIA-568.5 (2022): Establishes SPE as a first-class cabling infrastructure on par with 4-pair copper, defining channel, permanent link, and component requirements

7.3 Market Adoption Trends

Extended reach Ethernet adoption is accelerating across multiple sectors:

- Smart Buildings: Building automation systems increasingly adopt SPE (10BASE-T1L) to replace proprietary RS-485 and 4–20mA loops, leveraging existing copper infrastructure
- Campus Networking: Wi-Fi 6E/7 deployment economics favor CAT-XL over fiber for runs under 250m, as CAT-XL avoids the cost of media converters and optical transceiver pairs

© 2025 AEM Networks. Confidential.

- Industrial: IEC TR 63171-6 (SPE industrial cabling) and IIoT reference architectures increasingly specify SPE as the preferred IP connectivity medium for sensor-to-cloud architectures
- Automotive: SPE is now the dominant wiring technology in new vehicle architectures (e.g., automotive Ethernet for ADAS, infotainment, and body control)

8. Conclusions

This white paper has presented comprehensive PoE power delivery and SNR performance measurements across five extended-reach cable configurations, from 100m standard Cat5e to 1700m Single Pair Ethernet. The following conclusions are supported by the measurement data:

- 22AWG CatxL extended reach cabling effectively doubles the practical channel length while maintaining performance within 2% of the 100m baseline for both Gigabit Ethernet and PoE power delivery.
- PoE power delivery degrades predictably with distance: 79.1W at 100m, 77.7W at 200m, 72.1W at 250m, and 66.5W at 300m. All configurations exceed the IEEE 802.3bt Type 3 minimum (51W).
- SNR margins remain positive at all tested distances when using appropriately rated extended-reach cable, confirming link viability for each respective speed tier.
- Single Pair Ethernet (10BASE-T1L) achieves data connectivity at 1700m on 23AWG cable — 70% beyond its 1000m specification — demonstrating remarkable PHY adaptability for long-haul IoT applications.
- DC loop resistance is the primary PoE design constraint; conductor AWG (22AWG vs. 24AWG) is the single most impactful cable selection parameter for extended-reach PoE deployments.
- Field certification with PoE load testing — using a platform like AEM TESTPRO — is essential for validating extended-reach installations. Standard 100m limit sets are insufficient; vendor-specific or IEEE extended-reach limits must be applied.

Recommendation

For new extended-reach deployments requiring both data and PoE, specify 22AWG CatxL cable and target a minimum 3 dB SNR margin on all parameters. Conduct full certification including PoE load testing. At 300m, verify PD device minimum input voltage compatibility before installation. For IoT and sensor applications beyond 300m, consider Single Pair Ethernet with 18AWG cabling for data + power or 23AWG for data-only links.

References

- IEEE Std 802.3-2022: IEEE Standard for Ethernet (Consolidated), IEEE, December 2022

© 2025 AEM Networks. Confidential.

- IEEE Std 802.3cg-2019: Amendment for 10BASE-T1L and 10BASE-T1S, IEEE, November 2019
- IEEE Std 802.3bt-2018: Power over Ethernet (Type 3 & 4), IEEE, September 2018
- ANSI/TIA-568.2-E: Balanced Twisted-Pair Telecommunications Cabling and Components Standard, TIA, 2023
- ANSI/TIA-568.5: Single Pair Ethernet Cabling Standard, TIA, 2022
- TIA TSB-184-A: Guidelines for Supporting Power Delivery over Balanced Twisted-Pair Cabling, TIA, 2017
- ISO/IEC 11801-1:2017: Generic Cabling for Customer Premises, Edition 3, ISO/IEC, 2017
- ISO/IEC TR 11801-9906: Single Pair Ethernet Cabling Technical Report, ISO/IEC, 2022
- IEC 63171 Series: Connectors for Single Pair Ethernet (Parts 1–7), IEC, 2021–2024
- BICSI TDMM, 15th Edition: Telecommunications Distribution Methods Manual, BICSI, 2022
- Patel, A.C.: “Field Testing of SPE and 4-Pair Extended Reach Cabling,” BICSI Japan, November 18, 2025
- AEM Networks: “Cable Testing — Extended Reach 100m/200m/250m/300m/1700m,” AEM Internal Technical Report, 2025
- IEEE P802.3dg, P802.3dm, P802.3da Draft Standards, IEEE 802.3 Working Group, 2024–2025
- TIA TR-42.7 Technical Subcommittee: Extended Distance Copper Channel Guidelines (Draft), TSB 5073, 2025

About AEM Networks

AEM Networks is a global leader in network testing, certification, and verification solutions. The AEM TESTPRO platform delivers professional-grade cable certification for structured cabling installations worldwide, supporting TIA-568, ISO/IEC 11801, IEEE 802.3, and Single Pair Ethernet standards. AEM serves telecom operators, enterprise IT, industrial IoT, and smart building markets world-wide.

https://aemnetworks.com • arvind.patel@aem.com.sg

© 2025 AEM Networks. Confidential.