



APPLICATION NOTE

An Introduction to Single Pair Ethernet



Smart Solutions for Smart Buildings

An Introduction to Single Pair Ethernet

Introduction

The Internet of Things (IoT) continues to grow at a rapid pace. By 2025 it is estimated that the total global worth of IoT technology could be as much as \$6.2T. (McKinsey)

How will Enterprises incorporate these new devices into their existing networks? Many of these new devices, such as sensors, RFID readers, building automation and security devices do not require high bandwidth connections. Furthermore, they are often located further than the typical 100m structured cabling maximum distance and may require remote power.

Meanwhile, industrial Ethernet is also seeing a huge increase in the need for remote sensors, actuators, readers, and other systems. Legacy industrial automation connections have been made with a Fieldbus (non-ethernet) type of connection. Unfortunately, not all Fieldbus systems are compatible or interoperable, with several manufacturer-specific variations. What if there was a lower cost, Ethernet-compatible, secure, easily installed and maintained alternative?



As shown in figure 1, over 75% of all IoT devices consume less than 1 MB of data per month.

Enter Single Pair Ethernet. It is the perfect solution for low bandwidth, long distance, secure, powered bidirectional communications. Everyone accepts the ubiquity of Ethernet. With the advent of Single Pair Ethernet (SPE) however, reach and applications will extend even further.

SPE's advantages are clear: 75% fewer wires, less weight, reduced cost, lower complexity, a smaller footprint, up to 10x the distance, simpler to test, ability to supply power and easier installation. Traditional 4-pair Ethernet will work in harmony with SPE, as they do not compete. SPE is designed to support new use cases like interconnecting IoT, industrial ethernet (replacing Fieldbus), vehicle communications and long-distance end devices.

IoT Industry Snapshot Monthly Data Consumption Profile

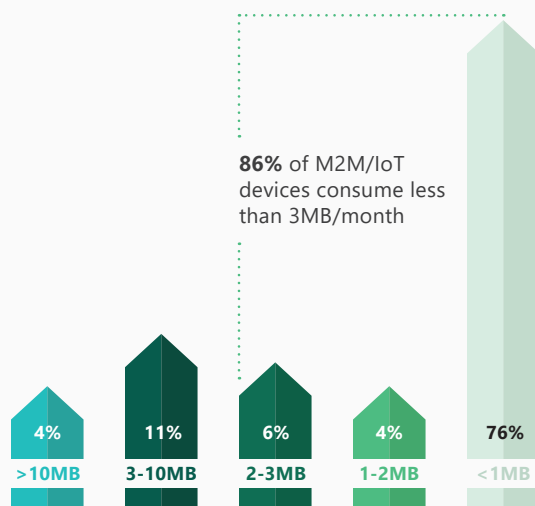


Figure 1: Monthly Data Consumption of IoT Devices
(James Brehm & Associates, 2015)

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2018-2023
**10% Compound Annual Growth Rate
 Expected for IoT Devices**

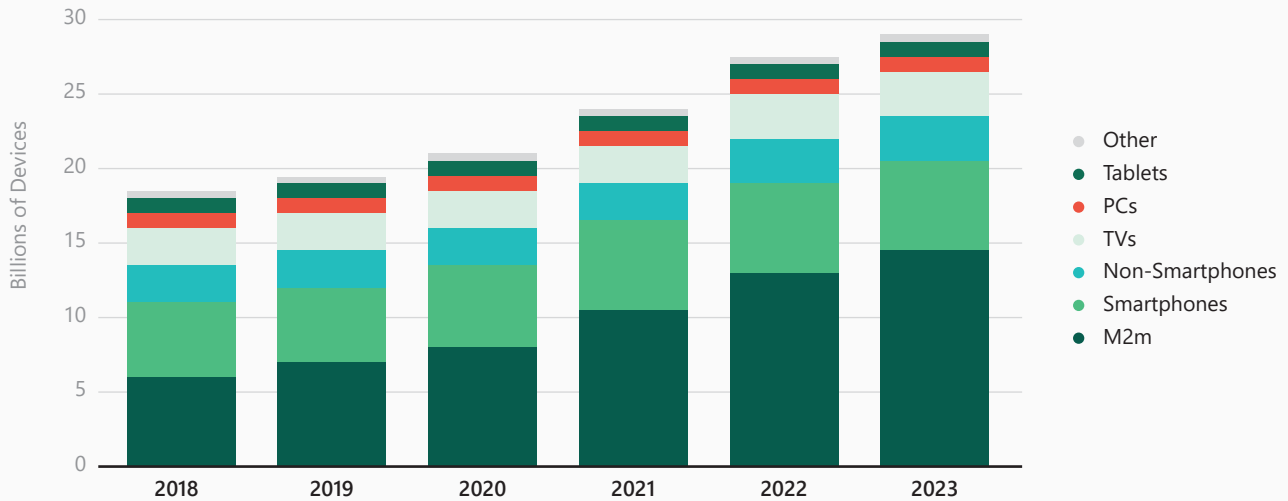


Figure 2: M2M represents 50% of IoT devices, growing at 33%/year (Credit: Cisco, 2018)

IoT and IIoT can be supported in both wired and wireless applications. Batteries may last for years, but the replacement effort is significant. Many IoT devices will be behind walls and other hard to reach places. Not only do single-use batteries need to be replaced, but they must also be disposed of responsibly, which leads to a permanent power connection as a better alternative.

SPE supports Single Pair Power Over Ethernet (SPoE) and Power over Data Line (PoDL). Devices supported with these powering technologies are greener, lower maintenance, and lower cost since they eliminate the need for external power supplies and related wiring, or single-use batteries.

802.3 cg
Single-Pair Ethernet 10Mbps/sec and Power

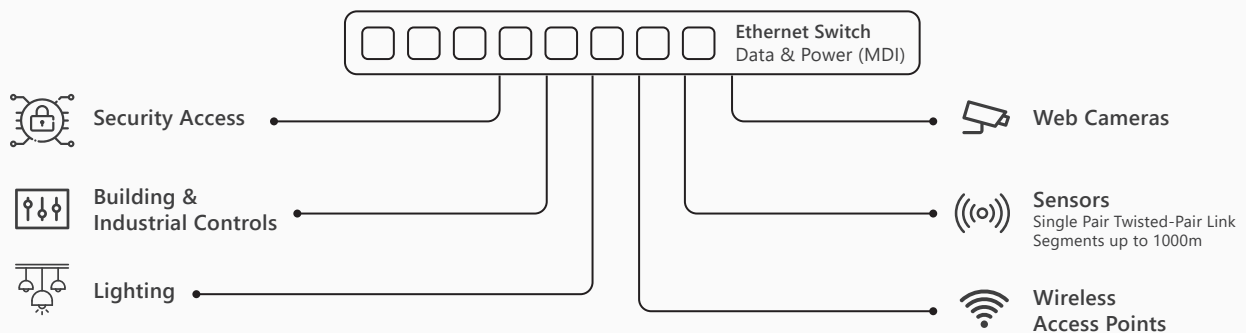


Figure 3: Single Pair Ethernet has the ability to supply power to a wide range of IoT devices

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Use Cases

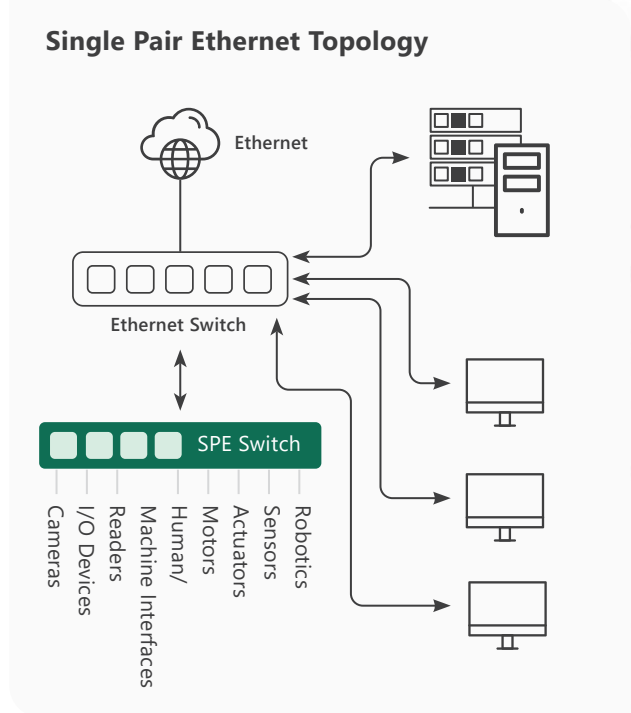
1. IIoT (Industrial Internet of Things)

Until recently, there was no specification for Ethernet that supported long distances (>>100m). Many applications for remote sensors, gauges, cameras and IoT devices have had to be served with other technologies because Ethernet couldn't go the distance.

Now, with 10BASE-T1L, 10Mbps communication and power delivery up to 1km is supported. Since many IoT devices were designed for Ethernet, SPE eliminates the need for protocol conversion, additional controllers, and more complex cabling required for legacy non-Ethernet architectures.

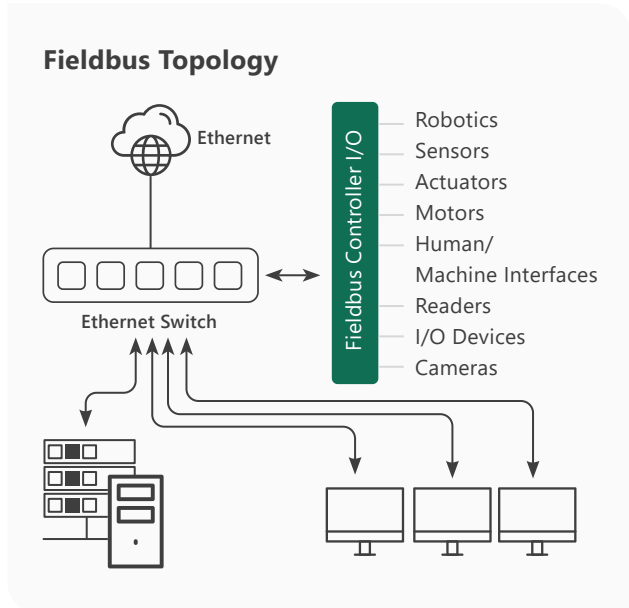
The Industrial Internet of Things (IIoT) is a major use case, as SPE can replace many instances of Fieldbus or other non-Ethernet automation networks. SPE is perfect for sensors and devices that don't need much power or bandwidth but do require efficient, fast, reliable transmission.

Maximum distance depends on gauge of wire used. For example, to get 1000m @7.7W of power delivery, you will need 18AWG.



2. Higher Density

SPE has double the packing density of RJ45, lower cost, and allows designers for the first time to easily extend Ethernet to the edge of the network's most remote devices.



Courtesy R&M

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3. Eliminate the Need to Supply Power at the Edge

SPOE and PoDL are inherently supported in SPE. It can deliver up to 52W for shorter distances, or 7W at 1000m. Lower cost, higher security and provides power vs wireless alternatives. Greater power efficiency of SPE vs. alternative methods, thus reducing carbon emissions.




4. Automotive Applications

Automotive industry has replaced the old CAN (Controller Area Network) bus systems with SPE.

5. Building Automation

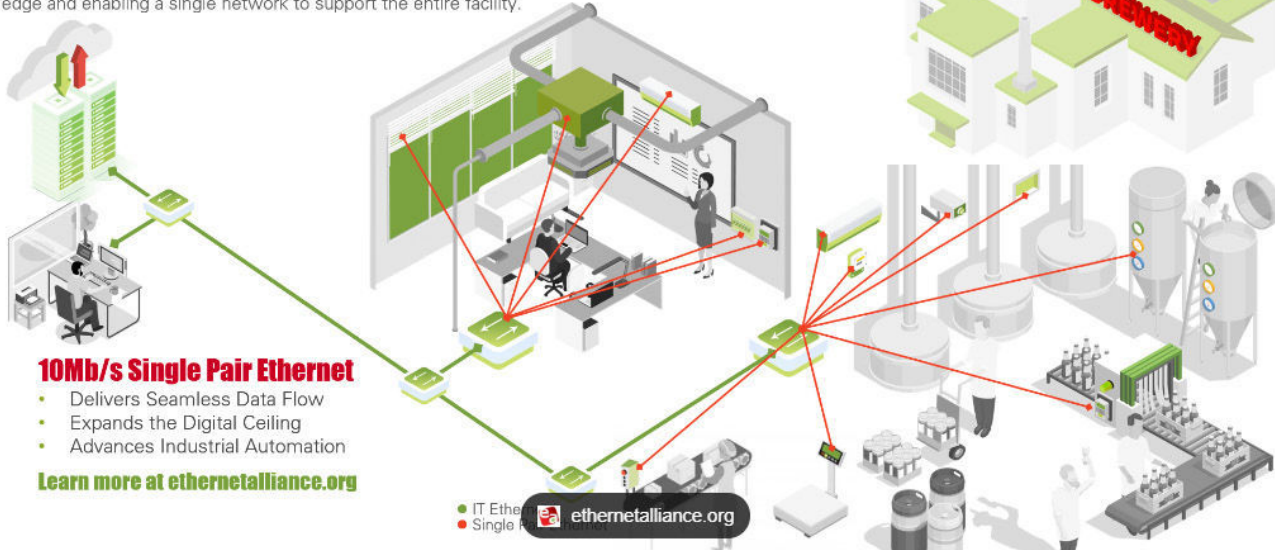
Digital signage, RFID and card readers, sensors, elevator and escalator control, fire alarms, HVAC and more.





10Mb/s Single Pair Ethernet

Device communications in buildings and machine often use auxiliary power to operate and use gateways to convert and transmit data. Single Pair Ethernet brings Ethernet communications and power to these devices over two wires and familiar topologies. No batteries, and no gateway programming – simplifying IoT to the edge and enabling a single network to support the entire facility.



10Mb/s Single Pair Ethernet

- Delivers Seamless Data Flow
- Expands the Digital Ceiling
- Advances Industrial Automation

Learn more at ethernetalliance.org

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Status of Standards

Standard	Description	Status
IEEE 802.3bw	100BASE-T1, 15m automotive focus	Published 2015
IEEE 802.3bp	1000BASE-T1 15m automotive, 40m aircraft/railway/bus/truck and IIoT	Published 2016
IEEE 802.3bu	Power over data lines (PoDL). Up to 52W over single pair	Published 2016
IEEE 802.3cg	10BASE-T1L, 10Mbps with PoDL power up to 1km	Published 2019
IEC 63171-1	LC Connector for SPE	Published 2020
IEC 63151-6	Industrial connector for SPE	Published 2020
IEC 61156-13	Single Pair cables with transmission characteristics up to 20 MHz - Horizontal floor wiring	Published May 2023
IEC 61935-e ED1	SPE cable testing requirements	2022
TIA 568.5	Single pair cabling and components electrical and mechanical specifications for cable, connectors, cords and channels	Published March 2022
TIA 568.6	Single Pair Multi-Drop (SPMD) cabling and component specifications	Initial draft
TIA 568.7	Balanced Single Twisted-Pair Communications Cabling and Components Standard for Industrial Premises	Expected to publish in 2024
TIA 5071	Requirements for Field Instruments and Measurements for Balanced Single Twisted-Pair Cabling	Published 2022
ISO/IEC TR 11801-9906:2020	Technical report specifying operation of SPE channels up to 600 MHz in industrial and enterprise environments	Published 2020
ISO 11801-1:2017		Published 2017
ISO 11801-3 AMD1:2021		Published 2021
ISO 11801-6:2017		Published 2017

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What about Connectors?

Unlike normal RJ45 structured cabling, SPE allows for wires to be terminated in common spade lugs and screw terminals. But to get higher speeds, impedance-matching connector pairs must be used.

SPE connectors are specified in IEC 63171. There are 6 variants:

- 63171-1 - Commscope, Panduit
- 63171-2 - Phoenix Contact, Weidmuller, RdM
- 63171-3 - Siemon
- 63171-4 - BKS
- 63171-5 - Phoenix contact, Weidmuller
- 63171-6 - Harting

The IEEE has weighed in and recommends using 63171.1 & 63171.6 compliant connectors. It should be noted that even within one variant, there can be different connector housing.

Note that the 63171.1 connector has the unfortunate and confusing designation as a “LC” connector. This is a copper SPE connector and has nothing to do with fiber optics.

AEM currently supports M12, GG45, Tera, 63171-1 and 63171-6.

ISO/IEC 63171 Connectors for Electrical and Electronic Equipment

	IEC 63171-1	IEC 63171-2	IEC 63171-3	IEC 63171-4	IEC 63171-5	IEC 63171-6
Company	Commscope, Panduit	PxC, WM, RdM	SIEMON	BKS	PxC, WM, RdM	Harting
Picture						
Type	LC-Style	Rectangle	TERA IP	Square-Shaped	M8/M12	Rectangle/M8/Push Pull
#Pairs	1	1	1/4	1	1/4	1
Degree of Protection	IP20	IP20	IP20	IP20	IP67	IP20/IP67

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AEM

Testing Requirements

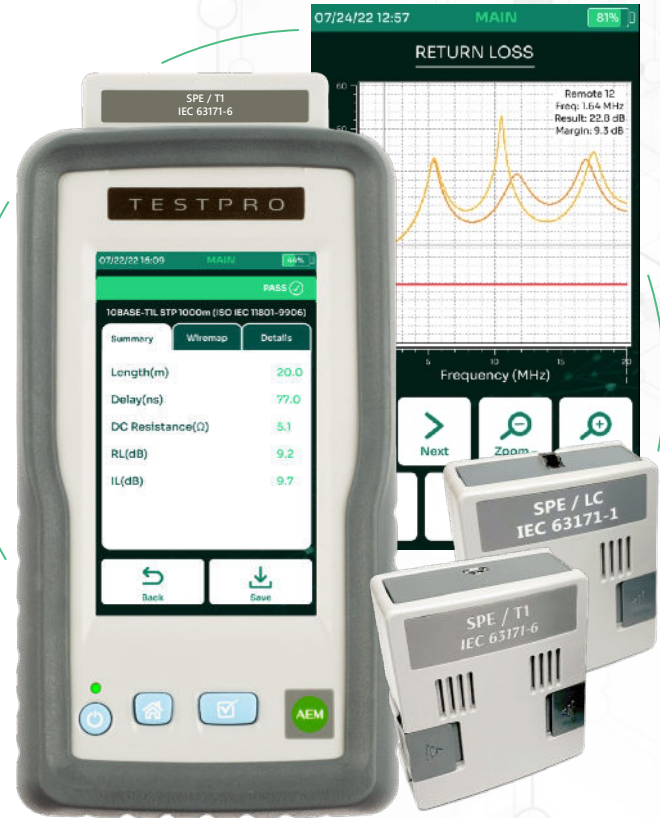
Field testing requirements for SPE are specified in TIA 5071. AEM was very active in the development of this standard.

AEM recognizes that structured cabling professionals who deploy SPE will also be supporting traditional copper and fiber cabling and will not want to purchase an entire new test set just for SPE installations.

The TestPro has been designed to be fully modular, and testing SPE will be as simple as using hot swappable test adapters.

AEM's TestPro is the only field tester to offer SPE certification testing compliant to the TIA 568.5 standard, which includes the following for 1km SPE links supporting 10BASE-T1-L communications standard:

- Dual-ended testing with test frequency range from 100kHz to 20MHz and step size of 20kHz.
- DC Resistance, Return Loss, Insertion Loss and optionally TCL.
- Provides a PASS/FAIL result; detailed test results can be saved, viewed, and converted to pdf with the convenient TestDataPro software.
- Currently available test adapters: 63171.1 (also known as LC), 63171.6, breakout adapter for GG45, TE MATENet, Rosenberger, and many variants of automotive SPE test adapters.



TestPro covers test requirements for both high-speed short reach SPE links and long distance SPE links with the same device. The measurements and limits can scale with emerging standards without having to send the tester back to the factory.

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Revision 13/02/2024 | V1.4