Single Pair Ethernet White Paper

Extending Network Reach with Single Pair Ethernet (SPE) and Single Pair Power over Ethernet (SPoE)

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Omnitron's Solution: SPE and SPoE Switches and Media Converters

Omnitron Systems provides a full portfolio of Single Pair Ethernet and Single Pair Power over Ethernet products designed for industrial and commercial environments.

RuggedNet® and OmniConverter® 10BASE-T1L Solutions

Omnitron's RuggedNet and OmniConverter SPE/SPoE products include:

- Managed and Unmanaged Switches with 10BASE-T1L interfaces
- Media Converters that connect traditional Ethernet (RJ-45 or fiber) networks to single-pair copper infrastructure
- SPoE-capable Ports that provide both data and DC power over one twisted pair

These devices enable seamless connectivity between modern IP networks and remote IoT or industrial endpoints using single-pair cabling, extending Ethernet to 1 km without the need for intermediate power or active equipment.

Introduction

As modern networks continue to expand into smart buildings, industrial environments, transportation systems, and remote infrastructure, the need for efficient connectivity solutions capable of reaching longer distances with simplified cabling has become critical. Traditional Ethernet cabling (Cat 5e/6) is limited to 100 meters (328 feet), which often presents challenges for applications where endpoints such as sensors, cameras, access controls, and IoT devices are located hundreds of meters away from network equipment.

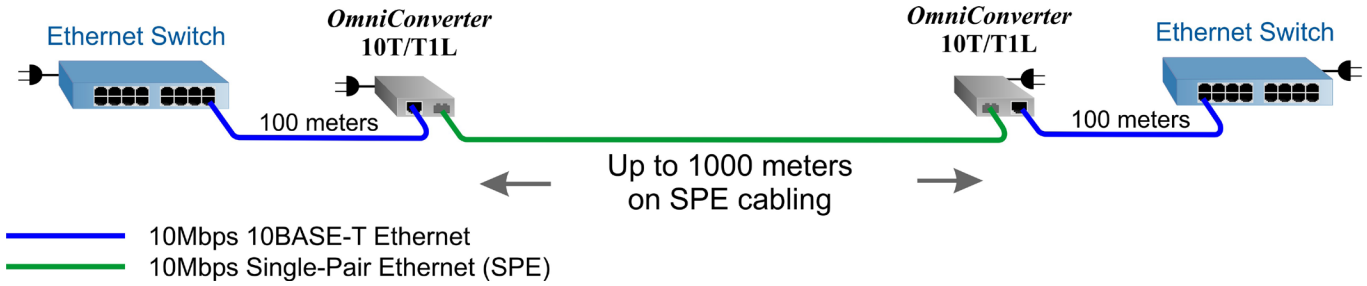
Single Pair Ethernet (SPE) and Single Pair Power over Ethernet (SPoE) technologies have emerged to bridge this gap. By transmitting data and power over a single twisted copper pair, these technologies dramatically extend reach—up to 1,000 meters (approximately 3,280 feet)—while reducing cabling complexity and cost.

Omnitron Systems' line of Single Pair Ethernet and Single Pair Power over Ethernet Switches and Media Converters (10BASE-T1L) provides a robust and reliable solution to connect distant IoT devices, sensors, and controllers, enabling customers to modernize infrastructure while maintaining simplicity and cost efficiency.

Understanding Single Pair Ethernet (SPE)

Single Pair Ethernet (SPE) is an innovative technology defined under the IEEE 802.3cg standard (10BASE-T1L). Unlike traditional Ethernet, which uses two or four twisted pairs, SPE uses only one pair of copper wires to transmit full-duplex Ethernet data at 10 Mbps over distances up to 1,000 meters.

The OmniConverter 10T/T1L extends Ethernet data connection across a single-pair Ethernet cable up to 1200 meters.

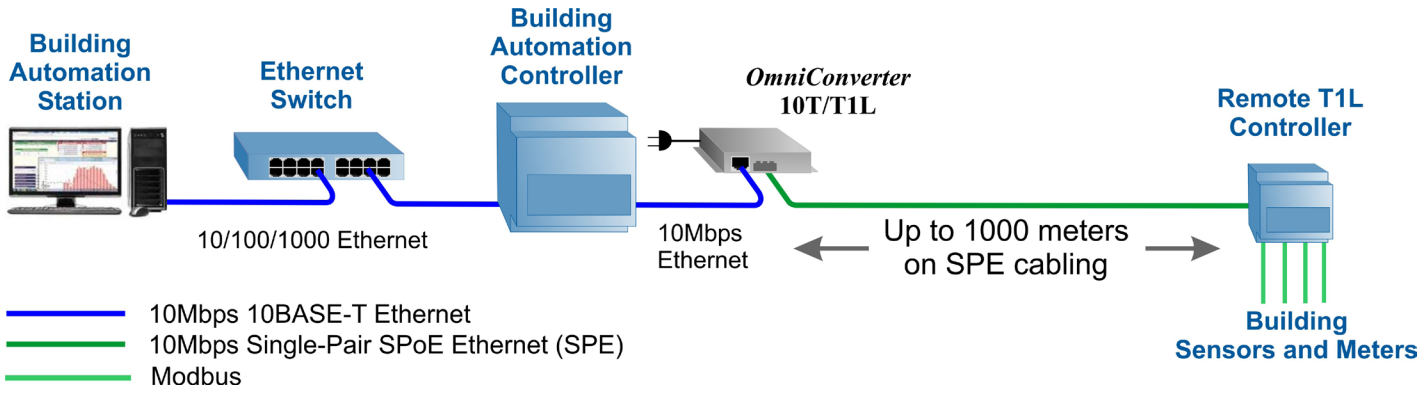


Key Features of SPE

- IEEE Standard: 802.3cg (10BASE-T1L)
- Cabling: One balanced twisted copper pair
- Reach: Up to 1,000 meters (1 km)
- Data Rate: 10 Mbps full duplex
- Compatibility: IP-based and interoperable with traditional Ethernet through media converters or switches

SPE provides a seamless migration path from legacy field-bus protocols (such as RS-485 or Modbus) to Ethernet-based IP systems, allowing integration of a broader range of IoT and industrial devices into unified network infrastructures.

The OmniConverter 10T/T1L extends Ethernet data connection from a Building Automation Controller over a single-pair Ethernet cable to a Remote Controller. The Remote Controller is gathering data from building sensors and meters.



Understanding Single Pair Power over Ethernet (SPoE)

Single Pair Power over Ethernet (SPoE) builds on SPE by delivering both data and power over the same single pair of copper wires. Similar to conventional PoE (IEEE 802.3af/at/bt), SPoE uses standardized power delivery methods to power connected devices (PDs) such as sensors, controllers, cameras, and access control systems—without requiring a separate power supply.

SPoE deployments use two operating line voltages (24V and 55V DC) depending on the distance and the Class of the end device. There are six Classes defined for SPE networks. Classes 10, 11, and 12 use 24V DC power and Classes 13, 14, and 15 use 55V DC power.

The table below shows the operating parameters for the six Classes.

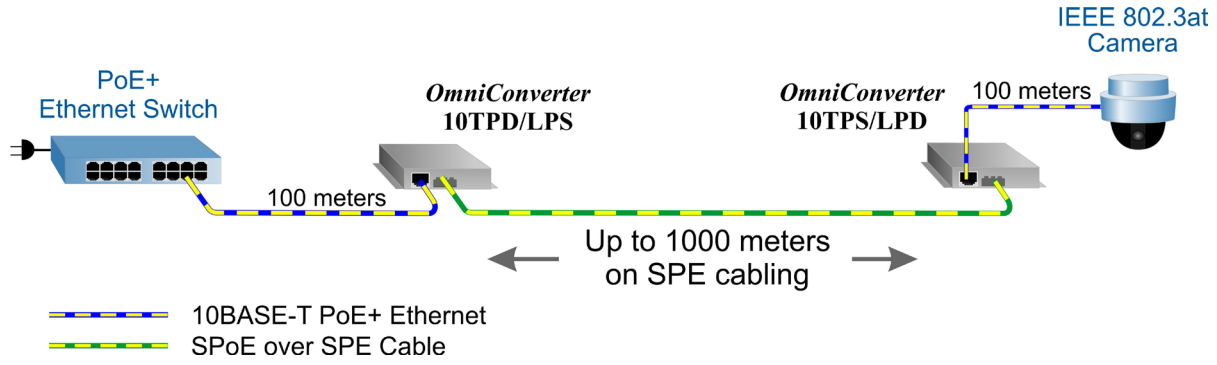
Operating Parameters	Classes					
	10	11	12	13	14	15
Supply Voltage V_{PSE}(min/typ/max)	20/24/30			50/55/58		
Voltage @ PD V_{PD}(min)	14VDC	14VDC	14VDC	35VDC	35VDC	35VDC
Power @ PD P_{PD}(max)	1.23 Watts	3.2 Watts	8.4 Watts	7.7 Watts	20 Watts	52 Watts
Current across cabling I_{CABLE}(max)	0.092A	0.240A	0.632A	0.230A	0.600A	1.579A

The table below shows actual test data for the different cable types using a bookend configuration (Class 13 - 15).

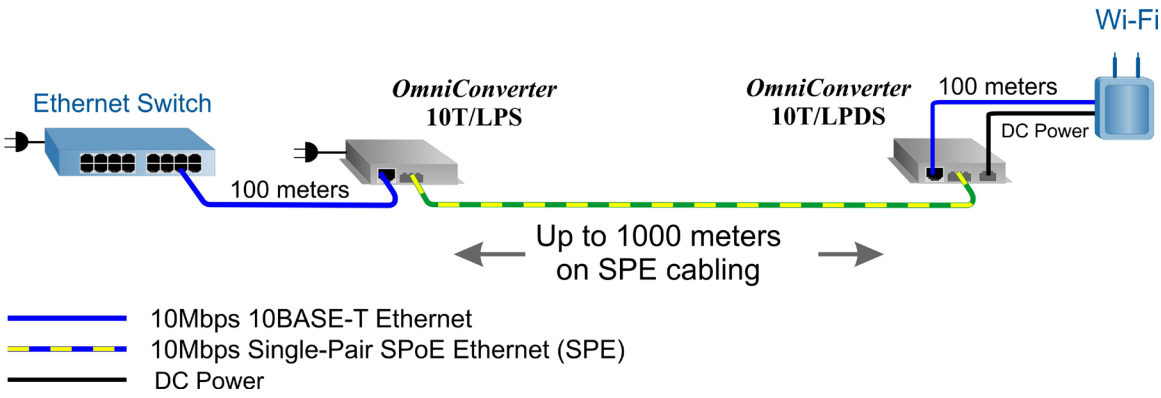
Cable Type	Cable Gauge	Max Cable Length with no data errors	Max SPoE Power at PSE for V_{PD} min (35V)	SPoE Power Available at PD after Max Cable Length	Power Available for PoE or Splitter
CAT5e	24 AWG	700m	8W	5W	n/a
CAT6a	23 AWG	900m	7W	4W	n/a
SPE101	18 AWG	1000m	23W	15W	10W
3090A	16 AWG	1000m	63W	40W	35W

The data shown for the 3090A cable is based on theoretical calculations.

An OmniConverter 10TPD/LPS is receiving power from a PoE+ Ethernet switch and delivering power (SPoE) across a SPE cabling to an OmniConverter 10TPS/LPD. The OmniConverter 10TPS/LPD is powering a IEEE 802.3at camera up to 100 meters in distance.



An OmniConverter 10T/LPS is delivering power (SPoE) across a SPE cabling to an OmniConverter 10T/LPDS. The 10T/LPDS is powering a Wi-fi access point using the 12V or 24V DC power out of the 10T/LPDS device splitter power port. This is useful when no external power is available at the far end.



The table below shows actual test data for the different cable types for directly connected devices (Class 10 - 12).

Cable Type	Cable Gauge	Max cable length with no data errors	Max SPoE Power at PSE for V_{PD} min (14V)	SPoE Power Available at PD after Max Cable Length
CAT5e	24 AWG	700m	3W	1W
CAT6a	23 AWG	900m	3W	1W
SPE101	18 AWG	1000m	9W	4W
3090A	16 AWG	1000m	18W	11W

The data shown for the 3090A cable is based on theoretical calculations.

SPoE Advantages

- Delivers data and power over one pair, minimizing cabling
- Supports long-distance deployments up to 1 km
- Ideal for IoT, building automation, and industrial systems
- Enables cost-effective remote installations where AC power is unavailable

Challenges in Long-Distance Installations

Many industries face the same network design challenge: connecting devices that are hundreds of meters away from network switches or power sources.

Examples include:

- Environmental or temperature sensors in remote corners of a manufacturing facility
- IP cameras positioned along a perimeter fence or tunnel
- Building automation controllers located on different floors or detached structures
- Lighting or HVAC sensors in ceilings or outdoor installations

Using traditional Ethernet for these scenarios requires repeaters, fiber optic cabling, or separate power runs—significantly increasing cost, complexity, and installation time.

Physical Requirements

Cabling

- Type: Single twisted copper pair (1 pair instead of the traditional 4-pair Cat 5e/6 cable).
- Impedance: Nominal 100 Ω balanced cabling.
- Conductor size: Typically AWG 18–26, depending on the distance and power requirements.
- Connectors: Defined by IEC 63171 series — different connector types for industrial, automotive, and building automation use (e.g., IEC 63171-1, -6, -7).

Visit Omnitron's Blog on "Connector Type: What's Best for Your Single Pair Ethernet Network?"

Transmission Distance

- Up to 1,000 meters (1 km) for 10BASE-T1L (10 Mb/s long reach).
- Up to 40 meters for 100BASE-T1 and 1000BASE-T1 (short reach, automotive/industrial).

Data Rates

- 10BASE-T1L: 10 Mb/s over 1 km.
- 100BASE-T1: 100 Mb/s up to 40 m.
- 1000BASE-T1: 1 Gb/s up to 40 m.
- Multi-Gigabit SPE: Future IEEE work targets 2.5G and 10G over single pair for short distances.

Power Delivery (Single Pair Power over Ethernet – SPoE)

- Based on IEEE 802.3bu / 802.3cg standards.
- Power delivery up to 50 W over the same single pair as data.
- Supports both Power Sourcing Equipment (PSE) and Powered Devices (PDs) similar to PoE.

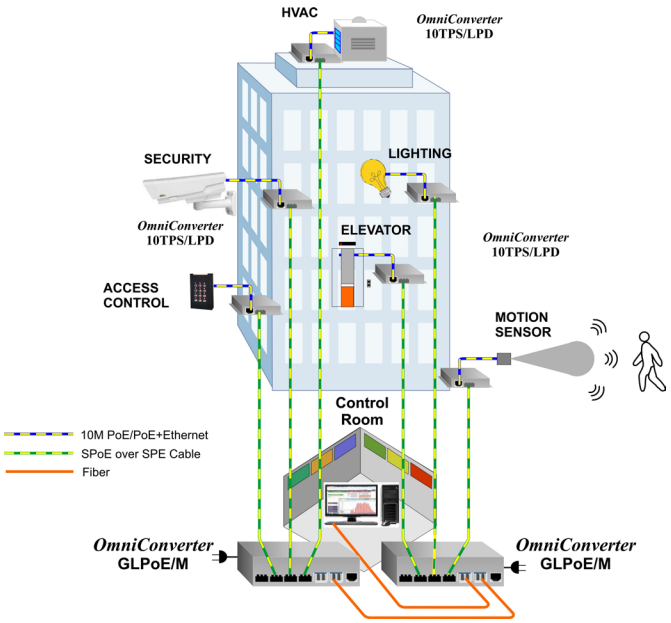
Environmental and Installation Requirements

- Temperature range: Typically –40°C to +85°C for industrial-grade operation.
- Mechanical robustness: Compact, vibration-resistant connectors for rugged environments.
- Bend radius and pull strength: Must meet industrial cabling standards (IEC 61156-13, -1x series).

Applications

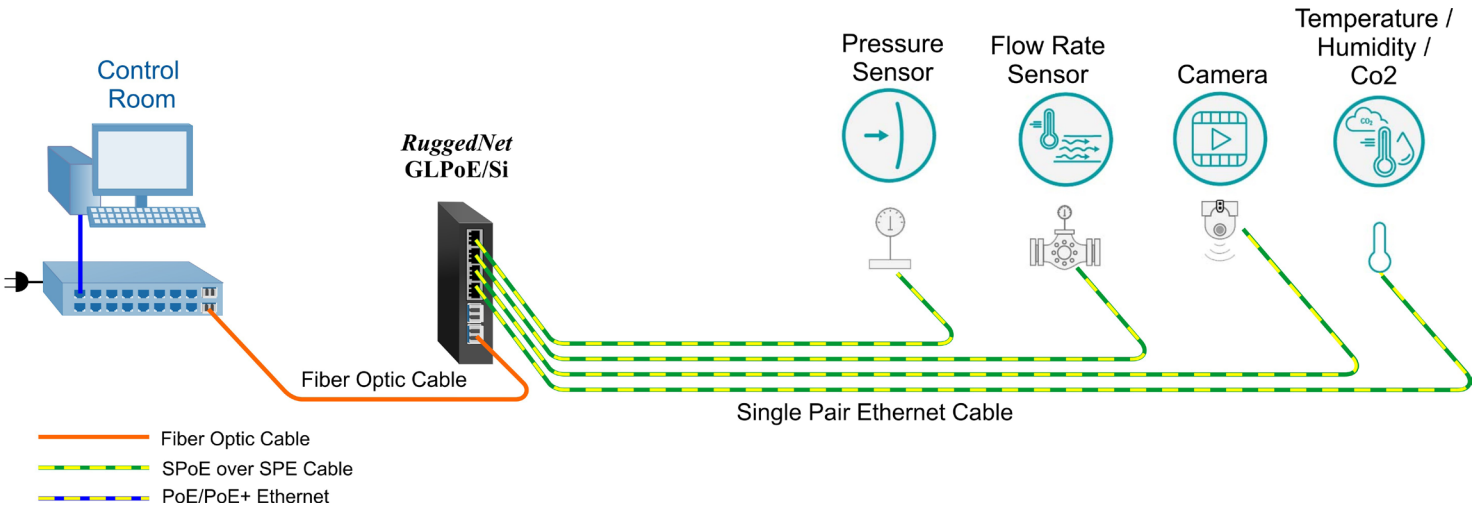
Building Automation

In a smart building or industrial facility, Omnitron's 10BASE-T1L media converters and SPE Ethernet switches can connect to long-distance sensors or cameras via single-pair cabling. The converters are powered over the single pair cable and transmits data and power remote devices, eliminating the need for additional electrical wiring or fiber runs.



Industrial Manufacture

Similarly, in a manufacturing plant, Omnitron's managed RuggedNet SPE switch can serve as a remote aggregation point, linking multiple sensors across a 1 km span. Fiber uplinks on the switch can then tie back to a central monitoring system, forming an integrated, long-distance hybrid network.



Benefits of SPE and SPoE

Advantages

1. Extended Distance: Up to 1,000 meters—10× farther than traditional Ethernet.
2. Reduced Cabling: Only one twisted pair is required, lowering installation time and cost.
3. Simplified Power Delivery: SPoE eliminates separate power runs to remote devices.
4. Compact and Lightweight: Smaller cables simplify installation in constrained spaces such as conduits or elevator shafts.
5. Backward Compatibility: Easily integrates with existing Ethernet networks using Omnitron converters.
6. Sustainability: Reduced copper usage and power consumption align with green infrastructure goals.
7. High Reliability: Omnitron's industrial-grade designs operate in harsh environments with wide temperature tolerances and high surge protection.

Disadvantages

1. Lower Data Rates: 10 Mbps is sufficient for most sensors and controllers but not for high-bandwidth applications.
2. Limited Power Output: SPoE provides less power than higher-class PoE (IEEE 802.3bt).
3. Device Compatibility: Not all IoT or industrial devices currently support 10BASE-T1L, though adoption is rapidly growing.
4. New Infrastructure: May require new cabling and connectors optimized for SPE (e.g., IEC 63171-1/6).

Use Cases

1. Industrial Automation:

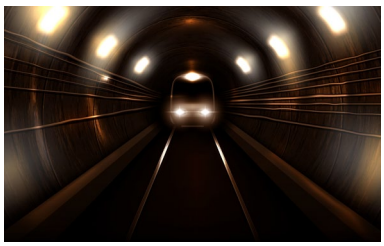
Connect distributed sensors, PLCs, and control devices across large plants without fiber.

2. Smart Buildings:

Integrate HVAC sensors, lighting controls, and access systems over simplified single-pair cabling. Upgrade the communication and surveillance systems in its elevator cars.

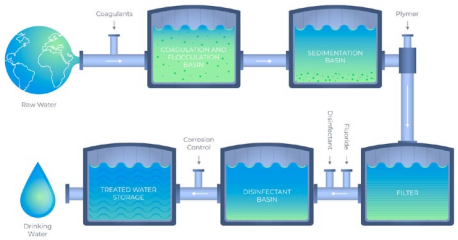
3. Transportation and Tunnels:

Deploy IP cameras and emergency intercoms along tunnels or rail lines using extended SPoE reach.



4. Energy and Utilities:

Monitor solar arrays, wind turbines, or remote substations where long-distance power and data are essential. Also, Water Reservoirs / Wastewater Treatment facilities requiring power and data services.



5. Smart Cities:

Support connected lighting, signage, and environmental monitoring using compact, low-power network infrastructure.

Conclusion

Single Pair Ethernet (SPE) and Single Pair Power over Ethernet (SPoE) are transforming the way networks connect and power remote devices. By delivering both data and power over a single twisted pair up to 1,000 meters, these technologies dramatically simplify network design, reduce costs, and extend Ethernet connectivity to previously unreachable areas.

Omnitron Systems' RuggedNet and OmniConverter 10BASE-T1L product families provide the ideal foundation for customers transitioning to IoT-driven infrastructures. With flexible deployment options, managed and unmanaged models, and support for both SPE and SPoE, Omnitron enables organizations to expand intelligent networks with the same reliability and scalability expected from modern Ethernet systems.

SPE and SPoE are not just extensions of Ethernet—they are enablers of the next generation of smart, connected, and efficient networks across every industry.

Want to learn more? Explore our full line of Single Pair Ethernet switches, media converters, and SPoE solutions, and discover how they can transform your industrial network.

Contact our engineering team today to schedule a free network design consultation and see how Single Pair Ethernet can extend your reach and power your edge devices up to 1 km away.

Click here for information on Omnitron's new 10T/APS (Ethernet-APL Compatible) Single Pair Ethernet Converters.

About Omnitron Systems

Omnitron Systems designs and manufactures fiber media converters for Ethernet, Power-over-Ethernet (PoE), Serial, and TDM protocols, as well as Ethernet and PoE switches, demarcation devices and WDM and TDM multiplexers that are deployed in thousands of networks worldwide.

Omnitron's network connectivity products can integrate various cabling types, extend network distances, inject PoE / PoE+ / PoE++ and expand fiber capacity.

Omnitron Systems is a privately held company headquartered in Irvine, California, and all products are manufactured in the United States.

Omnitron has built a reputation of delivering reliable products for mission critical networks. Every employee at Omnitron is involved in delivering high-quality, user-oriented fiber access solutions. By building strong relationships with our end-users and understanding the challenges they face, Omnitron engineers design products and features that provide value to our customers.