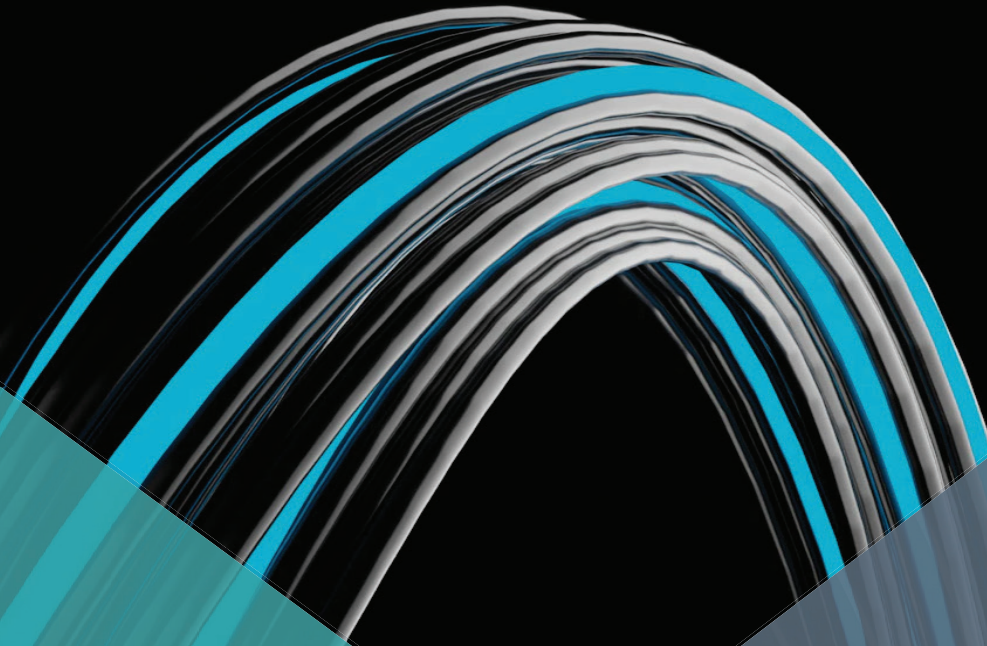




**BENEFITS & PRACTICAL ASPECTS
OF IMPLEMENTING SPE NETWORK SOLUTIONS
FOR EXISTING & NEW TWO-WIRE CABLE INFRASTRUCTURES**



WHITE PAPER – JUNE 2024

Introduction:

Modern infrastructure systems rely on interconnected devices that are monitored and managed through a network and their respective management systems. Applications are vast and include security and surveillance, HVAC, building & factory automation, cameras, door controllers, sensors, IoT, elevator call systems, to name but a few.

Interconnected systems may be divided primarily into two main types, Ethernet networks, i.e. LAN networks and two wire field buses, i.e. LONwork, 4-20mA control loops, RS485 buses. The latter predates the former which has and still serves well in many applications; however, the former reflects current and future trends.

Field buses originally offered relatively low-cost management solutions over two wire cable; however, today's sophisticated devices demand more than can be practically provided by them. Although later covered in this paper, here are but a few reasons. Two wire field buses are relatively slow and are only Half-Duplex, thus limited for bidirectional data intensive environments. They cannot deliver power over the two-wire bus, thus requiring a separate remote power source. They rely on legacy, and in many cases proprietary protocols for which the expertise to support them is vanishing. Security is vastly inferior compared to Ethernet protocols and they are more susceptible to noise.

New devices, such as industrial controllers, cameras and security managed systems are built to be network ready for LAN and internet, as that is the trend for reasons to be explained later. However, it is recognized that many networked systems till now required more expensive four wire paired CAT5e cable and that cable distance, as well was limited to 100m.

The new SPE (Single Pair Ethernet) network standard, known by IEEE802.3cg or referred to as 10BaseT1L or simply T1L was ratified & released November 7, 2019 [1] has basically erased the above cited disadvantages and has added a few new measurable advantages

This Whitepaper will describe what SPE is, how to practically implement it and provide real product solutions for its implementation over existing deployed two wire buses, where Ethernet device upgrades are desired or to design into new two wired network structured systems.

What is SPE:

- SPE (Single Pair Ethernet) allows to connect Ethernet devices over two wire (UTP) cable instead of the 4 pair CAT5e type cable.
- Ethernet network formats are governed by the IEEE, [2], an international organization that creates and ratifies Ethernet standards to ensure Plug & Play behavior between all networked devices.
- SPE is described by the IEEE802.3cg standard.

The main SPE features in a practical network installation are as follows:

- Network speed is 10Mbps, Full Duplex based on the 10Base-T1L Ethernet protocol.
- Power may optionally be provided over the SPE UTP cable to the remote device.
- The cable length is up to 1000m (3,280'), but some manufactures extend this further.

A Bit More Detail:

Detail can be helpful but is not always necessary to know for practical applications. Analogously, many people are familiar with connecting a POE Ethernet system, without intimate knowledge of what happens under the hood, however, should you still desire the punishment please continue to read.

IEEE802.3cg standard mainly comprises:

1. Communication protocol, 10Base-T1L (10Mbps speed, Full duplex), and...
2. Optional Power over the SPE, known as SPoE (Single Pair PoE) or synonymously as PoDL (Power over Data Line).
 - A) SPoE PSE (Power Sourcing Equipment) headend link negotiates with the remote PD (Powered Device) to accommodate power requested via SCCP (serial communication classification protocol). Think of CAT5 POE PSE that negotiates with a remote PD, but uses a different protocol, such as 802.3af (15W), 802.3at (30W) or 802.3bt (90W).

To simplify some instances the standard allows a PSE to skip classification and power up a PD that provides a valid detection signature only.
 - B) The negotiated voltage & power levels depend on the Class. Classes 10-15 are governed by 802.3cg which basically covers all applications (building, automation, security...) except for automotive applications. The latter is covered by short distance 802.3bu (Classes 0-9) standard and not of interest in the scope of this paper.
 - C) A T1L device may use a special connector, but this is not common as a two-pin terminal block is more than sufficient and is prominently used instead.



What Does a Typical SPE Installation Look Like:

A typical installation is as follows: An RJ45 switch port is connected to a T1L SPE media converter device, which then connects via a UTP cable to the T1L compliant remote device... Simple!



Single Port T1L Media Converter
1000m+ to T1L device

Advantages & Considerations of SPE as an Upgrade to Existing and New Two Wired Systems:

New Network Installations -

- Lower cost single pair UTP (**shielded or unshielded**) or similar vs 4 pair CAT5e.
- Cable length is at least 10x more (1000m) than normal Ethernet (100m), thus avoiding repeaters.
- Power can be delivered to devices over the cable if desired, thus avoiding a remote power supply cost (*thicker AWG for more power can be utilized*).
- All the benefits attached to Ethernet; noise immunity, error correction schemes, standard link connection protocols, encrypting...

Upgrading of Existing Two Wire Buses, such as LONwork or RS485 or 4-20ma Control Loops to a Compliant Ethernet Network:

Many two wired infrastructures are being or plan to be replaced and upgraded to an Ethernet network to accommodate networkable devices, i.e. cameras, controllers for security, elevator call systems, building & factory automation, etc. In some cases, this is imposed due to EOL (End of Life) notices for products or support, such as is widely reported for LONwork bus devices [3,4,5].

- Upgrades could be costly and painful. Many municipalities require removing the unused deployed two wire cable. Thus, removal and new cable installation expenses are incurred.
- SPE allows to repurpose the existing installed two wire cable, even for lengths that greatly exceed 100m, by simply connecting an SPE T1L media converter on one end and the T1L compatible device on the other of the deployed cable.
- Optional power can be delivered, as well, over the same cable (not possible with older buses), thus avoiding the need for a remote power supply and perhaps an electrical outlet installation cost.
- The IT world has embraced Ethernet largely. And all new network managed installations are Ethernet.
- However, T1L SPE is generally a point-to-point or star link connection, so strategies for multi-point drop-offs are to be considered. Multi-point drop-off options are described with concrete application examples further on in this paper.

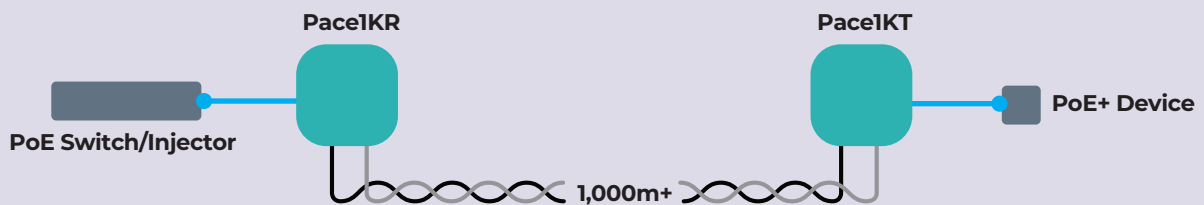
Practical Upgrades for Two Wire Field Buses & New Network Installations:

First it is important to identify what installation factors are crucial for a system. For instance, many installations are only concerned with long cable lengths, hence they will take advantage of T1L network transmission, but may prefer ubiquitous RJ45 ports on both ends of the cable as are typically used with network switches and devices.

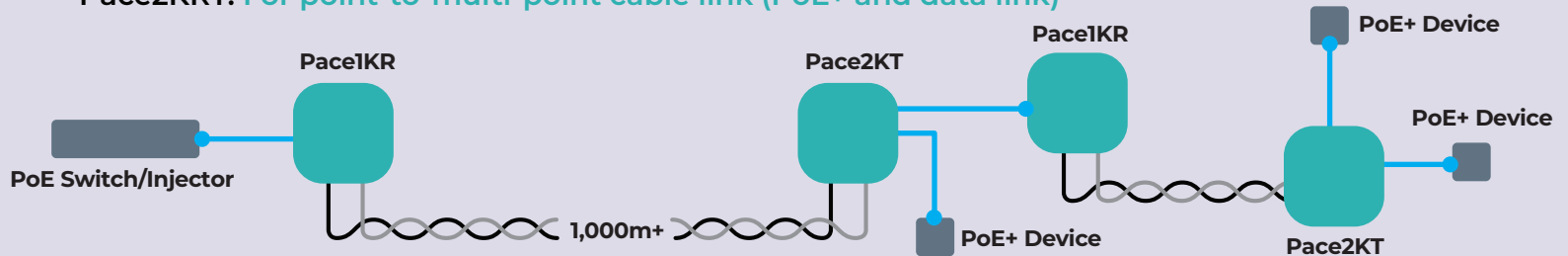
For such standard devices in long link installations, Altronix offers Plug & Play solutions whereby T1L protocol is completely transparent to the headend switch & remote end device(s):

Standard Long Distance Link Solutions:

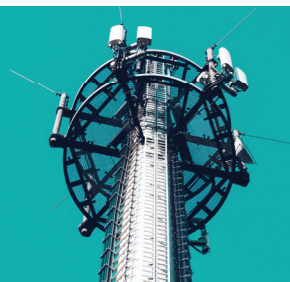
Pace1KRT: For point-to-point cable link (PoE+ and data link)



Pace2KRT: For point-to-multi-point cable link (PoE+ and data link)

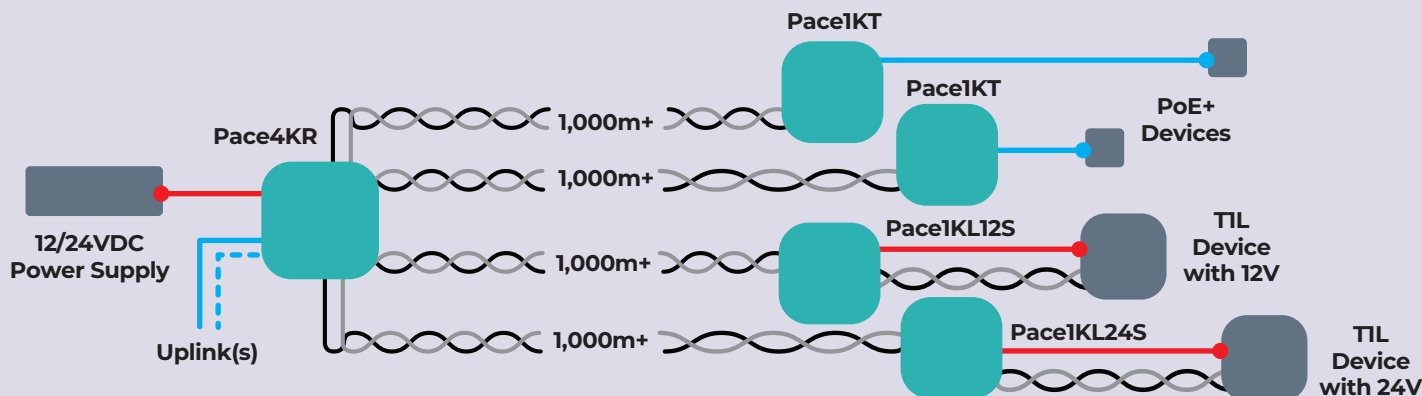


In the above setups the remote end device/s can operate with POE enabled or not. If enabled, remote power supply is not required. POE can also deliver power more efficiently than SPOE Classes 10-12.



Standard Long Distance Link Solutions (cont'd.):

Pace4KR(Q): For point-to-multi-point cable links (PoE+ and data link)

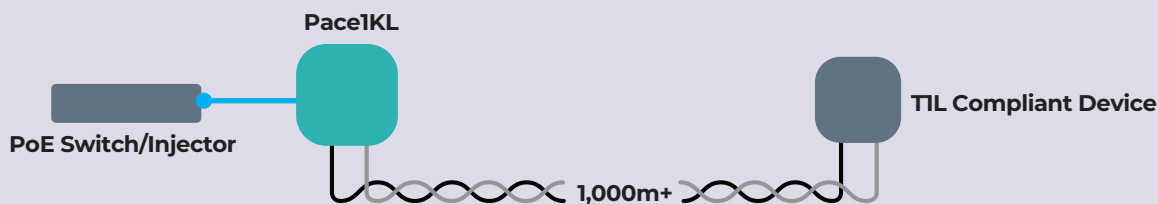


The Pace4KR adaptor/switch feature two network uplink ports and can be paired with four Pace1KT adaptors to remote PoE devices. Pace4KR can also be paired with up to four Pace1KL12S or Pace1KL24S TIL media adaptor/splitters to TIL devices and split power. Network managed versions allow for control, monitoring, and reporting of power diagnostics and feature a single network uplink port.

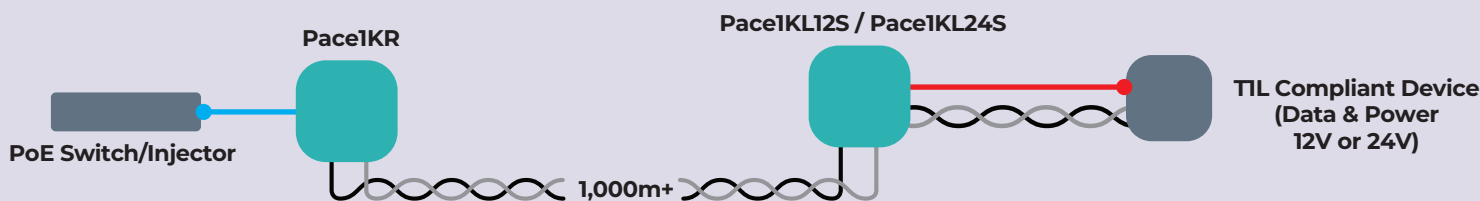
TIL Long Distant Link Solutions:

For installations that need to connect to a TIL compliant remote device, Altronix offers the following Plug & Play solutions:

Pace1KL: For point-to-point cable link (TIL Data only Link)



Pace1KRL12S (12V) | Pace1KRL24S (24V) For point-to-point cable link (TIL Data & Split Power Link):

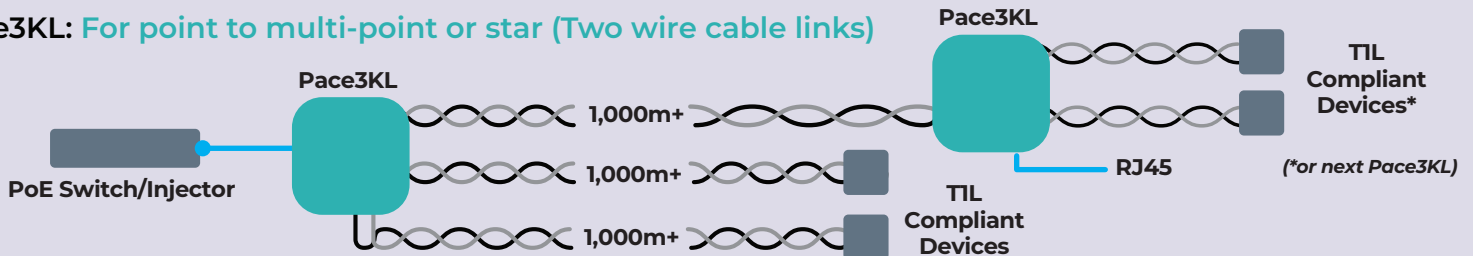


The above setup allows standard TIL data to communicate directly with the TIL remote device, but also splits out 24VDC (Pace1KL12S for 12VDC) to power the same device, thus saving a remote power supply. Since 802.3cg SCCL SPOE/PoDL capable devices are not popular, the above setup facilitates power for any TIL device that is powered by 12V or 24V, as currently are more popular on the market.

T1L Long Distant Link Solutions (cont'd):

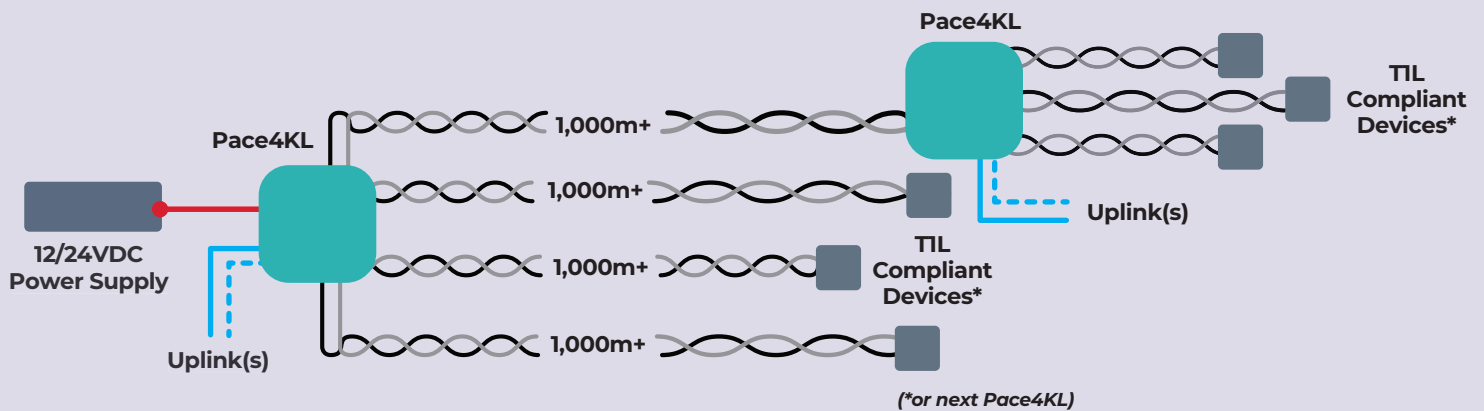
For installations that need to connect to a T1L compliant remote device, Altronix offers the following Plug & Play solutions:

Pace3KL: For point to multi-point or star (Two wire cable links)



The above scheme shows the first Pace3KL in a typical star configuration, while the second Pace3KL shows how to configure for a continued multi-point drop-off using additional T1L switch to connect T1L compliant devices in multiple locations.

Pace4KL(Q): For Multi-point-to-multi-point cable link (PoE+ and data link)



The Pace4KL T1L adaptor/switch can connect directly to up to four 3cg, T1L devices and feature dual network uplink ports. An additional Pace4KL can be added to the remote end to connect more compliant devices. Network managed versions allow for control, monitoring, and reporting of power diagnostics and feature a single network uplink port.

Altronix Plug & Play 2-Wire / SPE Solutions:

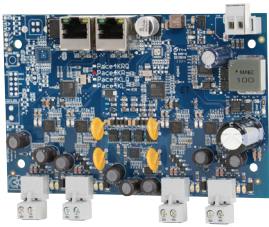


Pace1KRT – Single Port SPE Adaptor Kit

Long Range Single Pair Ethernet Adaptor Kit for deploying IP devices 1000m+ over a single pair. Passes PoE/PoE+, and includes Pace1KR Receiver and Pace1KT Transceiver.

Pace2KRT – Dual Port SPE Adaptor Kit

Long Range Single Pair Ethernet Adaptor Kit for deploying multiple IP devices 1000m+ over a single pair. Passes PoE/PoE+, and includes Pace1KR Receiver and Pace2KT Transceiver.



Pace4KR – 4-port SPE Adaptor/Switch Board*

Long Range Single Pair Ethernet Adaptor for deploying multiple IP devices 1000m+ over a single pair. Powered via 12/24VDC and connects to Pace1KT Transceivers.

Pace1KL12S – Long Range SPE/T1L Media Adaptor/Splitter (12VDC)

Enables connecting 10Base-T1L, IEEE802.3cg compliant devices to the network, while providing 12VDC power.

Used with Pace1KR Receiver.



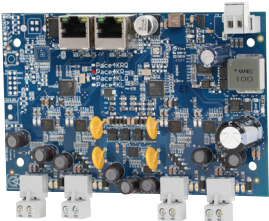
Pace1KL24S – Long Range SPE/T1L Media Adaptor/Splitter (24VDC)

Enables connecting 10Base-T1L, IEEE802.3cg compliant devices to the network, while providing 24VDC power.

Used with Pace1KR Receiver.

Pace3KL – 3-port T1L Adaptor/Switch

Enables connecting multiple 10Base-T1L, IEEE802.3cg compliant devices to the network. Powered by PoE or 12/24VDC.

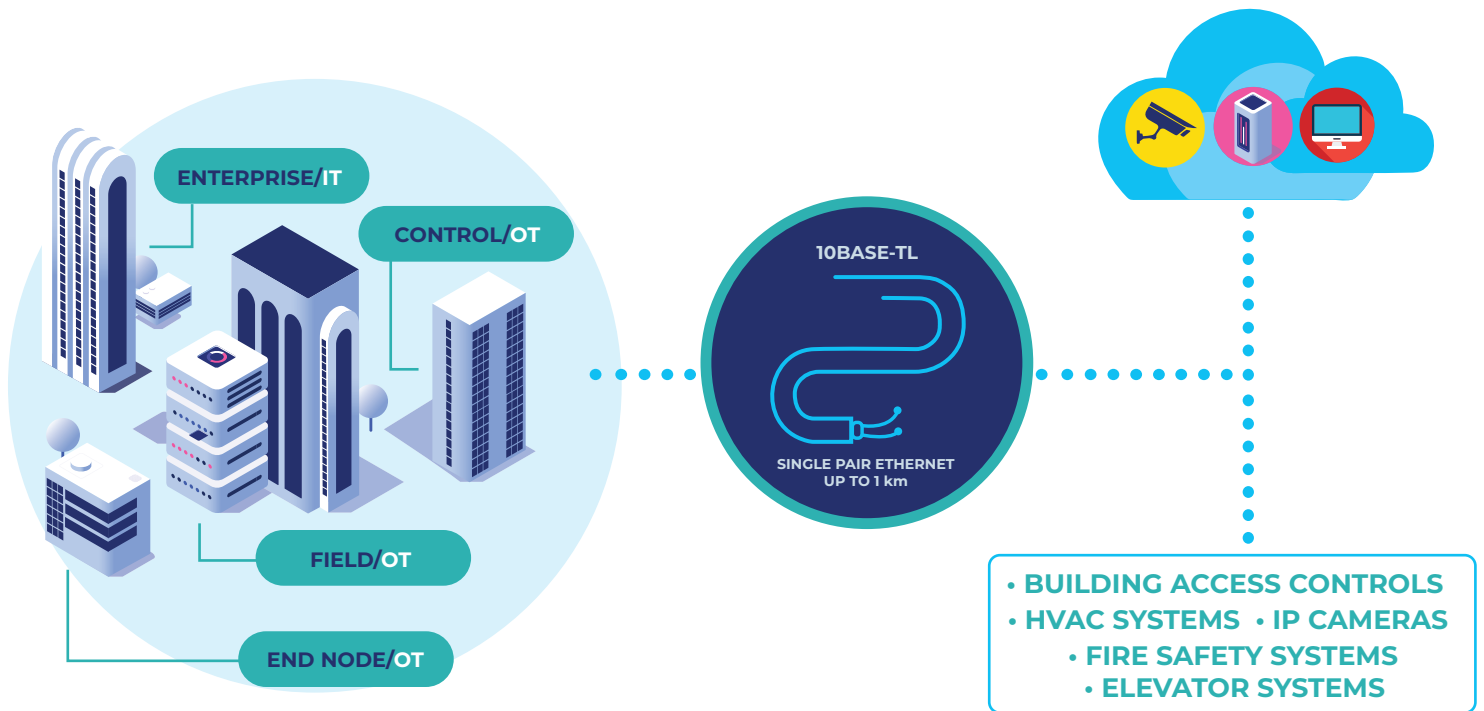


Pace4KL – 4-port T1L Adaptor/Switch Board*

Enables connecting multiple 10Base-T1L, IEEE802.3cg compliant devices to the network. Powered by 12/24VDC.

* Network managed versions allow for control, monitoring, and reporting of power diagnostics.

Intelligent Building Automation Unbounded Edge-to-Edge Connectivity:



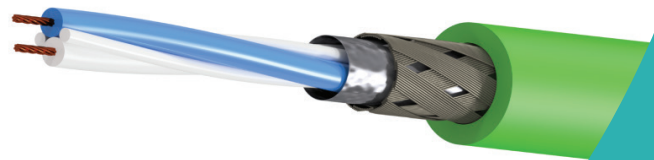
Conclusion:

Today's remote monitored & managed feature rich devices installed to maintain industry's security, surveillance & control are designed to interconnect via an Ethernet network, i.e. LAN, MAN, Internet. Ethernet is chosen due to its proven robust and reliable performance, ubiquitous deployment and its harmonized international standards that allow for Plug & Play link connections.

Hitherto, a shortcoming in the Ethernet was its inability to extend links beyond 100m over CAT5e 4 pair copper cables, unless interceded with repeaters or fiber optic transmission. However, this is no longer the case, as 802.3cg SPE supports single lower cost UTP or similar two pair wire cable over 10x the length using a highly robust 10Base-T1L transmission protocol with all the system advantages accorded by the globally adopted Ethernet standards. SPE is emerging as a leading strategy for efficient Ethernet upgrade over legacy two wire buses and as low cost SPE solution for where long length cabling is required.

References:

- [1] - [Standards.ieee.org/ieee/802.3cg/](https://standards.ieee.org/ieee/802.3cg/)
- [2] - Institute of Electrical and Electronics Engineers, standards.ieee.org.
- [3] - Emerson notification, Discontinuation of Echelon Products, LONworks.
- [4] - [Hallam-ics.com](https://hallam-ics.com), Upgrading Your LON-Based TGMS.
- [5] - Marcom, EOL notification LON controllers



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