

6口单对以太网+2口双对以太网
CLSW-6SPE-2ETH工业交换机

使用说明书



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技术背景

单对以太网（Single-Pair Ethernet, SPE）是一种仅使用一对双绞线进行数据传输的以太网技术，它通过精简线缆数量，在保持以太网高效通信的同时，显著降低了布线的复杂度、成本与空间占用，特别为工业自动化、汽车电子等领域带来了变革。

SPE的革新性体现在以下几个核心方面：

- **极简布线：**与传统以太网需要四对或两对双绞线相比，SPE仅用一对双绞线即可完成数据传输，这直接降低了线缆的重量、体积和成本。

- **数据线供电（PoDL）：**SPE支持通过同一对双绞线为远端设备（如传感器、执行器）提供直流供电，省去了独立的电源线，极大地简化了安装。

- **长距离传输与高带宽：**SPE技术在距离和带宽之间提供了多样化的选择。例如，从10BASE-T1S的15米，到10BASE-T1L的长达1公里，10BASE-T1L的速率可达10 Mb/s。

- **无缝融入以太网生态：**SPE遵循标准的以太网协议（OSI模型第2-7层），这意味着现有基于以太网的上层软件、协议（如TCP/IP）无需修改即可直接使用，实现了从信息层到现场设备层的端到端无缝连。

凭借上述技术特点，SPE正在多个领域快速普及：

- **工业自动化：**在工厂中，SPE能够直接将现场的传感器、执行器和I/O模块连接到PLC或控制器，简化了传统复杂的层级网络，实现了从传感器到云的直连。它既能替代传统的现场总线，也能作为现有多对以太网的轻量化替代方案。

- **汽车电子：**SPE最初因汽车需求而标准化，现已成为连接车载摄像头、雷达、激光雷达（LiDAR）及信息娱乐组件的理想选择，有助于减轻线束重量和复杂度。

- **流程工业：**基于10BASE-T1L的Ethernet-APL技术，能够长距离为现场仪器（如压力传感器、流量计）提供通信和供电，即使在危险区域也能安全运行，是实现预测性维护等高级应用的关键。

- **建筑与基础设施：**在楼宇自动化中，SPE可以简化照明控制、暖通空调（HVAC）、安防传感器等设备的连接，通过更细的线缆实现以太网接入。

单对以太网（SPE）通过“化繁为简”的设计哲学，将以太网的能力延伸到了此前难以触及的角落。它不仅是线缆的简化，更是推动运营技术（OT）与信息技术（IT）网

技术背景

络深度融合，实现工业物联网（IIoT）和“工业4.0”愿景的关键桥梁。随着技术的持续演进，SPE有望在更多场景中取代传统总线和技术，成为构建全连接世界的底层基石。

酷蓝公司推出的CLSW系列SPE和以太网交换机，内部构成包括两个部分，物理介质转换与数据交换。它与SPE（单对以太网）技术是相辅相成的关系—SPE解决了“最后一公里”的物理连接问题，而交换机则是在汇聚点对这些连接进行智能管理和数据交换。使得SPE设备可以无缝地接入现有的标准以太网网络，是构建从现场传感器到云平台端到端以太网架构的理想解决方案。

- **物理介质转换：**实现物理层的介质和信号编码方式。它将10BASE-T1L的SPE信号100BASE-TX或1000BASE-T的标准以太网信号进行相互转换。采用ADI（亚德诺半导体）的最新ADIN1100芯片作为SPE的物理层接口芯片。

- **数据交换，**基于数据链路层（OSI第二层）进行数据交换，二层交换机是一个智能的、基于硬件的数据帧转发设备。它通过“学习MAC地址，按需精准转发”的核心机制，高效地组织了局域网内部的通信。

它具有6个符合IEEE802.3cg-2019 10Base-T1L 标准的10Mbit/s 单对以太网口，最大SPE传输距离1500 米。2个100M/10M 自适应标准以太网口，采用RJ45接口。交换机的6个SPE 端口支持通过双绞线电缆PoDL供电，允许对连接远程SPE 终端设备供电，例如各种现场传感器、执行器、网络摄像头等。支持PoDL 功率等级Class10、Class11、Class12 和Class13、Class14。各个SPE端口之间采用公共的输入电源电压，相互之间没有电源隔离，但与SPE信号通道隔离。供电省去了复杂检测和功率分级过程，采用拨码开关选择，通过交换机内部的半导体开关切换供电，由相应的红色LED指示供电状态。每个SPE口输出的PoDL 电源电压等于本交换机输入的工作电源电压。需要注意6个SPE 口输出的电源总功率需要小于本交换机输入的电源总功率。

技术参数

通用参数	输入电压(V)	DC18~60V
	功率(W)	交换机功能5W
	PoDL供电	6口独立控制PoDL供电, Class 10 to Class 14; IPI(MAX) = 600mA with PP D(MAX) = 20W。 总的6口总消耗功率需要小于供电电源功率
	SPE端口	6端口PortAWG20~AWG24 具有接口极性检测和自动校正功能
	以太网口	2 Port RJ45
	信号隔离	供电电源与交换机内部电源隔离, SPE端口之间隔离 SPE 端口和以太网口隔离, 以太网口之间隔离
	交换机原理	物理层数据透传, 基于MAC地址端口交换
SPE端口	传输速率	10Mbit/s全双工
	标准	IEEE802.3cg-2019, 10Base-T1L
	线缆	线缆长度1500 m, 1.0Vp-p和2.4V p-p
	LED指示	6个SPE口工作指示, 绿灯, 6个SPE端口供电指示
以太网端口	传输速率	100/10Mbit/s自适应
	标准	IEEE8023, 100Base-TX/10BASE-T 以太网标准Ethernet Standard
	线缆	线缆长度5类四芯双绞线100米
	LED指示	以太网端口状态
工作环境	工作温度	-40~80摄氏度
	安全及电磁辐射标准	CCC,CE,UL
	命 Life Time	>100000小时
其他	尺寸	122*104*45mm
	安装方式	DIN35 mm 导轨安装 Rail Installment,挂耳式安装, Ear Fixing Installment,IP20防护等级 Protection Level

接线方式

●6端口SPE 10BaseT1L 电源输入 接线示意图

+接SPE线缆正, -接SPE线缆负, S接屏蔽线。SPE线缆可以采用AWG22 (0.3平方mm), 或者AWG20 (0.5平方mm), 剥皮8mm左右, 如果是多股线需要搪锡处理, 要用一字螺丝刀按下橙色按钮, 插入对应孔内, 松开橙色按钮, 导线即被插座内部簧片卡紧。电源进线采用AWG18 (1平方mm), 同样方式接入DC电源输入插座。

●PoDL选择开关 LED指示灯 RJ45端口

电源指示红灯在电源上电时点亮。

PoDL供电选择开关选择1~6SPE端口是否由交换机对远端SPE设备供电, 开关拨到下方对应供电使能, 相应通道的红色LED灯点亮。

绿色LED表示对应的SPE端口已与远端SPE设备建立了连接, 绿灯闪烁表示有数据传输。

RJ45端口接双对以太网线缆。对应的LED闪烁表示建立了连接并有数据传输。

网络连接拓扑

CLSW-6SPE-2ETH交换机是一种在物理层的交换机, 实现SPE信号和以太网信号的双向透明转换, 支持所有工业以太网的上层协议, 如Ethernet/IP, PROFINET、MODBUS TCP/IP、EtherCAT、CC-Link IE、POWERLINK、HART/IP、OPC UA、QTT协议等。在这些上层协议的组态配置时, 本交换机只负责中间数据转换, 不需要配置IP地址和进行网络管理。

CLSW-6SPE-2ETH交换机可单独使用, 也可通过标准以太网口级联连接多个交换机, 扩展的数量没有限制。

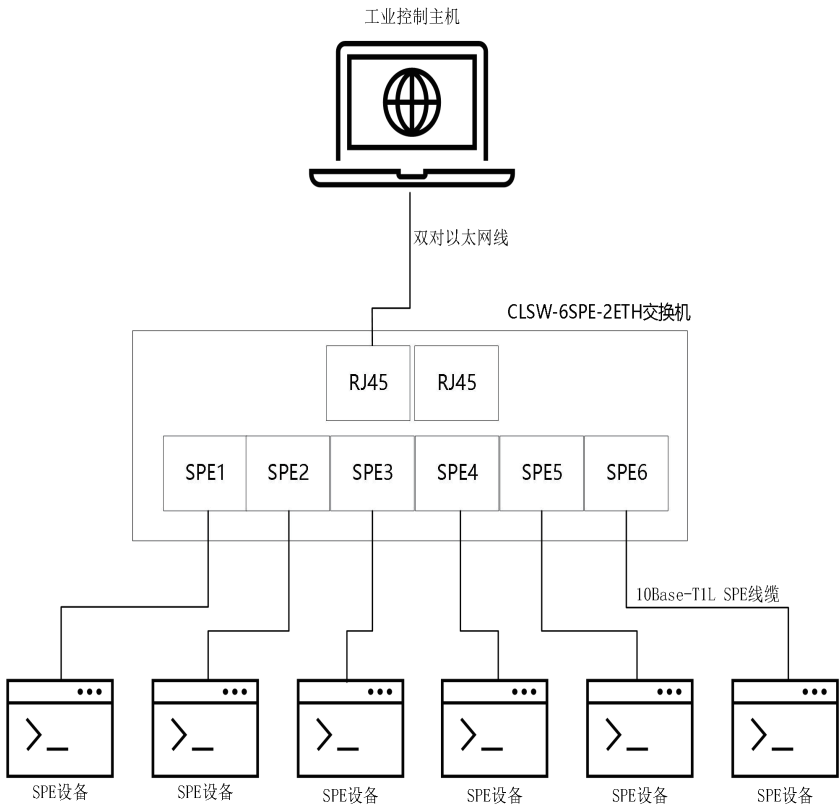
对于不支持SPE但具有RJ45接口的设备, 可以通过酷蓝CLMC-SPE-ETH转换器接入到SPE设备, 充分利用SPE协议可远距离长达1500米通讯的特点。CLMC-SPE-ETH转换器可以通过PoDL方式由CLSW-6SPE-2ETH交换机进行供电。

对于支持MODBUS-RTU设备, 可以选择酷蓝CLMC-MOSBUS-SPE转换器接

网络连接拓扑

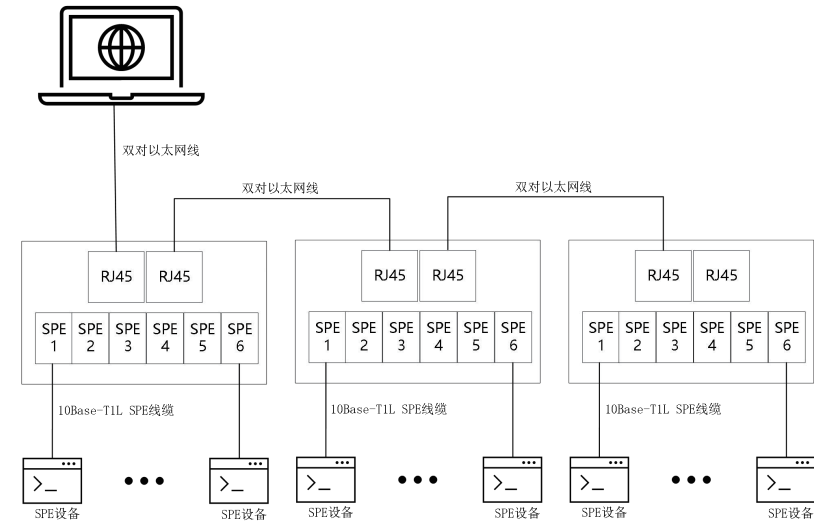
入到SPE交换机，充分利用SPE支持远距离通讯的特点。CLMC-MOSBUS-SPE转换器通过PoDL方式由CLSW-6SPE-2ETH交换机进行供电。MODBUS-RTU设备在转为SPE设备的同时，通讯协议也转换为了MODBUS Over TCP协议，上位机可以直接使用MODBUS Over TCP的驱动程序进行通讯。

●单机使用拓扑

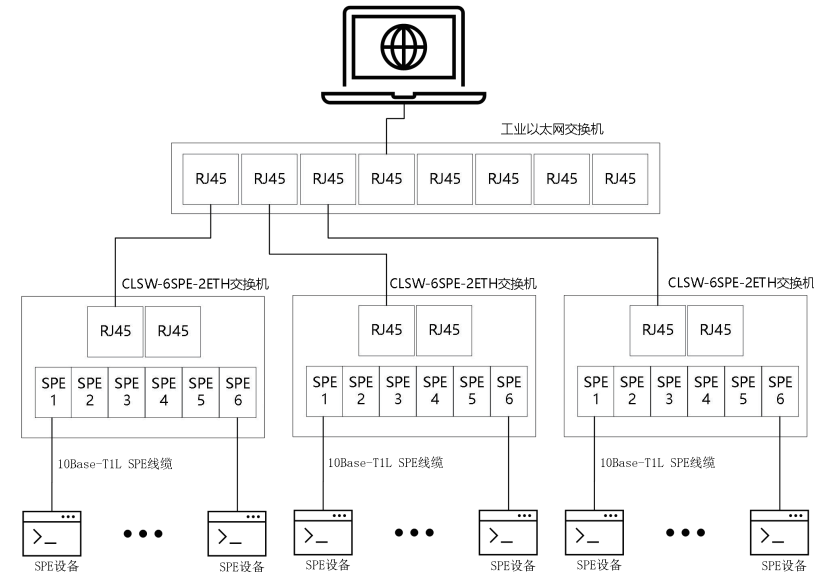


网络连接拓扑

●多个交换机连接拓扑1



●多个交换机连接拓扑2



6-Port SPE + 2-Port Ethernet

CLSW-6SPE-2ETH Industrial Switch

User Manual



点亮灵感
Ignite Inspiration

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Single-Pair Ethernet (SPE) is an Ethernet technology that uses only one pair of twisted wires for data transmission. By reducing the number of wires, it maintains the efficient communication of Ethernet while significantly lowering the complexity of wiring, costs, and space occupation, particularly bringing about changes in industrial automation, automotive electronics and other fields.

The innovative aspects of SPE are as follows:

- **Minimal wiring:** Compared to traditional Ethernet which requires four or two pairs of twisted wires, SPE uses only one pair of twisted wires to complete data transmission, which directly reduces the weight, volume and cost of the cables.
- **Power supply on Data Line (PoDL):** SPE supports providing direct DC power to remote devices (such as sensors, actuators) through the same pair of twisted wires, eliminating the need for separate power lines and greatly simplifying the installation.
- **Long-distance transmission and high bandwidth:** SPE technology offers diverse options in terms of distance and bandwidth. For example, from 15 meters of 10BASE-T1S to up to 1 kilometer of 10BASE-T1L, with a rate of up to 10 Mb/s.
- **Seamless integration into the Ethernet ecosystem:** SPE follows standard Ethernet protocols (layers 2–7 of the OSI model), meaning existing upper-layer software and protocols (such as TCP/IP) can be directly used without modification, achieving end-to-end seamless connection from the information layer to the field device layer.

With these technical features, SPE is rapidly gaining popularity in multiple fields:

- **Industrial automation:** In factories, SPE can directly connect on-site sensors, actuators and I/O modules to PLCs or controllers, simplifying the traditional complex hierarchical network and achieving direct connection from sensors to the cloud. It can replace traditional field buses and serves as a lightweight alternative to existing Ethernet cables.
- **Automotive electronics:** SPE was initially standardized for automotive needs and has now become an ideal choice for connecting automotive cameras, radars, LiDARs and infotainment components, helping to reduce the weight and complexity of wiring harnesses.
- **Process industry:** Based on 10BASE-T1L Ethernet-APL technology, it can provide communication and power supply for on-site instruments (such as pressure sensors, flow meters) over long distances, enabling safe operation even in hazardous areas, and is key to achieving advanced applications such as predictive maintenance.
- **Building and infrastructure:** In building automation, SPE can simplify the connection of lighting control, HVAC, security sensors and other equipment, and achieve Ethernet access through finer cables.

Single Pair Ethernet (SPE) adopts the design philosophy of "simplifying complexity" to extend the capabilities of Ethernet to previously inaccessible areas. It is not merely a simplification of cables, but also a key bridge that promotes the deep integration of operational technology (OT) and information technology (IT) networks, enabling the Industrial Internet of Things (IIoT) and the "Industry 4.0" vision. With the continuous evolution of technology, SPE is expected to replace traditional buses and technologies in more scenarios and become the fundamental cornerstone for building a fully connected world. The CLSW series of SPE and Ethernet switches launched by COOLED Company consists of two main functions: physical medium conversion and data exchange. SPE (Single Pair Ethernet) technology solves the problem of physical connection at the "last mile", while the switch performs intelligent management and data exchange at the convergence point, enabling SPE devices to seamlessly integrate into existing standard Ethernet networks. It is an ideal solution for building an end-to-end Ethernet architecture from on-site sensors to the cloud platform.

- **Physical medium conversion:** Implementing the medium and signal encoding methods at the physical layer. It converts the SPE signal of 10BASE-T1L to the standard Ethernet signals of 100BASE-TX or 1000BASE-T. Using the latest ADIN1100 chip from ADI (Analog Semiconductor) as the physical layer interface chip of the SPE.
- **Data exchange:** Based on the data link layer (OSI second layer), the Layer 2 switch is an intelligent, hardware-based data frame forwarding device. It efficiently organizes communication within the local area network through the core mechanism of "learning MAC addresses and forwarding as needed". It has 6 10Mbit/s SPE ports that comply with the IEEE802.3cg-2019 10Base-T1L standard, with a maximum SPE transmission distance of 1500 meters. 2 10M/100M adaptive standard Ethernet ports, using RJ45 interface. The 6 SPE ports of the switch support power supply through twisted-pair cables, allowing power supply to remote SPE terminal devices, such as various field sensors, actuators, network cameras, etc. It supports PoDL power levels Class10, Class11, Class12, Class13, and Class14. Each SPE port shares a common input power supply, without power isolation between ports, but isolated from the SPE signal channel. The power supply eliminates the complex detection and power grading process, using a dip switch selection, switching power supply through semiconductor switches inside the switch, and indicated by the corresponding red LED for the power supply status. The output power voltage of each SPE port is equal to the input working power voltage of this switch equipment. It should be noted that the total power output of the 6 SPE ports needs to be less than the total power input of this switch equipment.

Technical Specifications

General Parameter	Input Voltage(V)	DC18~60V
	Power(W)	Switch Function <5W
	PoDLPoDL Power Supply	6Port Switch Controlled PoDL, Class 10 to Class 14; IPI(MAX) = 600mA with PPD(MAX) = 20W. Total 6 power consumption shall be less than Power Supply
	SPE Port	6Port AWG20~AWG24, MDI polarity detection and correction
	Ethernet Port	2 Port RJ45
	Signal Isolation	External Power and Internal Working Power IsolatedMultiple SPE Ports IsolatedSPE Ports and Ethernet Ports IsolatedEthernet Ports Isolated
	Switch Principle	Physical Layer Data Transparently Transported, Switching based on remote MAC address
SPE Port	Data Rate	10Mbit/s Full Duplex
	Standard	IEEE802.3cg-2019, 10Base-T1L
	Cable	Cable length1700 m, 1.0 V p-p/2.4 V p-p
	LED Indication	6 SPE Port Active Flag, Green Light 6 SPE Port Power on Flag, Red Light
Ethernet Port	Data Rate	100/10Mbit/s Self Negotiated
	Standard	IEEE802.3, 100Base-TX 10BASE-TEthernet Standard
	Cable	Catalog 5 Cable length 100Meter
	LED Indication	Ethernet Port Status Indication
Working Environment	Working Temperature	-40~80 Degrees Celsius
	Safe and EMC Standard	CCC, CE, UL
	Life Time	>100000 Hours
Others	Installment	DIN35mm Rail Installment, Ear Fixing Installment,IP20 Protection Level

Wire connection

●6-port SPE 10BaseT1L power input wiring diagram

+ connects to the positive cable of the SPE, - connects to the negative cable of the SPE, S connects to the shielded wire. The SPE cable can use AWG22 (0.3 square mm) or AWG20 (0.5 square mm), which was stripped about 8 mm. If it is a multi-strand wire, it needs to be tin-plated.

Press the orange button with Philips type screw driver and insert wires into the corresponding hole. Release the orange button, and the wire will be clamped by the internal spring of the connector. The power input cable uses AWG18 (1 square mm), and is connected to the DC power input connector in the same way.

●PoDL selection switch, LED indicator, RJ45 port

Red color Power indicator is on when the power is powered on.

The PoDL power supply selection switch selects whether the SPE ports 1~6 are powered by the equipment to the remote SPE devices. When the switch is turned to the corresponding power enable position, the corresponding red LED light on SPE ports is on.

The green LED indicates that the corresponding SPE port has established a connection with the remote SPE device, and the green light flashes indicating data transmission.

The RJ45 port connects to Ethernet cables. The corresponding LED flashes indicating a connection setting up and data transmission.

Network Connection Topology

The CLSW-6SPE-2ETH switch is a physical layer switch that realizes bidirectional transparent conversion of SPE signals and Ethernet signals, and supports all industrial Ethernet upper-layer protocols, such as Ethernet/IP, PROFINET, MODBUS TCP/IP, EtherCAT, CC-Link IE, POWERLINK, HART/IP, OPC UA, QTT protocol etc. This switch equipment only performs intermediate data conversion and does not require IP address configuration or network management.

The CLSW-6SPE-2ETH switch can be used alone or connected to multiple switches through standard Ethernet ports, with no limit on the number of expansions.

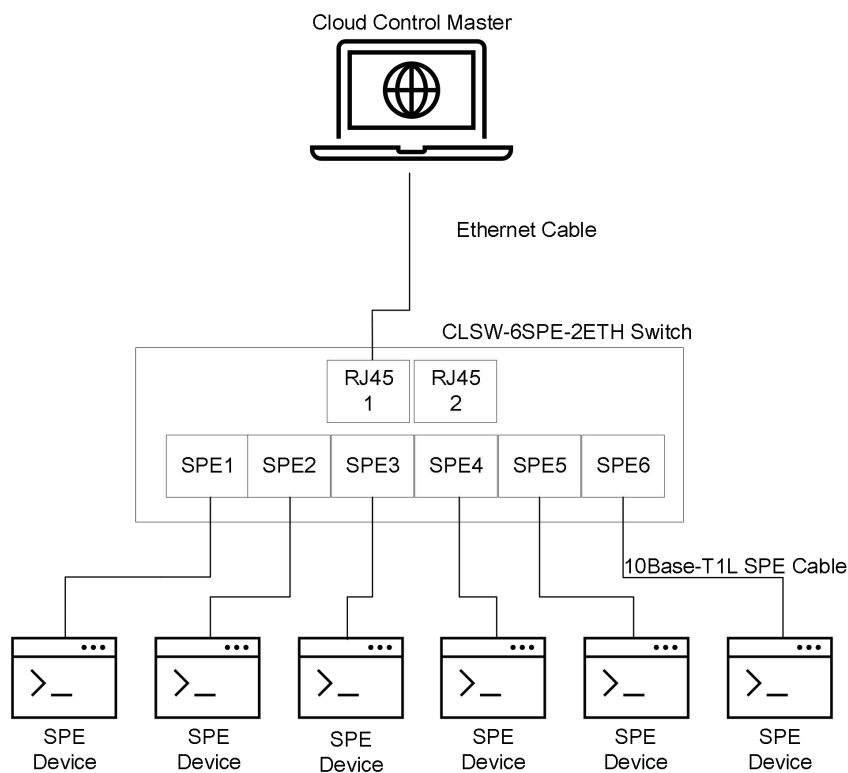
For devices that do not support SPE but have RJ45 interfaces, they can be connected to SPE devices through the Cooled CLMC-SPE-ETH converter, fully utilizing the long-distance communication feature of SPE protocol up to 1500 meters. The CLMC-SPE-ETH converter can be powered by the CLSW-6SPE-2ETH switch equipment through the PoDL method.

For MODBUS-RTU devices, the Cooled CLMC-MOSBUS-SPE converter can

Network Connection Topology

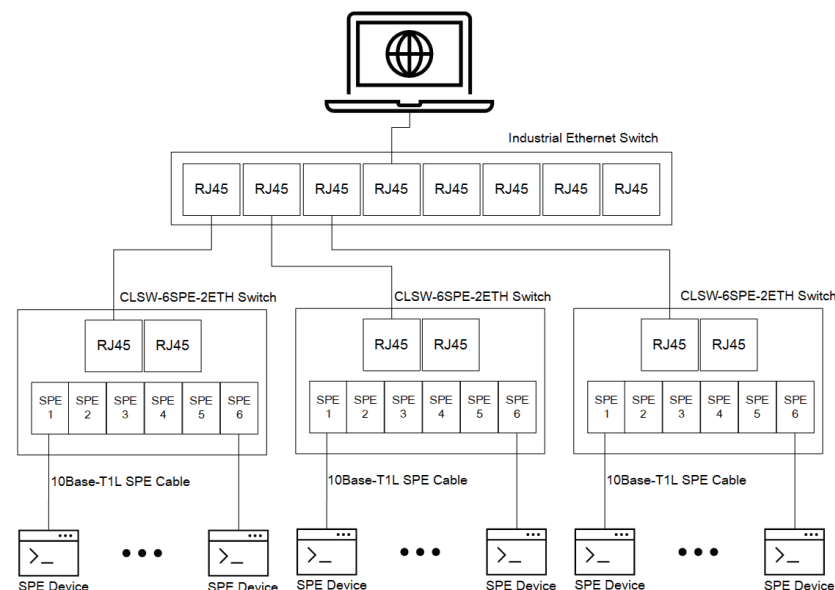
be selected to connect to the SPE switch, fully utilizing the long-distance communication feature of SPE. The CLMC-MOSBUS-SPE converter could be powered by the CLSW-6SPE-2ETH switch through the PoDL method. When the MODBUS-RTU device is converted to a SPE device, the communication protocol also converts to MODBUS Over TCP protocol. The upper controller can directly use the MODBUS Over TCP driver program for communication.

● Standalone usage topology



Network Connection Topology

● Multiple switch connection topology1



● Multiple switch connection topology2

