The 10BASE-T1L single-pair Ethernet and Ethernet-APL to standard Ethernet universal media converter

User's Guide

Product Model: IE-APL01

summary：

Single Pair Ethernet (SPE) represents a new trend in industrial automation data transmission applications and forms the foundation for industrial IoT development. SPE technology overcomes the limitations of Ethernet's high space requirements and transmission costs, enabling communication from remote networks to field devices with significantly reduced space usage and lower expenses. SPE transmits Ethernet data using only a single pair of twisted copper wires while simultaneously powering end devices—including sensors, actuators, and cameras—through Power over Data Line (PoDL) technology, which delivers both data and power via the same cable. SPE opens up extensive, even limitless possibilities for industrial Ethernet and IoT data transmission.

Although the SPE physical layer employs a single twisted pair for transmission, it retains all the upper-layer protocols specified in the original IEEE 802.3 standard at the protocol level—particularly the 10BASE-T1 standard, specifically designed for industrial automation and building automation (with two variants: 10BASE-T 1S and 10BASE-T1L)—and provides enhanced support for various industrial Ethernet protocols such as PROFINET, MODBUS TCP/IP, Ethernet/IP, CC-Link IE, and POWERLINK.

The Ethernet Advanced Physical Layer (Ethernet-APL) is a protocol designed for process automation, based on the 10BASE-T1L physical layer specified in the IEEE 802.3cg-2019 standard. While similar to Single Pair Ethernet (SPE), it adopts distinct industry-specific standards in certain aspects—particularly regarding power supply for data cables—for example:

IEC TS 63444-2023 Industrial Networks-Ethernet-APL Port Profile Specification

IEEE Std802.3-2022 IEEE Standard For Ethernet

The Single Pair Ethernet (SPE) and Ethernet-APL Universal Media Converter IE-APL01 integrates single pair Ethernet with Ethernet-APL technology, enabling bidirectional transparent data transmission between single pair Ethernet, Ethernet-APL, and standard Ethernet. This product features one 10 Mbit/s standard Ethernet port (using an RJ45 connector), one 10 Mbit/s single pair Ethernet (Ethernet-APL) interface compliant with IEEE 802.3c/g-2019 and 10Base-T1L standards (using a 5.08-3-pin plug-in spring-loaded terminal). The Ethernet port utilizes a twisted-pair cable for full-duplex data transmission and PoDL power supply, with a maximum transmission distance of 1000 meters. It operates within a voltage range of 9–60 V DC at temperatures from −20°C to +75°C and is mounted on DIN35 standard mounting rails. The device supports various PoDL power supply voltages ranging from 9 to 60 V DC, covering all PoDL voltage and power levels specified by SPE and Ethernet-APL standards.

IE-APL01 as a single-pair Ethernet-to-standard Ethernet media converter:

The power supply operates at 24 V DC, supporting PoDL power classes 10,11, and 12 with an output power of ≥12.63 W.

The power supply operates at 54 V DC, supporting PoDL power classes 13,14, and 15 with an output power of ≥79 W.

The IE-APL01 is an Ethernet-to-APL standard Ethernet media converter (equivalent to a single-port APL field switch):

The power supply operates at 12 V DC, supports PoDL power levels A and C, and delivers an output power of ≥1.1 W.

The IE-APL01 is an Ethernet-to-APL standard Ethernet media converter (equivalent to a single-port APL power switch):

The power supply operates at 48 V DC, supports PoDL power levels 3 and 4, and delivers a maximum PoDL output of 92 W.

The IE-APL01 medium converter selects the appropriate power voltage within the ultra-wide operating range of 9–60 VDC, depending on the specific SPE (APL) powered device (PD device) connected downstream. **The PoDL output voltage from its SPE port (APL port) matches the input operating voltage of this product, while the PoDL output power at the SPE port (APL port) equals the input operating power of the product, with a recommended safety margin of over 40%.**

This product's PoDL power supply does not employ the Power Detection and Grading (SCCP) process; instead, it uses a dial switch to activate or deactivate the data line power supply (PoDL) for the SPE (APL) port. Upon power-on, it begins supplying electricity to the terminal device (PD) via the SPE (APL) cable. Users must therefore verify that the terminal device supports PoDL power supply and that its PoDL voltage matches the operating power supply voltage of this product. If PoDL power supply is not used, these considerations are unnecessary.

apply

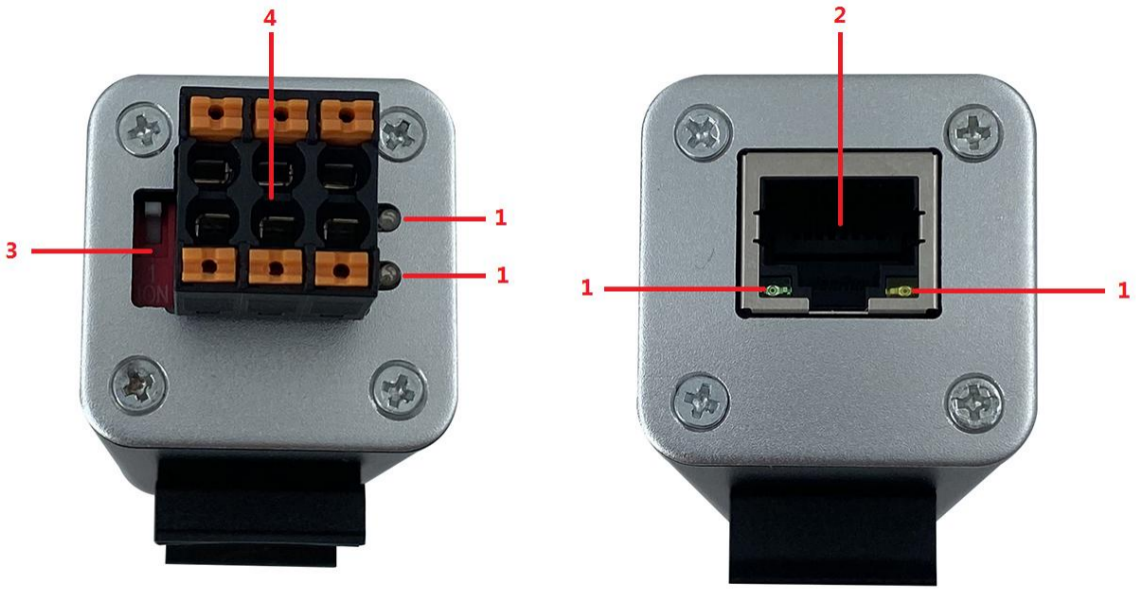
■ industrial automation■ Building Automation■ security system■ Traffic Control System■ Industrial Internet of Things

Main Technical Parameters:

Basic Parameters of the Single-Ethernet to APL Media Converter IE-APL01

Parameter classification	Project	Metric
Standard Ethernet Port Parameters	Interface type	Standard RJ45 connector.
	Transmission speed	10Mbit/s。
	Network Cable Adaptation	The network port features MDI/MDI-X auto-jump functionality, automatically adapting to both straight-through and crossover network cables.
	Maximum Transmission Distance	Five-category 4-core twisted-pair cable (Cat.5) with a maximum length of 100 meters.
	Connection Instructions	Ethernet port connection indicator light.
	Network Port Protocol	Complies with the IEEE 802.3 and 10BASE-T Ethernet standards.
	Number of Network Ports	1 RJ45 port.
Single Ethernet Port Parameters	Interface type	5.08-3 Pin plug-and-play spring-loaded press-type terminal block.
	Transmission speed	10 Mbit/s full-duplex, compliant with standard 10BASE-T1L and IEEE 802.3CG-2019.
	Output Signal Peak-to-Peak Value	The default peak-to-peak voltage (VPP) at factory output is 1.0 V. To achieve VPP = 2.4 V, remove the shorting cap (jumper cap) from pin J3 on the circuit board.
	Transmission medium	SPE single-pair twisted-pair cable, ranging from 26 AWG (0.14 mm ^{2}) to 14 AWG (2 mm ^{2}).
	Maximum Transmission Distance	The transmission distance is limited to 1000 meters when powered by PoDL. This distance is constrained by power supply capacity, connected terminal devices, and cable cross-sectional area. The national standard specifies a maximum distance of 200 meters for APL field switches and 1000 meters for APL power switches.
	Connection Instructions	SPE port status indicator light and PoDL indicator light.
	PoDL Power Level	When operating at a 24 V DC supply voltage, it supports SPE power classes Class 10,11, and 12. When operating at a power supply voltage of 54 V DC, it supports SPE power classes Class 13,14, and 15. When operating at a 12 V DC power supply, it supports Ethernet-APL power ratings A and C. When operating at a 48 V DC power supply, it supports Ethernet-APL power ratings 3 and 4.
	Number of SPE Ports	1 SPE (APL) port.
	SPE Interface Protection	Equipped with TVS surge protection and ESD electrostatic protection, compliant with standards IEC61000-4-4, IEC61000-4-5, and IEC61000-4-2.
SPE protocol	IEEE 802.3CG-2019 (10Base-T1-L) enables transparent data transmission and supports all Ethernet upper-layer protocols, including PROFINET, MODBUS TCP/IP, Ethernet/IP, CC-Link IE, POWERLINK, and others.	
General Parameters	Power Supply Voltage	Supports any voltage range from 9 to 60 VDC, featuring polarity reversal protection and surge protection. The system requires selecting different power voltages for various downstream terminal devices connected to the SPE (APL).
	Power supply power	When not powered by PoDL, the power consumption should not exceed 1 W; when powered by PoDL, it must be at least 40% higher than the power requirement of the connected device.
	Interface isolation	The network port is isolated from the SPE (APL) port and from the power supply port, with an isolation voltage of 1500 V DC. There is no electrical isolation between the SPE (APL) port and the input power supply port (they share a common PoD voltage).
	Levels of protection	IP20
	Working temperature	-20℃～+75℃。
	Outline dimension	Dimensions: 120 mm × 32 mm × 32 mm (length × width × height); Weight: 100 grams.
	Way to install	Installed with DIN 35 mm standard rail.

Product Appearance and Component Specifications:



1、 Indication Lights: Names and functions of the LEDs on the panel.

Indicator Light Name	Indication Light Status		
	Always On	Twinkle	Extinct
PWR （Huang）	The power supply is functioning normally.	-	The power supply is not turned on or there is a hardware fault.
Link (Green)	The network port is connected normally	-	The network port is not connected or has a connection error
Act (Green)	SPE connection is normal	The SPE port is transmitting data	The SPE port is not connected or has a connection error
PoDL (Green)	Enable PoDL Power Supply	PoDL power supply is abnormal	Power supply to PoDL is shut down or there is a short circuit in the SPE cable

2、 A 10 Mbit/s Standard RJ45 Ethernet Port With the Following Signal Specifications:

Pin	Signal Name	Function	Type
1	Tx+	Positive-phase Ethernet data transmission uses a differential signal line.	Output
2	Tx-	Negative-phase Ethernet data transmission uses a differential signal line.	Output
3	Rx+	Positive-phase Ethernet data reception differential signal line	Import
4	Not used		-
5	Not used		-
6	Rx-	Negative-phase Ethernet data reception differential signal line	Import
7	Not used		-
8	Not used		-

3、 PoDL Code Switch: This code switch controls the power supply activation for the PoDL. Turning it downward (as indicated by the arrow) sets it to ON, enabling power supply to the PoDL through the SPE (APL) port while illuminating the PoDL indicator light; at this state, the SPE (APL) cable transmits both data and power, with its output voltage matching the product's input voltage. Turning it upward sets it to OFF, cutting off power to the PoDL and extinguishing the indicator light; the SPE (APL) port then transmits only data without power supply.

This product's PoDL power supply does not involve a PD detection or power grading (SCCP) process. When the PoDL switch is ON, power is delivered to connected devices via the SPE cable immediately upon power-on. Users must ensure that the connected devices support PoDL power supply and have the same operating voltage as the device's own power source. If PoDL power supply is not enabled, these considerations are unnecessary.

4、 The wiring terminals for SPE (APL) and the working power supply are defined as follows:

Terminal Shape	Symbol	Explain	Type
	D+	The SPE (APL) signal is positive (Rx/Tx+).	Input/Output
	D-	The SPE (APL) signal is negative (Rx/Tx−).	Input/Output
	S	Connect to the shielding layer of the SPE cable	-
	+V	Connect to the positive terminal of any DC power source between 9 and 60 V	Import
	0V	Connect to the negative terminal of any DC power source between 9 and 60 V	Import
	FG	Case Base (Earth)	-

Connect this product to the working power supply according to the following principles:

- As a single Ethernet media converter:

The operating voltage ranges from 20 V to 30 V DC (nominal value: 24 V DC), supporting single-pair Ethernet PoDL power ratings Class 10,11, and 12, with a PoDL output power of ≥12.63 W at the SPE port.

The power supply operates at 50V to 58V DC (nominal value: 54V DC), supporting single-pair Ethernet PoDL power ratings Class 13,14, and 15, with a PoDL output power of ≥79 W at the SPE port.

- From an Ethernet-APL to a standard Ethernet media converter (equivalent to a single-port APL field switch):

The operating voltage ranges from 9 V to 15 V DC (nominal value: 12 V DC). In this configuration, the APL port functions as a spur port, supporting PoDL power levels A and C with an output power of ≥1.1 W.

➢ From an Ethernet-APL to a standard Ethernet media converter (equivalent to a single-port APL power switch):

The operating voltage ranges from 45 V to 50 V DC (nominal value: 48 V DC). In this configuration, the APL port serves as a trunk line, supporting PoDL power levels 3 and 4, with a maximum PoDL output power of 92 W.

Special Note: When PoDL power supply is enabled, if the connected power source voltage is 54 V, do not use an SPE (APL) cable to connect terminal devices operating at 24 V or lower, as this may damage them.

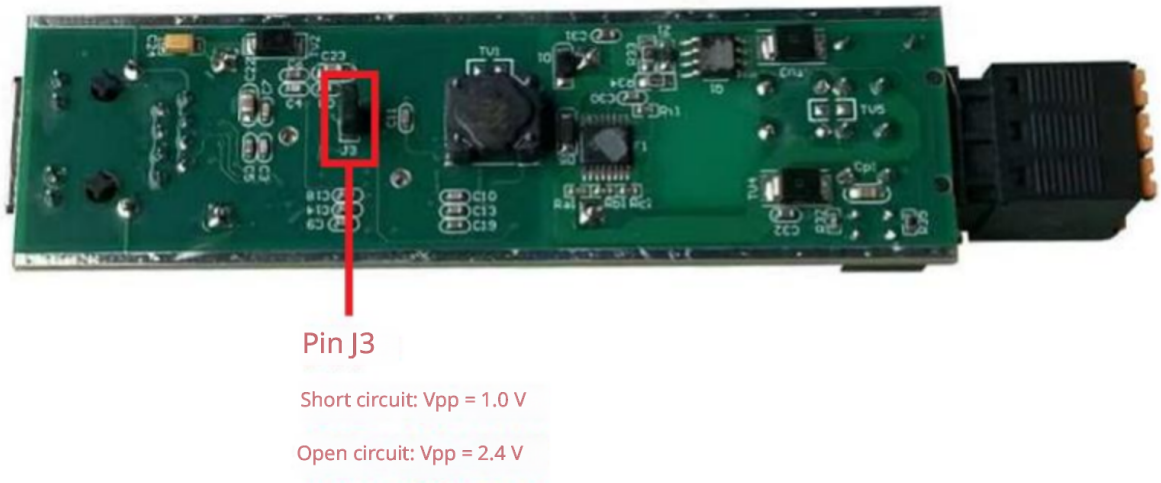
When PoDL power is enabled, the required operating power of this product must exceed the power consumption of the SPE (APL) terminal's load equipment by at least 40% as a safety margin. The PoDL output power from this product's SPE (APL) port can reach up to 92 W. Without PoDL power supply, the device's power consumption does not exceed 1 W.

Of course, unless PoDL power is enabled, this product has no specific requirements for the operating voltage; it can operate within any range from 9 to 60 V DC.

Settings on the internal circuit board (usually not required):

When used as an APL field switch, the IE-APL01 requires a SPE output signal with a peak-to-peak voltage (Vpp) of 1.0 V (factory default setting). The pin J3 on its circuit board comes pre-connected with a shorting cap (jumper cap) upon delivery.

When used as a power switch, the IE-APL01 requires a peak-to-peak output voltage (Vpp) of 2.4 V from the SPE. In such cases, the shorting cap on pin J3 of the circuit board should be removed, as some manufacturers specify identical Vpp values at both connection terminals; otherwise, while the link may be established, communication cannot be enabled. This step is unnecessary when connecting to products from Fourstar Electronics, whose Vpp signals (1.0 V and 2.4 V) are mutually compatible with those of most other manufacturers.



Installation and Usage Guide

When PoDL power supply is not activated, there are no specific requirements for the cross-sectional area of the SPE (APL) twisted-pair cable; AWG22 (with a cross-sectional area of approximately 0.3 mm ²) twisted-pair cable is typically sufficient, supporting a maximum transmission distance of 1000 meters.

When using PoDL power supply, the power current flowing through the SPE (APL) cable induces a voltage drop—this drop increases with both power magnitude and cable resistance. Thus, for different power ratings of connected devices, the cable's cross-sectional area determines the maximum transmission distance; refer to Table IEEE 802.3c for details.

IEEE 802.3cg Class Power Requirements Matrix for PSE and PDs

Class Symbol and Unit	Class Description	Class 10	Class 11	Class 12	Class 13	Class 14	Class 15
V_{PSE} (V)	PSE output voltage	20 to 30			50 to 58		
$I_{PI(MAX)}$ (mA)	Cable current	92	240	632	231	600	1579
$P_{CLASS(MIN)}$ (W)	PSE output power	1.85	4.8	12.63	11.54	30	79
$V_{PD(MIN)}$ (V)	PD input voltage	14			35		
$P_{PD(MAX)}$ (W)	PD power	1.23	3.2	8.4	7.7	20	52
$R_{LINK\_SEG\_LOOP}$ (Ω)	Cable resistance	65	25	9.5	65	25	9.5

IEEE 802.3cg Class Power Requirements Matrix Example Link Segment Maximum Distances

	Maximum Lengths (m)					
Example Cable	Class 10	Class 11	Class 12	Class 13	Class 14	Class 15
14AWG, 14 Gauge Cable	1000[1]	1000	400	1000[1]	1000	400
18AWG, 18 Gauge Cable	1000	400	158	1000	400	158
24AWG, 24 Gauge Cable	300	100	40	300	100	40

1、 The IE-APL01 is a single-pair Ethernet-to-standard Ethernet media converter:

The IE-APL01 is a physical-layer media converter that enables bidirectional, transparent data conversion between single-pair Ethernet and standard Ethernet. It supports all industrial Ethernet upper-layer protocols—including PROFINET, MODBUS TCP/IP, Ethernet/IP, EtherCAT, CC-Link IE, and POWERLINK—and requires no additional configuration as a communication device when setting up network software topology for these protocols; it can simply be treated as a standard cable. The transparent-mode switch also does not require an IP address.

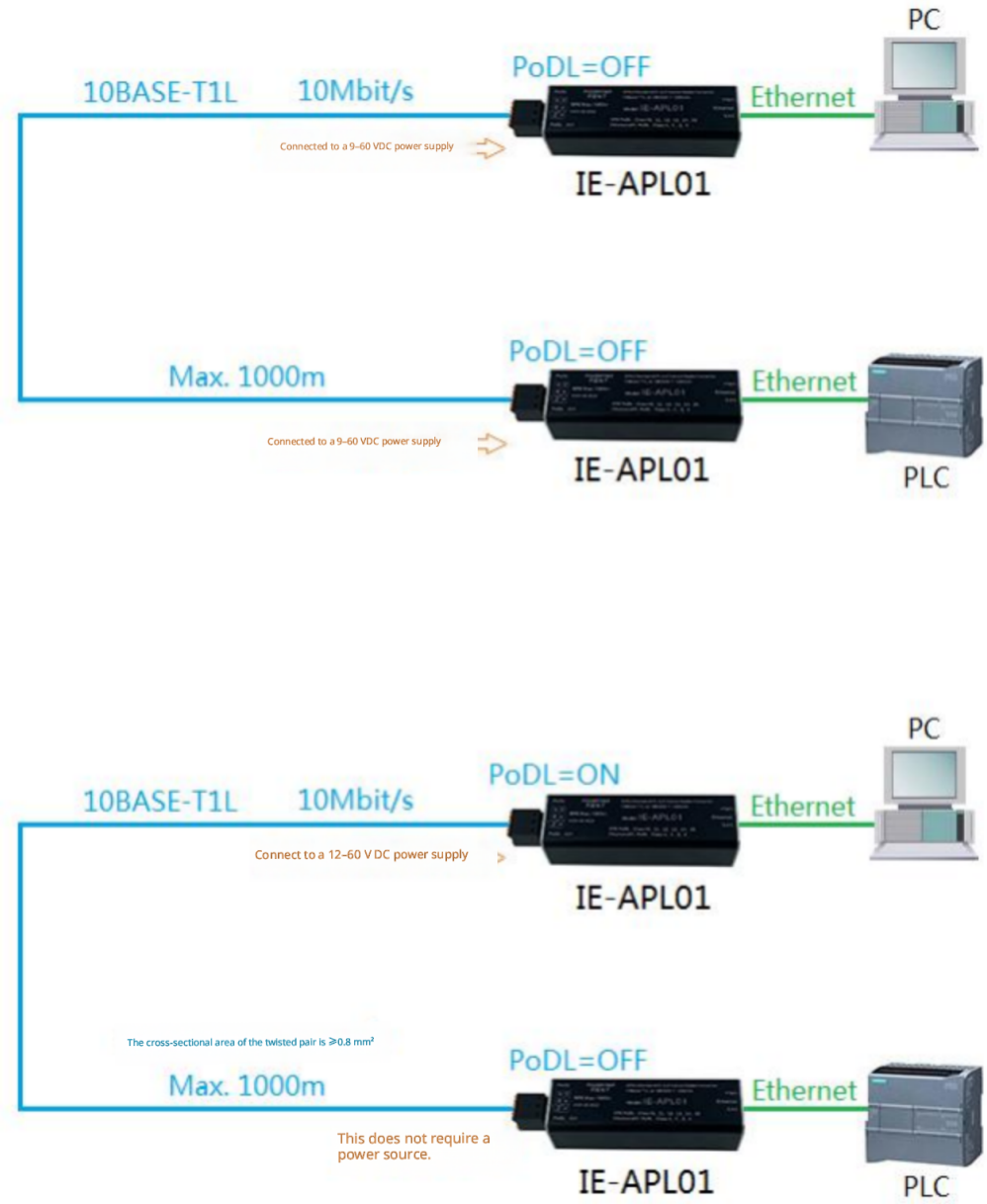
When used as a single Ethernet media converter, the Power Over Data Line (PoDL) standard specifies two voltage levels for data cable power supply; ensure that the operating voltage of this device matches that of the user's SPE-powered device (PD).

The 24 V DC supply (range: 20–30 V DC) supports PoDL power ratings Class 10,11, and 12, with a PoDL output power of ≥ 12.63 W at its SPE port.

54 V DC (range: 50–58 V DC), supporting PoDL power ratings Class 13,14, and 15, with a PoDL output power of ≥79 W at the SPE port.

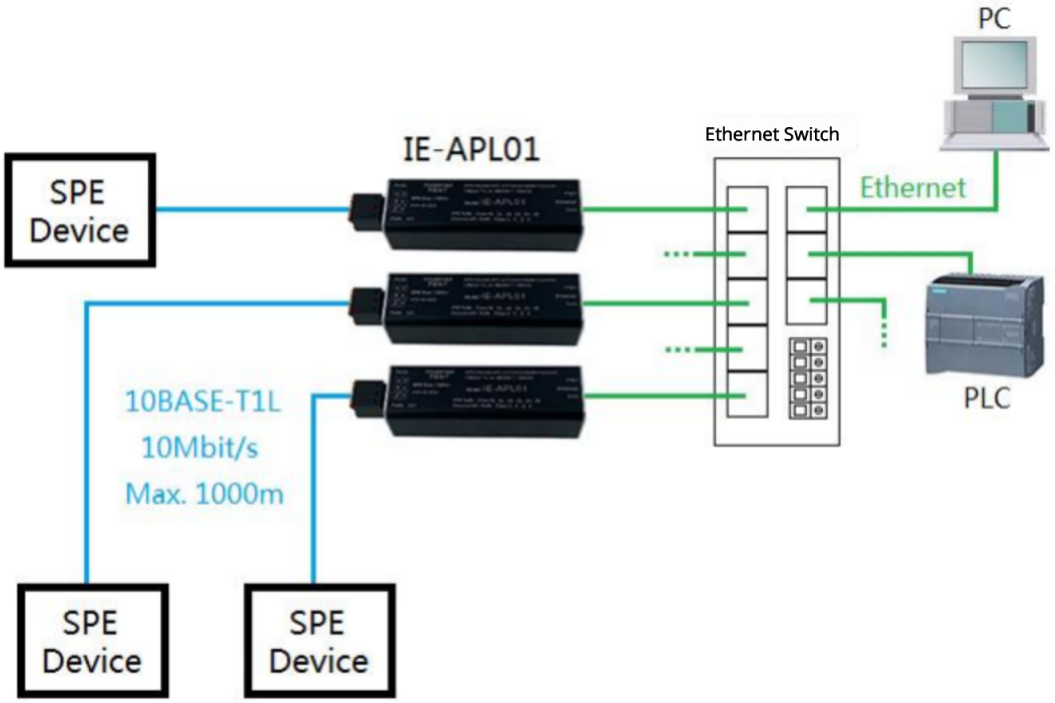
The IE-APL01 single-pair Ethernet media converter can be used independently or connected via a standard Ethernet port to an Ethernet switch for expanding connections to multiple devices without any limit on the number. The IE-APL01 inherently features intrinsically safe explosion-proof capabilities, and the following illustrates common connection topologies.

SPE Media Converter IE-APL01 Connection Topology 1



SPE Media Converter IE-APL01 Connection Topology 2

In the lower section of Connection Topology 2 diagram, the lower IE-APL01 unit can operate without an external power supply, with its PoDL switch set to any position (typically OFF); the upper IE-APL01 supplies power via data cable (PoDL switch set to ON) to the lower IE-APL01, which serves as the PD device. The operating voltage of the upper IE-APL01 is ≥12 V DC, and when the twisted-pair cross-sectional area is ≥0.8 mm ^{2}, the maximum transmission distance remains up to 1000 meters.



SPE Media Converter IE-APL01 Connection Topology 3

2、 As an Ethernet-APL to standard Ethernet medium converter (equivalent to a single-port APL field switch): This product serves as an Ethernet-APL to standard Ethernet medium converter, functioning as a single-port APL field switch with auxiliary power supply.

This device features an APL interface with a SPur branch configuration, enabling point-to-point connections to field APL devices (such as instruments, sensors, and actuators). It operates on a 12 V DC power supply (range: 9–15 V DC), supports PoDL power classes A and C, and delivers an APL interface output power of ≥1.1 W. Its standard uplink network port connects various controllers, switches, PLCs, DCS systems, computers, and more, making it highly convenient for APL device debugging.

For IE-APL01 as a single-port APL field switch, the signal peak-to-peak voltage (VPP) is 1.0 V. Port types are: S (APL branch); P (power supply port; 4: 15 V DC/1.11 W); X (non-hazardous zone/hazardous zone with non-essential safety rating).

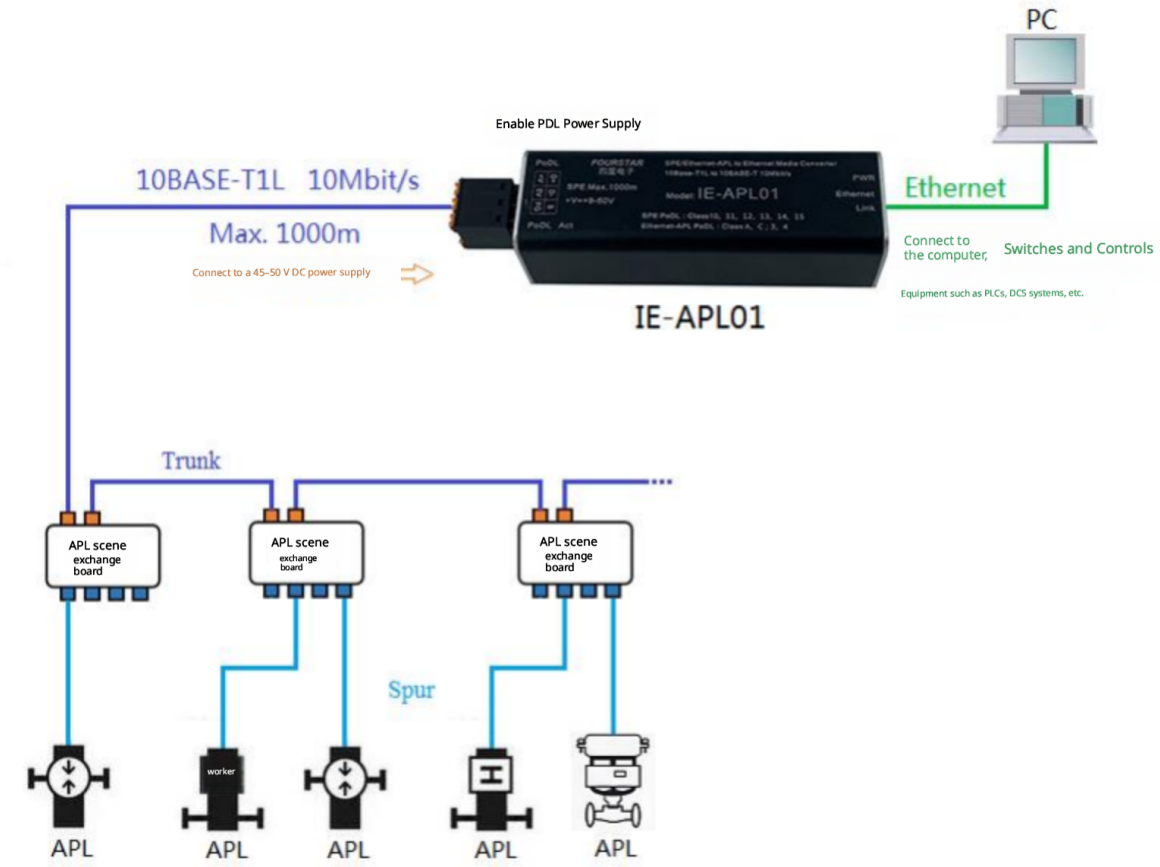
APL-to-standard Ethernet media converter (equivalent to a single-port APL field switch) connection topology

3、 As an Ethernet-to-APL to standard Ethernet medium converter (equivalent to a single-port APL power switch):

When functioning as an Ethernet-to-APL single-port power switch, this device uses its single Ethernet interface as the APL trunk interface for connection.

The APL field switch features a trunk interface and operates without auxiliary power supply, with its power supplied via the APL interface (here serving as the APL trunk interface) of the IE-APL01 unit. The device operates at a working voltage of 48 V DC (range: 45–50 V DC), supports PoD Level 3 and 4, and delivers a maximum PoD output power of 92 W from the APL trunk interface. Its uplink standard network port connects various controllers, switches, PLCs, DCS systems, computers, and other devices.

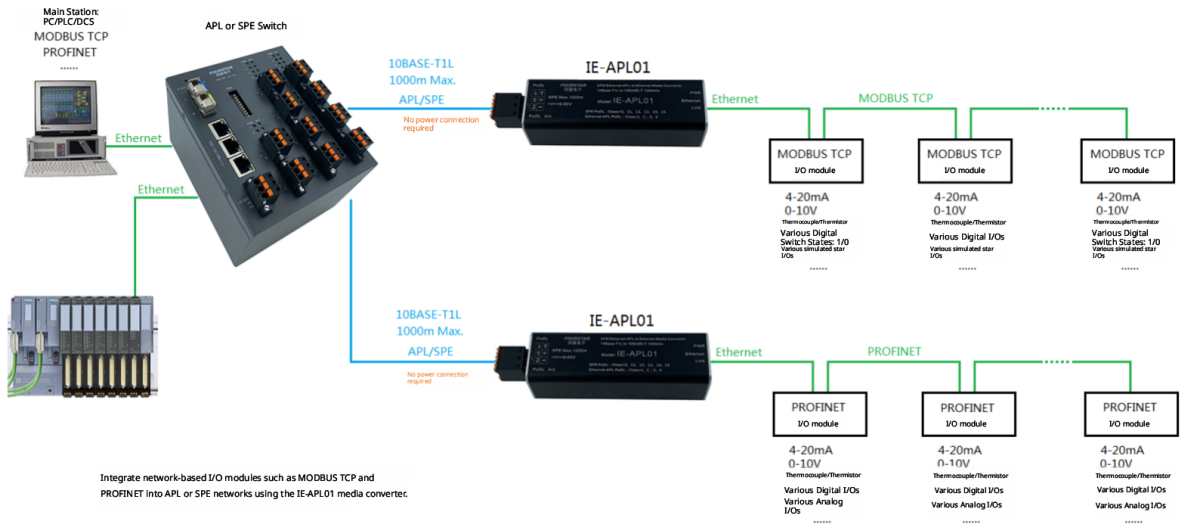
For IE-APL01 as an Ethernet-APL single-port power switch, the signal peak-to-peak voltage (Vpp) is 2.4 V. In this case, the shorting cap (jumper cap) on pin J3 of the circuit board may need to be removed. The port configuration is: TP4X (T: APL trunk; P: Power port; 4: 50 V DC/92 W; X: Non-hazardous zone/Hazardous zone non-essential safety).



APL-to-standard Ethernet media converter (equivalent to a single-port APL power switch) connection topology

4、 In industrial settings, traditional analog and digital I/O sensors, instruments, and actuators—including those operating on 4–20 mA, 0–10 V, thermocouples, and thermal resistors—are still widely used. To reduce wiring complexity, these devices are typically converted to Ethernet via network-based I/O modules such as MODBUS TCP or PROFINET before being connected to controllers like PCs, PLCs, or DCS systems.

The IE-APL01 medium converter transforms standard Ethernet interfaces into APL/SPE signals, integrating various analog and digital I/O signals (e.g., 4–20 mA, 0–10 V, thermocouples, thermal resistors) from connected I/O modules into an APL/SPE network, enabling centralized access and control of field devices from upper-layer controllers. The IE-APL01 requires no external power supply and is powered by the PoD-L data cable of an upstream APL/SPE switch; it operates with any voltage within the 9–60 VDC range and supports all power specifications of upstream APL/SPE devices. As a pure hardware-based physical layer converter, it requires no modifications to existing communication protocols or software, offering plug-and-play functionality.



Integrate network-port-based I/O modules into the APL/SPE network

Disclaimer: This document provides guidance for users operating the IE-APL01 single-pair Ethernet and Ethernet-APL to standard Ethernet universal media converter. Due to rapid technological advancements, product specifications are subject to actual performance.