White paper

Revolutionizing Process Industries with Advanced Physical Layer (APL) Technology

Zone 1 Field Devices with Ethernet connectivity

Find out more about:

- Intrinsic Safety into Zone 1/0
- Two wire connection
- Data and Power
- Full Duplex communication
- Seamless Integration

PHOENIX CONTACT

Introduction

In the dynamic landscape of the process industry, achieving reliable, high-speed communication in hazardous environments has long been a challenge. Advanced Physical Layer (APL) technology addresses these challenges, enabling seamless integration of Ethernet communication at the field level. This white paper explores APL's transformative potential and highlights the benefits for its installation in the digital age.

ethernet-apl™
advanced physical layer

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What is APL?

Advanced **P**hysical **L**ayer (APL) is based on the IEEE 802.3cg standard, specifically the 10BASE-T1L specification – also known as **S**ingle **P**air **E**thernet (SPE). It allows both power and bi-directional communication at Ethernet speeds. This derivative of SPE incorporates 2-WISE (**2**-**W**ire **I**ntrinsically **S**afe **E**thernet) technology described in the IEC 60079-42 TS (Technical Specification), ensuring that both power (up to 1,17 Watt) and bi-directional data (up to 10 Mbps) can be transmitted safely over a single two-wire cable into the hazardous environments of either Zone/Division 2 and Zone/Division 1/0 to an APL Field Device. It also addresses the needs defined in the NAMUR NE 168 recommendation and is described in the IEC 60079-42 Technical Specification.

Ethernet-APL is a specification designed to extend Ethernet communication using simple Intrinsically Safe categories up to 200 meters to the field device level in process industries. To date, field instruments have relied on simple 4-20 mA signals, HART over 4 to 20 mA, and fieldbus technologies – all limited in bandwidth and speed – and requiring investment in equipment and extensive operator training.

Ethernet-APL therefore enables high-speed, reliable, and intrinsically safe communication over a two-wire cable and provides power to connected devices in plants where higher levels of the automation pyramid already use ethernet technology as a backbone.

The Ethernet-APL standard currently supports 10 Mbit/s full-duplex communication over a single twisted-pair cable, making it suitable for long-distance communication and power delivery in industrial settings – 10,000 x faster than HART signals, and 300 x faster than conventional fieldbus communication protocols. It addresses the need of existing plant operators to use the shielded, twisted two wire cables installed between the control room, junction boxes and the field instruments in their hazardous environment.

Why APL?

Addressing the Needs of the Process Industry
Ethernet-APL offers numerous benefits throughout the project lifecycle.

The simplicity and speed of Ethernet-APL technology promises to reduce engineering time and allows for quicker turnaround time during the commissioning phase. The wealth of data available inside the field device reduces delays in the maintenance stages of a plant – and the remote access assures quick resolution of issues that may arise after long periods of service. Future project upgrades are made possible with steps similar to the upgrade techniques used in replacing IT equipment in the office environment. The NAMUR Working Group activities are focused on enhancing the user experience in a process application – without the need for IT-skills – and with procedures already known in replacing 4 – 20 mA, or Fieldbus instruments.

Many plant operators run their plants over a multi-decade period, with many of these operational on a 24/7 basis. In fact, high availability is therefore a crucial requirement, since switching off some processes may mean a catastrophic end to an expensive long-term investment. Process Automation Systems therefore require the ethernet network to be redundant – or set up as a ring with paths in opposite directions to guarantee as much uptime as possible.

The use of ethernet provides real-time access to both infrastructure and field devices located in remote areas of production or storage sites. This speeds up both fault-finding, and repair work when required – all managed from the control room.

The data from field devices and related equipment can be viewed in the control room sooner and eliminates unneeded in-the-field inspection and reduces the occasional errors associated with device identification. With the ethernet network connections deployed in the offices of a process plant, the various managers with access to the Ethernet-APL installation can conduct numerous tasks to both the assets and the process – just like IT-specialists manage equipment like pc's, printers and plotters in a regular office environment.

APL therefore offers significant advantages for asset administration in industrial and process automation settings. Here's how APL can enhance asset management:

1. **Enhanced Data Collection and Monitoring:**
   APL enables real-time, reliable data transmission from field devices to the ethernet network of a de-centralized system. These systems include plant and performance operations staff, asset and maintenance teams, as well as local access provided to management. This means that live monitoring of asset performance, asset history, equipment behavior, process efficiency and firmware revisions are all accessible directly to those who need accurate data. In the past, additional data required the device be physically accessed at its point of installation – requiring many safety steps to ensure personnel and process integrity. With APL and ethernet network access, this can now be done from the control room.

2. **Improved Diagnostics and Predictive Maintenance:**
   Advanced diagnostic information embedded in the field devices is available for immediate analysis. Normally, multiples of the same brand and make/ model of field devices are deployed, allowing machine learning and artificial intelligence to be used to compare relative performance and predict device failure ahead of time. Identifying potential issues before they lead to catastrophic failure leads to increased profitability of the plant, and efficient use of ingredients in any process recipe.
   Since many APL Field Devices include such attributes as totalization or wear-and-tear data, they provide immediate information that reduces additional programming or personnel

to uncover data already on hand. The NAMUR NE 107 Traffic Light system provides easy go / no-go attributes of APL field devices and can provide access to predictive maintenance strategies that reduce downtime and extend the lifespan of assets.

3. **Simplified Network Infrastructure:**
   By using the single pair connection of just two wires, as used before in 4 – 20mA + HART, or Fieldbus systems, technicians and maintenance crew are working with a recognizable technology used over many decades. APL supports both power and data transmission over a single two-wire cable, now over ethernet, and existing network infrastructure. This reduces installation complexity and maintenance costs, making it easier to manage and administer assets, and train staff responsible for installation, maintenance, and upgrades.

4. **Increased Safety and Simplified Compliance:**
   The implementation of the 2-WISE intrinsically safe feature reduces the complexity associated with the entity parameters and FISCO installation that are common in the 4 – 20mA + HART and fieldbus installations. By using power classes, the connection of field devices in hazardous areas with the ports of the APL Field Switch is easy to match. This reduces potential errors when using spreadsheets or other tools to confirm factors including inductance, capacitance, and impedance, and ensures the correct pairing between power source and device load. The 2-WISE concept promises to make process compliance easier and simpler for even mechanics or electricians to understand and deploy. This reduces the risk of accidents and ensures a safer working environment.

5. **Seamless Integration with Existing Ethernet Systems:**
   As a physical layer, APL is compatible with existing Ethernet-based systems and supports common industrial protocols. The NAMUR NE 168 recommends the use of EtherNet/IP and Profinet as the protocol over this physical layer. Both the ODVA and Profinet International have device specifications that allow for seamless integration into exiting higher layer ethernet networks. APL allows the connection between devices in the hazardous area to systems on the network in the safe area to communicate as long as the ethernet protocol used is the same at both ends.
   As an intelligent APL field switch, the monitoring the field devices load, as well as built in diagnostics on the managed network allow the switch to be treated as an asset with many additional insights available as to the performance and reliability of the entire APL system.

6. **Scalability and Flexibility:**
   The scalability of APL technology means it can be easily expanded as the number of possible connected field device assets grow. This flexibility ensures that asset administration can adapt to changing operational needs without significant overhauls. And as the technology of field devices is enhanced, the installed field switch is able to support these capabilities.

How will APL be installed?

The APL Project – a joint effort of the 4 Standards Development Organizations (SDO's) and twelve technology leaders in the process automation industry – was created in 2018 and dissolved in August 2022. The most important output of their work was the creation of a protocol-independent physical layer suitable for process automation industry using simplified intrinsically safe development techniques and criteria to satisfy the most demanding of process automation field instrument applications.

Two distinct topologies were developed as part of their coordinated efforts to ensure a universal platform for future development:

1. The **compact topology** is characterized by the star topology of the field devices with a maximum distance of 200 meters from the APL Field Switch ports. The APL Field Switch is suited for either safe zone, or Zone / Division 2 area. The connection to the field from the higher network is achieved with both copper (100 meters) and/ or fiber (more than 1,000 meters) using SFP modules. The ring structure allows such attributes as MRP (Media Redundant Protocol) to ensure high availability. Local Zone / Division 2 Power Supplies provide 24 Vdc power to the APL Field Switch.

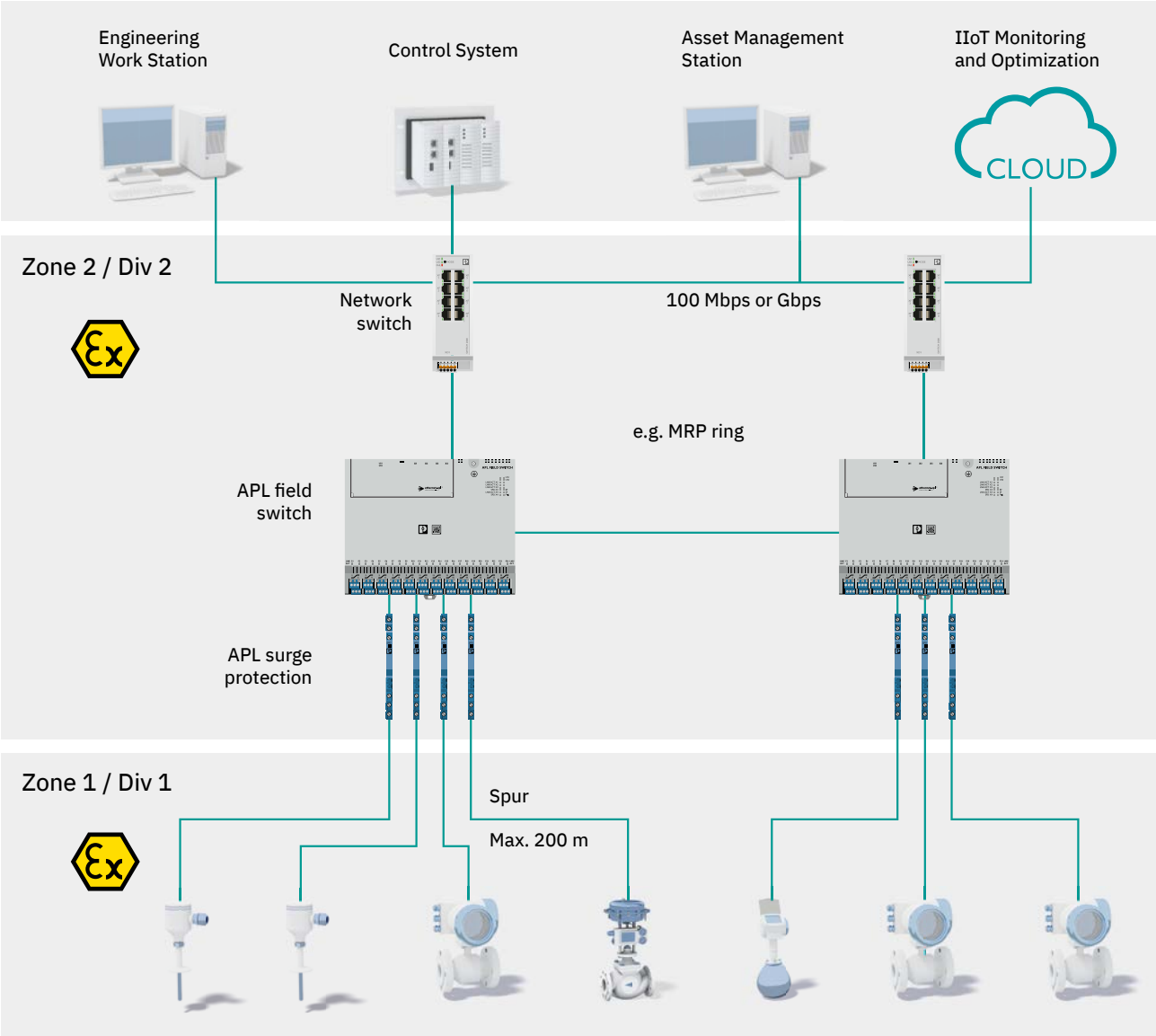

Figure 1: The compact topology

2. The **long-range topology** uses the well-known fieldbus technique of a trunk-spur layout. The APL design allows for a so-called cascade extension of a combined 1,000 meters from the APL Power Switch to the first APL Field Switch, through to a second APL Field Switch – both installed in Zone / Division 1.
   Phoenix Contact has presented its design concept for two Power Class 3 (57.5 W) ports on the Power Switch. Due to cable losses associated with the long reach, a reduced port count of the APL Field Switch in the Zone / Division 1 area is to be anticipated.

Here the power budget for all the equipment attached to the trunk / cascade segment is supplied from the APL Power Switch.

Initial developments of Ethernet APL eco-system components by the infrastructure providers have focused on the compact topology and the Zone / Division 2 installed Field Switch. Design Concepts for the Zone / Division 1 APL Field Switch were first shown in October 2021, and more customer input and use case requirements are needed to continue the product development.

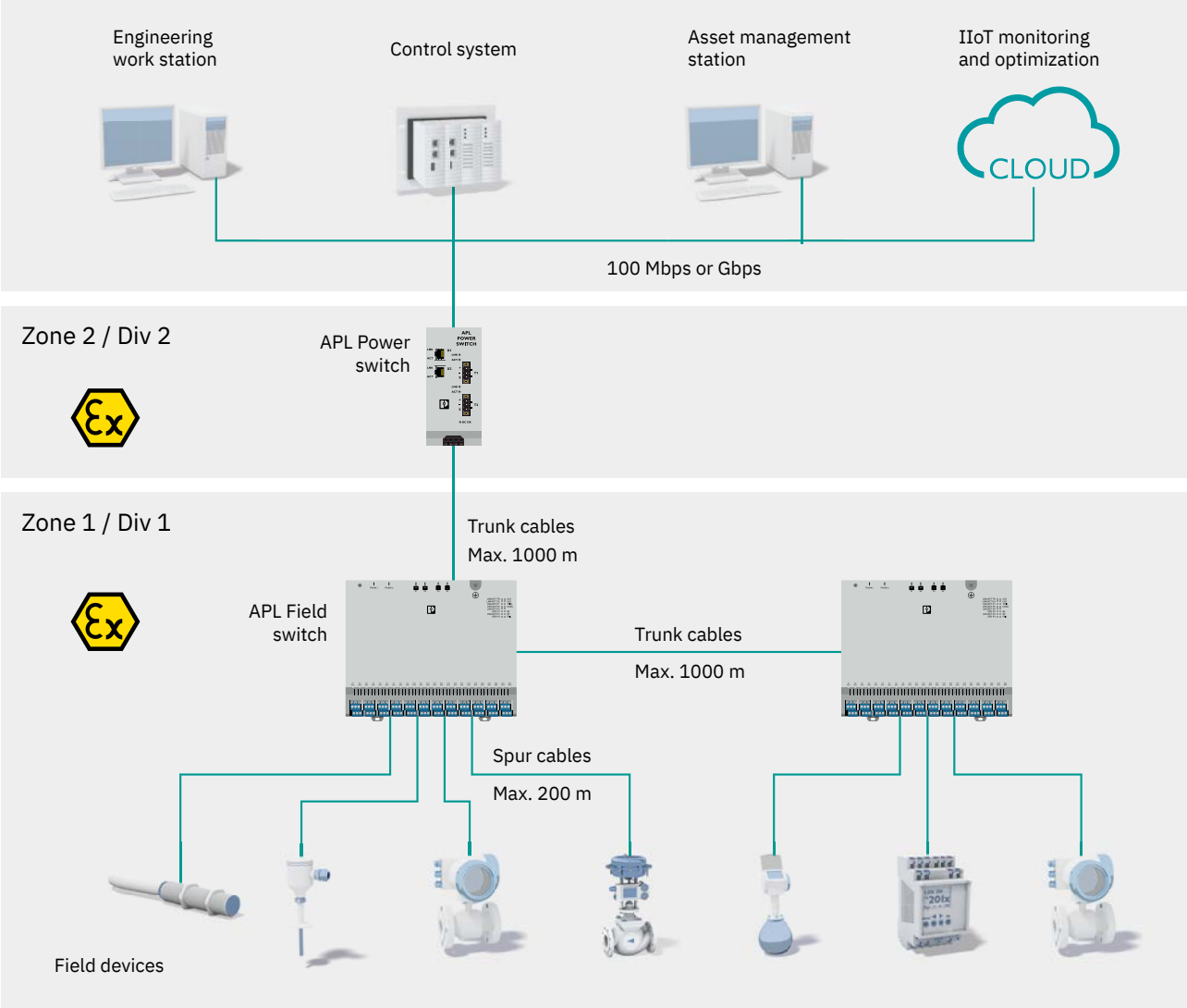

Figure 2: The long range topology

Simplified Intrinsically Safe Design criteria

The 2-WISE parameters are simpler in their protection class assessment compared to existing Entity parameters used in industry. While the Entity parameters are evaluated in a tabular form, and must be archived as reference for the future, the 2-WISE methodology requires the matching of just 4 parameters on either end of the cable – between the power load and the power source link.

Figure 3 illustrates the port classification scheme, which outlines various options for each class. The categories supporting Ethernet APL technology are shown from left to right. However, not all combinations of these options are possible. The permitted combinations are specified in the respective subclauses for each port class of the 2-WISE technical specification.

1. The segment classes are either (S): Spur (up to 200 metre cable length), or (T): Trunk (up to 1,000 metre cable length support).
2. Port classes define the port powering characteristic, either (P) Power source that provides power to a power load port, (L) Power load port requires power from a power source port, or (C) Cascade powered port which can be power source or power load port. Cascade ports can be used in a powered ring or in a powered daisy chain configuration on the trunk side of the Ethernet-APL Field Switch.
3. The power classes are the electrical characteristics of power source ports „P“, power load ports „L“ and cascade ports „C“. Power classes A and B are used for intrinsically safe rated

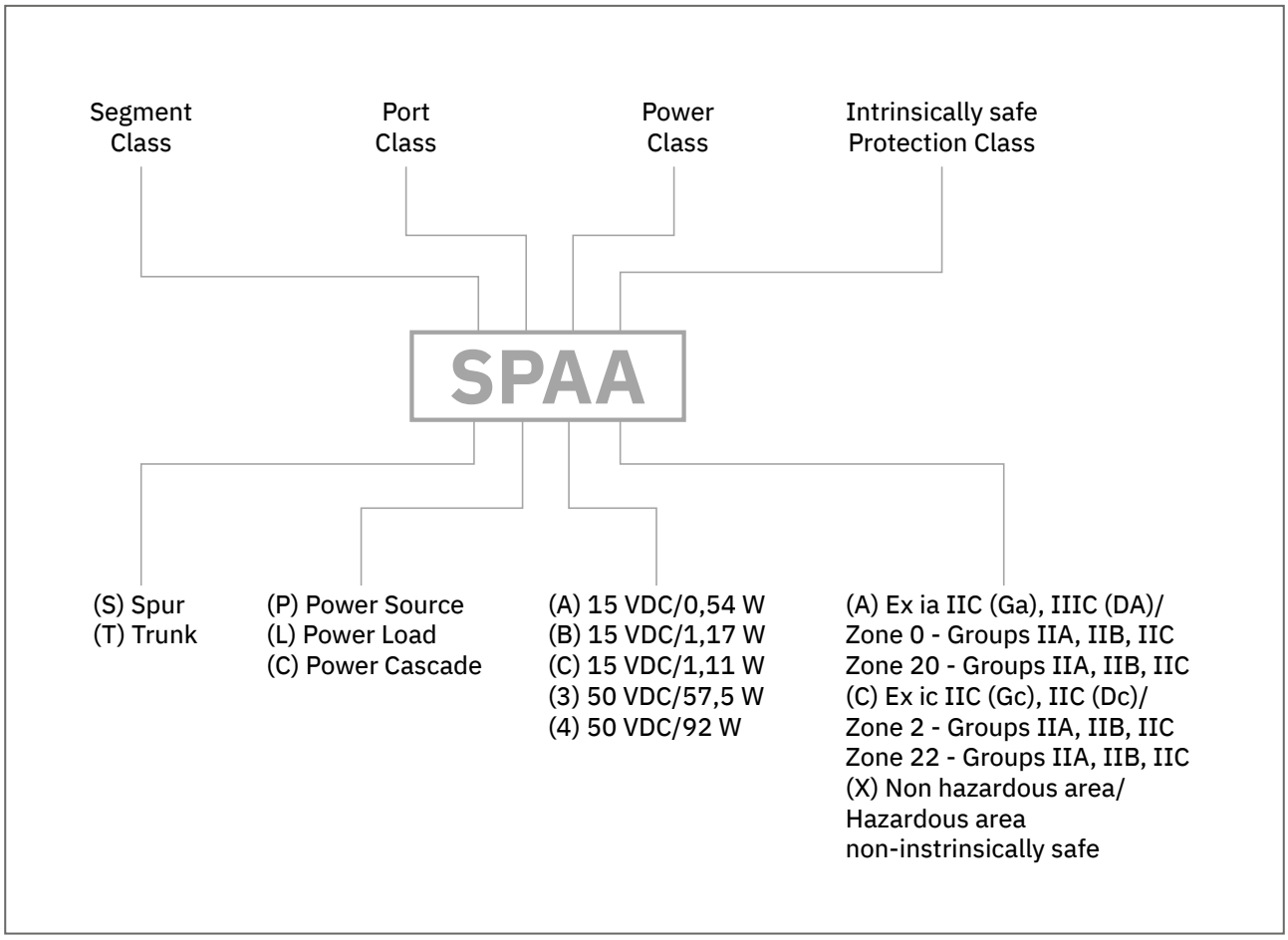

Figure 3: The 4-step Classification of 2-WISE interoperability (from the original Ethernet-APL draft)

spurs in the Ex ia area, and Power Class C supports the Ex ic application.
Power Class 3 & 4 is intended for the trunk segment of a long-range installation of APL Field Switches, like the trunk portion of a Fieldbus segment, and are non-intrinsically safe rated trunk ports.

4. The fourth parameter is the intrinsically safe protection class, which defines the protection level for the intrinsically safe use of a port circuit in both the Field Switch and the APL Field Device link. The various protection levels are detailed in the table below:

Intrinsically safe protection class	Definition
A	Intrinsically safe Ex ia IIC (Ga)/ IIIC (Da)
C	Intrinsically safe Ex ic IIC (Gc)/ IIIC (Dc)
X	Non-hazardous area/Hazardous area non-intrinsically safe

The initial launch of APL Field Switches and APL Field Devices all have supported the Power Class A attribute. To demonstrate the simplicity of the 2-WISE Hazardous Area Validation, the user needs to use an Ex ia rated Power Source and Power Load device on each end. The Port on the APL Field Switch would therefore be SPAA, and the matching pair on the APL Field Device would be SLAA. If both devices are 2-WISE and the appropriate cable is properly rated, no further calculations are required, and the link is ready for installation.

From a power matching perspective, an APL Field Device with classification SLAA can be connected to an APL Field Switch port with classification SPAA or SPBA – and still maintain the required intrinsically safe parameters.

An APL Field Switch with intrinsic safety protection Class C (Ex ic) can only be connected to devices in Zone 2, and by extension, an APL Field Switch with intrinsic safety protection class A (Ex ia) can be connected to a device in Zone 2, 1 or 0.

As the ecosystem of APL Field Devices expands, and more suppliers enter the market, more customer options will become available.

Without 2-WISE, an installer is required to examine the entity parameters of the Power Source, the Power Load, and the cable to then verify through calculations that combining these devices will not exceed safe limits required to ensure an intrinsically safe combination.

Key industry segments and applications to use APL technology

APL technology is ideal for a variety of end-users in the process industries, particularly those that operate in hazardous environments and require robust, reliable communication systems. Here are some key industry segments that should consider using APL technology:

1. **Chemical and Petrochemical Plants:**
   These plant processes involve flammable solvents or reactive chemicals. APL's 2-WISE intrinsic safety ensures safe communication in these sensitive environments. APL technology increases throughput – particularly in batch and continuous process applications – where set-up and menu download times reduce overall efficiency of the capital investment.

2. **Oil and Gas Industry:**
   From the beginning, and as a system enhancement over existing fieldbus technology, APL plays a crucial role in the oil and gas industry by providing intrinsic safety features that ensure secure communication in explosive environments, such as offshore platforms and refineries with exposure to corrosive gases like methane and hydrogen sulfide. Additionally, APL enhances the monitoring and diagnostics of critical systems, including pipeline pressure sensors and blowout preventers, helping to minimize equipment failure risks and maintain regulatory compliance.

3. **Pharmaceutical Manufacturing:**
   The first project deployed with APL technology is a pharmaceutical manufacturing plant. Here, APL ensures secure communication and monitoring in critical areas such as chemical mixing and processing, where volatile chemicals are used, and solvent storage areas, where flammable chemicals or explosive vapors are present, preventing sparks or energy surges that could trigger explosions or fires. Many other process industry technologists continue to observe the experiences and possible industry gains of this state-of-the-art reference site.

4. **Water and Wastewater Treatment:**
   With digesters and numerous treatment chemicals on-hand, the possible installation of APL's intrinsic safety ensures safe communication in crucial areas in the water and wastewater treatment. Applications include chemical dosing areas, sludge handling stations, and biogas production facilities, where flammable chemicals, combustible gases, or dry dust may pose significant explosion or fire risks.

5. **Alternative Fuels:**
   New energy sources such as Hydrogen, Methanol, Biogas, Biomass and Sustainable Aviation Fuels (SAF), as well as hazardous materials like Lithium as required in battery energy storage systems all require Ex-protection methods along their product life cycle. The use of Ethernet-APL is an essential element in all aspects of their production, transport, monitoring, storage and delivery.

6. **Regulatory Monitoring:**
   Real-time monitoring to fulfill regulatory obligations are essential to reduce the burden of fines, or potential enforcements like plant shutdowns would benefit from the long-range capability of APL. Applications such Methane monitoring and smokestack CO2 (and other hazardous gases), Leakage detection on pipelines and storage systems, as well as Air Quality are all possible with next generation field instruments. Due to the significantly larger data payload possible, APL devices normally used in laboratory applications can now be designed for in-situ and real-time monitoring applications.

Why Phoenix Contact developed an Ethernet-APL switch

Phoenix Contact has a distinguished 25-year history of facilitating the implementation and growth of Ethernet in industrial settings. Our efforts started first in the Factory Automation arena: both in the simple un-managed and more complex managed switch applications. Included are the techniques required in modern day ethernet applications such as remote monitoring, cyber security and industry specific attributes.

Our first Process Automation solutions were demonstrated at ACHEMA 2018. Together with in-house engineering and manufacturing expertise developed over the past decade including Fieldbus, FISCO, High Power Trunk and intrinsic safety, we became an active contributor of the APL Project.

Key outcomes in our first APL Field Switch development project were the following:

Figure 4: APL Field Switch from Phoenix Contact

1. **Global Certification Compliance:**
   Our Phoenix Contact switch is globally certified to meet end-user standards worldwide. The overall global market requirement of IECEx, and additional approvals such as ATEX for Europe, UKCAEx for the United Kingdom, CCCEx for China and UL / CUL for the North American market.

2. **Managed switch functionality:**
   The Layer 2 managed switch delivers robust and secure network management capabilities essential for industrial applications.
   - It offers multiple configuration options, including web-based management, CLI via Telnet/SSH, and SNMPv1/v2/v3, ensuring ease of use and comprehensive control.
   - Efficient IP assignment is supported through DCP, BootP, DHCP, and topology-based IP assignment via LLDP, while also preventing IP conflicts.
   - Data transmission is optimized with flow control and fiber monitoring protocols
   - Network traffic is prioritized using Class of Service and Profinet Protocol.
   - Redundancy features such as RSTP, fast ring detection, and MRP Client/Manager ensure network reliability and minimize downtime.
   - Security is a primary focus, with features like SSH/HTTPS for secure remote access, role-based user management, MAC-based port security, and server-based user authentication via LDAP and RADIUS.
   - The switch also supports multicast filtering with IGMP snooping and network segmentation through VLANs.
   - Time synchronization is maintained using SNTP, and comprehensive diagnostics tools, including port mirroring, event logging, RMON, and syslog, ensure network health and performance.

3. **Terminal Block Location/Orientation:**
   The field switch is installed in a junction box closer to the process than a typical DCS cabinet, and close to where the field instruments are connected. Standard cabinet design positions the cable gland entries at the bottom to prevent water ingress from pooling moisture. However, with digital communication, it's essential to maintain the cable's bend radius to avoid signal distortion or reflections. Our wiring approach reduces the complexity of routing wires inside the junction box by allowing direct wiring to the terminal block. Visually and practically, the network connections are positioned on the one side of the APL Switch, and the field terminations on the opposite side of the switch (and mounting rail) to keep the network wiring and field wiring separated. Strain relief can be applied, either through a clamp inside the control box or by properly torquing the cable gland to the appropriate rating. This ensures the cable is not bent beyond its acceptable installation limits.

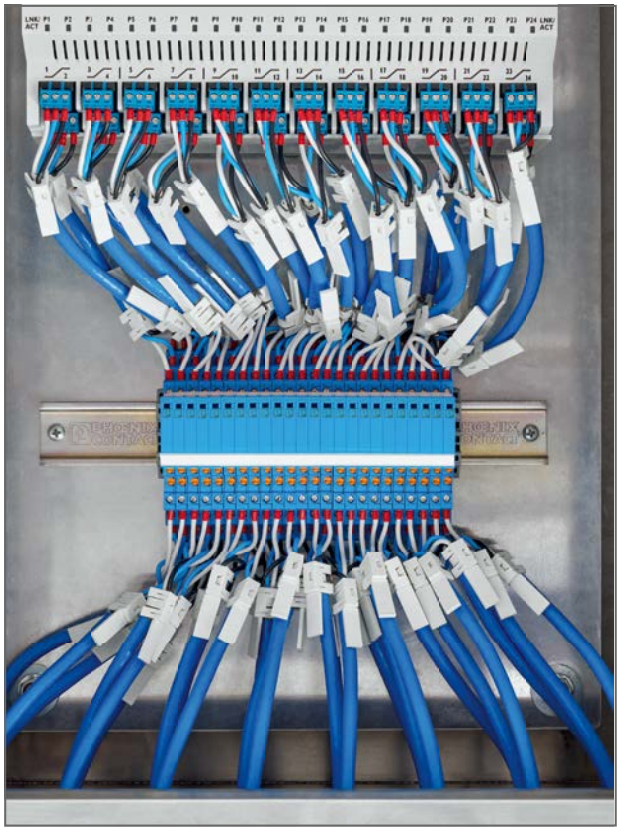

Figure 5: Direct wiring to the terminal block

4. **Advanced Diagnostics and Interface Capabilities of the APL Switch:**
   - Physical Layer Diagnostics via Web-Based Management (WBM) of the connected APL Field Devices including power-related diagnostics, including voltage, current, and signal quality indicators (SQI).
   - Network Diagnostics through WBM and SNMP: Monitoring packet integrity and port status to ensure reliable network performance.
   - Application Layer Integration: Seamless interfacing enabled through FDI (Field Device Integration) and DTM (Device Type Manager) technologies.
   - PROFINET Device-Level Diagnostics: Comprehensive diagnostics utilizing GSDML (General Station Description Markup Language) for enhanced device monitoring.
   - Management System Support: Access interfaces designed to facilitate and streamline integration with management systems.

› Find more information about the APL Switch here: phoe.co/ethernet-apl-switch

Conclusion

To sum up, the integration of Advanced Physical Layer (APL) technology into process industries marks a transformative shift towards more efficient and safer operations. APL‘s ability to provide high-speed Ethernet communication for field process instruments and power over a single two-wire cable simplifies network infrastructure and enhances data collection, diagnostics, and maintenance. Embracing APL technology will streamline processes and ensure compliance with safety standards, paving the way for a more connected and resilient industrial future for the process automation market in both heavy and light configurations.

Contact

Talk to us
For more information, please get in contact with us and review the various documents listed on the Ethernet-APL website, including the Engineering Guideline at: https://www.ethernet-apl.org/document/ethernet-apl-engineering-guidelines/

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