Ethernet

OMNIMATE® Data Ethernet-APL
Reliably connecting field devices in the process industry

Whitepaper

Content

1. Introduction

Already today the device manufacturers are facing more and more challenges. Space is limited and devices are designed smaller and smaller, while performance is increasing. Accordingly, the connection technology with a more compact size must transmit high currents, signals and data reliably and with the lowest possible losses to the printed circuit board and ensure a mechanically stable connection. At the same time, it is important to make handling safer and more convenient. For this the individual components need to be reliable and the product selection has to be efficient and future proof.

In the factory of the future in particular, machines and systems will be continuously connected to each other via a consistent data infrastructure. To support digitization in industry, Weidmüller has therefore extensively expanded its important portfolio of data connectors.

Figure 1: Overview of the Ethernet-APL portfolio from Weidmüller

Especially in the process industry, Ethernet-compatible interfaces are increasingly needed to access data from the field via IIoT. While digitization only partially touched the process industry so far, the new technology Ethernet-APL (Advanced Physical Layer) now enables direct access down to the field and device level via an internationally standardized two-wire solution. This requires efficient IIoT devices with qualified components.

2. What is Ethernet-APL?

Ethernet-APL stands for Ethernet Advanced Physical Layer and describes a physical layer for Ethernet-based communication that meets the special requirements of the process industry. As already in the industrial environment, it is increasingly necessary to transmit power and communication signals over long distances at high speed also in the process industry. So far, there has been no consistent standard for collecting information from the field level efficiently, which is based on cost-effective, space- and weight-saving components. While Industrial Ethernet represents the common standard in industry and connects devices to the Industrial Internet of Things (IIoT) or Industry 4.0, it is thanks to Ethernet-APL now also for the process industry possible to transfer various data from sensors and different field devices and make them available in the cloud on an easy and efficient way.

Ethernet-APL offers a high level of security and reliability, especially for the demanding requirements of the different applications in the process industry. Technologically, a two-wire cable is used, which can connect distant devices through different connection technologies. This two-wire Ethernet is based on the 10BASE-T1L standard according to IEEE 802.3cg with additional protective measures for the process industry, of which some also enable connection within potentially explosive areas.

There is a development from the automation pyramid to the automation network. The following figure illustrates the integration of individual devices via Ethernet and Ethernet-APL from different (field) levels into the company network with cloud connection:
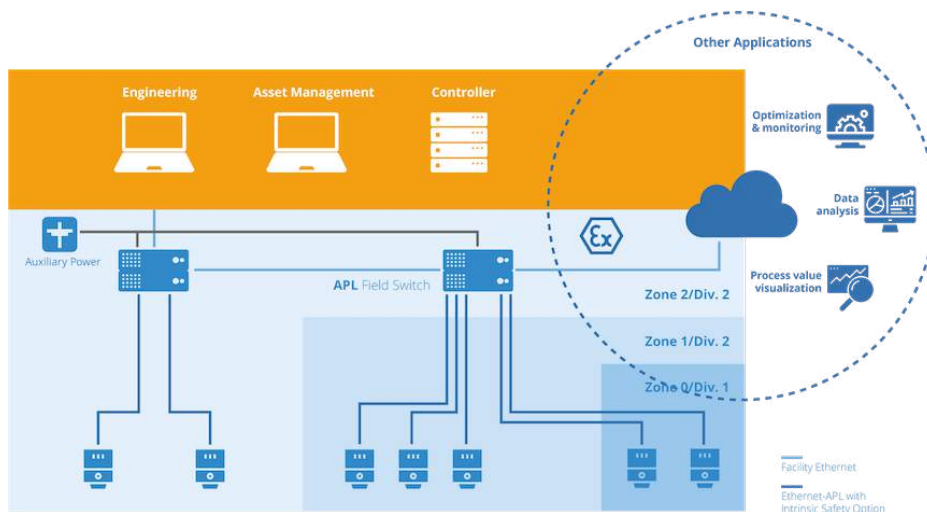

Figure 2: Networking of the entire automation pyramid (Source: www.ethernet-apl.org

Within the APL specification there are certain tests and guidelines for port classification and component requirements, network configuration rules including cabling and electromagnetic compatibility, derived from the IEEE 802.3cg and 10BASE-T1L standard. Important test parameters are the voltage test, derating, contact resistance, insertion loss, return loss and PS ANEXT (Power Sum Alien Next). The following figures clearly show the relevant limits/thresholds:

Return Loss
Ethernet-APL Network and Port Requirements
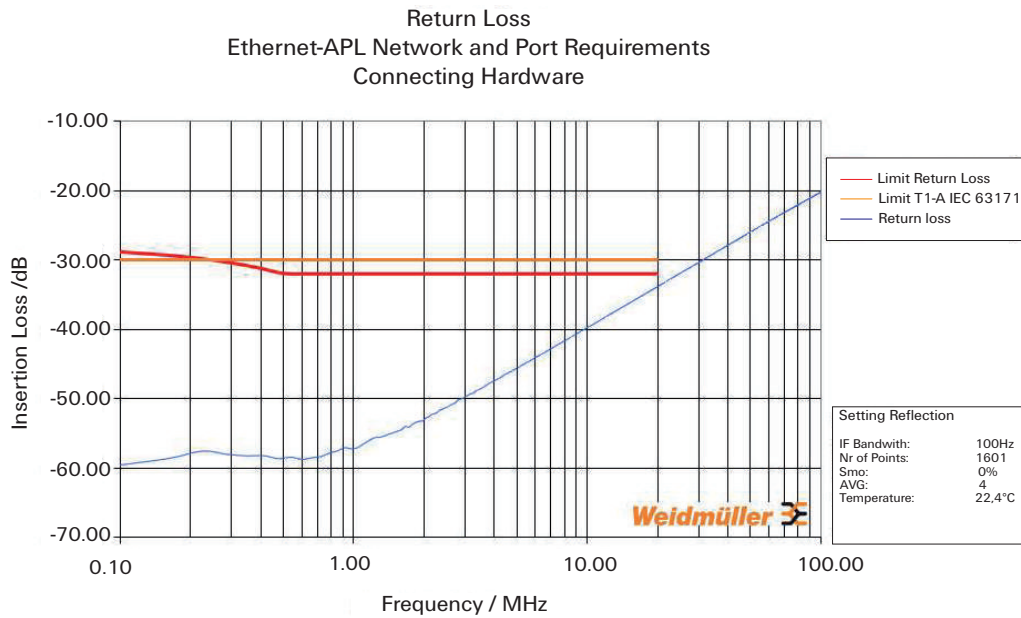**Connecting Hardware**

Figure 3: Limits/Thresholds Return Loss

Return Loss: In a reflection a part of the signal is reflected by an impedance difference. As the impedance depends on the frequency, the reflection also depends on the frequency. The return loss is given in dB and expresses the logarithmic ratio between the reflected signal and the input signal. The greater the return loss, the better the impedance match. Return loss is particularly important for applications with simultaneous transmission in two directions.

Insertion Loss
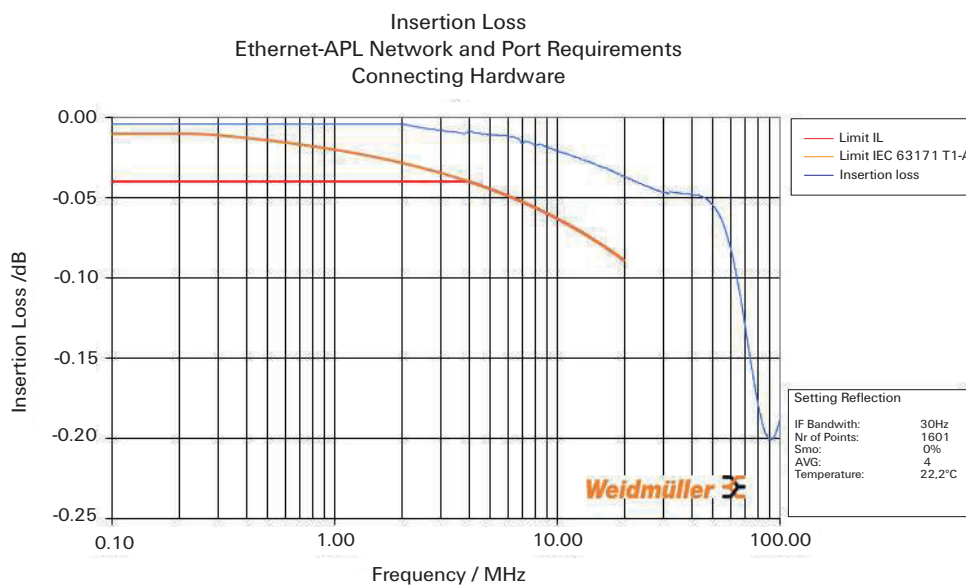**Ethernet-APL Network and Port Requirements**
Connecting Hardware

Figure 4: Limits/Thresholds Insertion Loss

Insertion Loss: A balanced input signal is applied at the near end of a pair's cabling link, while the differential signal is measured at the far end of the same pair. The attenuation is specified as a logarithmic ratio of input to output power of a two-port network in decibels (dB)..
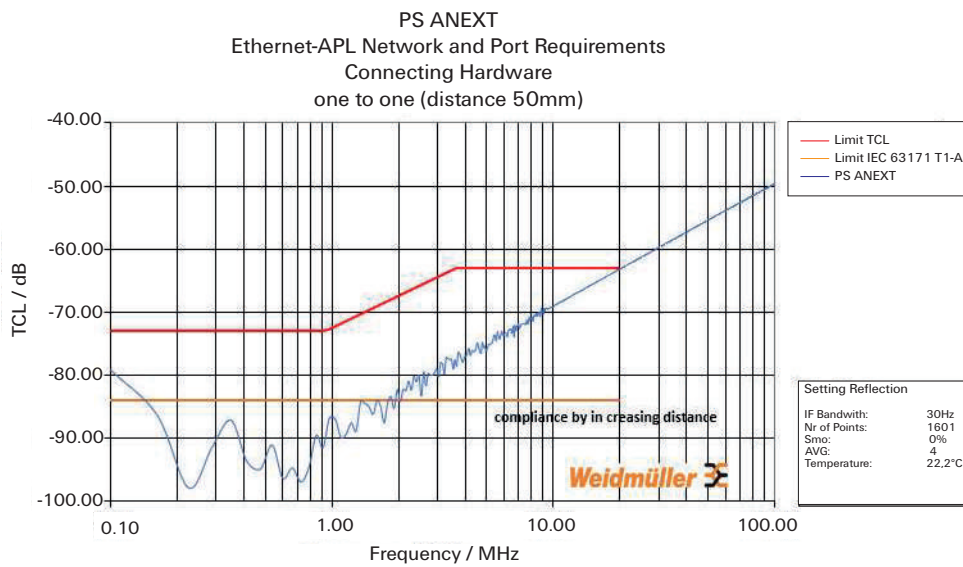

Figure 5: Limits/Thresholds PS ANEXT

Power Sum Alien Next (PS ANEXT): The ANEXT contributions to a total PS ANEXT are measured by injecting a near-end signal into a wire pair of a noisy link technology and measuring the injected signal at the near-end of a noisy link technology. This process must be repeated for each pair of conductors in an interfering connection technology and for all other connection technologies in the vicinity. The PS ANEXT for each wire pair in a faulty link technology is obtained by summing the power of the ANEXT results on the wire pair from all wire pairs in faulty link technology from the environment.

The individual test components must contain the requirements of the APL specification in order to be qualified for Ethernet APL. The measurement results must be reproducible with the corresponding components.

3. **What is the advantage of Ethernet-APL for the process industry?**

Also in the process industry there is the challenge that information from sensors and devices in the field is required, with large distances having to be bridged. In addition, various IIoT devices must be integrated into the network infrastructure. Meanwhile there is only limited space in the device. To be able to access the data in the field reliably and directly also in the process industry, a continuous connection without interruption or protocol conversion is needed. The following figure provides an overview of individual advantages for the process industry:

Advantages of Ethernet-APL for the process industry

• Consistent Connection from the sensor to the cloud

• Direct connection via two-wire solution leads to less material expenses and cost reduction

• Access to the field level, sometimes also in the hazardous area

• 10 Mbit/s Communication for long distances according to IEEE 802.3cg-2019

• PoDL (Power over dataline) – remote powering according to IEEE 802.3bu

• Bridging large distances of up to 1.000 m

• Increased system availability through information on individual devices

• Production- and plant data is available immediately

Ethernet-APL is an easy solution for a fast and efficient communication between the field level and the cloud. The physical layer of the communication system gets standardized and provides information on the system status in real-time. Ethernet-APL enables direct connection via a two-wire solution using low-cost printed circuit board components. The use of only two wires results in less material expenses for the cable and an overall cost reduction. If classic terminals are also used instead of connectors, further costs and space in the device can be saved.
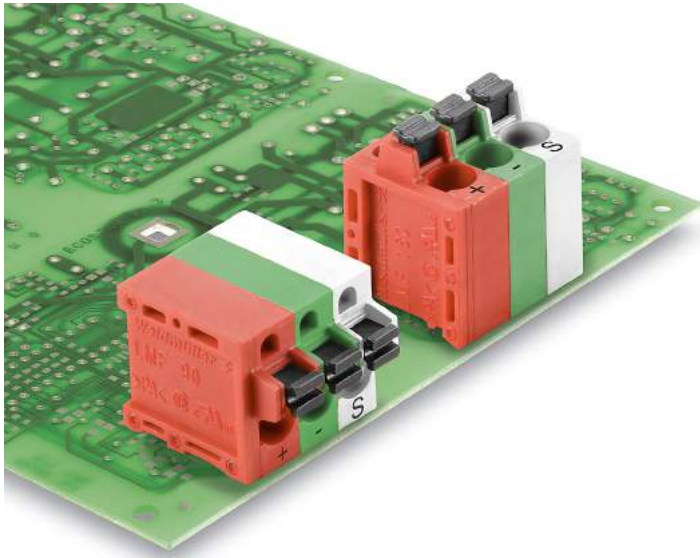
Figure 7: Ethernet-APL PCB-Terminals

It is also possible to bridge large distances of up to 1,000 m via Ethernet-APL, while data and voltage can be transmitted on just one line at the same time (PoDL).
Overall, this leads to increased system availability and production data: The collection, use and analysis of data from devices in the field is possible without any problems to ensure and increase system availability and to implement new solutions.
Another advantage of Ethernet-APL is the ease of the installation. Existing systems and installations do not have to be replaced, which promises further costs savings. Via Ethernet-APL the different devices and sensors from the field can be connected to all common Ethernet-based systems, without protocol conversion between the interfaces.

4. Is Ethernet-APL only for hazardous areas?

Is Ethernet-APL only for hazardous areas and requires explosive approvals? In the process industry, Ethernet-compatible interfaces are increasingly needed to access data from the field via IIoT. This can certainly also affect the dangerous areas of the systems, where special self-protection and corresponding approvals are necessary. But not only there!
Also in the process industry there are still many sensors and devices in the field outside of the hazardous areas that have not yet been connected via Ethernet. For a large number of applications, there is the possibility of connecting various IIoT devices via Ethernet-APL and integrating them into networks with the common protocols such as PROFINET, EtherNet/IP or EtherCAT.

5. Differences between Ethernet-APL and Single Pair Ethernet (SPE)

You may rise the questions, what is the difference between Ethernet-APL and Single Pair Ethernet (SPE)? Both are a two-wire Ethernet-technology, isn't it the same?
In fact, Ethernet-APL is a part of Single Pair Ethernet. In the process industry, Ethernet-compatible interfaces are increasingly needed to access data from the field via IIoT, too. Single Pair Ethernet describes different Ethernet standards, which are all based on a two-wire technology: 10Base-T1S, 10Base-T1L, 100Base-T1, 1000Base-T1. With these standards different transmission speeds are described from 10 Mbit/s up to 10 Gbit/s and a cable length from 15 m to 1000 m.
Herein Ethernet-APL is a dedicated definition of 10Base-T1L and needs qualified components which allow reliable data transmission at 10 Mbit/s and simultaneous power supply via twisted pair cable up to 1,000 m. You can say that Ethernet-APL is the Single Pair Ethernet for the process industry. Within the Ethernet standard certain requirements were added to describe characteristics of cables and plugs, power supply and explosion protection in hazardous areas. While Single Pair Ethernet will mainly be used in factory automation and building infrastructure, Ethernet-APL was specifically developed for the process automation industry and the components need to fulfil the special requirements in that area. The following overview shows the differences between SPE and Ethernet-APL:

	Single Pair Ethernet	Ethernet-APL
Technology	Two-wire technology	Two-wire technology
Ethernet standards	10Base-T1S, 10Base-T1L, 100Base-T1, 1000Base-T1	Dedicated definition of 10Base-T1L
Data transmission	10 Mbit/s up to 10 Gbit/s	10 Mbit/s
Cable length	15 m to 1,000 m	up to 1,000 m
Main application	Factory automation and building infrastructure	Specifically developed for the process industry
Special features	Miniaturisation, Industrial suitability, Simplicity, Future-proof	Certain requirements were added to the standard to describe characteristics of cables and plugs, power supply and explosion protection in hazardous areas.
Connection technology and our offer	Connectors with miniaturized mating faces, patch cables, field attachable plugs, M8 adapters as well as IP20 and IP67 sockets in different outlet directions	Classical terminals with screw or tension spring connection, like OMNIMATE® PCB components, built-in and field attachable plugs (M12).

Luckily, Weidmüller can deliver components for both application fields.

For Single Pair Ethernet for industry and building automation mainly considers connectors with miniaturized mating faces, patch cables, field attachable plugs, M8 adapters as well as IP20 and IP67 sockets in different outlet directions.

Figure 9: Weidmüller's SPE portfolio

Regarding Ethernet-APL the process industry relies on classical terminals with screw or tension spring connection. Here Weidmüller offers a variety of components, which are qualified for Ethernet-APL, like OMNIMATE® PCB components, built-in and field attachable plugs (M12).

Figure 10: Weidmüller's Ethernet-APL portfolio

6. What do I need Ethernet-APL components for as a IIoT Device Manufacturer?

If you as an IIoT device manufacturer are active in the process industry and develop devices specifically for this area, then the topic of Ethernet APL will play a major role for you in the future. It is still a new standard, but the first applications and devices are already available. Digitization is progressing continuously and connecting more and more devices and sensors to the cloud and the IIoT, also in the process industry.

When you have the challenge in the process industry to integrate IIOT devices into the network infrastructure, our Ethernet-APL components can help you with Ethernet-compatible high-speed data transmission with a top performance of 10 Mbit/s. Ethernet-APL enables direct connection via a two-wire solution using economic PCB components. Within compact devices there is limited space for RJ45 or M12 connectors. The Ethernet-APL PCB components reduce space and weight.

7. Is there also a benefit in building infrastructure?

Although the process industry is the target market for Ethernet-APL, our components can also support you to integrate IOT devices into the building network infrastructure and cover long distances. Especially when you need economic alternatives to compact connectors or RJ45 jacks.

In system architectures with consistent and direct communication, up to 50 devices can be supplied with up to 60 W. By this, various sensors can be integrated to enable access controls, intrusion detection or the control of sun protection modules.

For this the communication between sensor and cloud works via Ethernet-APL. Further advantages are the miniaturization of the communication infrastructure as well as the reduced cabling effort and low installation costs.

8. What is Weidmüller's offer for Ethernet-APL?

Weidmüller offers a variety of components, which are qualified for Ethernet-APL. This includes OMNIMATE® PCB components, built-in and field attachable plugs. They provide a reliable connection to field devices using two-wire technology. This makes plant data available in real time. Weidmüller offers the individual components with tried and tested connection technologies. Thanks to their colour-coded markings an intuitive and error-free wiring is supported.

Fast data transmission

The qualified products by Weidmüller meet the high requirements of the process industry. They allow reliable data transmission at 10 Mbit/s and simultaneous power supply via twisted pair cable up to 1,000 m.

Figure 11: Example of a process plant

Wide range of applications

Ethernet-APL is suitable for all IIoT devices and is compatible with all common protocols such as PROFINET, EtherNet/IP, or EtherCAT. Especially the Ethernet-APL PCB components are a cost-effective alternative to conventional RJ45 and M12 connections. Furthermore the portfolio is expanded more and more.

Figure 12: Colour-coded markings facilitate the installation

Proven connection technologies

OMNIMATE® PCB components are optionally available with PUSH IN, SNAP IN, clamping yoke and tension spring connections, all built for high levels of contact and vibration safety. Colour-coded markings facilitate error-free installation.

Figure 13: Different connection technologies

As the inventor of the PCB terminal and technology leader in device connection technology, Weidmüller not only offers high-quality components for Ethernet-APL and other connection options, but also unique design-in services that promise real added value for your device design. Within the entire design-in process, Weidmüller provides support with the required information about the products and possible uses, technical details and product data. The online catalogue, a free sample service and the AppGuide also help device manufacturers to find the right products for individual requirements and applications.

Advantages of Weidmüllers's Ethernet-APL components

- Ethernet-APL compliant connection from the PCB to the field

- 10 Mbit/s communication for long ranges according to IEEE 802.3cg-2019

- PoDL (Power over data line) remote power supply according to IEEE 802.3bu

- Available with PUSH IN, SNAP IN, clamping yoke or tension spring connection

- Suitable for THT and THR soldering processes with space and weight saving design

- Corresponding shield connection clamp available as an accessory

9. Summary and conclusion

In the process industry, Ethernet-compatible interfaces are increasingly required in order to be able to access data from the field via IIoT. While Single Pair Ethernet is primarily used in factory automation and building infrastructure, the specific Ethernet-APL standard was created for the process industry. This makes it possible to integrate data from devices and sensors in the field into the company network and the cloud. Derived from the 10Base-T1L standard, a specific version enables access to an additional physical layer via Ethernet. For this reason, Ethernet-APL can also be referred to as THE Single Pair Ethernet for the process industry.

The individual components and devices must meet special requirements that are described in the APL guideline. Certain specifications must be complied with and the Single Pair Ethernet standard has been expanded to include a number of safety-related aspects, which is particularly important for this industrial segment. The reliable connection of individual field devices is made exclusively by qualified components, including printed circuit board components, built-in connectors and field attachable connectors that can be assembled in the field in various forms. Entry into the wide field of IIoT should be kept as simple as possible for the user, so that compatibility with common protocols such as PROFINET, EtherNet/IP or EtherCAT must be guaranteed. This results in a wide range of applications and uses for the device manufacturer and end user. The connection technology and cabling must also be intuitive, quick and easy to avoid errors. Errors would lead to a stop in production, which must be avoided at all costs in the process industry. For this reason, Ethernet-APL can help to read out critical data in good time and ensure system availability.

The first products are currently available on the market, components have been qualified and the first devices are being developed. It may still take a while before it is used across the whole process landscape, but it is clear that digitization is progressing unstoppably and everything is gradually being connected to the IIoT.

Weidmüller is your partner in this exciting topic and is already offering the first qualified components. The portfolio is constantly being expanded and gives you new options when designing your devices.

Further information:
https://www.weidmueller.com/int/products/connectivity/pcb_terminals_and_connectors/omnimate_ethernet_apl_components.jsp

Contact: PCB.components@weidmueller.de

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