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The Journal of Industrial Networking & IIoT

Special Supplement

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Ethernet-APL

The leading companies in process automation are working together under the umbrella of PROFIBUS and PROFINET International (PI), ODVA, and FieldComm Group to make Ethernet-APL work across Industrial Ethernet protocols and to accelerate its deployment. In this issue, IEN presets unprecedented cover age on Ethernet-APL, how it works and potential applications in the process industry.

Beginning on page 6, we present our cover story "Single Pair Ethernet and Ethernet-APL Moving Ahead" which provides the viewpoint of six industry experts weighing in on the development of two-wire Ethernet technology.

"SPE and Ethernet-APL use the same easy installation technology as today; two wire for data transfer and power supply but with higher transmission speed and longer distances. In addition, because both are neutral Physical Layer solutions supporting Ethernet, any Ethernet based protocol can run on them. So, no conversion is necessary. SPE and Ethernet-APL now give the possibility to have access to data from the top to the field," Dr. Jörg Hähniche, project manager for the APL Project, told IEB.

Bob Voss, Distinguished Engineer in PANDUIT Corporate Research and Development told IEB that Single Pair Ethernet (SPE) and Ethernet-APL are important technologies poised to advance automation and control networking solutions.

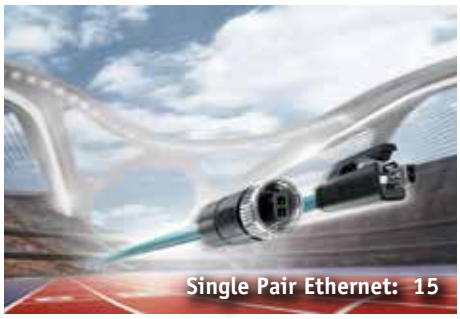
"What both technologies do is create a uniform physical layer at the edge of Industrial networks, capable of transporting all industrial Ethernet variants, nearly the 'one ring to rule them all' scenario," Voss said. "When deploying SPE or Ethernet-APL, legacy edge protocols are replaced, upgrading the speed, performance, and security of the 2network edge. Also, as the network edge has become the final frontier for Ethernet, the ideal state of a single, seamless protocol from cloud to edge, is realized."

Dr. Al Beydoun, President and Executive Director at ODVA, said a vast number of new possibilities are opened up via network connectivity including fast identification of failures via standard diagnostics or monitoring of devices for out-of-range operation to both predict premature failure and reduce negative impacts on quality.

Other articles that you should check out include "Ethernet-APL: actionable insights for process automation" (page 18) and "Networks for process automation using two-wire Ethernet-APL" beginning on page 21.

All in all, Ethernet-APL has the potential to make a major impact on process industry factory networks. IEB will continue to provide expansive coverage of this technology as new products and application successes roll out.

Al Presher



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Industrial Ethernet Book

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Red Lion Controls expands secure remote access offering

The MB connect line of highly secured hardware and software solutions will enhance Red Lion's modular and rugged industrial automation and networking technology.

RED LION CONTROLS, AN OPERATING COMPANY of UK-based Spectris plc, has announced the acquisition of MB connect line GmbH, a leading provider of secure connection of machines and plants for remote access, data collection, and M2M-communication.

The addition of MB connect line supports Red Lion's strategy to deliver secure, easy-to-use edge connectivity solutions - enabling organizations worldwide to gain secure real-time data visibility that drives productivity.

MB connect line is a recognized leader of Secure Remote Access, Industrial IoT, and Industrial Security services. MB connect line's highly secured hardware and software solutions enhance Red Lion's modular and rugged industrial automation and networking technology.

The addition of MB connect line builds on the strategic collaboration announced between the two companies in 2019. The acquisition expands Red Lion's portfolio by adding a full complement of products from an industry recognized leader in industrial cyber-security and offers customers a Remote Service Portal for remote monitoring and remote configuration. Customers will be able to meet the demands of industrial environments and strengthen their operational resiliency with secure remote access solutions.

SOURCE: RED LION CONTROLS

5G high bandwidth and low latency is driving process industries to partner with strategic 5G providers.

"Red Lion Controls and MB connect line are a powerful combination. With a shared focus on secure connectivity solutions, we will be better positioned to serve our customers seeking to strengthen their operational resiliency with the convergence of Information Technology and Operations Technology. Red Lion is very excited about starting this new chapter, supporting customers with a broader product offering and greater technical resources," stated Jack Lee, President of Red Lion Controls.

"With the acquisition of MB connect line by Red Lion Controls, we are taking the next step in our successful partnership. MB connect line will continue to expand its comprehensive portfolio of solutions for secure remote maintenance and networking as well as edge and cloud connectivity. MB connect line is very excited to work together with Red Lion Controls to provide the best solutions for the digital transformation in the industry - and to benefit from Red Lion Controls' strong global presence," stated Siegfried Müller, CEO and founder of MB connect line.

*News report by **Red Lion Controls**.*

Registration of first process automation FDI Host System

FieldComm Group announced that Emerson's AMS Device Manager has successfully completed conformance requirements testing under FieldComm Group's FDI Technology Host Registration Policy. Thus, AMS Device Manager became the first FDI host system to earn the right to display the FDI registration logo.

By pairing a registered FDI Device Package with a registered FDI host, end users are assured of achieving the multi-vendor interoperability FDI promise of "One Device – One Package – All Tools." In practice, this means any HART device supporting FDI will communicate seamlessly with AMS Device Manager, and with future host systems as these become registered.

"This is a monumental achievement for FDI technology and Emerson," says Ted Masters, President and CEO of FieldComm Group. "Over the past several years we have registered over 100 FDI Device Packages. However, the requirements for host registration are extremely rigorous to ensure compatibility among devices and hosts, making this advancement by Emerson very significant."

SOURCE: FIELDCOMM

5G high bandwidth and low latency is driving process industries to partner with strategic 5G providers.

There are several steps required when preparing host systems for conformance testing against current standards. An FDI host must conform to at least the HART Protocol test specification for host systems, in addition to the FDI specifications.

End users benefit because FDI is the preferred path to digital transformation in the process industry, and conforming host systems provide everything needed to advance existing HART process automation infrastructure, while delivering the latest offerings of new instrumentation with data rich FDI Device Packages.

*News report by **FieldComm**.*

The C7015: bringing multi-core in IP65 directly to the machine

Up to four cores in IP65: with its extremely robust, fanless C7015 ultra-compact Industrial PC, Beckhoff as a specialist in PC-based control technology offers the possibility to install a high-performance Industrial PC in a highly compact design directly at the machine. Versatile on-board interfaces enable connection to the cloud or to other networks. Thanks to the integration of an EtherCAT P interface, further EtherCAT P modules can be connected directly to the C7015. This provides the possibility of automation close to the machine. The integrated Intel Atom® CPU with up to four cores allows simultaneous automation, visualization, and communication in demanding industrial IP65 applications. In addition to classic control tasks, the C7015 is ideally suited for use as a gateway to connect machines and plant sections – and can even handle complex preprocessing of large data volumes thanks to its high processing power.

3 x LAN, 2 x USB, Mini DisplayPort and integrated EtherCAT P port

Scan to discover the full range of applications for the C7015

New Automation Technology **BECKHOFF**

Single Pair Ethernet and Ethernet-APL moving ahead

Industry experts provide their perspective on the development of Single Pair Ethernet and Ethernet-APL. Learn about the potential benefits and the work to be done to achieve what has become an ambitious vision that will ultimately shape the scope and future of Industrial Ethernet connectivity.

SOURCE: SIEMENS

In process automation, many plants are equipped with 4-20 mA with HART or fieldbus installations. Both solutions have limited transmission speed and need conversion to be integrated into upper layers of the automation pyramid.

SINGLE PAIR ETHERNET and ETHERNET-APL are in the process of redefining Ethernet connectivity solutions. In this special report, IEB reached out to industry experts to get their insights into the development of SPE and Ethernet Advanced Physical Layer to gain their perspectives on the megatrends and applications shaping and enabling development of these important technologies.

The consensus of the group is that two-wire Ethernet solutions offer a broad set of benefits that are vital to achieving digital transformation and Industry 4.0 objectives.

SPE and Ethernet-APL are base technologies, for example, that offer possibilities for high speed data transfer compared to today's analog or fieldbus solutions. Due to good transmission properties, even over longer distances, SPE optimally supports future-proof network communication. With the trend towards resource-saving, miniaturized devices, SPE offers more space for electronics thanks to space-saving cables.

Single Pair Ethernet (SPE) also allows for cost and size reductions in Ethernet PHYs, cable and connectors that enables cost effective connectivity for smaller devices. This opens up the possibility to connect simple devices to Ethernet that were previously only hardwired or controlled via fieldbus technology.

The list of potential benefits is long but there is still a lot of work to be done to achieve what has become an ambitious vision shaping the future of Ethernet connectivity

SPE and Ethernet-APL

High speed data transfers from the field

Today, everyone is talking about "Digitalization" and "Industry 4.0". That means a lot of data from the field needs to be transferred to the upper layer of the automation pyramid in order to use digitalization for plant optimization and increasing productivity and efficiency.

"In order to digitally transform industry, adequate technologies should be in place to provide the amount of data from the field. SPE and Ethernet-APL are base technologies that give the possibilities to transfer data from the field in a very sufficient way with high speed compared to today's Analog (4-29 mA) or fieldbus solutions," Dr. Jörg Hähniche, project manager for the APL Project, told IEB recently.

From the process automation point of view, many plants are equipped with 4-20 mA with HART or fieldbus installations. Both solutions have limited transmission speed and need conversion to be integrated into upper layers of the automation pyramid.

"SPE and Ethernet-APL use the same easy installation technology as today; two wire for data transfer and power supply but with higher transmission speed and longer distances. In addition, because both are neutral Physical Layer solutions supporting Ethernet, any Ethernet based protocol can run

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SOURCE: ISTOCK

Automotive Ethernet simplifies cabling and saves weight. Many of these advantages can also be transferred to industrial applications.

on them. So, no conversion is necessary. SPE and Ethernet-APL now give the possibility to have access to data from the top to the field," Hähniche said.

Networking impact

Hähniche said that both SPE and Ethernet-APL use switch technology. For Ethernet-APL in particular, two types of switches have been determined: both an APL Power Switch and APL Field Switch.

An APL Power Switch is able to provide the power for a segment that consists of APL Field Switches and up to 50 field devices. An APL Field Switch connects the field devices in the field. In Process Automation "field" means especially in hazardous, high explosive areas.

Because of the point-to-point connection between field devices and APL Field Switches, finding any problems in connectivity is easy since Field Switches are able to provide appropriate diagnosis information to the user.

Furthermore, Ethernet-APL uses existing cable specification – the so-called Fieldbus cable. That simplifies the introduction of Ethernet-APL because no specific cable needs to specified.

Focus on process industries

"Ethernet-APL has been developed specifically for the Process Automation industry. Standard Ethernet solutions cannot be used in the field of Chemical plants because of their specific requirements - protection against explosive atmosphere, long distance and 2-wire technology to connect field devices," Hähniche added.

"Ethernet-APL meets these specific requirements and gives the possibility to bring all the advantages of Ethernet down to the field. Based on the high bandwidth (10 Mbit/s transmission speed) use cases can now be fulfilled that were not possible with fieldbus solutions. Since Ethernet-APL is a neutral Physical Layer any Ethernet-based protocol can run on it, also in parallel based on the high bandwidth."

Based on the new technology, the access to the available information in the field is much easier than with today's solutions. In addition, a further advantage is now the homogeneous network technology from top of the plant to the bottom (field). This makes the access to any information from anywhere very easy.

He added that, not only does Ethernet-APL offer advantages for the process automation industry, SPE in general brings a lot of advantages to building automation and factory automation. The 2-wire technology offers the possibility to decrease necessary space for connection equipment (smaller connectors, less space for connection interfaces) and the long distance (up to 1000m in non-hazardous areas) is useful for such industries.

"Sure, the new technology brings some challenges to the engineering. On the one hand the installation is very easy because of only two wires which needs to be connected to the field devices. Since the connectivity is polarity independent no special knowledge is necessary," Hähniche said. "However, on the other hand the network needs to be planned. More effort is expected, e.g. number of devices per segment under consideration of power supply, different architectures (Star, Ring), redundancy and so on. For that reason, an Engineering Guideline has been developed for Ethernet-APL that helps to avoid mistakes during planning and installation of an Ethernet-APL network."

Targeting industrial uses

Leveraging solutions in Automotive Ethernet

According to Verena Neuhaus, Manager Product Management Data Connectors, Business Unit Field Device Connectors for Phoenix Contact, Single Pair Ethernet has already shown its strengths in the automotive sector. There they speak of automotive Ethernet and it was quickly recognized that a consistent communication protocol instead of many different fieldbus systems has many advantages.

On the one hand you save costs for gateways, on the other hand the Automotive Ethernet simplifies cabling and saves weight. Many of these advantages can also be transferred to industrial applications.

"The IIoT brings more and more communication participants who want to be networked with each other. And SPE brings many advantages in the field of industrial communication in this new networked world," Neuhaus said. "On the one hand there is the miniaturization, the consistency of the communication protocol from the sensor to the cloud, the greater range of the Ethernet protocol of up to 1000m, but also the simplified cabling with only 2 wires and the possibility of energy transmission at the same time as the data."

Technology trends

Neuhaus said that Single Pair Ethernet (SPE) can form the basis of all Ethernet-based communication. It opens up new fields of application and enables smart device

communication.

"Due to its good transmission properties, even over longer distances, SPE optimally supports future-proof network communication. With the trend towards resource-saving, miniaturized devices, SPE offers you more space for your electronics thanks to space-saving cables," Neuhaus said. "In the first step, the main incentives lie in the application area of sensor technology in order to close the gap in IP-based communication from the sensor to the cloud."

She added that there are several different Ethernet standards that are being developed by different automation companies and the OSI layers need to be adapted to support real-time requirements. Some protocols are based on classic TCP/IP-based Ethernet, others modify layers 3 and 4, and still others require special hardware at the data link layer.

"All Ethernet variants are able to connect the shop floor in production environments the with the office networks and thus improve the performance, transparency and availability of the system. However, the complexity of Ethernet and the network topology as a daisy chain or switched network make it noticeably more difficult to integrate peripheral devices such as sensors and actuators. Single Pair Ethernet standardization efforts aim to close this gap and pave the way for a seamless, Ethernet-based IP network infrastructure," Neuhaus said.

Application solutions

Neuhaus noted, as already mentioned, that Single Pair Ethernet has its origins in the automotive sector. With the many sensors installed in an automobile, the wiring harness became more and more complex and heavier due to the different fieldbus systems.

The advantages of a less complex cabling structure with single pair Ethernet and the resulting weight and cost savings as well as a consistent communication infrastructure can also be projected onto other areas of application.

"For industrial applications, the focus is on the areas of factory automation, building automation and process automation. Possible use cases in these areas can be found in applications such as mechanical engineering, robotics, sensor technology, but also in the building control of a smart building or in infrastructure applications such as traffic engineering," Neuhaus stated.

She added that the Ethernet protocol has been established in the local data networks of the company and control levels for decades. With Single Pair Ethernet, data cabling is reduced to one pair of wires and the range is increased. This enables efficient transmission concepts at the field level - right down to the sensors. Corresponding switches and different sensors are currently being developed.

The high EMC requirements in the industrial environment and the implementation of simultaneous power transmission with PoDL (Power over Dataline) are challenges in the development process that should not be underestimated.

Even more network participants and components are required for the entire ecosystem of SPE. This is also the reason why Phoenix Contact is also promoting the topic of SPE holistically within the SPE System Alliance.

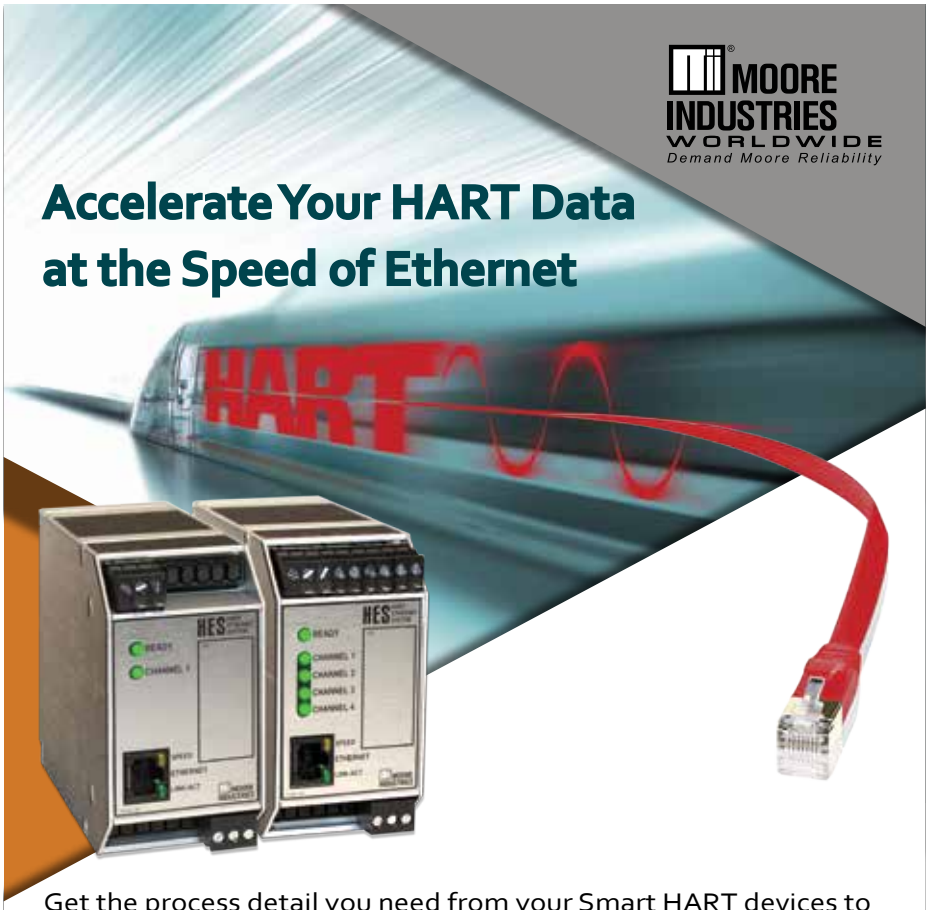
A worldwide association of almost 40 leading technology companies with the common goal of implementing and further developing the future-oriented Single Pair Ethernet technology.

Uniform Physical Layer

Replacing legacy edge protocols

Bob Voss, Distinguished Engineer in PANDUIT Corporate Research and Development told IEB that Single Pair Ethernet (SPE) and Ethernet-APL are important technologies poised to advance automation and control networking solutions. While Ethernet-APL is a process industry optimized version of SPE, both Ethernet-APL and SPE are based on the formative IEEE 802.3cg standard.

"What both technologies do is create a uniform physical layer at the edge of industrial networks, capable of transporting all industrial Ethernet variants, nearly the 'one ring to rule them all' scenario," Voss said. "When



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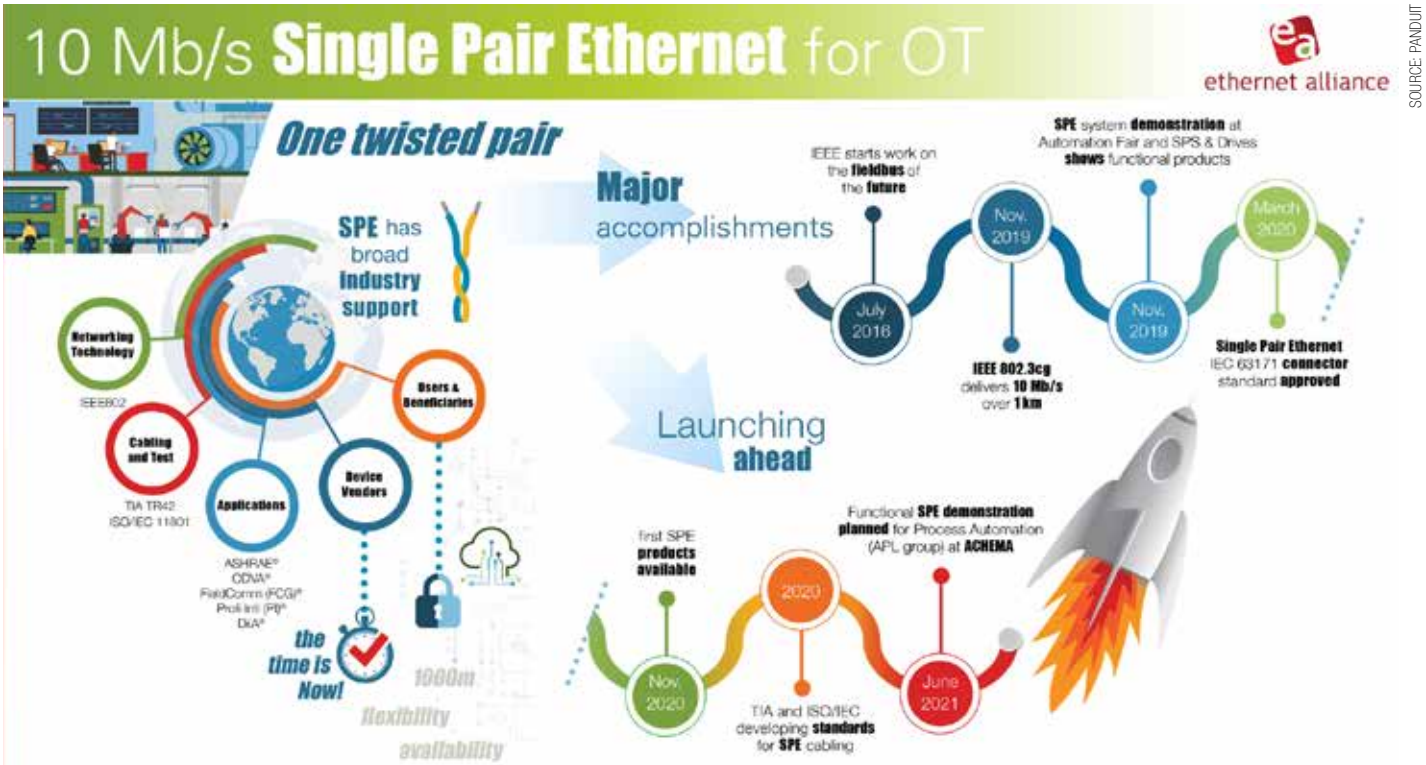


Single Pair Ethernet has been on a continuous development path but there is still more work to be done.

deploying SPE or Ethernet-APL, legacy edge protocols are replaced, upgrading the speed, performance, and security of the network edge. Also, as the network edge has become the final frontier for Ethernet, the ideal state of a single, seamless protocol from cloud to edge, is realized."

Key technical benefits and trends are driving the move to Single Pair Ethernet and/or Ethernet APL technology, creating incentives that is influencing expected adoption rate among manufacturers.

"If you asked me the adoption rate question five years ago, I would tell you that Industrial networks have painfully slow refresh rates, often well more than 10 years. However, SPE and by extension Ethernet-APL, deliver important benefits," Voss said. "As such, I expect the adoption rate to accelerate sharply. Coincident with gaining better cybersecurity, higher speed transmission, better data portability and ease of maintenance and deployment, SPE also addresses a serious business continuity risk for companies. The legacy protocols being replaced by SPE, and Ethernet-APL are old, slow and crabby like the engineers that support them. Kidding aside, the technical community that supports the non-Ethernet Industrial network edge today is old enough to retire. That factor alone puts the crosshairs on maintainability and reliability at the network edge and that should scare the heck out of businesses."

"So, how do we accelerate the adoption rate? The control engineers I've just frightened need to make certain SPE and Ethernet-APL are on their favorite automation manufacturers' development roadmaps. Progressive automation and IT companies are already doing so but don't leave it to chance in your situation. Also, Ethernet-APL launched with a fair number of solutions and given its importance to the process industry, I expect solution development to ramp up sharply."

Cabling and network topologies

Voss said that the development of single pair Ethernet (SPE) standards came from auspicious beginnings, in that the IEEE 802.3cg drew the attention and contribution of noted automation experts. Given the goal of replacing legacy protocols, physical layer topologies like long distance point-to-point links and trunk/spur links are accommodated in the standard. So, in some regard, its sort of "Back to the Future" in that we're doing the old proven topologies with modern 10 Mb/s Ethernet.He added that Ethernet-APL is built for purpose. Part of the Ethernet-APL optimization of SPE includes optional PHY operating modes in the 802.3cg standard but it is also physically architected to permit operation in hazardous areas.

"Ethernet-APL uses the 10BASE-T1L PHY chip from the 802.3cg standard, retaining the ability to create links up to 1000 meters in length at 10 Mb/s. Power is handled differently than SPE, utilizing a separate power infrastructure to allow all the best safety methods to be included in device powering schemes," Voss said. "Not to be repetitive but the chief advantage is a single, uniform physical layer that can support all Industrial Ethernet variants. Not too shabby …"

Impact on factory automation

Voss said that the target for SPE and Ethernet-APL is the edge of the network. That means sensors, drives, actuators, and the like. And fun fact for readers who don't do Building Automation, but SPE solves the same problem in buildings that it does for industrial setting. It creates a high performing Ethernet edge. Remarkably, a lot of the same topologies appear in building edge networks that we use in industrial edge networks. It's not designed to cannibalize 4-pair Ethernet applications elsewhere in the network.

By putting the whole network on Ethernet, there's a single protocol across the entire enterprise, cloud to edge. That makes ALL data infinitely transportable. It makes federating a wide variety of data fast and easy. That augments decision speed and quality. And really IoT isn't about getting all new data, its about getting the "nice to know" data in context with the mission critical data we already collect to make the business run better.

"Since I've already touched on IoT, SPE is also an IoT enabler. A number of pilot IoT applications proved their worth using battery-powered wireless sensors. A valuable means to quickly achieve a proof of concept but not a physical layer application that scales effectively. Enter SPE. Its simple to connect 2-wire cabling, 10 Mb/s transmission speed and ability to deliver device power make it an ideal IoT enabler that does scale," Voss said.

He added that one drawback to legacy cabling is the lack of methodology to diagnose and debug problems in the physical

layer without connecting and simultaneously debugging devices. This is a significant gap, since there is evidence that physical layer shortcomings make up a sizeable share of communication problems in serial networks. With SPE also comes standards and equipment that allows for validation of the installed system. This process has been well established for enterprise Ethernet connectivity, and provides confidence to end users that their installed cabling – which often make up the largest share of the cost – can support both short-term serial/analog applications as well as long-term APL and SPE upgrades.

What are the engineering challenges that the newest solutions are designed to address? Voss said that, first and foremost, there is an ability to support proven edge topologies.

"The value of a new technology diminishes rapidly if you must completely change the way you do the work. This objective also makes SPE a backwards compatible technology in that it may support the reuse of electrically healthy Fieldbus cables for SPE," Voss said. "While not a certainty, it something that can quickly be determined with the help of test instrumentation. What we're finding in laboratory testing at the Panduit Innovation Center is not all Fieldbus cable works. We have tested cable variants that, on paper, look like they'd work just fine for SPE but that assumption is not borne out by the performance testing."

Secondarily, he added that SPE is lightweight. There's not a lot of compute power required in the device for SPE. It operates happily with TCP/IP or UDP stacks. In fact, there are some excellent technical papers presented by ODVA in a category called "constrained devices" on the ability of SPE operating with UDP and supporting fully functional instantiations of EtherNet/IP.

"Finally, the creation of Ethernet-APL standing on the shoulders of SPE to bring Ethernet to edge industrial networks located in hazardous environments. That is a significant engineering challenge, elegantly overcome," he concluded.

On the one hand you save costs for gateways, on the other hand the Automotive Ethernet simplifies cabling and saves weight. Many of these advantages can also be transferred to industrial applications.

Ethernet in the field

Enabling digitalization and data-driven apps

According to Benedikt Spielmann, Marketing Manager Industrial Communication at Endress+Hauser Digital Solutions, Single Pair Ethernet and Ethernet-APL are important technologies advancing new solutions for automation and control networking.

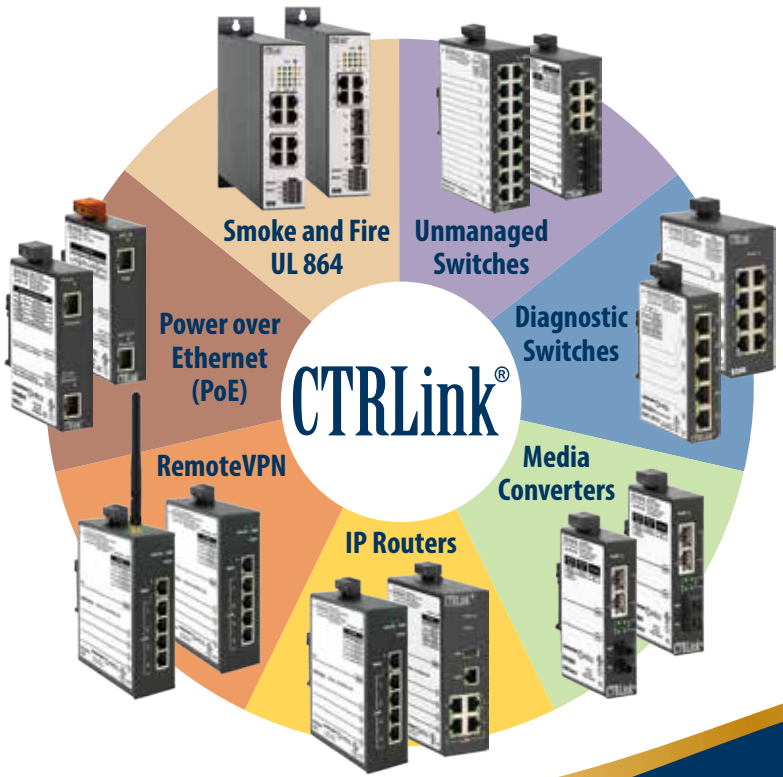
"The field level is typically equipped with 4-20mA analogue technology for many decades. The HART protocol above is mostly used for configuration or troubleshooting only. Digital fieldbuses could never really replace the analogue technology due to complexity in engineering and troubleshooting, protocol conversions, difficult driver allocation, etc.," Spielmann told IEB recently.

"In terms of digitalization and data-driven applications for Industry 4.0, a seamless data access for upper layer applications is crucial to unlock the data of smart instruments. Traditional technologies have limitations to meet this and have poor performance for transferring a large amount of data."

Spielmann said that, in industries without hazardous areas, Ethernet-enabled 4-wire field devices have been successfully established for many years. With SPE technology, it will also be possible to provide typical 2-wire devices with Ethernet. This will make it feasible to integrate all field instruments into the Ethernet network, with full data access and without protocol conversions.

"For heavy industries with hazardous areas, a special adoption of SPE enables the use of Ethernet in the field level including intrinsic safety: The Advanced Physical Layer for Ethernet. Ethernet-APL brings Ethernet to

Robust Ethernet Networks



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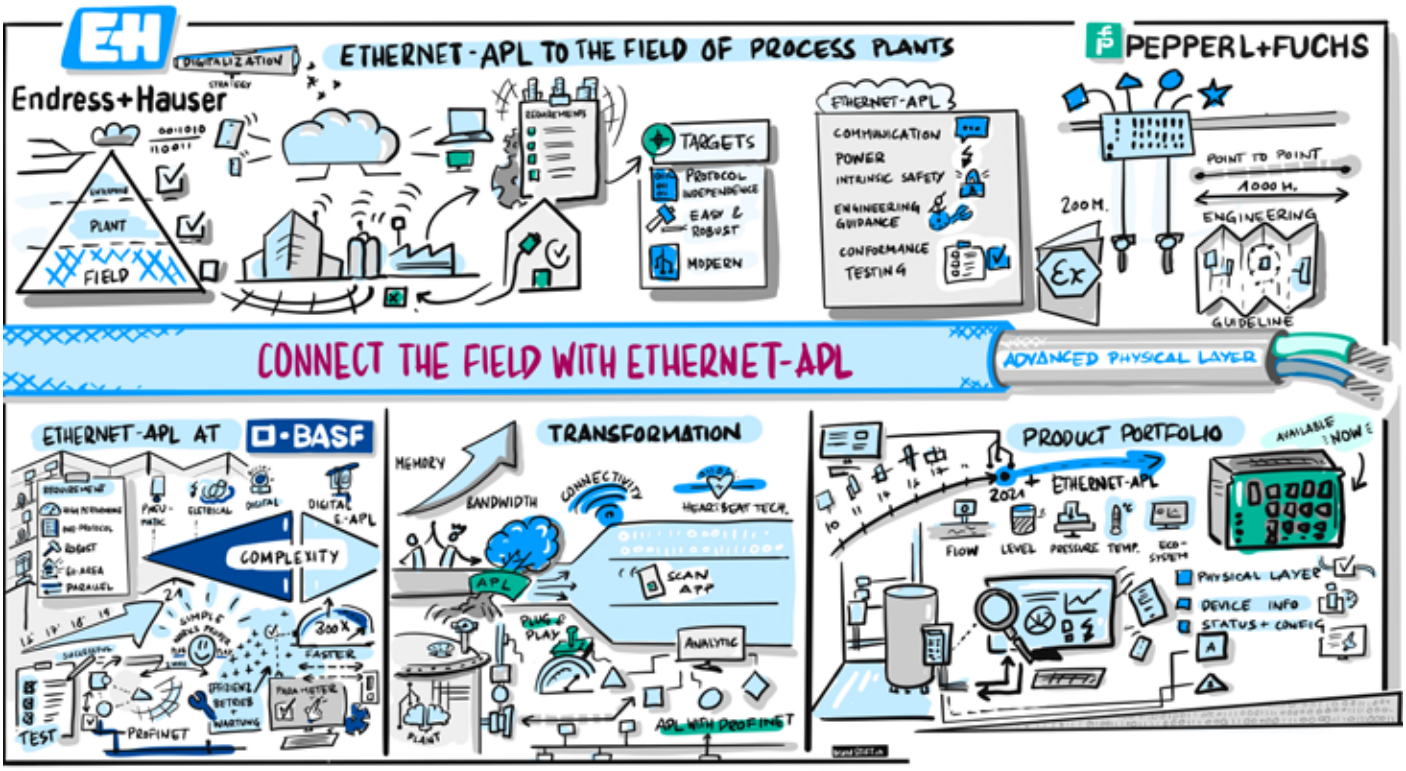


SOURCE: ENDRESS+HAUSER

Single Pair Ethernet has been on a continuous development path but there is still more work to be done.

the field level with power and data over the same 2-wire cable, enabling seamless data access and high performance for upper layer applications," he added.

Technology benefits

Spielmann's point of view is that two-wire Ethernet technology brings Ethernet to the field level, enabling one single network technology across all levels of the automation pyramid. And a major benefit of such a consistent network is the seamless data flow from the field level to upper layer applications.

"With traditional technologies we are always faced with complex protocol conversions through different infrastructure components of different vendors. This makes it nearly impossible to enable data-driven applications which are getting more important in the context of digitalization and Industry 4.0," he said.

"Also standardized concepts and use cases as defined in NAMUR Open Architecture need the data flow from the field level and the appropriate performance for the data transfer. Daily work orders of maintenance personnel can be much more efficient. Just imagine a parameter upload or download in some seconds per device instead of several minutes as known from HART protocol today. By multiplying this increase in efficiency by hundreds of devices in a plant, a real cost benefit can be calculated."

With the first APL field switches already available on the market, Endress+Hauser devices for all relevant measuring principles like flow, level, pressure, temperature but also actuators will be launched during 2022. This means that first real projects can start this year.

Impact of SPE

According to Spielmann, networks implementing Ethernet-APL or SPE are highly flexible and scalable. With Ethernet-APL for instance it is possible to set-up ring topologies with several APL Field switches. Thanks to features like the media redundancy protocol in the PROFINET context, a cable break between the APL field switches has no impact on the process as the communication will continue via the other way of the ring. Cables between the APL field switches can be selected depending on the application.

Either cheaper copper cables are possible with a maximum cable distance of up to 100 meters and 100Mbit/s or more expensive fiber optic can be chosen with cable distances of up to 2 kilometers and even higher data rates.

The connection between APL field switches and APL field instruments is always point-to-point which simplifies troubleshooting on the network, especially compared to fieldbus architectures. The preferred cable for these so-called spur lines is the Fieldbus cable type A which is specified in IEC 61158-2. With such a cable it is possible to reach maximum cable distances of up to 200 meters, even with intrinsic safety in all zones or divisions.

"Two-wire Ethernet fits to all applications in process industries with Ethernet-APL and discrete industries with SPE. It simplifies the network architecture, provides high-speed data communication, and enables the seamless data access for higher level applications," Spielmann added. "Ethernet-APL and SPE meet the requirements of the industries in terms of easiness and robustness while bringing added-value by the connectivity to the smart instruments and their data. This data can be used in various types of applications. Probably the data will be collected in a central data hub first and will then be transferred to the appropriate application or service where it is needed. 2-wire Ethernet is just the enabler technology to connect the field level and to transfer the large amount of data via the data highway."

Addressing engineering challenges

Process plants are one area that are typically equipped with 4-20mA analogue technology. Such topologies are typically designed by either a central IO with marshalling rack from where a multi-wire bulk cable goes out to the field or with remote IOs in the field level which are connected via fieldbus interfaces or standard industrial Ethernet to the controller.

Spielmann said that these topologies require either huge cable effort within the cable trays or expensive remote IOs. In addition, remote IOs are not standardized in terms of upper protocol integration which makes it nearly impossible to route through all the different components of different vendors for data access of upper layer applications.

"A major advantage of Ethernet technology is the transparent routing through the infrastructure components which decreases complexity compared to 4-20mA technology a lot. Same applies to intrinsic safety calculations which are quite time-consuming with 4-20mA

architectures but built-in into APL devices via the IEC specification 2-WISE," he said. "With Ethernet technologies, necessary redundancy concepts can be realized which are supported by the well-established industrial Ethernet protocols like PROFINET or EtherNet/IP. This increases plant availability which is a key performance indicator of process plants."

Connectivity for smaller devices

Cost and size reductions

Dr. Al Beydoun, President and Executive Director at ODVA, said that Single Pair Ethernet (SPE) allows for cost and size reductions in Ethernet PHYs, cable and connectors that enables cost effective connectivity for smaller devices.

"This opens up the possibility to connect simple devices to Ethernet that were previously only hardwired or controlled via fieldbus technology," Beydoun said, "and SPE also reduces the overall labor for panel installations and provides information for concepts such as prognostics. ODVA's in-cabinet resource-constrained device solution is a case in point as it enables contactors and push buttons to be connected to EtherNet/IP™ via a SPE multidrop flat cable."

"It's important to note that SPE encompasses 10BASE-T1L General Purpose SPE applications, 10BASE-T1S in-cabinet applications, and 10BASE-T1L Ethernet-APL applications. Furthermore, there are multiple IEEE SPE standards in addition those mentioned."

Emergence of Ethernet-APL

Ethernet-APL is an intrinsically safe (IEC TS 60079-47), two-wire extension of 10BASE-T1L SPE (IEEE 802.3cg-2019) that meets the requirements of the process industries. Ethernet-APL allows for power to field instrumentation, long cable runs of up to 1,000 meters as well as potential reuse of type A fieldbus cable (IEC 61158-2), and up to 10 Mbit/s communication speeds. As another physical layer for Ethernet, Ethernet-APL provides seamless connectivity from field instrumentation to the plant-wide Ethernet. Additionally, process instrumentation can easily communicate multiple variables such as temperature, level, and flow from one instrument via the increased bandwidth of Ethernet-APL.

Beydoun said that EtherNet/IP will be able to expand precise, efficient Ethernet-based control and commissioning across process field instrumentation via the Ethernet-APL physical layer. The full use of EtherNet/IP in process automation will enable concurrent seamless connectivity from the field devices to the controllers, to Industrial IoT applications, as well as the edge and cloud for prognostic analysis.

Technology trends

Beydoun said that the drive to digitalize the enterprise will be a key catalyst in adopting Single Pair Ethernet and Ethernet-APL technology on the plant floor to connect more and more field devices.

Key incentives to adding devices to Ethernet networks include remote commissioning, digital troubleshooting enabled by diagnostics, analytics and edge and/or cloud enabled prognostics. The cost savings from being able to quickly and easily add a new device to the network and to identify a malfunctioning device without having to physically test for failures adds up quickly between labor savings and downtime reduction.

The overall SPE adoption rate among manufacturers is likely to reach the majority quickly as digitalization, the Industrial Internet of Things (IIoT), and Industry 4.0 are used to reduce the impact of significant labor shortages that are being experienced across multiple sectors, as well as to contain increasing cost pressures to stabilize margins.

"The functionality in EtherNet/IP for in-cabinet resource-constrained device connectivity powered by SPE allows for the usage of a flat cable to reduce material cost, space used, and installation time," Beydoun said. "The flat cable includes both switched power, network power, SPE, and a select line to enable multi device connectivity at a low cost. This compact low-cost flat cable allows devices to be easily attached via a safe and simple piercing connection."

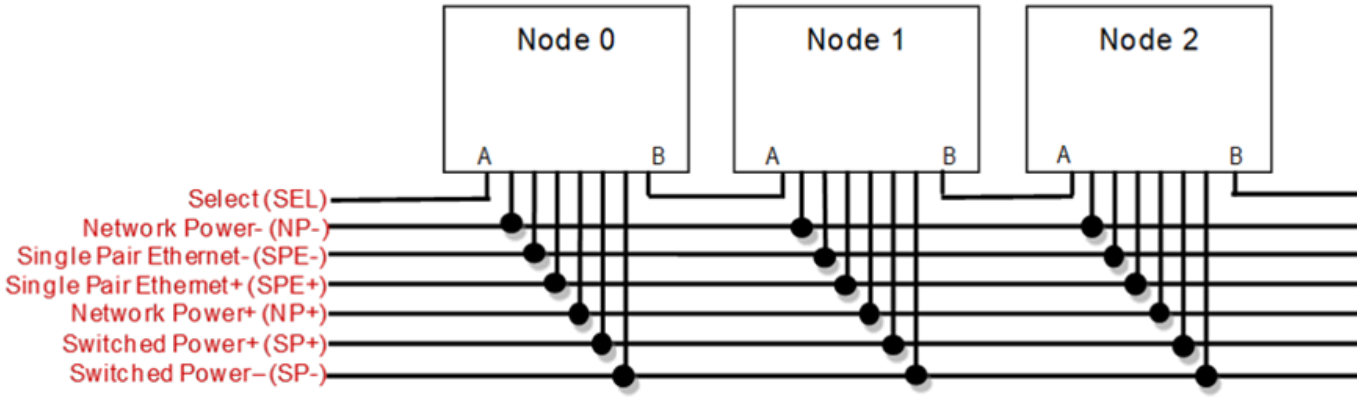
He added that Ethernet-APL supports trunk and spur, line, and star topologies as well as Type A fieldbus cable to meet the requirements of the process industries. The trunk and spur topology will be seen in the vast majority of instances for powered and intrinsic safety applications, but a ring topology is possible for non-powered and non-IS applications to enable redundancy for critical applications in sectors such as Water Treatment Plants. Ethernet-APL also enables the use of Parallel Redundancy Protocol (PRP) for network technology that have this as an option, as EtherNet/IP does.

Targeted application areas

10BASE-T1L SPE is geared more toward discrete and hybrid industrial automation applications to reach low-cost sensors and actuators within sectors such as automotive, tire, electronics, distribution and packaging. However, the EtherNet/IP functionality for in-cabinet 10BASE-T1S resource-constrained devices can be implemented in discrete, hybrid and process industries.

Ethernet-APL is purpose-built to meet the needs of the process industries, including placement in Zones 0/1/2 for flammable liquid/gas in sectors such as oil & gas and chemical. Ethernet-APL may also have some applications within hybrid industries that require intrinsic safety such as food/beverage and pharmaceutical.

"SPE and Ethernet-APL both allow devices to be connected to Ethernet that were previously hardwired or connected via point-to-point or multidrop fieldbus solutions. A vast number of new possibilities are opened up via additional network connectivity including fast identification of failures via standard diagnostics or monitoring of devices



EtherNet/IP In-Cabinet 10BASE-T1S SPE Multidrop Flat Cable with Select Line.

SOURCE: ISTOCK

Single Pair Ethernet (SPE) can form the basis of all Ethernet-based communication in the factory. It opens up new fields of application and enables smart device communication.

for out-of-range operation to both predict premature failure and reduce negative impacts on quality. OEE can also be positively impacted by adding new device metrics to automated KPI models that can help identify and remove bottlenecks via improved visibility to improve overall throughput," Beydoun said.

Engineering challenges

His view is that in-cabinet resource-constrained device solutions will address the challenge of cabinet space being some of the highest cost real estate in the world. SPE can dramatically reduce the amount of space that the wiring takes up within the cabinet, allowing for either smaller cabinets or fewer cabinets to be installed. The savings can add up quickly in factories and plants with thousands of nodes.

The simple and quick installation enabled by SPE cabling can also help to address labor shortages, enable quick problem identification and resolution during validation processes during plant commissioning, and can enable last minute design changes with dramatically lower impact on production schedules.

"Ethernet-APL meets the ruggedness, simplicity, and security expected by the process industries for a control network. Ethernet-APL leverages the same Type A fieldbus cable that is currently installed in process plants today. In fact, existing Type A cable may be reused if the cable integrity is verified and resistance standards of 100 ohms with +/- 20 ohms tolerances are met," Beydoun said.

"A screwdriver and related wire preparation tools are all that is needed to physically connect field devices. Since it is just a physical layer, Ethernet-APL allows end users to access standard safety and security services built on IEC 61508 and ISA/IEC 62443 from the leading industrial automation standards bodies. This includes CIP Safety™ and CIP Security™ capabilities for EtherNet/IP."

Extending the reach of Ethernet

Addressing new application areas

According to Michael Clark, Director of OPC Foundation North America, SPE and Ethernet-APL extend the reach of Ethernet to support additional industrial use cases at the field level, including discrete, process, and hazardous applications.

"High-speed Ethernet connectivity to field devices (sensors and actuators) provides the ability to make data directly available from the source seamlessly to the edge or even to cloud applications. These technologies, thus, make an elementary contribution to the digital transformation of the industry," Clark told IEB recently. "In addition, SPE and Ethernet-APL bring significant advantages with regard to wiring & installation: cable lengths of up to 1000 meters, minimal space requirements, easy installation, and the possibility to transmit data and power over a single twisted pair cable."

Clark said that SPE and Ethernet-APL help to overcome many of the limitations that analogue interfaces or fieldbuses have imposed in industrial applications over recent decades. This is why SPE and Ethernet-APL, together with other IEEE standards such as Ethernet Time-Sensitive Networking (TSN), are key technologies for the OPC Foundation to further develop OPC UA (IEC 62541) as a communication solution that fully scales from the field to the cloud, with the support of all major IT & OT companies across the world. OPC UA then serves as the standard for semantic interoperability, which is key for exchanging data with an unambiguous, shared meaning across IT & OT systems.

Impact of networking technology

"The industrial networking environment today is often diverse with a variety of different communication interfaces (proprietary, analogue, or fieldbus types), with Ethernet as the backbone network to IT enterprise systems. With SPE and Ethernet-APL, Ethernet is extending its reach into the field level, thus becoming the single networking technology for IT & OT; greatly simplifying network infrastructure complexities and costs," Clark said.

He added that this architecture enables uniform operation, based on higher-layer protocols within Ethernet, i.e. parameterization, initialization, and programming. Operation and maintenance/troubleshooting of large and generally heterogeneous network structures are sustainably simplified. With this approach, the field level is as easy to operate and manage with SPE and Ethernet-APL as IT networks are with SNMP.

Targeted applications

Clark said that SPE and Ethernet-APL are ideal but, at the same time, not limited across a broad range of applications in discrete manufacturing and the process industry, including hazardous areas. Field devices, including sensors and actuators, can be easily integrated into an existing Ethernet environment, without the need for additional gateways or interfaces.

This is improving connectivity and, therefore, supports the digital transformation across different use cases, such as condition monitoring, predictive maintenance, energy optimization, and increased productivity and flexibility.

Some of the engineering challenges that companies implementing these solutions are related to physical layer conformance, along with safety and power requirements.

"Testing the physical layer is essential to ensuring correct operations of the products, including conformance to the physical layer, according to IEEE, as well as intrinsic safety and power requirements, according to IEC," Clark said.

"Cross-organization recognition of test results is required to avoid the need for device manufacturers to do physical testing, multiple times, in cases where they are supporting multiple industrial protocols."

Al Presher, Editor, ***Industrial Ethernet Book.***

Single Pair Ethernet – when will it have its big breakthrough?

The intensive prototype phase for SPE got underway quite some time ago. PHYs, cables, and connectors are available on the market. Now, the focus is on coordinating the systems and transferring the needs of industrial ambient conditions to Single Pair Ethernet.

SOURCE: PHOENIX CONTACT

The slogan "From the sensor to the cloud" will become a reality with Single Pair Ethernet.

WHEN IT COMES TO MODERN INDUSTRIAL communication technology, there's no avoiding the trend topic of Single Pair Ethernet – or SPE for short. The first components, including connectors, cables, and PHYs, have been available for a few months.

Device manufacturers are now able to design the first prototypes for end-to-end Ethernet-based communication and make the much-quoted slogan "From the sensor to the cloud" a reality.

Available SPE components

The cables for Single Pair Ethernet are described in standards IEC 61156-11/-12/-13 and -14. These four new standards for SPE cables define both their fixed and flexible installation. At this juncture, standards 61156-11 and 61156-12 have already been published. They define the requirements for transmission frequencies up to 600 MHz and a transmission distance of up to 40 m – and are suitable for the 100BASE-T1 and 1000BASE-T1 standards.

In 2020, Phoenix Contact launched its first connectors for end-to-end connection technology for SPE. The portfolio includes compact IP20 connectors as well as IP-protected M8 connectors for the connection of sensors. To bring these two worlds together, a universal pin connector pattern is used. This eliminates the need for cumbersome adapters, saves additional costs, and thus fully satisfies the key objectives of Single Pair Ethernet: compactness and consistency.

The IP20 connectors are standardized in accordance with IEC 63171-2 and feature the most compact pin connector pattern in the entire series of standards for SPE connectors. The IP20 portfolio includes pre-assembled patch cables in various lengths as well as compact device connections for the reflow soldering process available in different designs. The newest member of the family is a new insulation displacement connector for field assembly. The IDC connector featuring die-cast zinc housing promises to satisfy the requirement for robustness in all types of industrial applications. Phoenix Contact is thus providing its customers with even greater convenience when it comes to field cabling and greater flexibility when selecting cables.

The IP-protected portfolio in the M8 design is standardized in accordance with IEC 63171-5 and also includes pre-assembled patch cables with different cable types for different applications and device connections in the standard M8 design. For device manufacturers, the advantage of using standard M8 components is that they can benefit from easy design-in and maximum flexibility for the cabling.

Existing housing geometries and panel feed-throughs can be incorporated and assembled with the new SPE inserts. The inserts are available as straight and angled versions, and are also available for different soldering processes (THR and SMD). With the launch of this M8 portfolio in the fall of 2020, series

SOURCE: PHOENIX CONTACT

Phoenix Contact offers a consistent, compact and robust range of SPE connectors standardized in accordance with IEC 63171-2 (IP20) and IEC 63171-5 (M8 connectors).

items for connecting compact SPE sensors are now available on the market for the first time.

The SPE System Alliance

Right at the very early development stage of the new pin connector pattern for SPE, it was clear that the topic of Single Pair Ethernet would not just be confined to connectors. Indeed, it concerns all the infrastructure components involved: from PHYs through cables to sensors.

The SPE System Alliance, which Phoenix Contact co-founded, has been in existence for over a year. Leading technology companies from various industries and fields of application have come together to form a registered association in order to bundle their expertise and ensure the target-oriented exchange of this knowledge. Through this orientation toward a cross-industry and cross-application exchange platform, companies from all areas of the SPE ecosystem are coming together.

Together, all SPE System Alliance partners are pursuing the goal of driving the development of SPE further forward for the Industrial Internet of Things (IIoT).

The SPE System Alliance does not champion a specific connector system or product. Whatever the individual positions of its members, the System Alliance generally maintains a neutral and manufacturer-independent stance with regard to products. The objective behind the System Alliance's activities is to promote SPE technology.

The System Alliance focuses on the entire future SPE ecosystem and any open issues in this context. This encompasses far more than just physical components like cables, PHYs, connectors, sensors, or switches. For example, it deals with questions regarding topologies, standardization proposals, and application scenarios for different areas of application. This broad approach is also reflected in various working groups within the System Alliance, which focus on different issues.

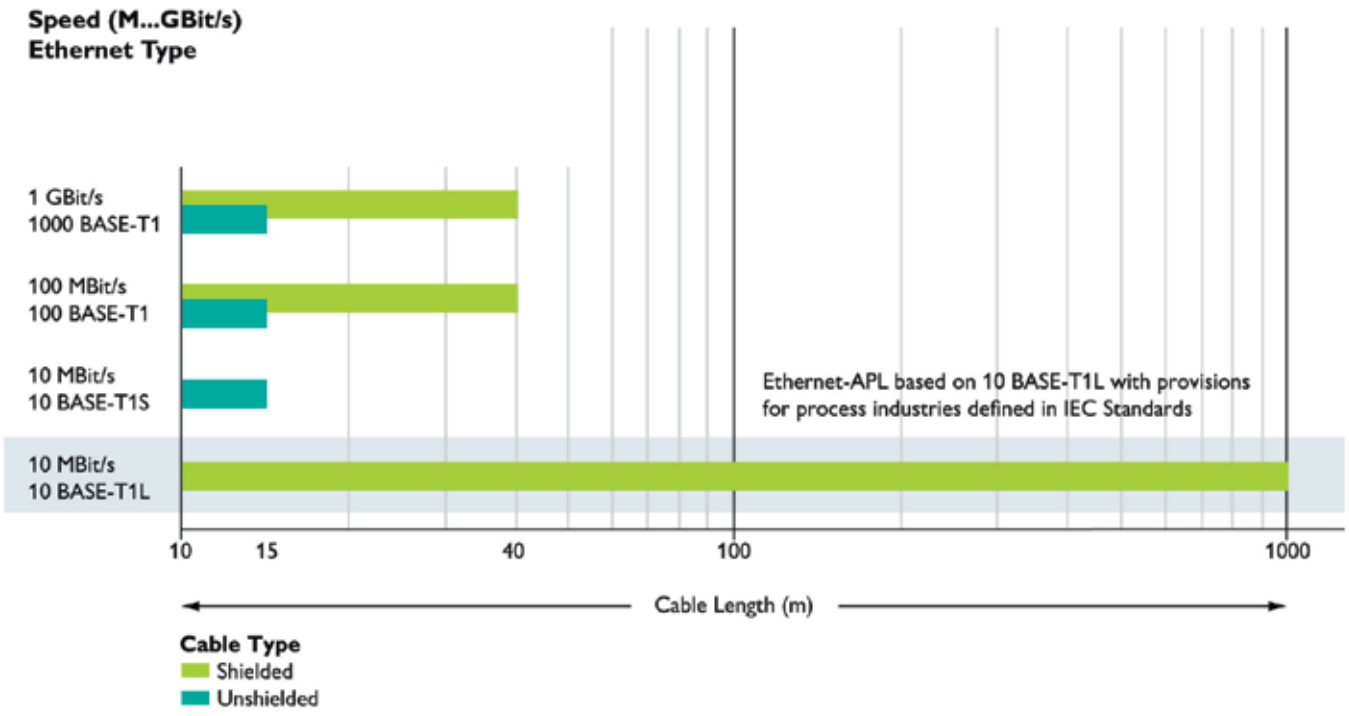
New IEEE standards waiting in wings

The adopted IEEE 802.3 standards for Single Pair Ethernet cover data rates from 10 Mbps to

SOURCE: PHOENIX CONTACT

The M8 device connectors enable compact and standardized connection for SPE switches or sensors in the field, for example.

SOURCE: PHOENIX CONTACT



Overview of the different SPE standards from IEEE 802.3.

10 Gbps and distances up to 1,000 m.

Driven by the automotive industry, the first standards covering shorter distances have been adopted. The 100BASE-T1 and 1000BASE-T1 standards transmit data rates of 100 Mbps and 1 Gbps over distances of up to 40 m (shielded).

Users in the field of factory and building automation are eagerly awaiting the further availability of components for the 10BASE-T1L and 10BASE-T1S standards from the "cg" working group. These standards enable 10 Mbps transmission over a distance of up to 1,000 m for the first time. In addition, multidrop applications are also possible for the first time with the T1S version. All other standards are based on classic point-to-point cabling. The plan is to expand upon these multidrop applications in the newest "da" working group and look at ranges beyond the 25 m mark of the current T1S standard.

The most recently adopted standard from the "ch" working group is MultiGigBASE-T1, which allows a data rate of 10 Gbps with a range of 15 m. There is also the Power over Data Line (PoDL) standard, which enables up to 50 W of additional power over the data line for SPE applications. The multidrop standards are still excluded from this function at present.

Overview of the IEEE standards for SPE:

IEEE 802.3da
10BASE-T1S – ~50 m (tbd) – 10 Mbps (multidrop)

IEEE 802.3cg
10BASE-T1S – 25 m – 10 Mbps (multidrop)
10BASE-T1L – 1,000 m – 10 Mbps (point-to-point)

IEEE 802.3bw
100BASE-T1 – 40 m – 100 Mbps (point-to-point)

IEEE 802.3bw
1000BASE-T1 – 40 m – 1 Gbps (point-to-point)

IEEE 802.3ch
MultiGigBASE-T1 – 15 m – 2.5/5/10 Gbps

IEEE 802.3bu
Power over Data Line (PoDL) includes different performance classes up to 50 W (max. 48 V)

When will first devices emerge?

The intensive prototype phase for SPE got underway quite some time ago. PHYs, cables, and connectors are available on the market. Now, the focus is on coordinating the systems and transferring the needs of industrial ambient conditions to Single Pair Ethernet.

One of the challenges is the EMC behavior in the overall system, as industrial environments differ greatly from the application area of automotive Ethernet. In contrast to an automobile, the influence of electromagnetic interference is unpredictable and often far more complex depending on the application.

The future is also exciting when it comes to the standardization of connectors. In total, the series of standards for SPE connectors (IEC 63171) currently contains six different standards for connectors – the seventh standard is already in preparation. Will there just be one type of SPE connector in future? Otherwise, which standards are best suited to certain applications? User organizations, such as the PNO and ODVA, that are currently working intensively on the topic of SPE will have a large say in this. Only time will tell how and when the popular slogan "From the sensor to the cloud" will really be true.

Verena Neuhaus, Product Management Data Connectors, Business Unit Field Device Connectors, ***Phoenix Contact.***

Visit Website

Ethernet-APL: actionable insights for process automation

The leading companies in process automation are working together under the umbrella of PROFIBUS and PROFINET International (PI), ODVA, and FieldComm Group to make Ethernet-APL work across Industrial Ethernet protocols and to accelerate its deployment.

ETHERNET-APL (ADVANCED PHYSICAL LAYER) specifies the details of the application of Ethernet communication to sensors and actuators for the process industry and will be published under the IEC. It is based on the new 10BASE-T1L (IEEE802.3cg-2019) Ethernet physical layer standard, approved on November 7, 2019, and specifies the implementation and explosion protection methods for use in hazardous locations.

Why is Ethernet-APL important?

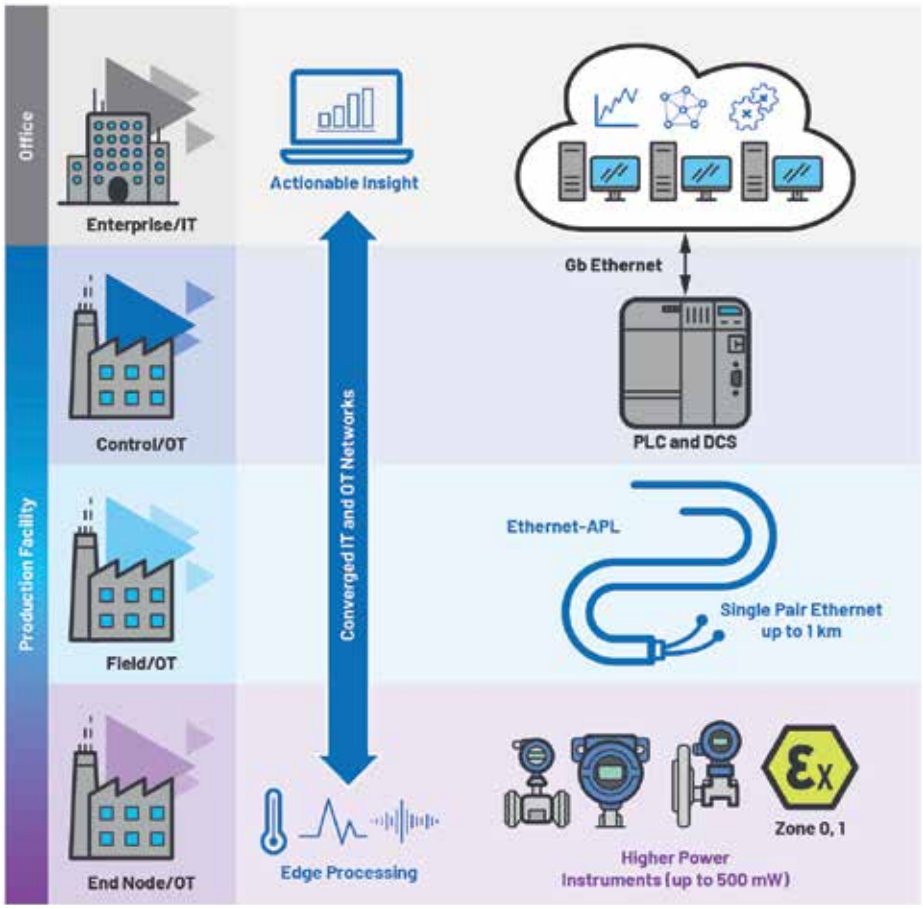
Ethernet-APL will change the process automation world by enabling high bandwidth, seamless Ethernet connectivity to field devices. It solves the challenges that, to date, have limited the use of Ethernet to the field. These challenges include power, bandwidth, cabling, distance, and use in hazardous locations. By solving these challenges for both brownfield upgrades and new greenfield installations, Ethernet-APL will enable new insights that were previously unavailable, such as combining process variables, secondary parameters, and asset health feedback and seamlessly communicating them to the control layer. These new insights will awaken new possibilities for data analysis, operational insights, and productivity improvements through a converged Ethernet network from the field to the cloud.

To replace 4 mA to 20 mA or fieldbus communications (Foundation Fieldbus or PROFIBUS PA) with Ethernet-APL in process automation applications, both power and data need to be provided to the sensors and actuators. The distance between field-level devices and control systems in process automation applications has been a significant challenge to existing Industrial Ethernet physical layer technologies being limited to 100 m. With distances of up to 1 km required in process automation applications, combined with the need for very low power and robust field devices suitable for use in Zone 0 (intrinsically safe) applications, a new approach to realize Ethernet physical layer technology for process automation was required. Ethernet-APL is this new approach.

Ethernet-APL is based on 10BASE-T1L physical layer capability of a full-duplex, dc-balanced, point-to-point communication scheme with PAM 3 modulation at a 7.5 MBd symbol rate, 4B3T coding. It supports two amplitude modes; 2.4 V peak up to 1000 m cable and 1.0 V peak at a reduced distance. The 1.0 V peak amplitude mode means that this new physical layer technology can also be used in the environment of explosion-proof systems (Ex) and meet the strict maximum energy restrictions. 10BASE-T1L enables long distance transmission on two-wire technology of both power and data over a shielded, single twisted pair cable.

When it comes to power delivery to field devices, Ethernet-APL can deliver up to 500 mW in Zone 0 applications, compared to that of approximately 36 mW delivered by 4 mA to 20 mA systems today. In nonintrinsically safe applications, up to 60 W of power is possible depending on the cable used. With significantly more power available at the edge of the network, new field devices with enhanced features and functions can be enabled because the power limitations of 4 mA to 20 mA and fieldbus no longer apply. For example, higher performance measurement and enhanced edge processing of data is now possible with this additional power. This will unlock valuable insights about process variables that will now be made accessible via a web server running on the field-level devices (field assets), and which will ultimately drive improvements and optimizations in process flows and asset management.

To exploit the rich dataset containing these valuable new insights, a higher bandwidth communications link is required to deliver the datasets from these new field devices across the process installation to plant-level infrastructure or up to the cloud for



SOURCE: ANALOG DEVICES

Seamless Ethernet connectivity with Ethernet-APL in process automation.

Table 1. 4 mA to 20 mA with HART® vs. Fieldbus vs. 10BASE-T1L Communications

Comparison	4 mA to 20 mA with HART	Fieldbus	10BASE-T1L
Data Bandwidth	1.2 kbps	31.25 kbps	10 Mbps
Higher Level Ethernet Connectivity	Complex gateways	Complex gateways	No gateways seamless connectivity
Power to Instrument	<40 mW	Limited power	IS: 500 mW non-IS up to 60 W (cable dependent)
Knowledge/Expertise	Shrinking knowledge/ expertise	Shrinking knowledge/ expertise	Ethernet technology is very familiar to all college graduates

SOURCE: ANALOG DEVICES

processing. Ethernet-APL removes the need for complex, power hungry gateways and enables a converged Ethernet network across the information technology (IT) and operating technology (OT) domains.

This converged network delivers a simplified installation, easy device replacement, and faster network commissioning and configuration. This results in faster software updates with simplified root cause analysis and maintenance of field-level devices.

Advantages of Ethernet-APL

By converging on Ethernet-APL, the need for expensive, complex, and power-hungry gateways has been removed. This also enables a transition from the hugely fragmented fieldbus infrastructure that has created data islands where access to the data within field-level devices is limited.

By removing these gateways, the cost and complexity of these legacy installations is significantly reduced and the data islands they created are removed.

Process automation applications to date have used the legacy communications standards, which have several limitations that the new 10BASE-T1L Ethernet standard overcomes. 10BASE-T1L provides the potential to reuse some of the existing installed cables, creating significant opportunities for brownfield upgrades of process automation installations with Ethernet-APL based on the 10BASE-T1L physical layer. To communicate with an Ethernet-APL enabled device, a host processor with an integrated medium access control (MAC) or an Ethernet switch with 10BASE-T1L ports is required.

Ethernet-APL cabling and network topology

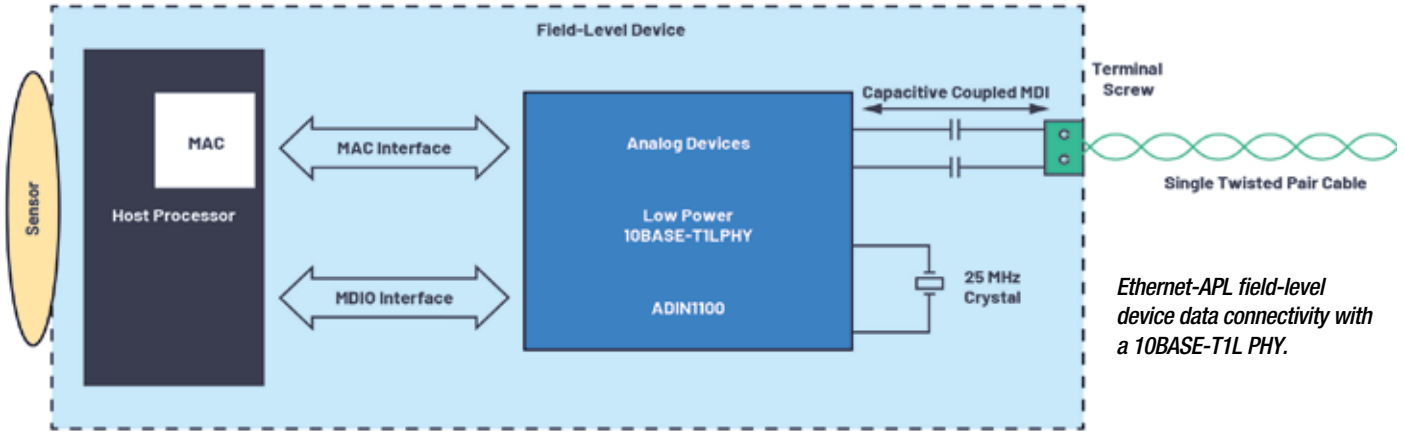
The 10BASE-T1L standard does not define a specific transmission medium (cable), instead it defines a channel model (return loss and insertion loss requirements). The channel model fits well with the fieldbus type A cables already used for PROFIBUS PA and Foundation Fieldbus today; therefore, some installed 4 mA to 20 mA cables can potentially be reused with Ethernet-APL. Single twisted pair cabling has the advantages of being lower cost, smaller size, and easier to install when compared to more complex cabling.

With the proposed network topology for Ethernet-APL, referred to as a trunk and spur network topology, the trunk cables can be up to 1 km in length with a PHY amplitude of 2.4 V peak and reside in Zone 1, Division 2. The spur cables can be up to 200 m in length with a PHY amplitude of 1.0 V peak and reside in Zone 0, Division 1.

A power switch resides at the control level, providing Ethernet switch functionality and supplies the power to the cable (over the data lines). Field switches reside at the field level in the hazardous area and are powered from the cable. The field switches provide the Ethernet switch functionality connecting the field-level devices on the spurs to connect to the trunk and pass the power to the field-level devices. Multiple field switches are connected on a trunk cable to provide for the high numbers of field-level devices to be connected.

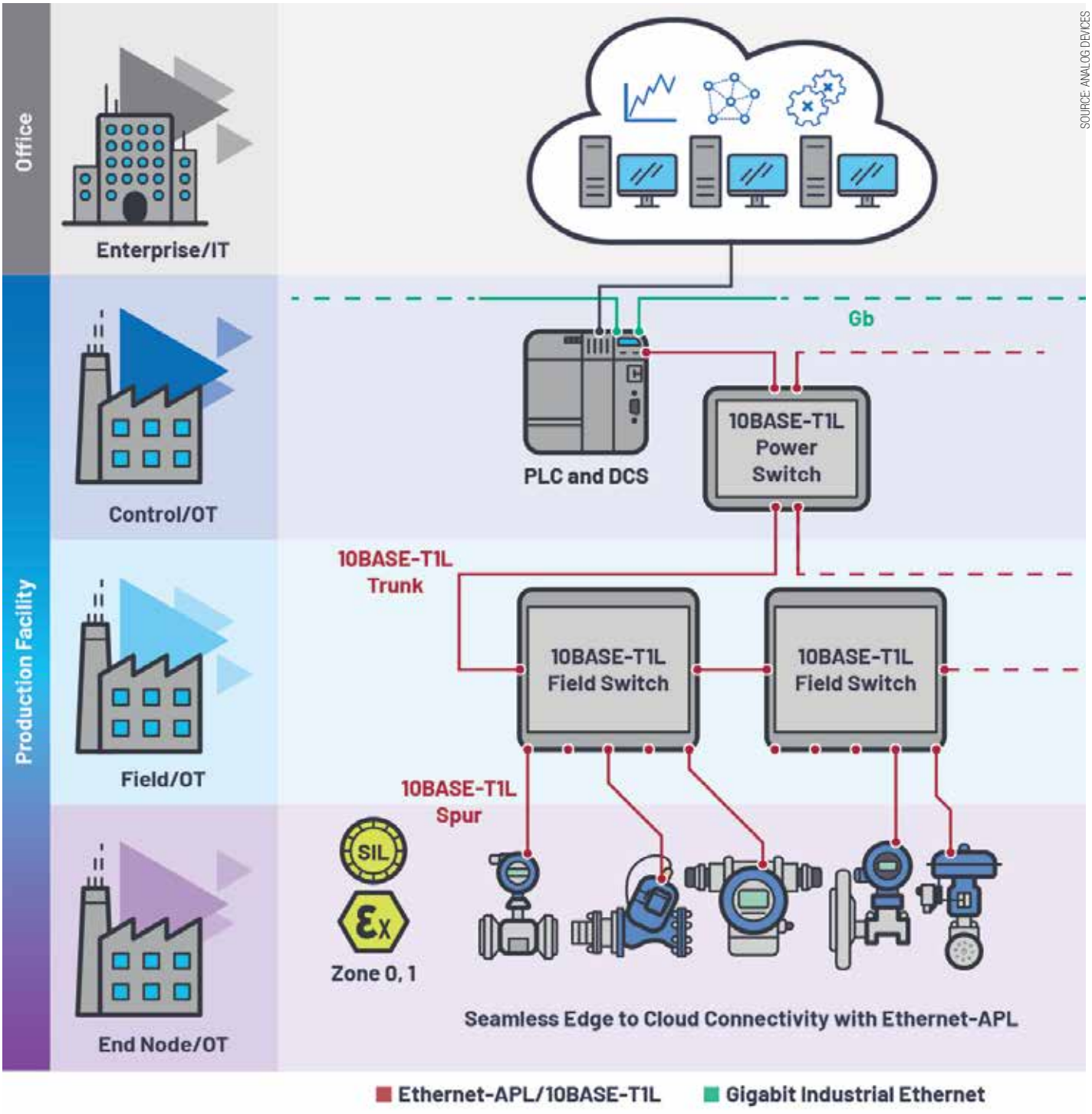
New Ethernet-APL devices to create new opportunities

Ethernet-APL will enable the transition to seamless field-to-cloud connected process automation installations, including hazardous locations for food and beverage, pharmaceutical, and oil and gas installations.



SOURCE: ANALOG DEVICES

Ethernet-APL field-level device data connectivity with a 10BASE-T1L PHY.



SOURCE: ANALOG DEVICES

With significantly more power available, new Ethernet-APL-enabled field devices with enhanced features and functions can be supported. These new devices will unlock rich datasets for cloud computing with powerful data analytics, driving process optimization with actionable insights. New business models for the process industry will now be possible, to deliver more complex process manufacturing flows and to create value from the new insights that are now available.

Solutions available today

ADI has extended its ADI Chronous™ portfolio with new offerings that bring long-reach, robust, 10BASE-T1L Ethernet connectivity to process automation in support of Ethernet-APL. The new Industrial Ethernet solutions are offered in two flexible options, MAC PHY (ADIN1110) and PHY (ADIN1100).

The ADIN1110 enables the industry's lowest power system design, which simplifies retrofitting for Ethernet in field instruments, sensors, or actuators, and preserves existing investment in software and processor technology. ADI's unique MAC-PHY technology provides an SPI interface to ultra low power processors without integrated MAC, to enable lower overall system power consumption.

The ADIN1100 provides standard Ethernet interfaces and supports use in more complex designs such as field switch developments. ADI's ADIN1100 and ADIN1110 10BASE-T1L solutions can transfer data over 1.7 km of single twisted pair cables and consume only 39 mW and 43 mW of power respectively. Single-pair Power over Ethernet (SPoE) or engineered power solutions combined with a 10BASE-T1L PHY or MAC-PHY provide both power and data over a single twisted pair cable.

Maurice O'Brien, Strategic Marketing Manager, ***Analog Devices.***

Visit Website

Networks for process automation using two-wire Ethernet-APL

Ethernet-APL (Advanced Physical Layer) provides a combination of ease of adoption, seamless integration, simplified installation, greater range and valuable data for process industry implementations. It enables a logical extension of Ethernet-based communications from enterprise systems to the field.

PROCESS AUTOMATION PLANTS OPERATE FOR 20+ years and are required to be safe for people, the product, and the environment. Explosion potential in hazardous areas and harsh conditions require that any deployment of new technology is both thoroughly tested and provides added business benefits.

Technology must not be complicated in handling or require extensive training. Ethernet is the de-facto communication standard in enterprises, but it does not meet the requirements in the field of process automation without modification.

Impact of Ethernet-APL

Ethernet with an Advanced Physical Layer (Ethernet-APL) will enable long cable lengths and explosion protection via intrinsic safety with communication and power over two wires. Based on IEEE and IEC standards, Ethernet-APL supports any Ethernet-based automation protocol and will develop into a single, long-term stable technology for the entire process automation community.

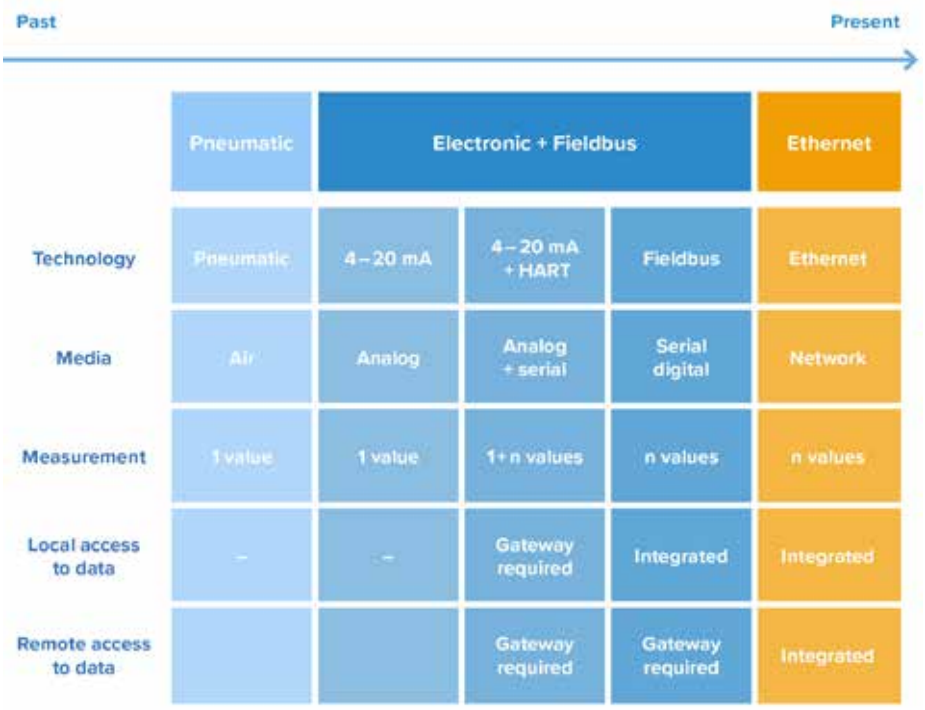
This article covers the business environment, technical specifications, implications for different user types, and the development status of Ethernet-APL. For the purpose of this article, fieldbus refers to digital communications technologies to the field within process plants such as HART, FOUNDATION Fieldbus H1 or PROFIBUS PA.

Situation & business environment for process applications

Process plants today compete to produce more products with less waste, and thin profit margins require increased output yield with increasing quality.

Digital transformation has made it increasingly worthwhile for companies to consider making investments to obtain more plant data from process automation systems and instrumentation. However, to do so, new procedures and products are required to gain access to this data from every part of the plant and to extract more value on every production run.

In manufacturing, the IIoT and Industrie 4.0 are already part of everyday operations, and in the near future, these technologies will also enter the field of process automation and instrumentation. In the process industries,



SOURCE: ETHERNET-APL

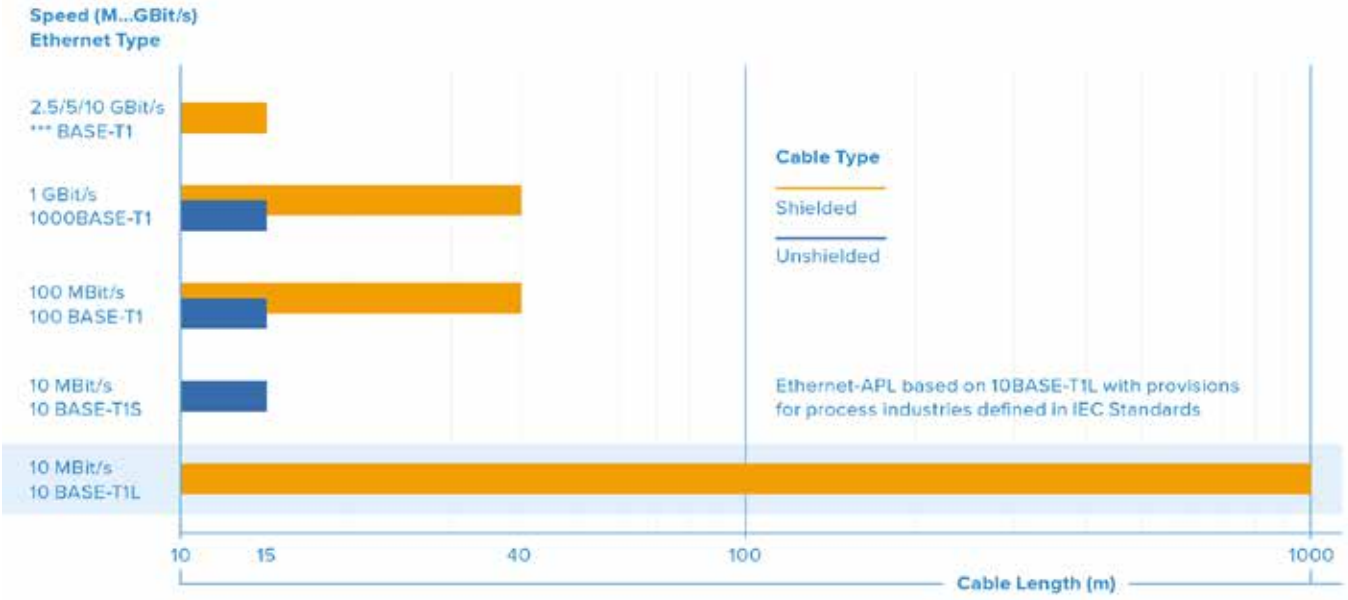
Figure 1: Technologies for the field of process automation comparing attributes of technologies connecting the field of process automation.

domain-specific concepts like the NAMUR Open Architecture (NOA) or the Open Process Automation Standards (O-PAS™) by the Open Process Automation Forum (OPAF) are presently attempting to simplify the efficient construction, commissioning, and operation of process plants. Broader use of wireless solutions, simplified field device integration, and Ethernet to the field represent integral components of these concepts.

Leading suppliers to process automation recognize the need from their customers to add the universality and communication speed of standard Ethernet to existing field device installations. Ethernet has been deployed at the upper levels of the automation pyramid and in the field with 4-wire Ethernet devices, such as drives, flow, analyzers and motor control centers. However, it requires enhancements to support applications in the field of process plants.

A key group of these leading suppliers and standards development organizations have come together with the goal of accelerating development and adopting a new open standard for an Ethernet physical layer for the use in process automation and instrumentation that can be deployed in hazardous areas, allow long-reach connectivity, and include an option for device power over the line. This new Ethernet advanced physical layer, called "Ethernet-APL," together with the automation protocols that define the structure and meaning of information being transmitted to and from field devices, will be one of the key enabling factors of the IIoT in process automation. It will provide a vital prerequisite to extend the digitized world to process automation and instrumentation.

This article also describes the standardization and development of Ethernet-APL: a single, ruggedized and reliable physical layer with attributes that meet the requirements for the field of process plants. Ethernet-APL enables a logical extension of Ethernet-based communications from enterprise systems to the field. This last meter of Ethernet connectivity would allow any enterprise boardroom to obtain data from all regions of its extensive network.



SOURCE: ETHERNET-APL

Figure 3: Ethernet-APL and Types of Single-Pair Ethernet defined in IEEE 802.3.

Organization of the cooperation

The agreement to develop the Ethernet-APL technology under "The APL Project" was established in 2018 and is backed by the leading industry standard development organizations (SDOs) FieldComm Group, ODVA, OPC Foundation, and PROFIBUS & PROFINET International, as well as by major industry suppliers of process automation, including ABB, Emerson, Endress+Hauser, Krohne, Pepperl+Fuchs, Phoenix Contact, R. Stahl, Rockwell Automation, Samson, Siemens, Vega, and Yokogawa.

The main objective of the cooperation is the specification of one single physical layer that meets the requirements of process automation. To achieve this goal, representatives of project members have been working on enhancements of IEEE and IEC standards underlying the technology, have been collaborating on the development of a port profile to fit the specific requirements of the process industries, and are participating in working groups to create or enhance the SDO's relevant specifications and guideline documents.

The finalization of all these standards and specifications makes this technology accessible to all users and vendors.

With the cooperation of large companies and the most important SDOs in process automation, as well as being based on existing and widely used standards, strong market adoption of the single physical layer "Ethernet-APL" is expected.

Technology for Ethernet to the field of process plants

Ethernet is a broadly accepted standard for wired digital communications that is standardized in IEEE 802.3. Its wide acceptance in industries and households created an eco-system of standardized tools for installation, troubleshooting, and diagnostics. This provides efficiencies in practice such as:

- Low network configuration efforts
- Same tool sets for troubleshooting and fault finding in OT and IT
- Low installation efforts

However, Ethernet's physical layers today do not address and fulfill the specific needs resulting from the harsh environmental conditions in the field of process plants. To be suitable for process plants, an Ethernet physical layer needs to meet the following criteria:

- Two-wire cable
- Long cable runs
- Power and communication on the same cable
- Support of all explosion protection techniques incl. intrinsic safety
- Simple installation technology
- Potential reuse of existing fieldbus cable type 'A', which reduces cost and provides easy migration strategies from fieldbus to Ethernet-APL
- Resilience to electro-magnetic interference Support of surge protection

Ethernet-APL is an enhanced physical layer for single-pair Ethernet (SPE) based on 10BASE-T1L. It communicates via a cable length of up to 1000 m at 10 MBit/s, full-duplex, which is more than 300 times faster than current technologies, such as HART or fieldbus.

It is the logical extension for Ethernet and provides the attributes required for reliable operation in the field of a process plant. Ethernet-APL is a physical layer that will be able to support EtherNet/IP, HART-IP, OPC-UA, PROFINET, or any other higher-level protocol.

Standardization for long-term stability

Communications are based on 10BASE-T1L as defined in IEEE Std 802.3cg-2019, which is being adopted by suppliers serving many market segments in building and industrial automation.

This significant market size enables manufacturers of semiconductors to provide chips in a high volume, contributing to a long-term, stable technology and platform, which can be integrated seamlessly into existing devices or instrumentation.

Ethernet-APL includes additional attributes required by process applications. The requirements result from outdoor installations and explosion hazardous area protection beyond the long cable lengths. The additional electrical features follow respective IEC standards and provide interoperability and simplicity in application.

1

2-WISE stands for 2-Wire Intrinsically Safe Ethernet. This IEC technical specification, IEC TS 60079-47 (2-WISE) defines intrinsic safety protection for all hazardous Zones and Divisions. For users, this includes simple steps for verification of intrinsic safety without calculations.

2

"The APL Project" creates the concept of Ethernet-APL by defining port profiles for multiple power levels with and without explosion hazardous area protection. Markings on devices and instrumentation indicate power level and function as sourcing or sinking. This provides a simple framework for interoperability from engineering to operation and maintenance.

SOURCE: ETHERNET-APL

Technical Attributes Applicable to Ethernet-APL

Parameter	Specification
Standards	IEEE 802.3cg-2019 (10BASE-T1L), IEC 60079, IEC 61158
Power supply output	Up to 60 W, on APL Trunk
Switched network	Yes
Redundant cable and switches	Optional
Reference cable type	IEC 61158-2, Type A (100 ohms resistance, +/- 20 ohms tolerance) for intrinsic safety
Cable cross section	0,324 … 2,5 mm^2 / AWG 26-14
Maximum trunk length	1000 m / into Zone 1, Div. 2
Maximum spur length	200 m / into Zone 0, Div. 1
Communications speed	10 MBit/s, full-duplex
Hazardous area protection:	For all zones and divisions. Inspired by fieldbus with optional intrinsic safety at the device.

3

Ethernet-APL allows wiring to screw-type or spring-clamp terminals, thus supporting cable entry through glands. Additionally, well-defined connector technology ensures simplicity during installation work.

Components & topologies

Ethernet-APL is designed to support various installation topologies, with optional redundancy or resiliency concepts and trunk-and-spur. Ethernet-APL explicitly specifies point-to-point connections only with each connection between communications partners constituting a "segment". Ethernet-APL switches thus isolate communications between segments. This eliminates disturbances such as cross talk and natively protects communications from device faults on a different segment.

Ethernet-APL defines two general types of segments:

- The "Trunk" provides high power and signal levels for long cable lengths of up to 1000 m. The "Spur" carries lower power with optional intrinsic safety for lengths of up to 200 m.
- Port profiles specify levels for power and communication signals, ensuring interoperability.

Ports can be classified as:

- P = Powered, power source
- L = Load, power drain
- C = Cascade, for daisy chain configurations
- U = Unpowered

Figures 4 and 5 illustrate the flexibility of topology choices for compact layouts and for plants requiring long cable runs.

Two typical types of switches enable full flexibility of topologies:

- The power switch feeds power and communication into one or more trunk ports. It is typically externally powered.
- The field switch provides at least one port to which a spur can be connected. It can be powered via the Ethernet-APL trunk or externally.

Scalability & redundancy

A managed switched network architecture, a power budget of up to 60 W, and data traffic at 10 Mbit/s provide for excellent scalability with regards to the number of Ethernet-APL switches and instruments that can be connected. Additionally, Ethernet-APL transports and enables the functions from higher levels of the ISO-OSI model. These higher-level functions fulfill the general requirements for simplicity, convenience, and automation of the network itself, which users generally expect from Ethernet-based communication.

These include:

- Automatic neighborhood detection at the switch that provides the means for simple device exchange.
- Multiple communications paths that can run in parallel. Users gain complete access to field instruments for asset management and dashboards in parallel and without interfering with process automation communications.

Ring redundancy or resiliency concepts at the network layer re-route communications in the case that an Ethernet-APL trunk segment fails for superior plant availability.

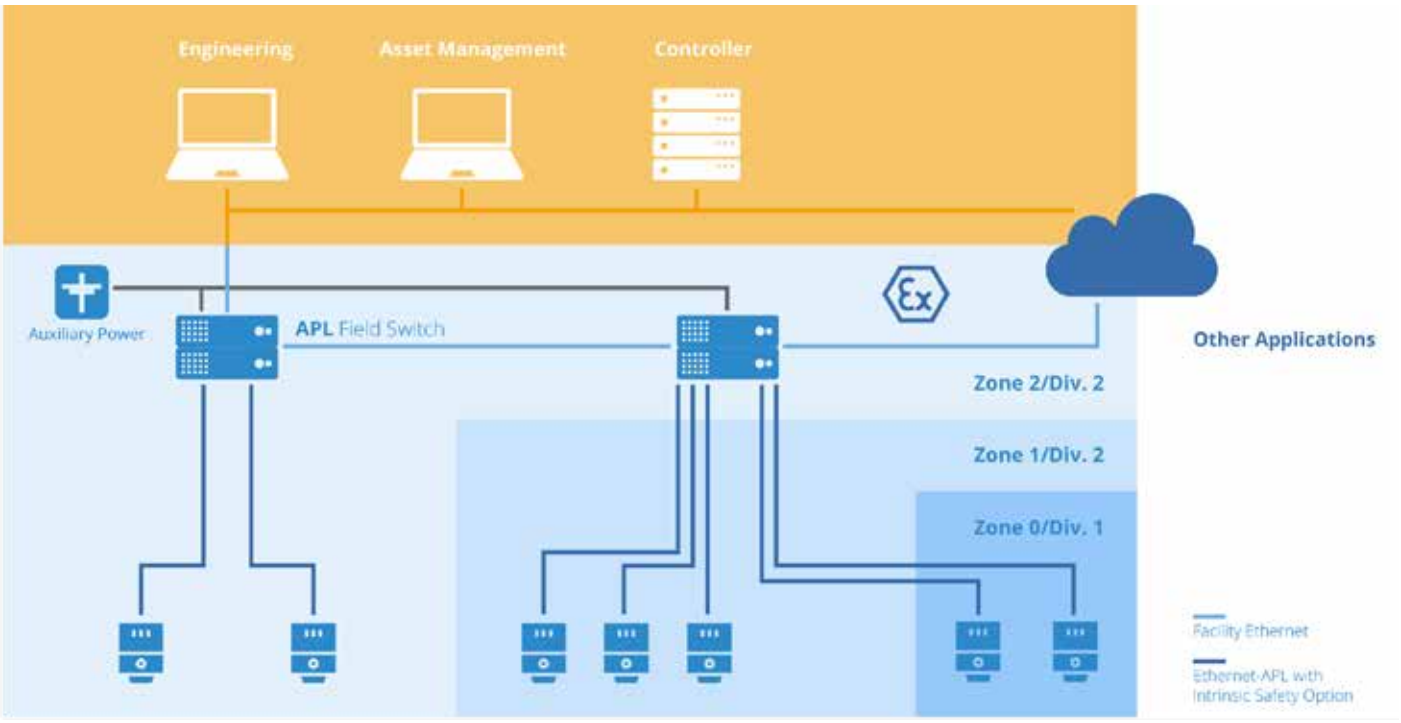
Ethernet-APL provides a single and highly ruggedized version for Ethernet that is fit for process plants. It provides the best possible simplicity in handling of all aspects with digital communications in the field.

Handling & installation

All connection choices standardized for Ethernet-APL are proven in use and well-known:

- Spring-clamp terminals
- Screw-type terminals
- M8 and M12 connectors

The simple two-wire cable, with shielding, requires just a screwdriver to ensure connectivity, and the related wire preparation tools to physically connect to the rest of the automation installation. Ethernet-APL specifies fieldbus cable type A (100 ohms



SOURCE: ETHERNET-APL

Figure 4: Example topology for a compact star installation.

resistance, +/- 20 ohms tolerance), IEC 61158-2 as reference cable of AWG classes 26 – 14, wiring cross section of 0,324 ... 2,5 mm2. This provides easy migration strategies for existing fieldbus installations, including support for intrinsic safety. Ethernet-APL prescribes polarity independence, reducing wiring errors during installation.

Inherent diagnostics of an Ethernet-based system can be easily utilized to determine network robustness, detect signal strength, and identify possible installation issues. Working in tandem with operational staff in the control room, the maintenance and engineering team can easily and quickly install, replace, re-connect and commission any device.

Installation guidelines from the standard development organizations provide details and guidance for technicians and electricians. The installation guides cover the planning and selection of cable types, cable lengths and parameters to be considered. Like all Ethernet-based technologies, numerous software and hardware tools exist to monitor, verify, and test system behavior throughout the lifespan of the installation.

Adoption of Ethernet-APL

Ethernet has proven itself as a reliable communications technology in an environment with strong requirements for interoperability. This is true for industrial industries, office buildings, and many private homes. High standardization of Ethernet technology causes a largely accepted environment with tools that range from product development and protocol stacks to network planning, commissioning, and troubleshooting.

The seamless implementation will ensure fast adoption, high involvement, and thus a long-term business environment for all parties in the life cycle of the process automation system: vendors, engineering companies, installers and operators. Increased flexibility and reduced risk are provided by the re-use of the already installed fieldbus cabling, which provides a path for clear migration strategies. This significantly reduces cabling cost as firewalls remain untouched.

Ethernet-APL supports all current and future higher-level communication protocols and services and flattens the network infrastructure. Ethernet-APL removes the need for protocol conversions and gateways, providing barrier-free and parallel accessibility and providing the extra speed required in a data-driven economy. Table 2 compares major attributes of communication technologies in use today.

Ethernet-APL combines the best attributes of Ethernet communication with two-wire installation techniques. This makes Ethernet-APL easy to deploy as a standard for field applications, from process plants with hazardous areas up to Zone 0 / Division 1 to hybrid plants, employing technologies from discrete and process automation. Since Ethernet-APL is the physical layer only, any current and future concepts for functional safety and security applications can be applied that reflects the needs of end users. New developments can be applied independent of the physical layer, providing long-term stability of the technology and protecting the investment in the installation. Like any other physical layer, Ethernet-APL transports application-layer safety and security services from the leading industrial automation standards bodies, which utilize standards such as IEC 61508 and ISA/IEC 62443.

Device development and implementation

Field devices oftentimes contain a lot of smart data about themselves, such as self-diagnostic functionalities.

Ethernet-APL provides the optimal method to access this data in parallel to process control. This technology provides access to the instrument separately, and thus combines the potential of smart instrumentation with IIoT applications. This enables product managers to design additional services, business models, and unique selling propositions for differentiation of the field device supplier. Ethernet-APL significantly reduces the costs to access this beneficial data in comparison to traditional technologies. Ethernet-APL reduces the need for protocol converters, additional system components or retrofit solutions, which would otherwise be required.

The case for considering Ethernet-APL in field device implementation is strongly bolstered by the expected market volume:

- Ethernet-APL fulfills the requirements of process automation (e.g., hazardous areas, long cable reach, simple maintenance, etc.)
- The availability of a single network technology opens new business potential for both device manufacturers and plant managers based on access to data from smart instrumentation.

SOURCE: ETHERNET-APL

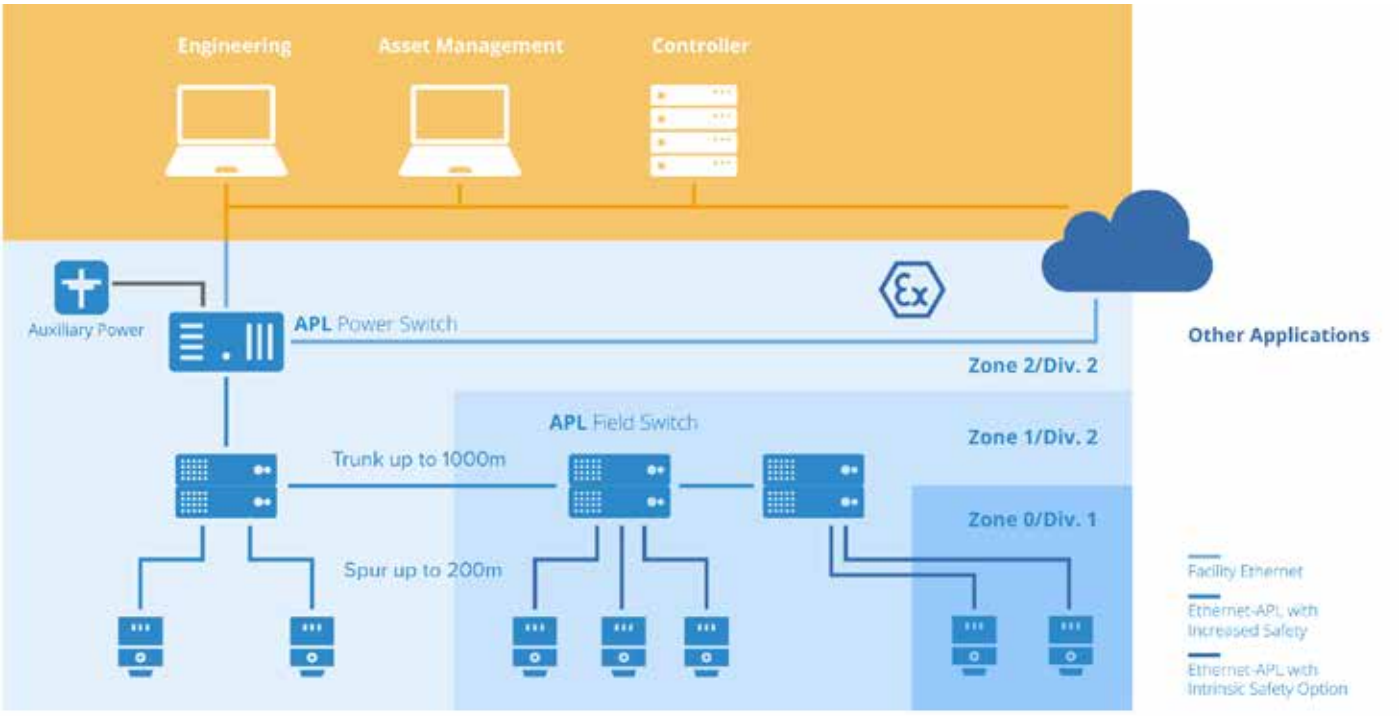


Figure 5: Example topology for long cable reach with up to 1000 m between switches on the trunk.

- Large companies and SDOs focused on process automation are involved in the APL Project and collaborate in the working groups, thus a high market acceptance for the technology can be expected.
- In order to strive for technological leadership in the market, Ethernet-APL must be considered in the product portfolio in the near future.

Implementing Ethernet-APL in smart instruments requires limited effort only concerning the PHY and the protocol stack. What must be considered during device implementation specifically for Ethernet-APL? The answer is simple:

- Ethernet-APL enhances the Ethernet physical layer. By implementing the corresponding 10BASE-T1L PHY in the field device hardware, the necessary connection is ensured. Standard PHY chips are available from reputable chip manufacturers.
- Due to the independence of the individual layers according to the ISO OSI model, there are no restrictions for the implementation of any Ethernet protocol. Therefore, no adaption is necessary for the implementation of Layer 3-7 protocols regarding Ethernet-APL. Application layer protocols, which have been in use for many years, especially in discrete automation, can easily be implemented according to their existing specifications, guidelines, and certifications.
- As part of the extension of the specifications on the Ethernet-APL physical layer, the corresponding test specifications and certifications can also be adapted. This ensures that the implementations comply with the standards.

Operation

Plant efficiency is becoming an increasingly important topic in process automation. For this purpose, it must be ensured that a process plant operates reliably, provides information on future maintenance intervals for the instrumentation, is easy to diagnose in case of failures, and works with devices from different device manufacturers. The basis for these aspects is the continuous collection and analysis of data from the installed base.

Ethernet-APL supports all of the following requirements of a highly efficient process plant.

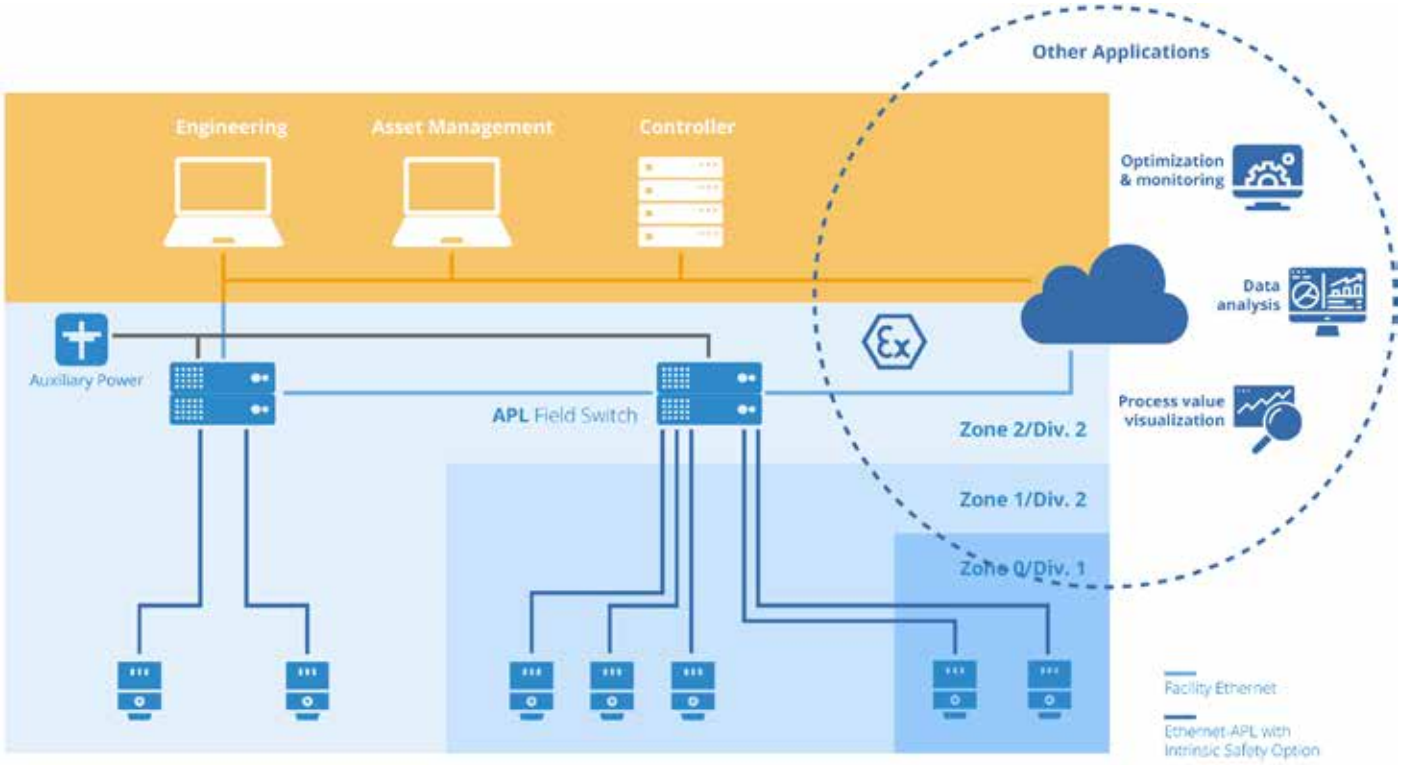
- *Reliability:* Based on well-proven Ethernet standards, the reliable operation of the plant is ensured. Ethernet has been the standard in the IT world for decades and has also been used successfully in discrete, process and hybrid automation for many years.
- *High availability:* Ethernet protocol features ensure the high availability of the process by availability concepts, e.g., system redundancy for controller failures or media redundancy for cable breaks.
- *Predictive Maintenance:* Smart field devices have the data for predictive maintenance inside. With Ethernet technology, the data can be made accessible and used for central monitoring of the device status.
- *Diagnostic:* For Ethernet technology, easy network diagnostic tools are available to identify the root cause and reasons for failures.
- *Interoperability:* For Ethernet-APL, test specifications and certifications will be available to ensure the interoperability of components from various device vendors and will also support device exchanges.

Summarized, Ethernet-APL supports this new paradigm of data by the technology consistency in and across the automation pyramid. With Ethernet technology in the field of process plants, operational technology (OT) is integrated with IT technology, and the vision of the single network technology is achieved.

The access to the data of the field enables new digital services according to the business needs of the process plant. Ethernet technology provides access to this information in real-time. There are hardly any limits to the further processing of the data within the frame- work of IIoT applications, for example those required by NAMUR Open Architecture (NOA). Maintenance dashboards or trend monitoring of process values support the specific process optimization.

Prototyping & engineering

Working habits and procedures based on Ethernet-enabled software and tools provide a high degree of automation to engineering within the field of process plants. Current and coming generations of engineers master these technologies with ease. Ethernet-APL enables



SOURCE: ETHERNET-APL

Figure 6: Networking the entire automation pyramid.

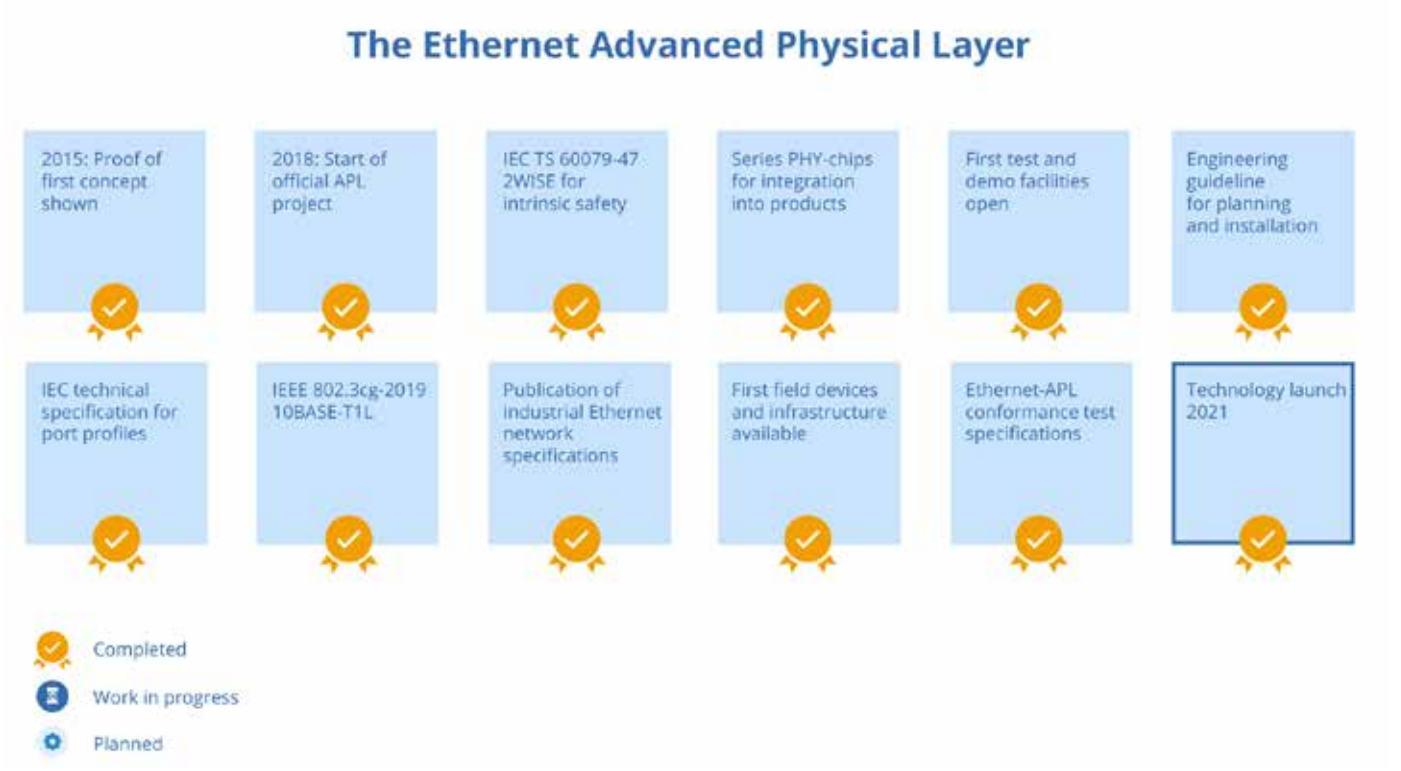
the easy integration of these features into the field of the process plant. With this, engineers can meet their project schedules through automation of many tasks.

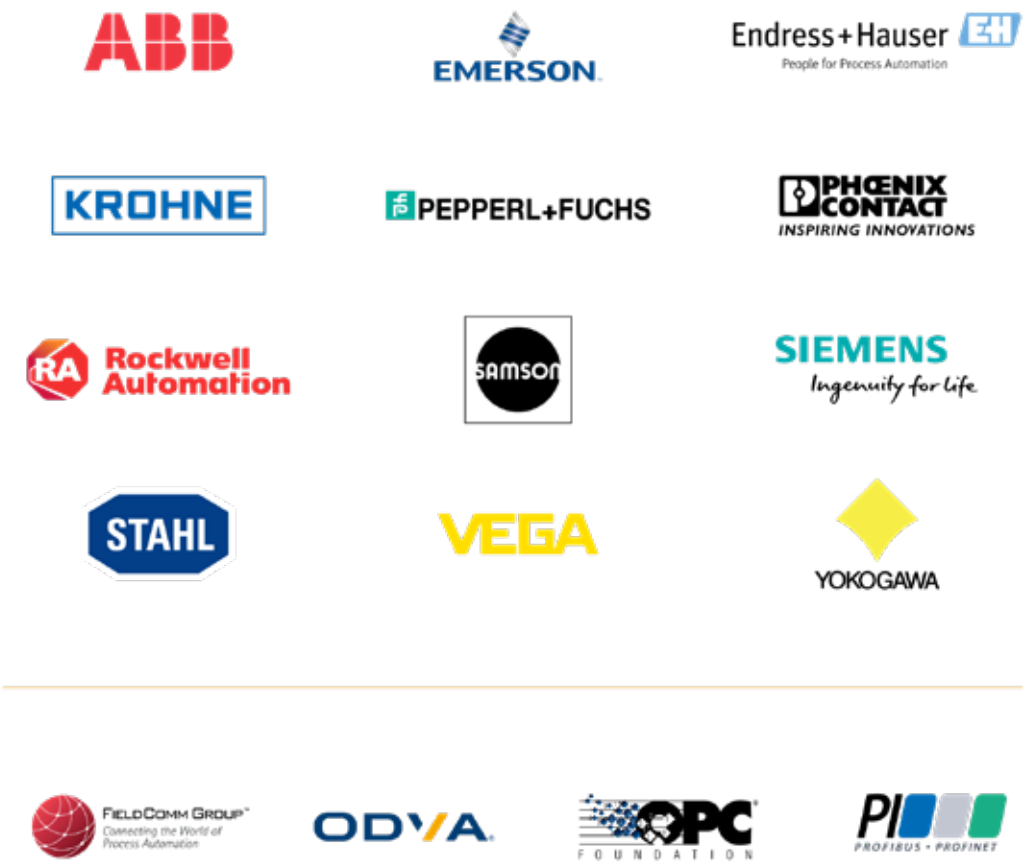
Software tools simplify or automate:

- Network planning
- Creation and design of typical control loops
- Access to all details stored in the instrument such as: device drivers and descriptions, e.g. FDI package manuals, certification
- Instrument parametrization and configuration
- Instrument diagnostics during operation

Engineering and maintenance of protocol converters and gateways will become obsolete. App-supported work procedures running on smart phones or computers satisfy the expectations of the new work force. Developers and experts of the SDOs and suppliers involved in The APL Project are in the process of developing guidelines and best practices for planning and installation. This facilitates an easy transfer of knowledge for early adoption of Ethernet-APL. Standard Ethernet diagnostic tools assist new or seasoned instrument techs and engineers in their daily work, providing a shallow learning curve.

Once all standards and guidelines are





Industry partners and associations of The APL Project.

available, a broad base of vendors are able to adopt Ethernet-APL in their devices or other product offerings. Companies providing engineering services to vendors and users already show an interest. It can be expected that a robust ecosystem will evolve.

Installation in the field

The network skills required by a new generation of electricians and instrument technicians are the result of numerous network upgrades, which many plants introduce to access and extract more data across their process automation systems. Wired or wireless, Ethernet has become part of the fabric of everyday life at home, in the office, and on the plant floor. From routers, switches and wireless access points, the only additional feature integrated in Ethernet-APL is the two-wire physical layer, including intrinsically safe ignition protection providing the same installation and protection rules that are familiar to field and instrument technicians. The instruments are not allowed to disturb one another and are only configured in a peer-to-peer manner. With features like polarity protection and the mandatory terminations inside the devices, the technology provides for a smooth and short learning curve.

While today's technician may require time to calibrate, configure, and prepare an analog field device prior to installation, the time spent preparing a digital field device will be significantly reduced. Supporting techniques include apps and wizards for automatic network setup, device discovery, configuration, and instantiation – as soon as the field device is installed and connected. The 2-wire Ethernet-APL cable allows the use of higher speed data transfer to simplify the installation and allow the technician to complete an assignment with confidence in very little time.

Together with a screwdriver, the handheld data device (such as a smart phone), cable test devices, and an improved user configuration will become additional parts of the technician toolbox in the transition from the analog to the digital field instrument with the related infra- structure devices.

Project scope, timeline and conclusion

The consideration of techniques providing power and data with high bandwidth on two wires inspired developers to develop a common physical layer that serves the needs of process plants. The experts created and published the vision for process plants: "Ethernet to the Field".

This evaluation project for the Advanced Physical Layer for Ethernet started in 2011 by a group of device suppliers. The objective of the evaluation project was to define a solution that fit the harsh requirements of process automation that didn't affect the application layer protocols and therefore the established Industrial Ethernet protocols. In 2016, the evaluation project ended successfully with identified enhancements of relevant specifications.

The project to develop Ethernet-APL has already achieved first milestones as visible in the infographic. Together with the release of the 10BASE-T1L specification in IEEE, the progress of IEC specifications for 2-Wire Intrinsically Safe Ethernet (2-WISE) and power port profiles have now officially been published by the APL Project and provided to the key standards development organizations. Final PHY chips are now available, so the first field devices and infrastructure components are expected to be available in 2021 as well. For the installation of an Ethernet-APL system, an Engineering Guideline is now available on www.ethernet-apl.org.

A first pilot project with Ethernet-APL prototypes in Germany proved the working principle and the benefits of the technology. The installation of 2-wire Ethernet field devices, both actuators and sensors for all kinds of measuring types, prove the simplicity of field device installation, integration in the process automation systems, and the parallel access to the data of field devices.

Meeting all these requirements will favor acceptance by users:

- extends easily into existing plants,
- enables transparency and open, parallel access to proven-in-use field instrumentation,
- ensures interoperability based on a single network,
- provides standardized and well-accepted procedures for explosion hazardous areas,
- achieves simple, flexible and vendor-independent use of all device functionality.

Enhanced connectivity provides a powerful tool to reduce complexity in daily operation and work. The availability of a single network technology opens new business potential for both device manufacturers and plant managers based on access to data from smart instrumentation.

*Technology report by **Ethernet-APL**.*

Visit Website

Single Pair Ethernet for condition monitoring applications

Condition monitoring continues to grow in importance, as equipment manufactures look to increase asset utilization with real-time monitoring of equipment, to extend equipment lifespans and increase throughput by utilizing predictive maintenance techniques to reduce maintenance costs and asset downtime.

CONDITION MONITORING IS DEPLOYED TO improve manufacturing quality and increase safety in manufacturing plants. Given that unscheduled downtime can amount to nearly a quarter of total manufacturing costs, predictive maintenance has the potential to unlock significant savings and productivity. Industry market reports focused on condition monitoring show growth projections for this market between 25% and 40% CAGR driven by the two growth areas.

First is the increased deployment of smart sensors to monitor the health of the assets and second is the increased use of artificial intelligence & advanced analytics to transform asset health data into actionable insights to deploy predictive maintenance capabilities and create new service based, predictive maintenance business model opportunities. Growth in new condition monitoring deployments will be across industries including water & wastewater treatment, manufacturing, food and beverage, pharmaceutical, metal & mining, energy and oil & gas installations.

Within these industries condition monitoring applications are expanding beyond the traditional rotating equipment applications (pumps, compressors and fans) to new applications in CNC machines, machine tools, encoders, conveyor belts, robotics and instruments. One key challenge that needs to be solved to enable the growth of condition monitoring applications, is the connectivity from the smart sensors to the higher-level management systems, that act based on the insights from the asset being monitored.

SOURCE: ANALOG DEVICES

Condition monitoring applications.

Technology approach

To date, condition monitoring applications have used wired or wireless connectivity solutions depending on the end application requirements. Wireless connectivity solutions have advantages in terms of ease of deployment but are often limited in terms of bandwidth and/or battery life. Wired connectivity solutions are sometimes limited in data bandwidth, long distance in a hash industrial environment is not always supported and often require a separate cable for power. Existing Industrial Ethernet solutions based on 100BASE-TX/10BASE-T provide high data bandwidth up to 100Mb, power over a CAT-5 or CAT-6/e cable with PoE but are limited to 100m distance and don't support hazardous area use case as they are high power solutions.

Condition monitoring applications require support for potentially remote sensors, that require robust communication over a long distance where the sensor node is in a space and power constrained IP66/67 enclosure due to the harsh industrial environmentally it is deployed in. These constrained sensor node applications need a low power, high data bandwidth communications solution that delivers both power and data on a low cost, easy to install cable with a small cable connector to the sensor node.

New SPE (single pair Ethernet) physical layer standards completed in IEEE are offering new connectivity solutions for communicating asset health insights for condition monitoring applications. 10BASE-T1L is a new Ethernet physical layer standard (IEEE 802.3cg-2019) that was approved within IEEE on November 7, 2019. It will dramatically change the automation industry by significantly improving operational efficiency through seamless Ethernet connectivity to field-level assets. 10BASE-T1L solves the challenges that, to-date, have limited the use of Ethernet to the field assets. These challenges include power, bandwidth, cabling, distance, data islands, and intrinsically safe Zone 0 (hazardous areas) applications. By solving these challenges for both brownfield upgrades and new greenfield installations, 10BASE-T1L will enable new asset health insights that were previously unavailable and seamlessly communicate them to the control layer and to the cloud/private server. These new insights will awaken new possibilities for data analysis, operational insights, and productivity improvements through a converged Ethernet network from the field assets to the cloud or private server

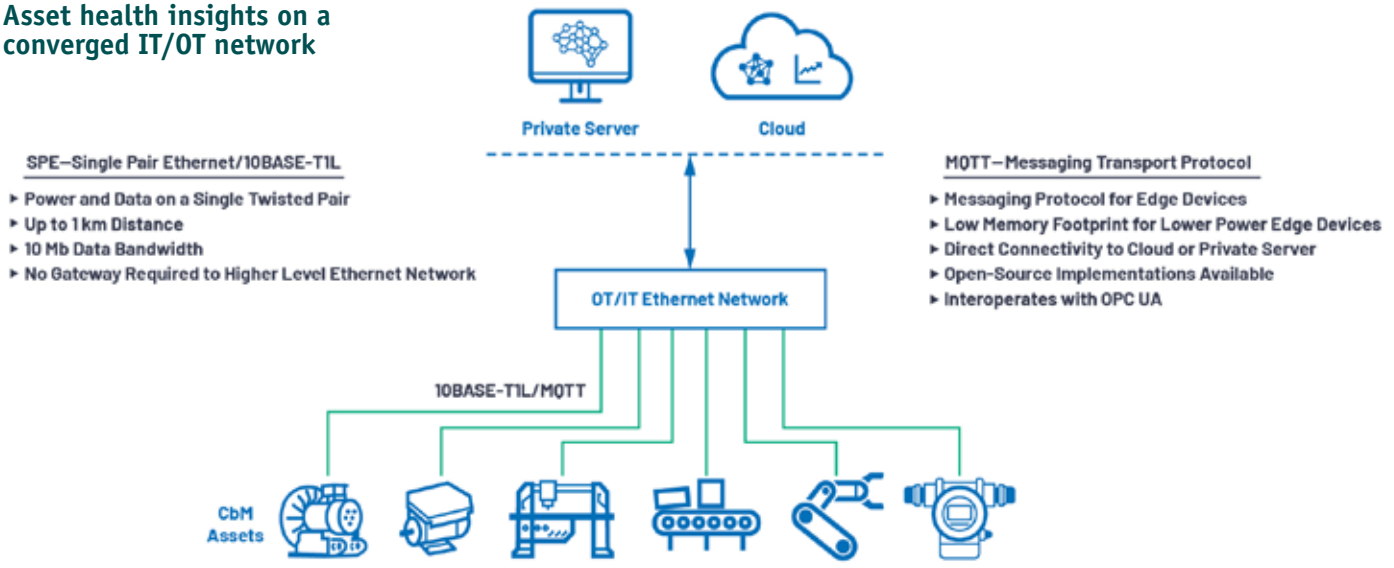
10BASE-T1L removes the needs for complex, power hungry gateways required by legacy communications to connect to the control and management network and enables a converged Ethernet network across the information technology (IT) and operating technology (OT) networks. This converged network delivers a simplified installation, easy device replacement, faster network commissioning and configuration.

This results in faster software updates with simplified root cause analysis and maintenance of field-level assets. 10BASE-T1L physical layer combined with MQTT (Messaging Transport Protocol) provides a messaging protocol for field assets with a low memory footprint for lower power smart sensors. MQTT provides direct connectivity of asset health insights to the cloud or a private server for advanced data analytics for predictive maintenance techniques.

To communicate with a 10BASE-T1L enabled field asset, a host processor with integrated

SOURCE: ANALOG DEVICES

Asset health insights on a converged IT/OT network



medium access control (MAC), a passive media converter, or a switch with 10BASE-T1L ports is required. No additional software, no customized TCP/IP stack, and no special drivers are required (see Figure 3). This results in clear advantages for 10BASE-T1L devices:

- 10BASE-T1L is a very low power physical layer technology that can enable very low power smart sensors deployments with a high data bandwidth connectivity solution.
- A smart sensor connected with 10BASE-T1L is accessible over the network and can be remotely updated anywhere, at any time. Sensors are becoming more complex and the probability of software updates increases. This is now possible within realistic periods of time via a fast Ethernet connection.
- Access to advanced Ethernet network diagnostic tools to simplify root cause analysis.
- Increased smart sensor installation flexibility via a single twisted pair cable up to 1km and beyond, with power and data on a single twisted pair cable.
- Asset heath insights are now available remotely, via a web server running on the field asset and can now be accessed anywhere, reducing the need for a maintenance technician "to walk the floor" to monitor an assets health, a significant cost saver.

ADIN1100 ADI's 10BASE-T1L PHY enables lower power, Ethernet connectivity on a single twisted pair cable > 1,200m with only 39mW of power consumption. With 10BASE-T1L both power and data can be provided on a single twisted pair cable. A 10Mb data bandwidth communication link with significant power capability over the same cable provides field assets smart sensors, the power and connectivity bandwidth to enable new condition monitoring applications. With 10BASE-T1L connectivity, asset health insights are now more accessible, as the insights are now available across a converged IT/OT Ethernet network. 10BASE-T1L supports hazardous area use case applications (Intrinsically Safe Zone 0) for process automation deployments and is sometimes referred to as Ethernet-APL. 10BASE-T1L/Ethernet-APL will enable new lower power connectivity solutions, to connect asset heath monitoring smart sensors to the higher-level data management systems for AI & advanced analytics to transform asset health data into actionable insights to deploy new predictive maintenance services.

Analog Devices is delivering complete, system level solutions for condition monitoring applications that enable real-time monitoring of field assets. ADI's commitment to enabling next-generation condition monitoring applications leverages decades of experience in sensing, signal processing, connectivity, mechanical packaging techniques and artificial intelligence. ADI OtoSense™, is an AI-driven platform that senses and interprets in real-time, any sound, vibration, pressure, current, or temperature for continuous, condition-based monitoring and on-demand diagnostics, enabling AI integration at all levels of our customers systems. It operates on the field asset at the edge, in real-time, both online and offline, for continuous condition monitoring of field assets. ADI OtoSense™ detects anomalies and learns from interaction with condition monitoring domain experts while creating a digital fingerprint to help identify faults in a machine so it can predict breakdowns before they cause costly downtime, damage, or catastrophic failure.

ADI's domain knowledge across sensing, signal chain and system design considerations combined with our AI sensing and interpreting platform enables our customers to deploy new condition monitoring systems faster. Extract more value out of their condition monitoring solutions via access to higher quality data and insights. Improve their customers' manufacturing processes, extend their equipment lifetime in the field and reduce unscheduled downtime while maintaining the highest levels of quality and safety.

Maurice O'Brien, Strategic Marketing Manager ***Analog Devices.***

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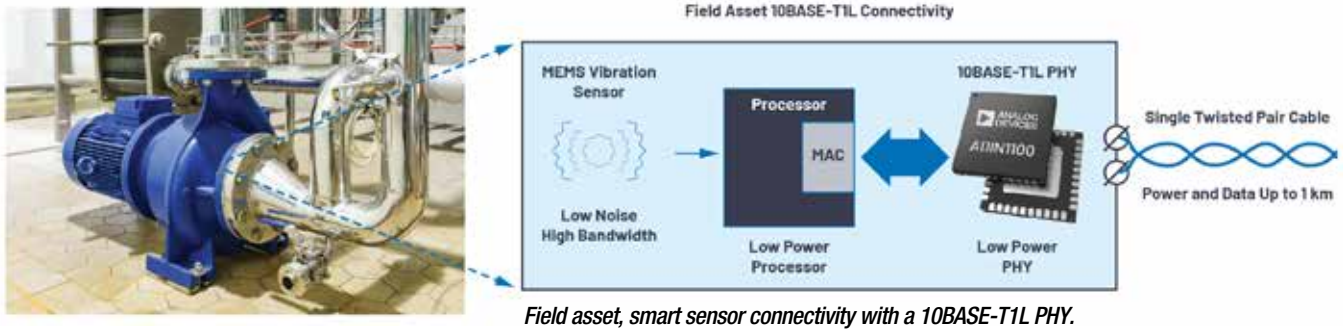

Field asset, smart sensor connectivity with a 10BASE-T1L PHY.

Intelligent to the edge of process plants

What are the benefits to the control engineer of moving intelligence to the edge? Operators and vendors alike expect to gain insight into the status of process equipment and the process plant to achieve high output quality while maintaining safety standards to protect people, the plant and the environment.

INSIGHTS CAN HELP REDUCE ENERGY COSTS while meeting production demands through monitoring and optimization. Intelligence at the edge of process plants, i.e., in smart sensors and actuators, has been available for some time. Processing power enables multivariable instruments. This results in lower capital costs for the instrument, including attributable costs and effort for engineering, piping, fittings, and even spare parts inventory.

Valve position sensors can report breakaway and run times, allowing maintenance teams to take a predictive approach to plant maintenance, leading to lower operational costs. Valves with FOUNDATION Fieldbus H1 interface can run a PID algorithm locally based on input from flow or level measurement on the same segment in the field. However, this intelligence is only used to a limited extent today – partly due to limited bandwidth and the lack of flat network technology.

At a glance:

- Intelligence already exists at the edge, i.e., in the field of process plants
- Access to this intelligence is costly, so it remains "locked in" in the instrument.
- Latest developments in technology allows users to harness this intelligence
- Ethernet-APL enables a fast and flat network infrastructure in the field
- Pepperl+Fuchs technologies provide seamless access to remote I/O

Ethernet-based industrial protocols and infrastructure enable flat networks and open architectures. However, it is only recently that these technologies have the features required for process automation that now enable intelligence to be deployed at the edge of process plants.

As of today, an Ethernet-based, flat network can be deployed in the field within process plants. The Ethernet Advanced Physical Layer, or Ethernet-APL for short, is a robust physical layer which carries power and communication on two wires. It is an open and complete set of standards available to any vendor or user, providing high bandwidth, long cable lengths, and explosion protection with built-in intrinsic safety. Because it is only a physical layer, Ethernet-APL can carry all Ethernet-based protocols.

Industrial protocols now offer "profiles" for simple engineering, such as a standardized description of device types independent of make, type and manufacturer; controllers can be reconfigured "in run" for continuous operation. Profile-based communication, e.g., with PROFIBUS PA or PROFINET, enables operation and device replacement as simple as users know it from 4-20 mA – and even eliminates the need for PV scaling.

SOURCE: PEPPERL+FUCHS

For new plants, engineers should consider Ethernet-APL as the main infrastructure.

With this combination of technologies, users can now take advantage of data that was previously unavailable. While the controller and device maintain their cyclic data exchange, an asset management system can log historical data or store configuration settings via HART-IP or OPC UA protocols. At the same time, a maintenance worker can access a device's website via a smartphone to retrieve status information. Open communication via Ethernet-based physical layer and protocols provides operators and maintenance teams with application and handling advantages that were much more difficult to achieve with the existing technology portfolio.

And how could this task be solved in brownfield plants with existing legacy control equipment (and at what cost)?

For brownfield upgrades, a significant benefit lies in protection of the investment in existing assets while at the same time upgrading communications to the controller via Ethernet. This enables or improves access to data currently "locked in" the instrumentation. The cost is the same as a typical brownfield system upgrade.

Ruggedized remote I/O systems such as Pepperl+Fuchs' LB/FB remote I/O systems, installed in the field, connect to the same backbone and provide access to modern instruments with 4-20 mA interfaces. They require an external power supply and a standard or fiber optic Ethernet connection back to the control room. In addition to the primary reading, the remote I/O station can translate status and diagnostic data, secondary readings or historical data traces from HART to the Ethernet-based protocol of choice. This access is as fast as it can get, as the remote I/O uses individual HART masters per instrument, eliminating bus cycle times.

For PROFIBUS PA instrumentation, the new Ethernet-APL rail field switch from FieldConnex offers dual-purpose spur/instrument ports. This option automatically detects and adapts to PROFIBUS PA or PROFINET over APL communication. A single infrastructure can connect and operate both generations of communication technologies simultaneously, saving significant investment costs for instrumentation and infrastructure. Even minor upgrades are possible when the value of high-speed, Ethernet-based communication is required, such as for certain mission-critical sensors or actuators. Ethernet-APL field switches can be installed in junction boxes near instrumentation and can share the same communication and power connection as remote I/Os.

For new plants being built today, engineers should consider Ethernet-APL as the main infrastructure. This provides a future-proof infrastructure with access to all device types and technologies that can be upgraded at any time. Ethernet-based communication via standardized protocols such as PROFINET, EtherNet I/P, OPC UA and HART-IP enables access to intelligence that is already at the edge: In the sensors and actuators installed in plants today. Users can leverage this data from any process plant and without constraints to improve the efficiency of standard operating procedures and move from reactive to predictive and proactive plant maintenance, monitoring and optimization.

Gerriet Lohmann and Andreas Hennecke,
Pepperl+Fuchs.

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industrial ethernet book
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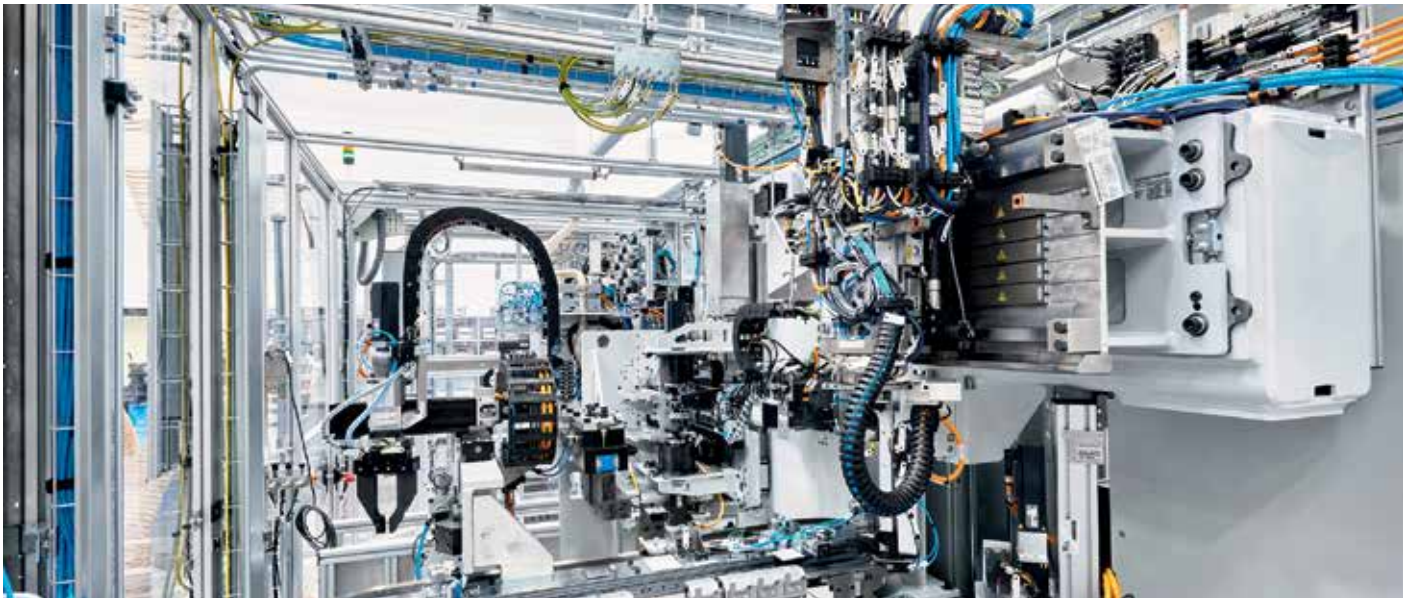
Special Supplement

EtherCAT Solutions Update

Learn about the technology and trends, applications and products shaping the newest generation of EtherCAT solutions.

EtherCAT technology and applications update

Ethernet for Control Automation Technology (EtherCAT) is a real-time Industrial Ethernet technology. An update from industry experts reveals an industrial protocol with a continuing technology focus on its roots: short cycle times (≤100 µs), low jitter for accurate synchronization (≤1 µs) and low hardware costs.



SOURCE: BECKHOFF

A look inside an EtherCAT-controlled machine is often represented by the complexity and variety of its motion sequences.

ETHERCAT AUTOMATION, MOTION AND MACHINE control solutions have been a stalwart piece of the Industrial Ethernet networking ecosystem for nearly 20 years.

For our Special Report on EtherCAT, the Industrial Ethernet Book reached out to Dr. Guido Beckmann, Senior Management Control System Architecture & International Key Accounts at Beckhoff Automation and Martin Rostan, Executive Director at the EtherCAT Technology Group to provide readers an update on this key Industrial Ethernet technology.

Dr. Guido Beckmann, Senior Management Control System Architecture & International Key Accounts, Beckhoff Automation

Martin Rostan, Executive Director, EtherCAT Technology Group

What key technical trends are driving the adoption of EtherCAT automation, control and networking solutions?

Dr. Guido Beckmann: Performance, ease of use and low cost were the goals when we developed EtherCAT in the early 2000s. Performance, because the Lightbus, which we introduced to the market in 1989, no longer matched the performance increase of PC-based control technology: Beckhoff is, after all, the pioneer of this approach and has been using PCs as industrial controllers since 1986. Ease of use, as we were accustomed to with the Lightbus; just plug it together, without having to set addresses or configure switches and routers. And low costs are of course always desirable - in this case, the low hardware costs and the simple handling, which saves commissioning costs, work together ideally. And this then supplemented by real openness.

That's why we opened EtherCAT to everyone, together with 32 partner companies founded the EtherCAT Technology Group in 2003 and thus contributed to EtherCAT become a leading bus technology. And these goals were not only important at that time, but they are also still technical trends today, followed by customers and manufacturers of automation solutions alike. EtherCAT is at its best at the lower levels of the IoT and Industrie 4.0 architecture: wherever hard real-time, flexible topology or low costs are important.

Martin Rostan, ETG: The mega-trend leading to EtherCAT as the bus technology of choice has been around for years, and away from proprietary PLCs and towards PC-based control technology. This means that computing power is no longer a limiting factor, and a

SOURCE: BECKHOFF

A sophisticated EtherCAT system uses PC-based control and AI support to help baker Juchheim offer pâtisserie-quality "Baumkuchen" layered cakes.

bus technology is needed that can cope with very short cycle times and does not represent a performance bottleneck. Users are realizing that bus systems cycle times in the range of milliseconds do not suit controllers that control in the sub-millisecond range.

EtherCAT is not only by far the best-performing Industrial Ethernet technology, but also the only one that enables hard real-time without any hardware extension in the control PC: a standard Ethernet port, as it is already on board every industrial PC, is completely sufficient with EtherCAT. Thus, EtherCAT not only saves costs, but also ensures openness: you are no longer bound to the hardware of one manufacturer.

The EtherCAT Device Protocol with its unique functional principle of processing on-the-fly is particularly well suited for networking controllers with I/Os, drives, sensors and alike. It is supplemented by the EtherCAT Automation Protocol for networking controllers with each other, which is classically switch-based and uses existing Ethernet infrastructure.

What are the key technical advantages of automation systems that utilize EtherCAT technology solutions? What are its primary technology benefits for automation and control networking?

Dr. Guido Beckmann: In addition to the above-mentioned performance paired with very easy handling of the system, our customers appreciate the complete freedom in network topology: Practically any number of nodes can be connected in a line without sacrificing performance due to integrated switch chips. Drop lines, tree and star topologies are also possible, as is line redundancy for applications with high availability requirements. For the latter, special devices are not even needed: every EtherCAT device with 2 ports supports this. The performance is perfectly leveraged by our special high-end I/Os with time stamping and oversampling, even overcoming the limits of cycle times. With just one click, the user can see not only the network topology and all the devices used, but also whether there are connection problems or disturbances anywhere – and without having to know the network or the application beforehand and again, every EtherCAT device supports this by default. And of course, Safety over EtherCAT plays an important role for more and more customers: seamlessly integrating functional safety into the system is an important benefit of EtherCAT. The Beckhoff TwinSAFE solution is based on Safety over EtherCAT and supports the integration of safety devices from the broad range of available products from different vendors.

Martin Rostan, ETG: The most important technical advantages of EtherCAT result from its unique "processing on-the-fly" principle. Instead of sending a frame to each network node in each cycle and receiving a response frame from each device, the controller sends a frame through all nodes, which read the output data intended for them and insert their input data. This not only leads to perfect bandwidth utilization and thus to the exceptional performance of EtherCAT, but also simplifies the system enormously. Manual address setting is not necessary, neither are routers, switches, and their configuration. Any topologies are possible without the limitation of cascaded switches. Bit errors and even loose connectors are not only detected but also localized, which drastically simplifies troubleshooting.

And because EtherCAT is not based on the Internet Protocol and the EtherCAT chips filter out all other traffic, the user does not have to worry about cyber security either. In addition to the technical advantages there are the strategic ones: EtherCAT has never been changed, only extended in a completely downward compatible way. This means there are no versioning problems. And because EtherCAT is also truly open on the controller side, the user can choose from by far the largest variety of devices on the market.

What is the impact of SPE and/or Ethernet-APL cabling and network topologies on the types of network architectures that are possible? What are the advantages of these new approaches?

Dr. Guido Beckmann: Single Pair Ethernet is sometimes misleadingly portrayed as a new bus system or an IoT enabler. SPE stands for several Ethernet physical layer variants, which were originally developed for in-vehicle applications, which is why it was initially only intended for very short cable lengths. Then the extension for long lines started, but so far only for 10Mbit/s and Gb/s. We are actively accompanying this development in the IEEE. We see an influence on the network architectures in automation technology mainly where 100m between two nodes is not sufficient – e.g. in large process plants, and there then with 10Mbit/s. APL was derived from 10Base-T1L and enhances this with power and intrinsic safety. For EtherCAT and 100Mbit/s for quite some time we have devices, which allow up to 300m cable length between two nodes.

Martin Rostan, ETG: SPE is a set of physical layer alternatives for Ethernet that can lead to longer cables between two nodes at 10 Mbit/s and 1 Gb/s, and shorter cables and higher costs at 100 Mbit/s. Therefore, SPE is not a reasonable alternative for EtherCAT. IEEE is about to start a project to specify longer cables also at 100 Mbit/s, but this will take several years. Ethernet APL combines 10 Mbit/s with power over the line and intrinsic safety, and that is incompatible with SPE using Power over Data Line (PoDL). APL may be interesting for slow process applications, although it is often overlooked that APL is specified for different cable than those currently installed in chemical plants. This is likely to become a challenge, at least at longer distances.

What are specific application areas are the newest EtherCAT solutions targeting? How are these solutions contributing to IoT and enterprise connectivity?

Dr. Guido Beckmann: EtherCAT was designed from the outset to be so universal that the technology is suitable for a very wide range of applications. Of course, many use EtherCAT for particularly demanding applications, in terms of cycle time, synchronization accuracy and throughput. This is why EtherCAT is also the leading bus system for all types of motion

SOURCE: BECKHOFF

Beckhoff's new MX-System is a uniform modular automation component designed to replace traditional control cabinets with modules in many applications.

control, and an ideal fit for advanced motion solution such as our XTS linear transport system or the new Planar motor system "XPlanar". But the simplicity of use, the flexible topology and last but not least the low costs lead to the situation that EtherCAT is also very well established in many applications where performance is not important at all. And combining EtherCAT with the TwinCAT connectivity solutions is the perfect fit for any IoT application: extremely fast data acquisition via EtherCAT together with any Ethernet based protocol, including but not limited to the EtherCAT Automation Protocol, OPC UA or MQTT.

Martin Rostan, ETG: With EtherCAT G, we will have an extension of EtherCAT which will offer even more bandwidth. The focus is not on even lower cycle time, whereby this is achieved along the way. Larger bandwidth than 100Mbit/s is needed for example for certain measurement applications with high sampling rates or cameras with live stream. With the EtherCAT Branch Controller technology, it will be possible to combine 100Mbit/s segments with network segments of higher data rates, thus keeping the robust and cost-effective 100Mbit/s technology where it makes the most sense: in the harsh machine environment.

Thanks to parallel processing of the segments, this even leads to significantly better performance while retaining the existing devices. At the same time, devices with higher bandwidth requirements can benefit from the higher data rates. EtherCAT G will therefore not replace the 100 Mbit/s technology but complement it. And EtherCAT is thus prepared for the future: EtherCAT will remain the fastest Industrial Ethernet technology in the long term and will still be the bus system of choice in 20 years. And the combination of the EtherCAT Device Protocol southbound of the controller together with the EtherCAT Automation Protocol or OPC-UA - depending on the requirements – north of the controller is the ideal solution for IoT connectivity.

What are the engineering challenges that the newest EtherCAT systems and architectures are designed to address, and how is EtherCAT evolving to provide more comprehensive solutions?

Dr. Guido Beckmann: One of our latest EtherCAT based systems is the planar motor system, XPlanar, which combines the advantages of conventional transport technologies with magnetic levitation. The levitating 2D product transport enables a wide range of new options for handling products within a machine and also between several machines. The user benefits from the freedom of movement of the object carriers: Individual goods can be transported to any location via any route. XPlanar combines this flexibility with the dynamics of conventional linear motors and offers added value through cycle-time-optimized linking of individual production steps.

Since in XPlanar systems we also close the control loops in a central PC to enable the best coordination of the movers, we need very short cycle times with maximum data throughput. Therefore, EtherCAT G is already used in these systems. A brand new EtherCAT based product is the MX-System. This is a uniform modular automation component that can be used to completely replace traditional control cabinets with modules in many applications. The MX-System consists of a robust aluminum baseplate in protection class IP67 with integrated module slots that feature EtherCAT for communication and an integrated power supply. EtherCAT forms the technological foundation for the standard interfaces of the MX-System. As EtherCAT covers the entire range of data transmission requirements, one bus system is sufficient for internal system communication as well as for external expansions, which can also be connected via EtherCAT P – the One Cable Automation extension of EtherCAT technology.

Martin Rostan, ETG: One of the toughest engineering challenges is to unlock new possibilities without having to accept technology disruptions: Continuity and stability are more important than disruption to users who need to keep a production plant running. That's why we have never changed EtherCAT, but always extended it carefully, prudently and completely backwards compatible: there is only one version of EtherCAT, and that will not change with EtherCAT G either.

And so with EtherCAT, you can add a new device to an old network without having to worry about the protocol version. And at the same time with EtherCAT you get the benefit of new enhancements to meet new requirements, as it is the case with EtherCAT G. The feedback from our members, both from the user and vendor side, shows that this approach is highly appreciated and is, in itself, a good reason to rely on our technology.

Al Presher, Editor, ***Industrial Ethernet Book.***

EtherCAT Conformance Test Tool Version 2.3 released

Version 2.3 carries forward all of the functionalities and tests of the first version of the Conformance Test Tool (CTT). Full backward compatibility has proven to be a significant advantage for all suppliers and users of EtherCAT solutions.

CONFORMANCE TO THE PROTOCOL STANDARD is the basis for the problem-free interaction of devices from different manufacturers in the same network, also called in short interoperability. And both are thus very important for the success of a communication technology. Therefore, the EtherCAT Technology Group attaches great importance to the conformance of EtherCAT devices. All ETG member companies commit themselves to test their devices with the EtherCAT Conformance Test Tool (CTT) before market release.

Every manufacturer of EtherCAT slave devices is therefore familiar with the test tool. It represents the official reference for the specification-compliant implementation of EtherCAT technology in EtherCAT field devices. The first version of the CTT was released in 2008, and so far, all updates have proven to be functional extensions and not functional changes.

SOURCE: ETG

New user interfaces have been added for controlling and testing specific EtherCAT protocol properties.

CTT Version 2.3

Version 2.3 carries on all functionalities and tests of the first version and thus underlines the stability of the EtherCAT technology itself, which after all has been always only extended and never changed. This full backward compatibility has proven to be a great advantage for all suppliers and users of EtherCAT solutions.

The CTT extensions, whether in tool functionalities or test coverage, are as usual based on practical requirements as well as feedback from device manufacturers. Thus, over the years, the tool has evolved from a pure test tool that checks conformance after development is completed to a very helpful "development accompanying" software that can be used to configure EtherCAT devices, put them into the desired state and specifically stimulate them to behave in certain ways. This continues in many of the new functionalities.

For example, additional user interfaces have been added for controlling and testing specific EtherCAT protocol properties. Both the firmware download via FoE and the AoE mailbox protocol as well as the diagnostic object, which provides a central entry point for application-level diagnostics, can now not only be tested but also be used specifically in the course of development, for example to prepare the device for the functional tests that go beyond protocol conformance.

In addition to the application level interfaces, other interfaces have also been added at the lower layers of the ISO/OSI models. Conveniently and unique because rarely supported by other tools, the CTT now allows read and write access to the PHY registers. This is a valuable feature especially during initial hardware prototype startup.

All CTT functionalities that are accessible via user interface have been again made available via the Remote-Control Interface. This means that they can also be used for the script-based control of the CTT, and they thus allow automated test sequences that can be integrated into the overall device acceptance test.

For example, it can be automatically checked whether a new firmware allows all members of a device family to remain compatible and whether the respective device description files also fully reflect the functionality. Thus, the Conformance Test Tool is an essential and useful development tool, which receives a lot of positive feedback from its numerous users.

Besides the many functionalities supporting the EtherCAT implementation itself, the core of the CTT has also been extended: the test coverage. Many semiconductor device profiles have been added to the standard test set. Tests that concern functional details in Safety-over-EtherCAT and point out possible errors or even simply improvement possibilities have been integrated. In addition, the coverage for the Servo-Drive-Profile according to IEC 61800-7-2 (the equivalent to CiA DS402) has been significantly increased.

The test logic and thus the tests themselves are defined and released by a special working group within the EtherCAT Technology Group, called the "Technical Working Group Conformance". The CTT software itself, on the other hand, which executes the logic defined in the tests and evaluates the behavior of the EtherCAT devices based on this logic, is developed and maintained by Beckhoff.

This ensures continuous further development of the tool. This includes new functionality with a built-in configurator as well as support for all current Windows operating systems, including the new 64-bit architecture. Version 2.3 of the Conformance Test Tool is available from now on to all ETG members.

*News by **EtherCAT Technology Group.***

PC-based control and EtherCAT boost machine throughput 55%

A fully integrated EtherCAT control platform has resulted in an efficient and precise machine for manufacturing transformer cores. A switch from a legacy PLC to an EtherCAT control platform helped increase production rates by more than half, while also improving the level of manufacturing precision.

SOURCE: BECKHOFF

Lamination coils of various widths can feed into the X-Shear, depending on transformer core sizes.

IN TRANSFORMER CORE MANUFACTURING, efficiency gains in production cannot sacrifice part accuracy. Therefore, OEM Micro Tool & Machine Ltd. (MTM) made repeatability its top priority while working on a redesign of its X-Shear machine. A switch in the automation technology from a legacy PLC to a fully integrated Beckhoff control platform helped increase production rates substantially by more than half, while at the same time improving the level of precision in manufacturing, among other things.

Based in Canadian Winnipeg, Manitoba, MTM provides machine solutions for the manufacturing of medium-size power transformers, along with aerospace, medical and other industries. Since its founding in 1964, the company has offered high degrees of customization to accommodate unique process flows or facility layouts.

The XS600-P20E X-Shear machine cuts, stacks and assembles transformer laminations using PC-based automation and robotics. In the cutting cell, the machine uses an X-shaped blade configuration to cut any required geometry from coiled lamination of varying widths. After that, two articulated KUKA robots in conjunction with two pick and place arms assemble the core pieces. The system is designed to cut and assemble up to four transformer cores at once in e-stacking modes and sort the cut laminations into 30 segment piles when not in e-stacking modes.

At 13 meters (43 feet) long by 8 meters (26 feet) wide, the X-Shear's footprint already measured up to three times smaller than many competitors, according to Gord Atamanchuk, General Manager of MTM. "Our integrated method for loading and unloading reduces the size of the machine. Most other machines stack segment piles in a linear fashion, while we use a space-saving grid format," he says. In the redesign of the machine, MTM engineers focused on optimizing throughput, while increasing cut accuracy and reducing component and labor costs.

Multitasking capabilities crucial

"One of the biggest keys was implementing a true multitasking controller. The previous control platform we used fell short of our runtime requirements. The system had limited capability to perform conditions or commands in parallel. This meant fewer parts per minute," Eduard Streichert, Electrical Lead at MTM, explains. In the five years leading up to this redesign, the engineering team had transitioned all other machines in the MTM portfolio to PC-based control from Beckhoff Automation. Now, they were ready to update the largest and most complex machine.

MTM found the multitasking control system needed to enhance the X-Shear in TwinCAT 3 automation software and the C6930 control cabinet Industrial PC (IPC) from Beckhoff. The multiple runtimes and core isolation capabilities in TwinCAT enable deterministic control for parallel tasks, including high-velocity coordinated motion used with the X-shaped cutters. Through Visual Studio®

SOURCE: BECKHOFF

The two articulated KUKA robots stacking the cut laminations can be integrated optimally with PC-based control technology from Beckhoff.

integration, TwinCAT enables programmers to use the best language for the project and the engineer, including IEC 61131-3 and computer science programming standards.

According to Eduard Streichert, the C6930 control cabinet IPC delivers impressive computing power with a seventh-generation Intel® Core™ i5 processor with four cores: "As a true multitasking controller, the C6930 reduces machine cycle times so that throughput is much higher. The IPC offers one combined solution for PC and PLC technologies. This includes everything from connecting to higher-level systems and enabling remote support to storing recipes and running the HMI in Visual Basic."

For operator interface, MTM selected a CP3921 multi-touch Control Panel with custom push-button extensions. This IP65-rated, 21-inch touchscreen is pole-mounted on the cutting cell. This was also the first time MTM used CP-Link 4 (One Cable Display Link) for panel connection, a one-cable solution that supplies power, USB 2.0 and the DVI signals, explains Beckhoff Regional Sales Engineer Amir Kassaian. The stacking cell also offers high operating convenience scaled to a built-in 12-inch CP2912 multi-touch Control Panel.

SOURCE: BECKHOFF

The 21.5-inch CP3921 multi-touch Control Panel with custom push-button extensions provides operator interface for the cutting cell, with a smaller touchscreen on the stacking cell.

EtherCAT and advanced motion control increase speed

For Beckhoff Applications Specialist Chris Timmermans, upgrades in motion control and networking were among the most important aspects in the X-Shear project. "MTM shifted fully to the Beckhoff platform by implementing AX5000 Servo Drives and AM8000 servomotors, along with various gearboxes for the cutting axes. The EL7211 EtherCAT Terminal for servomotor control also offered a highly compact motion solution with One Cable Technology (OCT) for AM8100 servomotors," Timmermans says. The tools inside TwinCAT software helped with fine-tuning movements for highest accuracy, Eduard Streichert explains: "When tuning motors on the X-Shear, we use TwinCAT Scope View and really push the system to its highest performance."

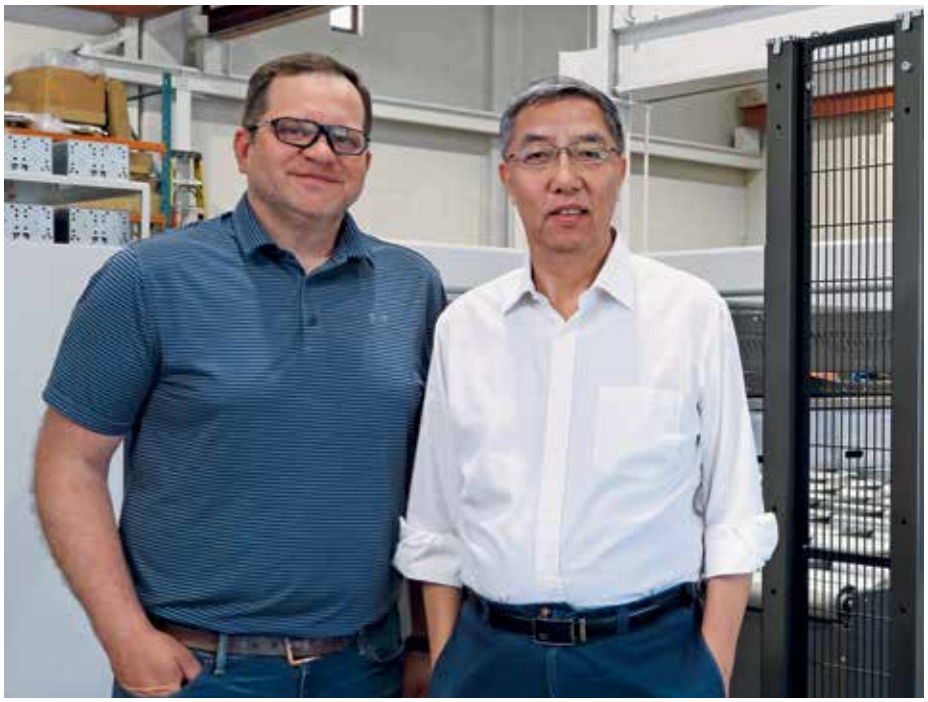
The EtherCAT system delivers fast communication, flexibility and a versatile range of hardware solutions. EtherCAT Terminals comprise the main I/O in the control cabinet, and IP67-rated EtherCAT Box modules distribute intelligence across the machine. In addition, TwinSAFE Box modules and terminals offer TÜV-certified functional safety with flexible programming in TwinCAT and

SOURCE: BECKHOFF

EtherCAT-based drive technology from Beckhoff including the AX5000 Servo Drives empower greater motion control capabilities and feedback across the machine, among other things.

communication over the standard network, also eliminating the engineering effort required for the hardwiring of black-box safety switches.

"The integrated architecture offered many advantages in terms of both commissioning and performance," Eduard Streichert explains. "Along with CP-Link 4, the EtherCAT and TwinSAFE solutions greatly reduced cabling and wiring effort. The EP Boxes allow the controller to capture signals from sensors, along with hydraulic and pneumatic devices, spread throughout the X-Shear. As a result, we increased performance while reducing expenses."



SOURCE: BECKHOFF

MTM company leaders (from left): General Manager Gord Atamanchuk and President Robin Lu.

Optimized performance

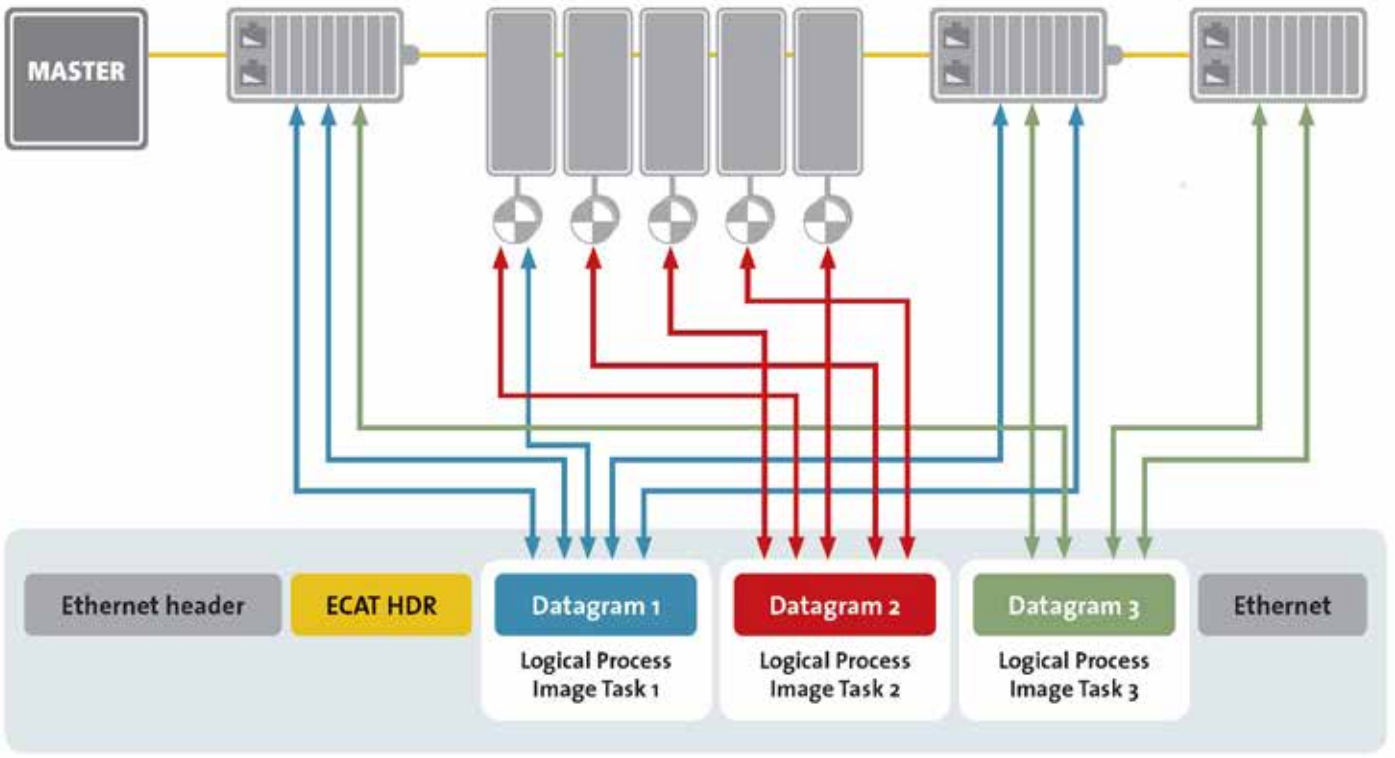
By transitioning to the Beckhoff control platform, MTM boosted performance and functionality for the XS600-P20E X-Shear. The machine increased its maximum cutting speed to 34 sheets per minute – a 55% increase in speed compared to previous models with the legacy PLC. These gains resulted in part from a significantly faster PLC cycle time of 1 ms. Beyond reducing cabling, control cabinet requirements and costs for the related components, the Beckhoff engineers also helped MTM optimize servomotor sizing. As a result, the X-Shear redesign accomplished its key goal – maintaining high cut accuracy – and helped improve the competitiveness of the machine by optimizing overall performance.

James Figy, Senior Content Specialist, Beckhoff USA, ***Beckhoff Automation.***

Learn More

EtherCAT communications in space robotics

The space industry is increasingly taking the approach that what has been successfully proved on Earth can also work in space. This is how the suppliers of space robotics came to EtherCAT, adapting technology for motion control applications on earth is well-suited for corresponding applications in space.



SOURCE: ETG

Functional Principle: EtherCAT devices insert data and extract data on the fly within the same Ethernet frame.

THE SPACE INDUSTRY IS KNOWN FOR THE FACT that only the best is good enough for it. After all, applications in orbit have particularly high requirements with regard to reliability; and the environmental conditions during launch, operation and, if necessary, landing of space components are also extreme.

Therefore, the space industry has mainly relied on technologies developed specifically for this case of application so far – and then again and again appropriate applications for these technologies were found for these on Earth. However, this approach naturally leads to high development costs and, not least because of quite modest number of suppliers, also to high costs for the components themselves and their operation.

For this reason, the space industry - not only the "New Space" companies with their unusual and pragmatic methods - is increasingly taking the opposite approach: what has been successfully proved on Earth can also work in space. The prerequisite, of course, is that the technology meets the additional requirements of the industry. And this is how the suppliers of space robotics came to EtherCAT: the most widely used communication technology for motion control applications on earth is well-suited for corresponding applications in space.

On the recent Space Symposium in Colorado Springs, which is considered the most important meeting place for the space industry, leading manufacturers of space robots and related components have published a white paper together with the EtherCAT Technology Group (ETG) on "How Space Robotics benefits from the World Standard for Motion Communication". Among the companies involved in the co-authorship of the white paper is mda, the Canadian aerospace company currently developing the Canadarm3 robotic arms for NASA's Lunar Gateway.

Canadarm in the Space Shuttle and the Canadarm2 robotic arm are also from mda. The latter plays a central role in the spacewalks on the International Space Station (ISS). Motiv Space of California developed the robotic arm for NASA's Mars Rover "Perseverance", an arm more than 2 meters long with five joints that carries some of the Rover's key scientific instruments for searching for signs of life on Mars. Tethers Unlimited is the manufacturer of the KRAKEN robotic arm, which provides the space industry with a compact, seven-degree-of-freedom manipulator that enables small spacecraft to perform assembly, manufacturing, and maintenance operations in space.

The Institute of Robotics and Mechatronics at the German Aerospace Center DLR has been using EtherCAT in a variety of applications for many years - and has already had EtherCAT-based systems in use on the ISS. The EtherCAT robot CAESAR (Compliant Assistance and Exploration SpAce Robot) was developed for a variety of tasks in space, such as assembling structures, maintaining and repairing satellites or removing space debris.

Requirements of a communication standard for space robotics

The white paper first discusses the general and specific requirements of space robots for a communication technology. From the functional perspective there is no real difference between robot services on earth or in space. The performance requirements are similar: although the movement velocities in space are usually lower, the extreme lightweight construction means that the systems are less rigid and therefore must be controlled highly dynamically and with low overall system delay margin. This requires cycle times down to significantly below one millisecond and precise synchronization accuracy for equidistance of position scanning and synchronization of multi-degree-of-freedom (DOF) systems, since space robots are no longer seen as individual axes lined up in a row, but as a complete system moved dynamically and synchronously.

Space robotics applications require a network structure that can adapt to dynamic configuration changes such as the addition of payload tools, sensors, cameras etc. to a robotics system. The data bus must accommodate a changing network topology by automatically detecting, addressing, and communicating with added nodes with minimal network initialization delays and hardware configuration changes.

It is obvious that high availability is of much greater importance in space than on earth. System reliability requires different levels of redundancy depending on the mission: from cable redundancy via controller redundancy to independent primary and secondary networks. A communication system for space robotics must also be able to meet the extended environmental requirements for radiation robustness, temperature, shock, vibration and so on.

Furthermore, radiation tolerant hardware must be available. Technologies that provide IP cores for the radiation tolerant path to flight FPGAs significantly reduce development time and cost associated with qualifying an ASIC for the flight radiation environment. And by combining the node controller with application specific firmware in the same FPGA, developers can optimize the PCB form factors that support the volume constraints of the space system assembly.

Space systems and their interfaces must be tested very carefully because implementation errors cannot be corrected during operation or can only be corrected with great difficulty. Accordingly, the testing effort usually exceeds the actual implementation effort, also for the communication interfaces. Extensive and proven conformance test systems for the bus technology significantly reduce this effort.

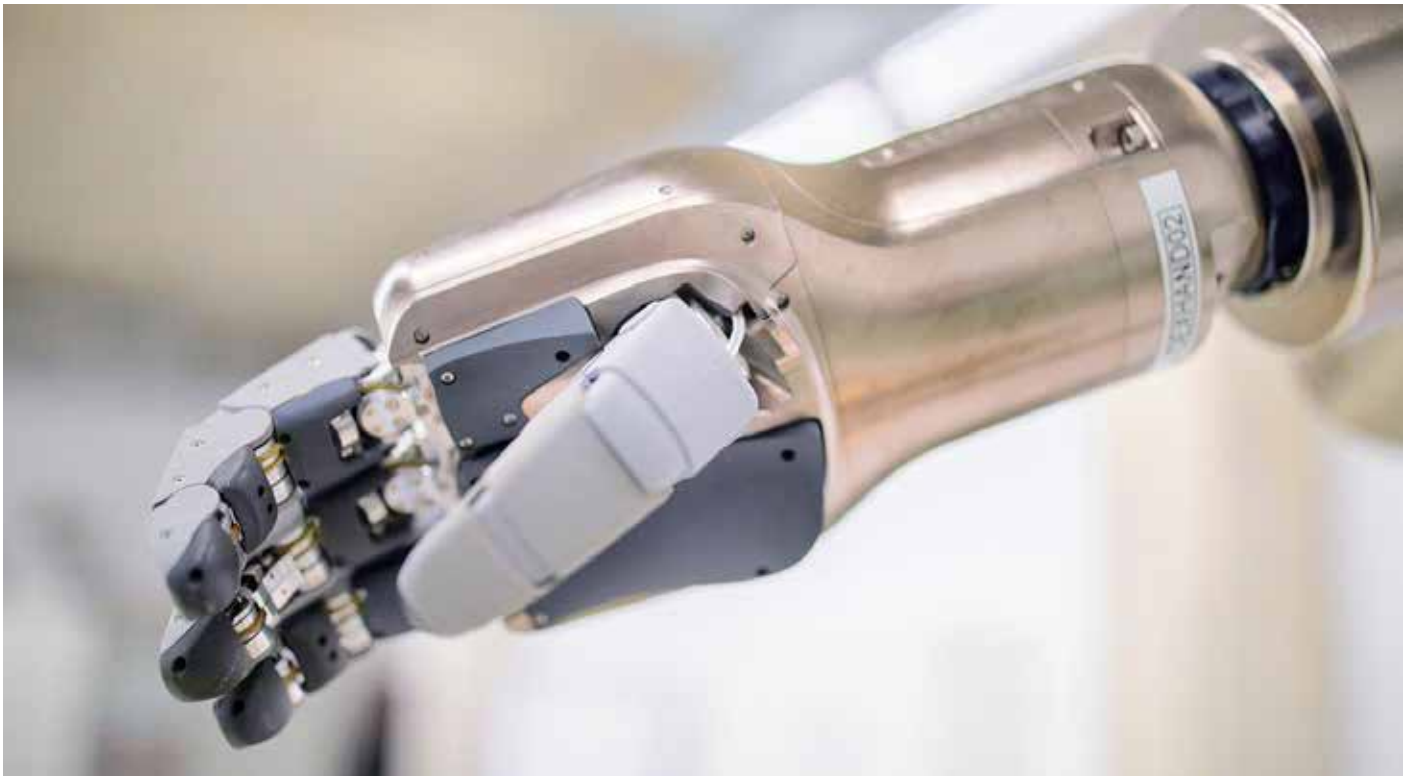
It is often necessary to integrate subsystems using other bus technologies – such as grippers or equipment for test set-ups – into the space robot control system. It must also be possible to integrate the robot itself into other environments. Therefore, the availability of interfaces to other bus systems is an indispensable requirement.

SOURCE: ETG

"CAESAR" at the Space Symposium in Colorado Springs, CO, USA.

Communication-integrated functional safety according to IEC 61508 is only slowly finding its way into space robotics. Up to now, humans have rarely been in the workspace of the moving robot in space, and so simple shutdown is usually sufficient for personal protection, also thanks to relatively slow movements combined with the low forces generated by robots in space. However, it is foreseeable that this will change. Therefore, a communication system for space robotics should fundamentally support integrated functional safety.

There are also strategic requirements for a communications standard for space robotics which are less detailed than the technical ones, but equally important. The first thing to mention here is openness: open access to



SOURCE: DLR (CC-BY 3.0)

***DLR Spacehand:** a space qualified robotic hand with EtherCAT interface, designed for long term operation in geosynchronous orbit.*

technology avoids dependency on individual suppliers and is therefore a central strategic requirement for a space robotics bus system. Ideally, openness extends beyond the space industry to increase supplier diversity and ensure the momentum of ongoing technological progress. Only when the bus technology is backed by a large community broad support for space robotics component and system providers is available. Moreover, a large supporting community leads to long term availability.

Stability is another key. Technical progress, improvements and functional enhancements are important and necessary, but should preferably not be accompanied by new incompatible versions of the technology, which are particularly problematic for space applications because development cycles are relatively long.

Costs are also playing an increasingly important role in space applications, and it goes without saying that the robotic bus system must contribute to cost savings.

And even if a bus technology already must meet all technical and strategic requirements today, the existence of a technology roadmap would be helpful because it suggests that future requirements can also be covered with the same solution.

How EtherCAT meets requirements

Performance: EtherCAT is known to be the fastest industrial Ethernet Technology, since it makes optimum use of the available bandwidth due to its functional principle. Typical cycle times start at 50µs, and 100 drives can be updated every 100 µs. The Distributed Clocks synchronization mechanism results in a jitter of less than 100ns, which is also achieved in networks without a precision clock in the master: the nodes share the clock time already present in the chips. The system scales very well, so that additional nodes have minimal effect on the latency, which is appreciated by every control software architect.

Topology: EtherCAT supports any topology without affecting performance and without the complexity that arises from cascading switches or hubs: line, tree, star topologies can be freely combined. There can be up to 65,535 nodes per segment and a controller can host several segments. EtherCAT main controllers can automatically detect network changes using a topology recognition feature which compares the actual network to the configuration expected by the master and can reconfigure accordingly. Hence, nodes can be connected and disconnected during operation. EtherCAT automatically assigns addresses to the nodes, and hence no manual addressing is required. This is highly supportive of the changing robotic manipulator configurations where the robotics must extend its internal data network to include external grappled loads and/or sensors.

High Availability: EtherCAT achieves cable redundancy by the ring topology without the network nodes or their chips having to have special properties. If a neighboring node (or tool) is removed from the network, the port is automatically closed so the rest of the network can continue to operate. Very short detection times < 15 µs guarantee a smooth transition. This also prevents the limitation that a failure in one node can disable the whole segment. Controller redundancy with hot standby is also possible. EtherCAT can detect topology changes due to failures, disconnection, or addition of nodes with a discovery method by querying the nodes through the network whereas the nodes not only respond with their identification, but also with information regarding the connection status of each port. Furthermore, the network nodes can be equipped with several EtherCAT chips to achieve multiple redundancy - the combination of all these possibilities is used e.g. by NASA in their Modular Robot Vehicle.

Environment: Chips with EtherCAT node functionality are already available from 12 semiconductor manufacturers: including those for extended environmental requirements such as temperature, shock or impermeability. A Beckhoff EtherCAT ASIC type was put through extensive irradiation tests in preparation for ISS missions (LEO) and was found to be suitable for space use. In addition, there are several FPGA manufacturers for whose devices an EtherCAT IP core is available: also for their respective radiation-tolerant and radiation-hardened space grade devices. Thus, EtherCAT semiconductors are available for the full range of space mission requirements.

Testability and Verification: Well-functioning interoperability is the prerequisite for the success of an open communication technology. That is why the EtherCAT

SOURCE: CREDIT: DLR/SIMON SCHÄTZLE (CC-BY 3.0)

***Kontur-2 Joystick RJo:** EtherCAT enabled Force-Feedback Joystick on the International Space Station.*

Technology Group has placed emphasis on testing and certification. The comprehensive EtherCAT Conformance Test Tool (CTT) tests devices with well over 1000 test cases for compliance with the standard, and accredited EtherCAT test centers in North America, Europe and Asia issue official test reports, on the basis of which the ETG issues certificates of conformance. The CTT can also be extended by the developer with additional test cases, which can be used e.g., in a consortium to test specific functional extensions.

Interfacing to other communication systems: The efficient bandwidth utilization of EtherCAT allows to tunnel other protocols over the network. These can be individual telegrams/frames or entire process images of fieldbus systems. With "Ethernet over EtherCAT" (EoE) any Ethernet protocols are tunneled via EtherCAT without affecting its real-time properties. The mapping of fieldbus gateways to EtherCAT is also standardized within the ETG, so that the process data and parameters are transferred consistently, and the controller does not have to differentiate functionally between native EtherCAT devices and devices connected to underlying bus systems. There are now gateways to 35 different fieldbus systems.

Functional Safety: the TÜV approved protocol extension "Fail Safe over EtherCAT" (FSoE also known as "Safety over EtherCAT) has a proven residual error probability of < 10-9/h and meets the requirements of Safety Integrity Level (SIL) 3 with single channel communication, whereas SIL4 can also be achieved with additional measures. A well-developed ecosystem including a TÜV-certified test tool facilitates implementation, and Safety over EtherCAT also meets the more stringent requirements of the latest edition of IEC61784-3 without modification.

Openness: EtherCAT is an open standard that can be implemented and used by anyone. As an IEC standard EtherCAT, the EtherCAT drive profile and Safety over EtherCAT are internationally recognized. In countries where IEC standards are not automatically acknowledged (such as China and South Korea) EtherCAT is also a national standard. The specification is available in English, Chinese, Korean and Japanese. EtherCAT is supported and maintained by the EtherCAT Technology Group, with over 6700 member companies from 69 countries the world's largest fieldbus organization. Several hundred of ETG's members are active in the space and aerospace sector.

Stability: ETG has succeeded in advancing EtherCAT without versioning issues known from other communication technologies: with EtherCAT new features have been added without changing the existing ones. Older devices can be easily replaced by newer ones without having to consider network protocol versions. This provides a stability of the technology that is second to none and ensures long-term availability and investment security.

Costs: The costs are primarily determined by two factors: Vendor variety and implementation complexity. A large variety of vendors ensures low prices and fully featured products. EtherCAT has the widest vendor and product variety of all Industrial Ethernet solutions; over 3000 vendors have registered as official EtherCAT suppliers, offering the full range of products for any type of application. Simple implementation is particularly important in space programs, as it reduces the probability of errors.

With EtherCAT, the complex part of the implementation is embedded in the chips and not in the stacks. The chips (including the IP cores) are deployed in many millions of nodes and are very mature. The EtherCAT protocol stacks are extremely lean – also on the controller side and have successfully implemented in thousands of products. The availability of tools from different manufacturers additionally contributes to easy implementation and thus to cost reduction.

Roadmap: EtherCAT is proven and mature a million times over, but it is far from the end of its possibilities: ETG is working on the next fully backward compatible extension: with bit rates of 1 Gbit/s and more, EtherCAT G provides even more bandwidth. A focus of this development is the seamless integration of 100 Mbit/s EtherCAT networks, so that current devices and developments will not become obsolete or redundant through EtherCAT G. EtherCAT G ensures that in 25 years EtherCAT will still be the technology of choice for fast, deterministic communication in control applications.

EtherCAT proven in space applications

EtherCAT has been used in space applications since 2015. It is permitted to report about the project "Kontur 2", a joint project of the German Aerospace Center DLR and the Russian Federal Space Agency ROSCOSMOS, as well as about the „Haptics-2" flight experiment within the METERON project of the European Space Agency (ESA) in conjunction with NASA.

In both projects an EtherCAT equipped joystick was deployed to ISS, and EtherCAT was selected for its determinism, its openness, and the radiation robustness of the ET1100 EtherCAT chip, which was tested extensively with different radiation sources and doses.

Currently the DLR Institute of Robotics and Mechatronics is setting up the CAESAR arm, which brings the benefits of terrestrial light weight robots and the philosophy used in the design of Cobots into orbit. The 7dof robot arm is equipped with torque sensors in each joint, intelligent joint control units and EtherCAT as the fast, deterministic communication system. CAESAR was prominently displayed at the exhibition accompanying the Space Symposium exhibition: the ideal place to present the white paper on EtherCAT in space robotics.

Martin Rostan, Executive Director, ***EtherCAT Technology Group.***

Download White Paper

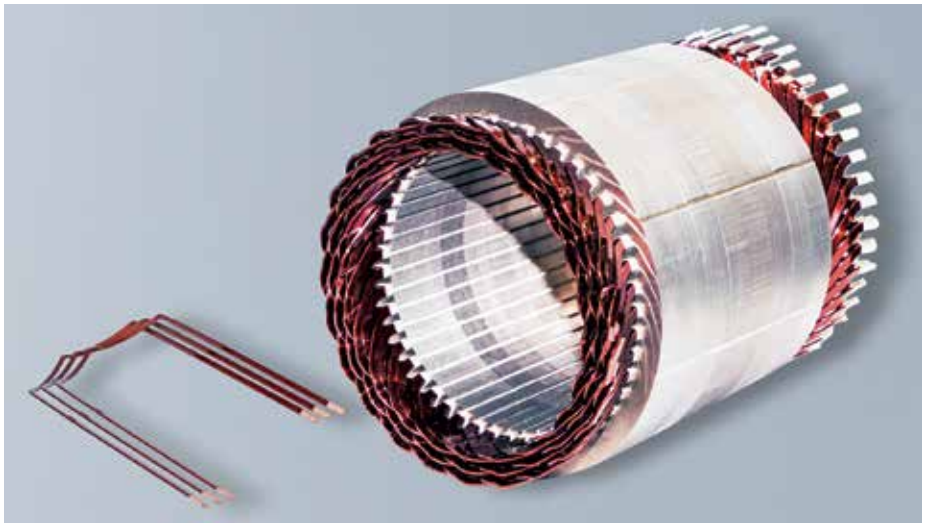
Fast cycle times for efficiency in hairpin stator production lines

A sophisticated production machine for hairpins, from which the stator winding rims of electric motors are formed, illustrates the advantages of this optimally scalable automation solution. It leverages TwinCAT 3 on a Beckhoff C603x ultra-compact Industrial PC as the central control platform and the XTS transport system.

SOURCE: BECKHOFF

The CP3918 multi-touch Control Panel, together with a specific push-button extension and the convenient user interface created with TwinCAT HMI, enables optimum use of all machine functionalities.

GROB, THE MACHINE TOOL MANUFACTURER, creates high-volume manufacturing and assembly systems to meet the important, rapidly growing requirements for electromobility. The decisive factors here are minimum cycle times and corresponding fast process sequences, as enabled by PC- and EtherCAT-based control and drive technology from Beckhoff.



SOURCE: BECKHOFF

GROB's electric motor stators (right) contain several winding rims made of individual hairpins (left).

A sophisticated production machine for hairpins, from which the stator winding rims of electric motors are formed, illustrates the advantages of this optimally scalable automation solution. It leverages TwinCAT 3 on a C603x ultra-compact Industrial PC as the central control platform and the XTS transport system.

As a globally operating family business, GROB-Werke GmbH & Co. KG in Mindelheim, Germany, has been developing systems and machine tools for the most renowned automotive manufacturers and their suppliers, among others, for over 95 years. The portfolio ranges from universal machining centers to highly complex production systems and manual assembly stations to fully automated assembly lines. This also includes production systems for electric motors as well as production and assembly systems for battery and fuel cell technology, as Fabian Glöckler, head of the control technology department in GROB's electromobility business unit, explains:

SOURCE: BECKHOFF

A C6030 ultra-compact Industrial PC provides optimal computing power for central control of all process sequences.

"In this area, we cover the entire production chain and offer customer-specific systems for the entire powertrain."

Electromobility requires powerful control technology

According to Martin Ellenrieder, Group Manager of Function Development in GROB's electromobility business unit, the trend toward electromobility also places new demands on control technology: "Compared to systems for internal combustion engines, the systems are characterized by more sophisticated stations, reduced PLC cycle times, a higher proportion of drive technology in assembly and sophisticated coupled movements." This is also evident in the hairpin machine (second generation), which is fully equipped with Beckhoff control and drive technology. In addition to four GROB spindles, a total of 57 NC axes are implemented – 40 real and five virtual axes as well as 12 movers of the eXtended Transport System (XTS) that are operated as individual servo axes. In addition, there is an extensive I/O level consisting of EtherCAT and TwinSAFE Terminals or Box modules, with 270 digital inputs and 150 digital outputs.

Using a C6030 or C6032 ultra-compact Industrial PC and TwinCAT software as the control core, the machine achieves an extremely high output rate based on a cycle time of just 2.3 s per hairpin. Around 200 individual hairpins require separate production for each stator. This is all the more impressive due to the complexity of the machining process and the wide range of control tasks involved, which extend from the infeed of the copper tube wire through its straight alignment, complex bending and stripping, to exact positioning in a pre-insertion nest:

- *Wire supply (from coil to straight copper wire, with or without electrical testing of wire insulation):* PC-based control for dancer control
- *Stripping copper wires on the fly:* axis positioning, cam plates and flying saw
- *Wire feed:* coupling of axes to a second encoder system, switchover of the encoder system depending on the operating status of the system, as well as switching of the axes used via interfaces for special operating modes (travel with or without wire)
- *Wire inspection:* transport and positioning
- *Press-fitting/cutting:* cam plates as well as compensation of material displacement during the pressing/cutting process via dynamic coupling factors of the virtual gear functionalities
- *2D bending:* dynamic cam plates generated by hairpin parameters which are coupled using dynamic coupling factors of the virtual gear functionalities
- *3D bending:* dynamic cam plates generated by hairpin parameters which are coupled to the XTS movers by dynamic coupling factors of the virtual gear functionalities
- *Pre-insertion of the hairpins:* cam plates or coordinated motion
- *Variety of infeed variants/positioning movements of the pre-insertion nest and clamping finger:* coupling of virtual and real axes

Daniel Gugenberger, group leader of electrical design at GROB's electromobility business unit, explains the difference between this and the production of internal combustion engines as follows: "The classic assembly processes, such as bolting, press-fitting and manual assembly operations, have been automated to a large extent and would not be able to be performed by a machine operator with the required quality, precision and speed." This is where PC-based control from Beckhoff has proven its worth, he says, because detailed machine and process data are of crucial importance due to the very high system throughput: "When a complete manufacturing process runs in two seconds, production monitoring and error analysis are possible only with appropriate analysis tools and high-speed cameras. We very often use the TwinCAT Scope View software oscilloscope for this."

Around 200 hairpins in approximately 50 different designs are required to build a stator winding. These are produced one after the other in the order required for placement in the pre-insertion nest. Inline error detection is therefore important. Fabian Glöckler explains: "In the event of a material or geometry error, the corresponding hairpin must be produced once again and inserted into the system using automated feed so that it can be inserted at the correct position. With the large number of motion axes and hairpin variants, this means an enormous management task for the control technology, as a wide variety of parameters, bending angles and cam plates need to be calculated just in time."

Proven automation system and innovative HMI

As early as 2004, the first GROB process machine was equipped with Beckhoff technology, Martin Ellenrieder recalls: "Initially, test stands and additional magazines followed, until 2017, when the first assembly line was also automated with PC-based control. The main reasons for the respective use were the short control cycle times as well as the high system flexibility with respect to future applications and requirements.

These include numerous interfaces to different bus systems, the extensive motion functions and a high diagnostic depth. TwinCAT offers as an advantage, a special openness – e.g. with the integration of MATLAB® which helped especially in the development process for the systems.

Process engineers could thus easily integrate simulations into test facilities. Further aspects include automatic code generation from the

E-CAD system through to the HMI, the simple integration of motion control blocks developed in-house, as well as the integration of version control, bug tracking and software testing. In addition, the flexibility of TwinCAT makes standardization in software development much easier for us."

The ultra-compact Industrial PC, C6030 or C6032 (if more interfaces are required), is used in connection with a CP3918 multi-touch Control Panel with customer-specific push-button extensions. "The IPC provides sufficient computing power to reliably achieve our target of a 4 ms PLC cycle time. Added to this are its very compact design and variable mounting options," says Fabian Glöckler.

In the case of the human-machine interface, the focus is on convenient and error-free machine operation, and the company has been relying on TwinCAT HMI from a very early stage: "Accordingly, close cooperation with Beckhoff, especially with the Munich subsidiary, was important at the beginning in order to be able to implement such a large HMI project. This worked very well – e.g. with the automatic coupling between HMI and PLC and the implementation of multiple languages – and resulted in an HMI tailored to our requirements with a focus on intuitive usability, clear parameter display and very high diagnostic depth. The result is a uniform and innovative operating concept for all of our systems."

Sophisticated motion via servo axes and XTS

The numerous rotary axes are implemented with AX5000 Servo Drives and in part with EL72xx and EP72xx compact drive technology and AM8000 servomotors. In this context, Martin Ellenrieder sees a particular advantage in the One Cable Technology: "OCT results in a significantly reduced cabling effort and minimizes the sources of errors.

Other important factors when using the AX5000 are the additionally covered encoder interfaces and the safe motion functions of the AX5805 TwinSAFE option card." Added to this is the rich set of functions within TwinCAT, such as TwinCAT NC PTP, NC Camming or NC Flying Saw, and above all the combination of these functions, he says.

The rotary motion axes are supplemented by XTS from Beckhoff. An oval, 3-meter-long track system with 12 movers transfers the individual hairpins to a linear portal for the final insertion process. According to Daniel Gugenberger, the XTS offers application advantages with the increased flexibility of the system and the ease with which new functions can be added. And further: "In addition to classic transport tasks, we use XTS for flexible positioning at different processing positions – the bending and camera stations. We benefit from the system's compact design as well as from its modularity, which makes it easy to integrate different stations. The transport system yields further advantages through flexible distance control according to the component status (no component, first bend, second bend), the reduction of cycle times, and the decoupling of individual processes so that, for example, varying process times do not directly affect the machine as a whole."

SOURCE: BECKHOFF

In addition to the compact drive technology, AX5000 Servo Drives are primarily used to control the AM8000 servomotors, with One Cable Technology (OCT) for minimization of installation space and cabling effort.

According to Martin Ellenrieder, TwinSAFE has proven itself overall as a system-integrated safety functionality and offers a high degree of flexibility in the safety application. In addition to the drive-based safety technology, the EL6910 TwinSAFE Logic module is also used as a dedicated safety controller. In complete production lines, the distributed safety applications of the individual machines and systems communicate with each other via the EtherCAT Automation Protocol (EAP). "This safety communication across control system boundaries is a very important aspect of machine safety, as our customers generally use a large number of systems that are also interlinked," sums up Martin Ellenrieder.

Tilman Plaß, Global Industry Manager Automotive, ***Beckhoff Automation.***

Visit Website

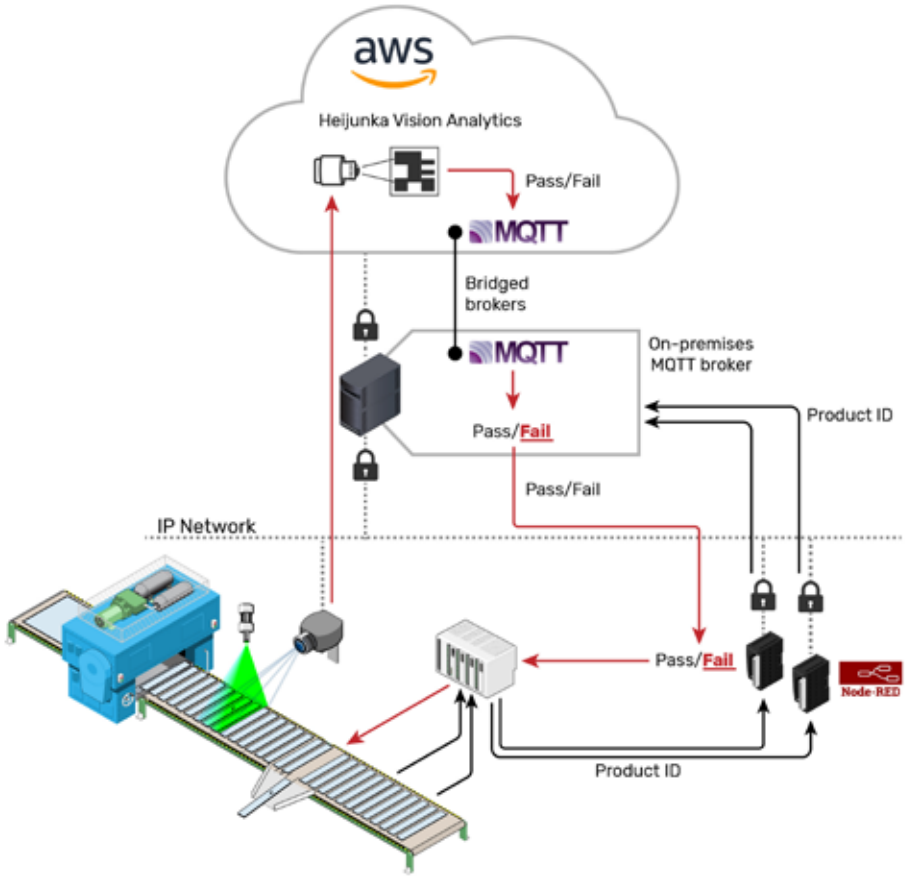
Using the cloud to automate quality control

Intrinsics Imaging's AI-powered vision system uses edge I/O to connect the cloud to the edge. A hybrid architecture used two groov RIO modules to allow cloud-hosted analytics to securely control action in the physical process at the edge of the network.

MACHINE VISION SYSTEMS CAN RECOGNIZE superficial aberrations in manufactured goods—like lines, spots, holes, color discrepancies, and more—that would typically require time-consuming manual inspection. However, these systems require specialized programming and maintenance, which can make them difficult to implement.

California-based Intrinsics Imaging solves this problem with its Heijunka Vision analytics-as-a-service software. Instead of programming specialized cameras, Heijunka provides a library of image processing and machine learning algorithms running in the cloud that allow any IP camera to perform intelligent defect detection. Intrinsics works with customers to tailor analytics to their specific objectives, then provides a concierge level of service so that customers no longer need to train, adapt, or maintain their vision system.

Typically, Heijunka integrates with SCADA systems to create analytics dashboards, alarms, and quality control actions. But when Intrinsics was approached by a customer hoping to integrate Heijunka directly into its process controls, it decided to adopt an edge-oriented approach using Opto 22's groov RIO.



SOURCE: OPTO 22

Intrinsics' hybrid architecture used two groov RIO modules on each production line to allow cloud-hosted analytics to securely control action in the physical process at the edge of the network.

Securing a path to the edge

For applications like manufacturing asphalt roofing and other kinds of building products, Heijunka not only finds defects in coatings, but also detects problems in fiberglass underlayment, color consistency, product wrapping, and even pallet counts. It can also continuously inspect in-process materials to ensure that specifications, such as dimensions, smoothness, straightness, and color, are met.

For this application, Heijunka would be looking at two production lines moving discrete boards at high speed.

The primary line cuts large sheets of raw material to size. Cut sheets would need to be inspected for excess moisture as well as dents, debris, and scratches as small as a grain of rice. The customer runs hundreds of different product types through this conveyor, each being cut to a different size and configuration.

The second line would be responsible for monitoring the quality of the milling process, specifically looking for chipping along the edges.

Unlike most Heijunka applications, the customer also wanted a PASS/FAIL I/O signal that it could integrate directly into the PLCs that would handle material rejection. By bypassing the SCADA and providing a direct path to PLC action, the customer hoped to simplify integration and reduce latency. However, Intrinsics hadn't integrated their cloud-based software directly with a hardware system before.

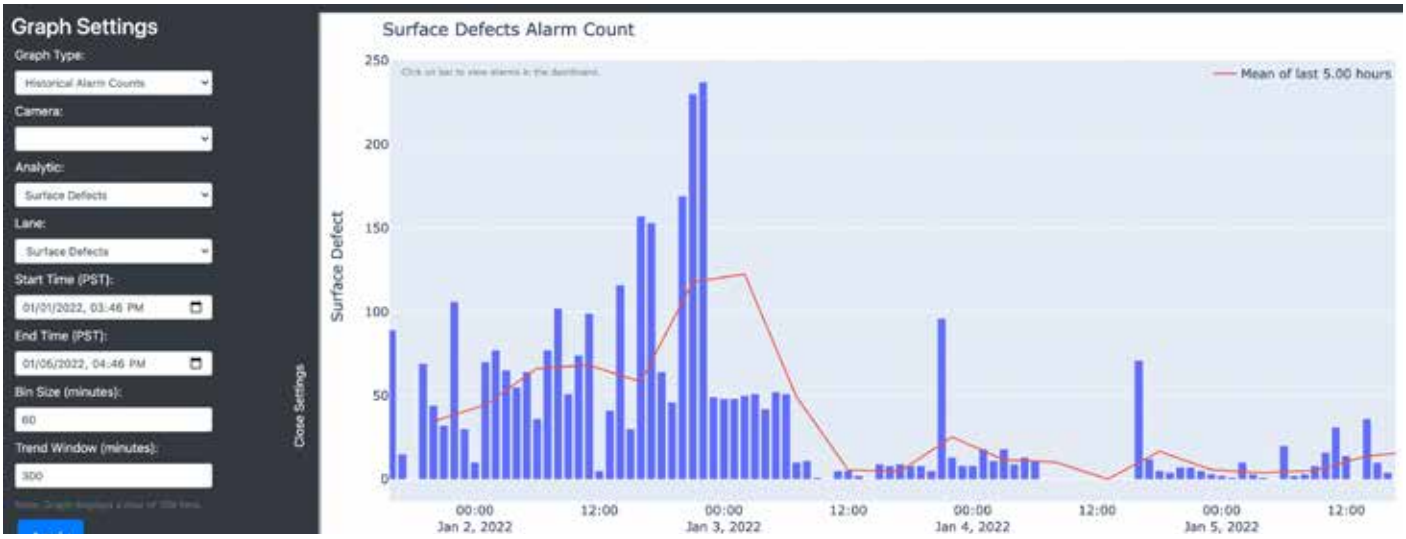
"This was surprisingly difficult to figure out," says Eric Cheng, CTO at Intrinsics. "I wasn't sure what kind of device could provide a physical interface to our cloud-based system and also satisfy our technical and operating requirements."

Besides needing a device that could tolerate an industrial environment and integrate with Heijunka's existing software stack, Eric needed something that would operate with minimal latency. From the time a given video capture was sent to Heijunka, the customer would have a roughly five-second window in which to detect and reject a problematic part. Heijunka would need to return a pass or fail indication that consistently fell within that window of opportunity.

Finding the missing piece

According to Eric, Heijunka's communication infrastructure is usually built on MQTT. "Generally, we set up an MQTT broker and publish to an agreed topic," Eric explains. "It's usually new for customers, but it's typically the best way to meet their performance and security requirements. [MQTT is] lightweight and low-latency, there's plenty of open-source support for it, and it doesn't require us to

SOURCE: INTRINSICS IMAGING



Each of the defects in the plot above indicates a product that triggered a reject signal in Heijunka that then made its way to the groov RIO modules via MQTT.

reach into their network from the outside. Amazon Web Services (AWS) has MQTT managed services to host a broker, and in cases where we are hosting the system ourselves, it's all [deployable] out of the box and in the cloud."

In this case, Heijunka was hosted on AWS and published MQTT messages to a hosted broker, which was then bridged to an on-premises broker in the customer's facility. (Bridging allows brokers to exchange data behind the scenes so that it's available to clients on both systems.) This architecture proved to be the key factor in choosing edge I/O for the final piece of Intrinsics' solution.

"The customer… made me realize that an MQTT device could work for what we were doing. [Edge I/O provided] exactly what we needed, and it was eye-opening to see everything we could do with it."

Edge I/O modules provide traditional, industrial I/O sensing for real-time applications along with multiple options for programming, data processing, networking, and communication, including MQTT. Eric also appreciated that Opto 22's groov RIO provided a web-based interface, a low-code Node-RED runtime, and an embedded firewall so that he wouldn't need to rely on a Windows PC for configuration, programming, and management.

Putting the cloud in control

Intrinsics built an isolated network to connect cameras and groov RIO MM1 modules (GRV-R7-MM1001-10) to the on-premises MQTT broker. A separate network connects that broker to the internet for video streaming to Heijunka Vision and data exchange with the hosted MQTT broker, both running on AWS.

The groov RIO MM1 module provides 8 channels of universal I/O with support for more than a dozen software-selectable signal types. I/O data can be shared via MQTT, REST, VPN, or traditional protocols like Modbus/TCP and secured with user authentication, a local firewall, and TLS X.509 certificates. Each module can then be connected to an industrial ethernet network with support for Power over Ethernet.

In this case, each edge I/O module makes an encrypted connection to the local broker, which has only port 8883 open, the standard port for MQTT TLS connections. The decision to bridge between two MQTT brokers is also for security. The local broker acts as a firewall for the OT side of the system while still allowing I/O data to be exchanged with Heijunka in the cloud. "The goal is to keep the [modules] inaccessible from the outside," says Eric.

To satisfy another customer request, each production line uses two modules configured to provide 8 discrete inputs each. Production line PLCs encode the product ID for the specific part being examined by Heijunka as a 16-bit integer and send each bit to one of the inputs on the module pair. Custom logic that Eric added to each module using the Node-RED language publishes its 8 input channels as MQTT topics, which Heijunka combines to decode the product ID and select the appropriate set of algorithms for that product type.

The modules also use Node-RED to subscribe to quality indicators, which Heijunka publishes to the MQTT broker. One of the relay outputs in each pair of modules is used to indicate the PASS/FAIL decision returned by Heijunka for a given part. The production PLCs watch these outputs and use them to trigger a physical rejection of the product if needed. Since Heijunka performs all the heavy computation and product identification, the groov RIO modules can run the same logic without regard for the product type, creating a clean interface between cloud and edge networks.

Fast, automated quality control

At this point, the customer has been automatically rejecting defects for several months and plans to introduce Heijunka in the rest of its facilities. Intrinsics confirmed a round trip time, from measurement to result, of less than two seconds.

"I'm impressed with how fast it is even though we are taking two or three steps," says Eric. "Most of that latency is due to transmitting video over the network."

Intrinsics' customer is using Heijunka to save on labor costs and increase quality with an overall goal of avoiding material returns. The customer can review system performance through Heijunka's built-in trending, which displays metrics like the number of defects detected per hour. Over time, the customer can monitor historical trends in defect rates and diagnose the root cause of elevated defect levels.

A user can click on any bar in the histogram and immediately bring up replay images to see every defect the system has ever detected. Each one of the defects in the plot above indicates a product that triggered a reject signal in Heijunka, which then made its way to the edge I/O modules via MQTT.

"We were under the gun to do this quickly," says Eric, "but we got it figured out in less than a month… Now we can provide a direct physical interface to low-level automation systems… Using [edge I/O] allowed us to own more of the 'last mile' between cloud software and physical action and allowed the customer to speak the language they were most comfortable with. That allowed a cleaner separation between our software expertise and their hardware expertise."

Heijunka can now be adapted to many more applications, supporting both hardware and software interfaces, whichever produces the best performance.

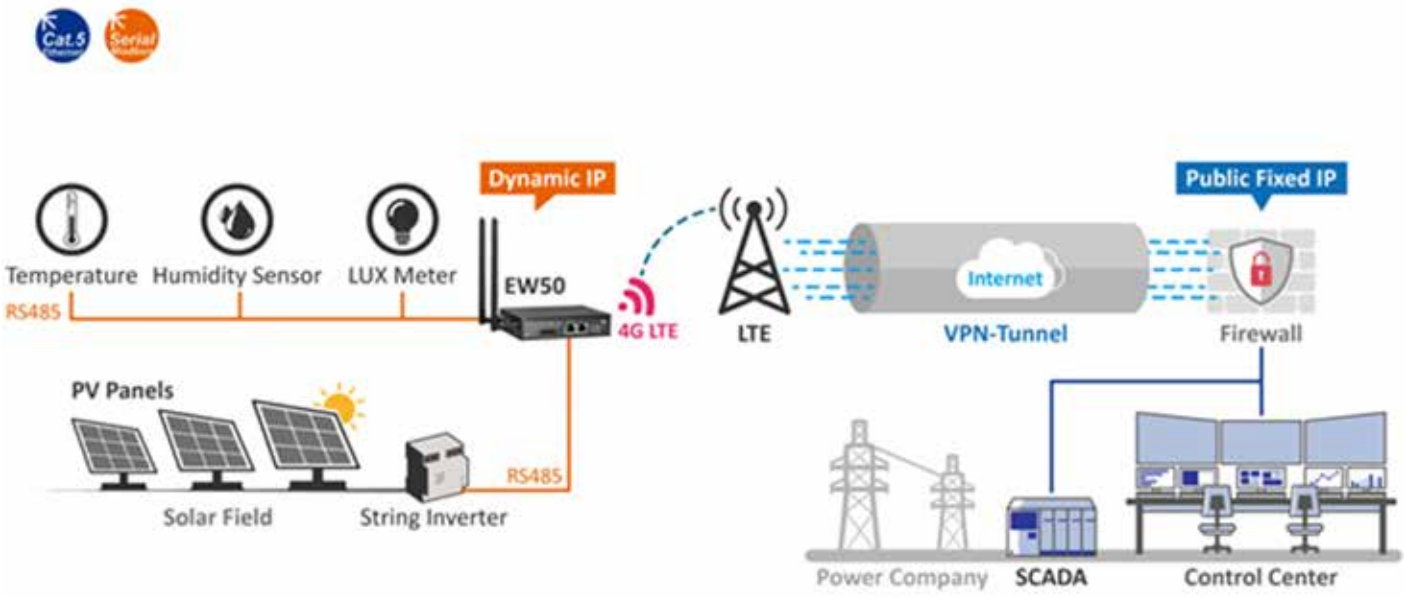
Josh Eastburn, Technical Marketing, ***Opto 22.***

Visit Intrinsics Website

Secure data and network in IIoT applications

Solar plants have critical monitoring and management needs. In many cases, traditional wired infrastructure for monitoring and management is not feasible, so equipping sites with appropriate 4G/LTE gateways provides a useful and comprehensive network backup mechanism to secure data and offer network stability.

SOURCE: ETHERWAN



The EW50 4G Industrial Gateway is an intelligent industrial grade gateway designed for critical infrastructure and industrial applications. It provides reliable and secure remote connectivity designed for harsh environments, giving operations and IT real-time awareness with remote monitoring.

A NEW SOLAR POWER PLANT IS UP AND RUNNING in the hot and sunny Tropic of Cancer. The field site for the solar panel installation includes a farm, a lake, and the tops of local buildings. Because solar panels that track the sun's movement can receive 10% to 40% more energy than fixed panels, the system is set up with a central controller for adjusting the panel angles.

Additionally, the facility has to record and transmit data about the current energy stability status and energy capacity, as well as check the field temperature and activate the cooling system as needed.

If, on a clear day in which the temperature is not too high, power generation is below the set parameters, the system will automatically notify attendants at the plant to clean the mirror faces.

The challenge

At that latitude, heat is a constant problem. Not just because excessive heat affects the power absorbing utility of the solar panel wafers, but also because overheating can damage or destroy the very expensive electrical and networking equipment installed on-site.

Another challenge is the remote location of the plant.

It was deemed impossible to run network cabling from the local ISP, yet the facility had to be online and linked to the Cloud. For a 4G LTE solution, SIM cards with public IP addresses are prohibitively expensive. Lastly, the system had to be able to effectively connect to a Modbus controller. Modbus is a communication protocol used for transmitting data over serial cables, and many devices in the solar facility used this protocol.

So the solution to be implemented had to overcome or work around these many obstacles.

System requirements include:

- Remote field monitoring and control through network connectivity
- Ability to send alarms to mobile phones
- RS-485 interface and support for Modbus protocol
- Support for MQTT cloud protocol
- Ability to operate in extremely high temperatures
- Various network failover mechanisms for redundancy
- Secure VPN tunnels

Network solution

The EW50 4G Industrial Gateway (EW50) from EtherWAN is an intelligent industrial grade gateway designed for critical infrastructure and industrial applications. It provides reliable and secure remote connectivity designed for harsh environments, giving operations and IT real-time awareness with remote monitoring.

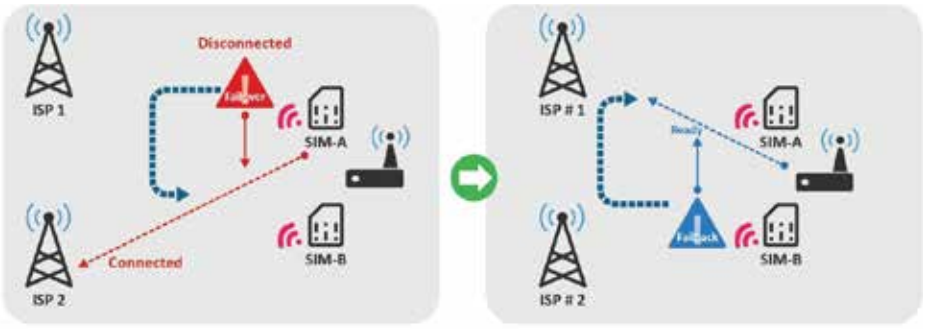
The EW50 provides 4G LTE mobile network, Ethernet, serial RS-485, DI/DO and Modbus bridging, providing an ideal connection to the many inverters, sensors, and other devices on the site.

Importantly, MQTT is supported. MQTT is a messaging protocol based on the publish-subscribe messaging pattern. It is the most basic way of communication with SCADA systems.

Moreover, the EW50 supports comprehensive network and connectivity to secure data and network connections, maintaining best data transfer conditions.

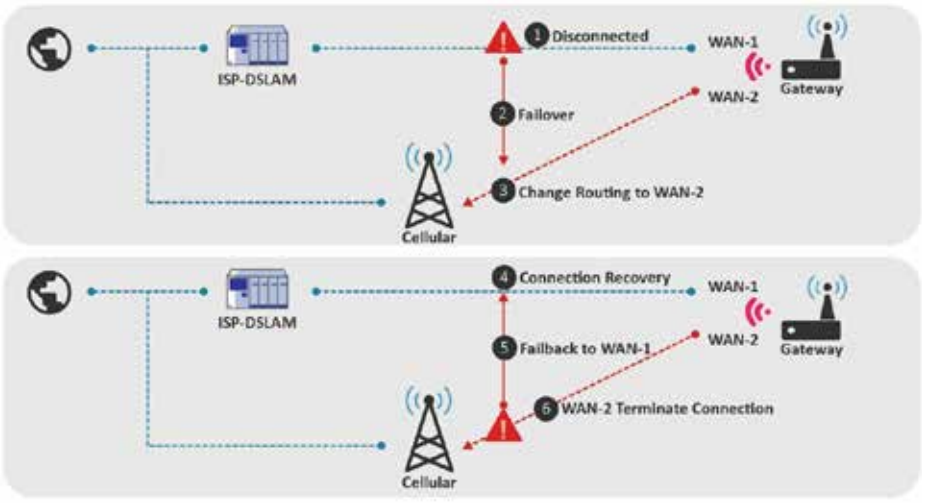
Three major ways to secure data and connectivity are used:

1) Dual SIM cards
2) Cellular WAN and Ethernet WAN failover
3) OpenVPN failover.

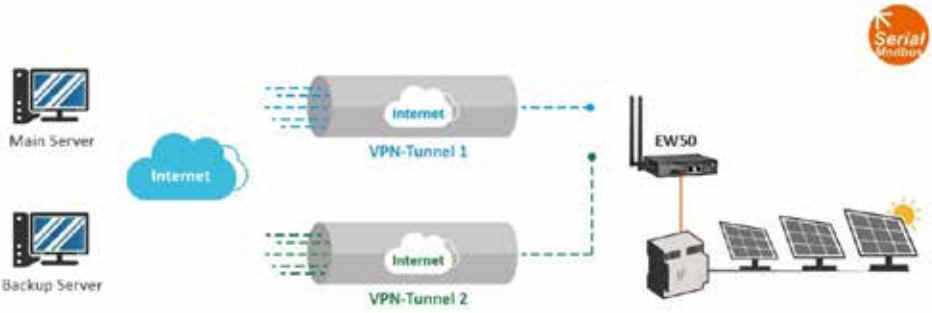


SOURCE: ETHERWAN

Dual SIM Fail Over Function.



Cellular WAN and Ethernet WAN failover backup connection.
WAN-1 / Physical interface: Ethernet operation Mode: Always On.
WAN-2 / Physical interface: 3G/4G LTE Operation Mode: Failover (WAN-1)



OpenVPN Failover.

Two OpenVPN Tunnels connect both servers with the EW50. A command script function can detect a main server connection. If there is no response for a period, the EW50 will switch to VPN Tunnel 2 to reconnect the data with the backup server.

Dual SIM Fail Over Function

SIM-A / SIM-B first with Failback enabled

With Failback option enabled, "SIM-A First" scenario (see diagram) is used to connect when the connection is broken. The gateway will switch to SIM-B. When the SIM-A connection is recovered, it will switch back to use the original SIM-A card.

OpenVPN Failover

To guarantee zero data loss, transmission redundancy will be necessary. Set up two server systems so if the main server goes down, the back-up server can receive the data. So, two OpenVPN tunnels are needed for the main server and backup server. In normal situations, the data is transferred to main server through VPN Tunnel 1. Once a failure occurs, the gateway can use VPN-Tunnel 2 for backup connection.

The solution is to set up two OpenVPN Tunnels in advance to connect to both servers with the EW50. Then, use the command script function to detect main server connection. If there is no response from main server for certain period, the EW50 will switch to VPN Tunnel 2 to reconnect the data with the backup server.

Conclusion

Solar power generation is becoming recognized as a renewable clean energy source and the number of distributed solar plants being built and in operation will continue to increase. These plants have critical monitoring and management needs, including real-time monitoring and messaging, control of panel tilt, power prediction, and power control systems. In many cases, traditional wired infrastructure for monitoring and management is not feasible, due to costs or environmental concerns. Equipping sites with appropriate 4G/LTE gateways is an effective approach, implementing a useful and comprehensive network backup mechanism to secure data, and keep the network always on and stable.

*Technical article by **EtherWAN.***

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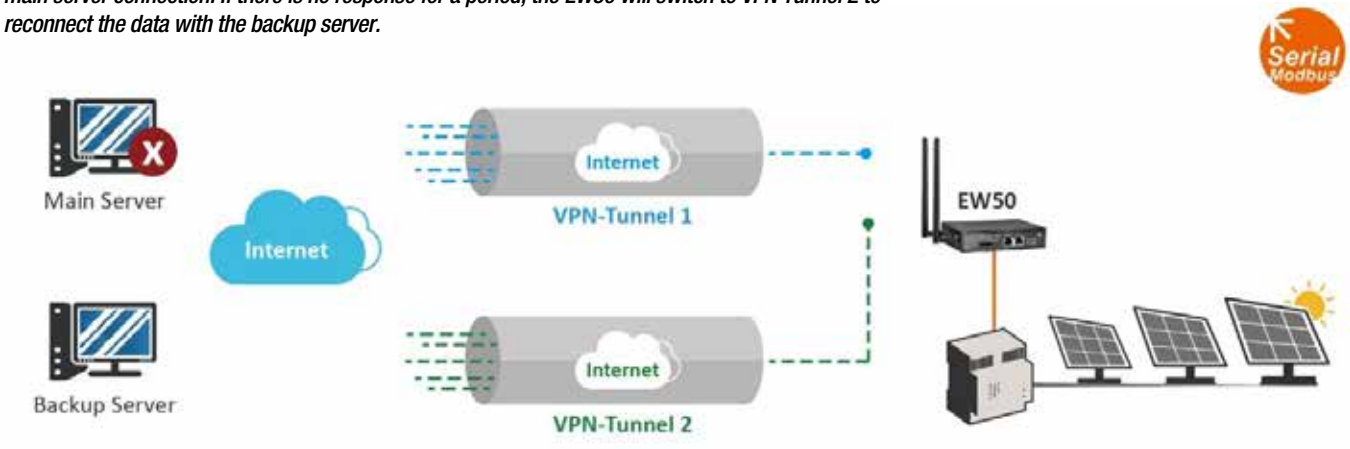
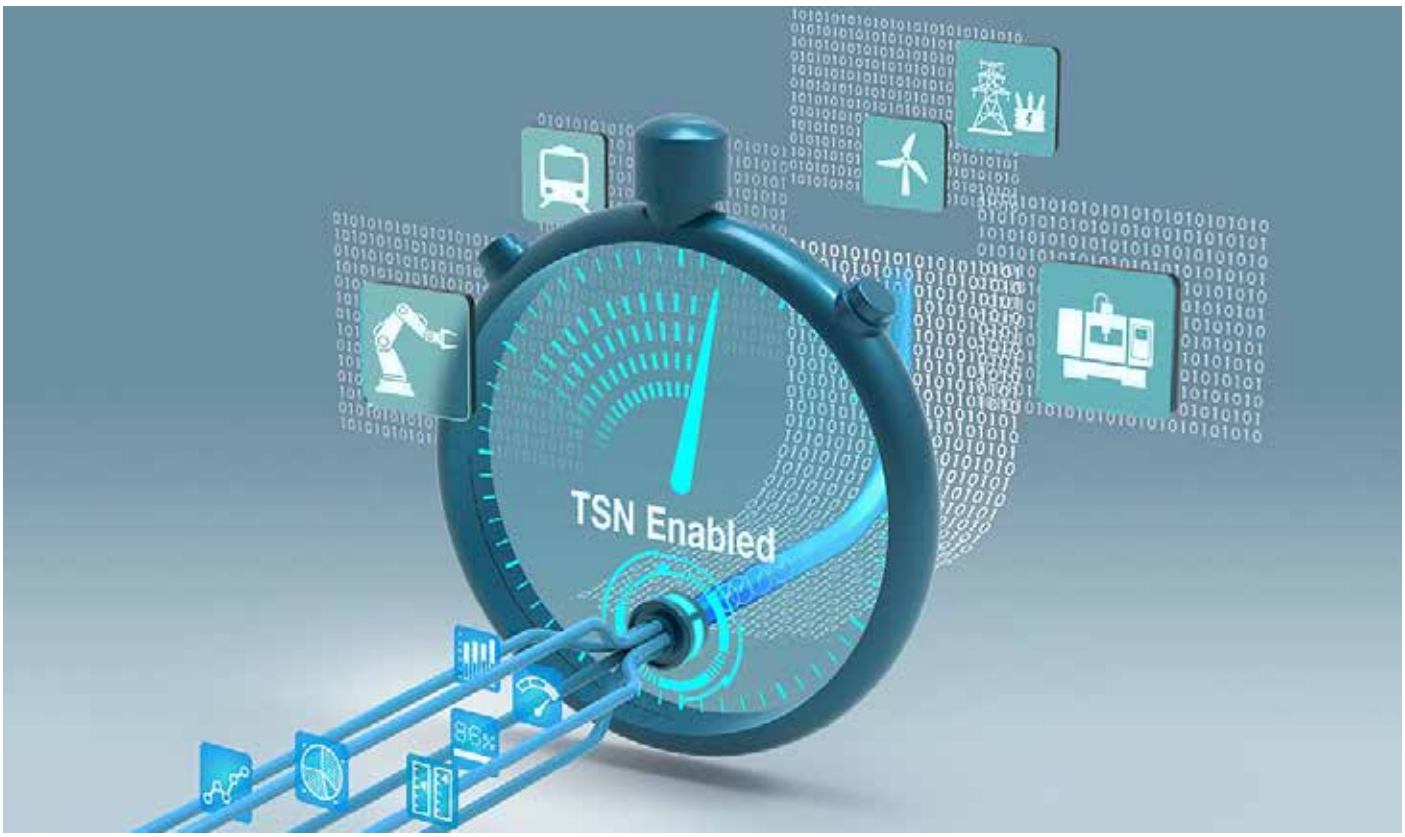


How TSN is accelerating digital transformation for industry

Time Sensitive Networking (TSN) is an advanced technology that helps industry leaders accelerate their digital transformation in industrial automation. In this article, we briefly introduced adaptive manufacturing and the core technology, TSN, that helps achieve it.



SOURCE: SIEMENS

Digital transformation can be achieved by real-time information made possible by TSN, enabling factories to optimize their production strategies.

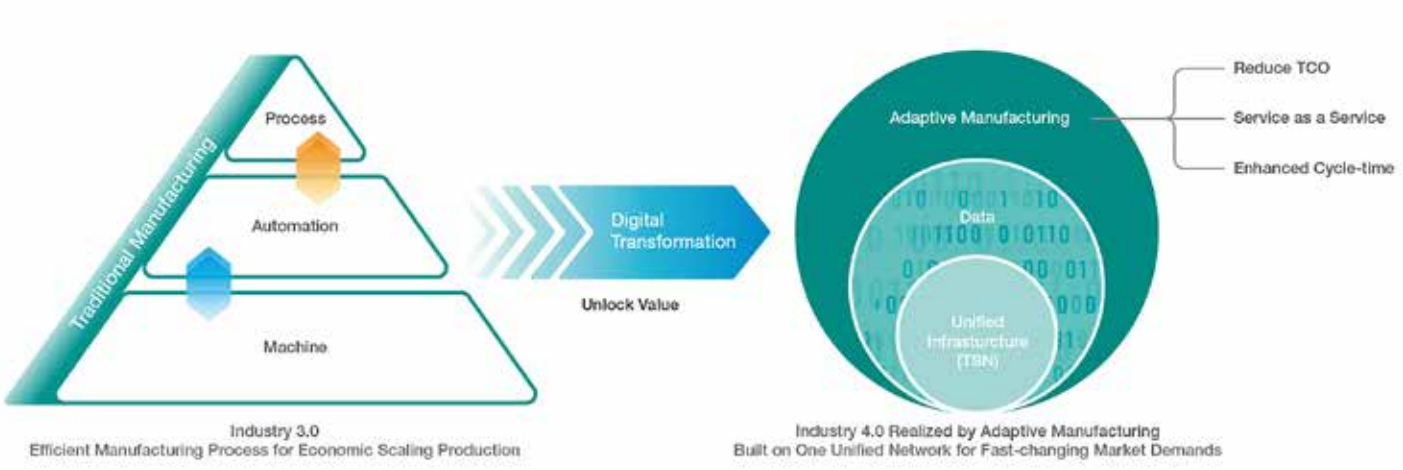
MOST COMPANIES TAKE ADVANTAGE OF economies of scale by producing a larger number of goods to gain proportionate saving in costs. However, it is not always the case that the more goods that are produced, the less each unit costs.

Nowadays, most companies have reached the optimum point of economies of scale and that the cost for additional units is increasing. As mass production is no longer the only answer, we find ourselves asking, what's next? The combination of markets continuing to change rapidly and global supply chain challenges have forced companies to find new ways to adapt to these challenges to become more competitive. How to implement Industry 4.0 and Industrial Internet of Things (IIoT) applications and transform smart factories using digital transformation becomes key to the survival of companies amid the current turbulent climate.

Concept of Adaptive Manufacturing

Product Aspect	Benefits and Results
Asset Management	Greater control over assets to ensure continuous operations and lower the TCO.
Service-as-a Service	Enhance connectivity to provide more efficient and innovative services.
Integration of Control Systems	Integrate control processes and automation systems on the production line to enhance production efficiency and operational excellence.

SOURCE: ANTAIRA



Implementing Industry 4.0 and IIoT applications using digital transformation becomes key to the survival of companies amid the current turbulent climate.

Adaptive manufacturing brings success now and in the future

To become agile and responsive to market demands, it is important to consider adaptive manufacturing. The concept of adaptive manufacturing lies in a company's ability to rapidly adjust production operations to meet the new, customized demands—an increasingly important capability for companies to stay competitive, and to cope with supply chain disruptions caused by COVID-19.

Adaptive manufacturing, which includes close co-competition within ecosystems and strategies for mass customization, is the foundation for Industry 4.0 and IIoT, as it uses a production system that focuses on data to ensure everything is connected, communicated, and that the right decisions can be made quickly. The table on the previous page illustrates the concept of adaptive manufacturing.

TSN bridges gap between traditional and adaptive manufacturing

It is never easy to choose the right approach to retrofit existing facilities, especially when it involves enlarging the facilities. Time-sensitive networking is a game changer for digital transformation in the automation industry and is the foundation of unified infrastructure. TSN offers time synchronization, low-latency communications, ultra-reliability, and better resource management.

This facilitates the merging of IT and OT networks to connect all end devices and centralize data collection on a standard Ethernet network. Digital transformation can be achieved by real-time information made possible by TSN, enabling factories to optimize their production strategies to fast-changing markets and emerging challenges.

The potential of adaptive manufacturing is huge. First, if we consider asset management, it saves costs from the very beginning when a unified infrastructure is built. TSN can connect multiple applications and diversified systems on one unified network, which makes it easier to operate and maintain as less equipment and cables are needed at the field level. Meanwhile, one unified network converges both IT and OT networks, which means modern IT technologies, such as artificial intelligence and machine learning, can be incorporated to assist operation efficiency and give owners more control over their assets.

Second, companies can evolve from selling products to selling services, offering more customization and reducing the minimum order quantity (MOQ) without losing profitability and giving owners more possibilities.

Third, integrating control systems substantially reduces the cycle time. A few years ago, it might have required weeks to shift the entire production process to producing a new product, but by integrating different control systems, it will only take a few days, making adaptive production not only feasible but also profitable.

Three real-world cases tap into the benefits of one unified network

Moxa has helped customers around the world tap into the benefits of adaptive manufacturing. Read on to understand how Time Sensitive Networking helps accelerate digital transformation for industrial automation.

One Unified Network to Realize Adaptive Manufacturing

A product manufacturer planned to connect their various systems—including production, assembly lines, and logistics systems—on one unified network to realize shorter production cycle times and lower the total cost of ownership.

From a production viewpoint, TSN accomplishes integration of control with reduced cycle times, reduces the total cost of ownership through a simplified topology with fewer assets to manage, and realizes service-as-a-service through one unified network.

Enabling Multiple Applications on a Unified TSN Network to Reduce the Production Cycle Time

A global leading manufacturer of industrial machinery is leveraging TSN technology to aggregate multiple applications in CNC machinery.

To achieve its scalable, accelerated sensing, and advanced machine control systems, the deterministic laser and motion control need to work harmoniously together. With TSN, the devices can be efficiently integrated, and the production cycle time can be successfully reduced.

AI-driven Operational Efficiency for a Hydropower Plant to Reduce the TCO

The operating company of a hydropower plant was determined to bring all their isolated networks together and implement an AI system for their control network by embracing the TSN standard, which was a perfect fit for this kind of use case, as performing services on a converged network was much easier than on disparate networks.

The hydropower plant improved efficiency and the ability to quickly adjust the total power output to the grid as needed, giving rise to a new hydropower plant with lower costs, easier maintenance, higher efficiency, and improved adaptability.

TSN is an advanced technology that helps industry leaders accelerate their digital transformation in industrial automation. In this article, we briefly introduced adaptive manufacturing and the core technology, TSN, that helps achieve it. Building on this point, the three real-world cases demonstrated how companies can revolutionize their industrial operations while tapping into the benefits of TSN.

Jack Lin Product Manager and Project Lead of Global TSN Initiative Project, ***Moxa.***

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Seven strategies to defend ICSs from cyberattacks

Security threats to industrial networks are a global issue. Government officials, industry leaders in I.T. security, and representatives from industrial industries have created a working set of standards and guidelines for securing industrial control systems.

CYBERSECURITY FOR INDUSTRIAL CONTROL Systems (ICS) has changed dramatically in recent years. The once considered trivial, inconvenient, and overlooked cybersecurity management features have transformed into a specialized security industry, specifically designed to protect industrial systems such as power plants, water treatment facilities, and transportation systems.

Without cybersecurity using managed Ethernet switches for ICS, everyday conveniences such as having fresh drinking water or getting food from the grocery store would be impossible.

Historically, industrial networks have been simple standalone analog systems, with little to no outside communication beyond its meters, gauges, and control sensors. They were small, isolated, and closed-looped with many in an "air gap" style configuration (physically disconnected from the enterprise network) with very little security.

Plant managers and engineers who operated these industrial networks viewed cybersecurity as a nuisance and often avoided configuring user authentication and access permission settings. As such, the ICS were left unguarded with no security measures in place to protect them from outside attackers.

Today's industrial control networks

Industrial automation and control networks have grown in scale and complexity. Thanks in part to the Industrial Internet of Things (IIoT) revolution which introduced industrial smart I.P. based sensors, instruments, and networking devices.

The once closed off standalone Operational Technology (OT) network developed into a robust, high-speed communication network requiring the same type of data link speed and backbone infrastructure as their Information Technology (IT) network counterpart. Therefore, the need to converge OT networks with IT networks became mandatory for IIoT IP based communications.

The convergence of these two networks meant greater flexibility and control over OT networks. This allowed administrators to create sophisticated OT networks by taking full advantage of IIoT smart devices for expanded communication, increased production, and optimized workflow.

SOURCE: SIEMENS

Industrial industries and the people, communities, and entities they serve are facing greater risks from cyberattacks.

Seeing the unforeseen

The convergence between the IT and OT network has led to unforeseen detrimental repercussions. For instance, the lack of knowledge and experience needed for advanced security configurations to safeguard IIoT IP devices had a negative impact on the industry. The engineering mindset that once left analog OT networks open and unsecure is now responsible for securing advanced IP devices that reside on interconnected networks.

A neglected network runs the risk of increased security vulnerabilities allowing for a potential outside force to gain inside access. This situation can have severe consequences. The absence of cybersecurity has led to worldwide cyberattacks on critical infrastructures. There have been national and state-wide examples of launching cyberattacks against power plants, electrical grids, transportation systems, and major manufacturing operations impacting millions of people. Companies lost hundreds of millions of dollars in revenue from network downtime.

Recent ransomware attacks on two U.S. chemical companies Hexion and Momntive left hundreds of employees locked out of computer systems and critical processing systems. The cost of these cyberattacks was estimated to be over 80 million U.S. dollars.

In 2010, the infamous Stunxnet cyberattack targeted the Supervisory Control and Data Acquisition (SCADA) systems responsible for damaging Iran's nuclear program. The computer worm was considered a cyberweapon built by American and Israel groups to impede the process of creating centrifuges for nuclear weapons. Since this event, adversaries have used similar types of cyberweapons against industrial control systems all over the world.

Global solutions

Global leaders in the I.T. security sector, controller manufacturing, and government-sponsored organizations have formed various oversight groups to assist in the development of best practice methods and security specifications to help address this cyber threat.

SOURCE: ANTAIRA

In 2009, the U.S. Department of Homeland Security (DHS) created the Industrial Control Systems Cyber Emergency Readiness Team (ICS-CERT) to address cybersecurity for the industrial industries. In 2018, the Cybersecurity and Infrastructure Security Agency (CISA) was created with the mission to reduce cybersecurity threats and create a national hub for cyber and communications information, technical expertise, and operational integration.

The CISA also established the Industrial Control Systems Joint Working Group (ICSJWG) to facilitate information sharing and reduce cyber risks on the nation's Industrial Control Systems (ICS).

Government agencies, oversight committees, and higher educational institutions are now recommending engineering students take computer systems and cybersecurity courses as part of their graduate studies. This approach ensures future generations of engineers managing and controlling ICS systems will have a basic understanding to the new threat landscape that awaits.

All of this resulted in the DHS and CISA creating a list of seven strategies to help protect, manage, and control industrial networks from cybersecurity.

Implement application whitelisting

Application Whitelisting (AWL) can detect and prevent attempted execution of malware uploaded by adversaries. The static nature of some systems, such as database servers and Human-Machine Interface (HMI) computers are ideal candidates for running AWL. Operators are encouraged to work with their vendors to baseline and calibrate AWL deployments.

Ensure proper configuration/patch management

Adversaries target unpatched systems. A configuration/patch management program centered on the safe importation and implementation of trusted patches will help keep control systems more secure.

Such a program will start with an accurate baseline and asset inventory to track what patches are needed. It will prioritize patching and configuration management of "PC-architecture" machines used in HMI, database server, and engineering workstation roles. Current adversaries have significant cyber capabilities against these management configurations, and infected laptops are a significant malware vector.

This program will limit the connection of external laptops to the control network and preferably supply vendors with known good company laptops. The program will also encourage initial installation of any updates onto a test system that includes malware detection features before the updates are installed on operational systems.

Reduce your attack surface area

Isolate ICS networks from any untrusted networks, especially the Internet. Lock down all unused ports. Turn off all unused services.

Only allow real-time connectivity to external networks if there is a defined business requirement or control function. If one-way communication can accomplish a task, use optical separation ("data diode"). If bidirectional communication is necessary, then use a single open port over a restricted network path.

Build a defendable environment

Limit damage from network perimeter breaches. Segment networks into logical enclaves and restrict host-to-host communications paths. This can stop adversaries from expanding their access, while letting the normal system communications continue to operate. Containment provided by enclaving also makes incident cleanup significantly less costly.

If one-way data transfer from a secure zone to a less secure zone is required, consider using approved removable media instead of a network connection. If real-time data transfer is required, consider using optical separation technologies. This allows replication of data without putting the control system at risk.

Manage authentication

Adversaries are increasingly focusing on gaining control of legitimate credentials, especially those associated with highly privileged accounts. Compromising these credentials allows adversaries to masquerade as legitimate users, leaving less evidence than exploiting vulnerabilities or executing malware. Implement multi-factor authentication where possible.

Reduce privileges to only those needed for a user's duties. If passwords are necessary, implement secure password policies stressing length over complexity. For all accounts, including system and non-interactive accounts, ensure credentials are unique, and change all passwords at least every 90 days.

Require separate credentials for corporate and control network zones and store these in separate trust stores. Never share Active Directory, RSA ACE servers, or other trust stores between corporate and control networks.

Implement secure remote access

Some adversaries are effective at gaining remote access into control systems, finding obscure access vectors, even "hidden back doors" intentionally created by system operators. Remove such accesses wherever possible, especially modems as these are fundamentally insecure.

Limit any accesses that remain. Where possible, implement "monitoring only" access enforced by data diodes, and do not rely on "read only" access enforced by software configurations or permissions. Do not allow remote persistent vendor connections into the control network.

Require any remote access be operator controlled, time limited, and procedurally similar to "lock out, tag out." Use the same remote access paths for vendor and employee connections; don't allow double standards. Use two-factor authentication if possible, avoiding schemes where both tokens are similar types and can be easily stolen (i.e; password and soft certificate).

Monitor and respond

Defending a network against modern threats requires actively monitoring for adversarial penetration and quickly executing a prepared response. Consider monitoring programs in the following five key places:

1) Watch IP traffic on ICS boundaries for abnormal or suspicious communications.
2) Monitor IP traffic within the control network for malicious connections or content.
3) Use host-based products to detect malicious software and attack attempts.
4) Use a login analysis (i.e; time and place) to detect stolen credential usage or improper access, and verify all anomalies with quick phone calls.
5) Watch account/user administration actions to detect access control manipulation.

Have a response plan for when adversarial activity is detected. Such a plan may include disconnecting all Internet connections, running a properly scoped search for malware, disabling affected user accounts, isolating suspect systems, and an immediate 100 percent password reset. Such a plan may also define escalation triggers and actions, including incident response, investigations, and public affairs activities.

Have a restoration plan, including having "gold disks" ready to restore systems to known good states.

Summary

Industrial industries and the people, communities, and entities they serve are facing greater risks from cyberattacks. Administrators and engineers who service industrial networks must be diligent in providing security measures to safeguard against attacks.

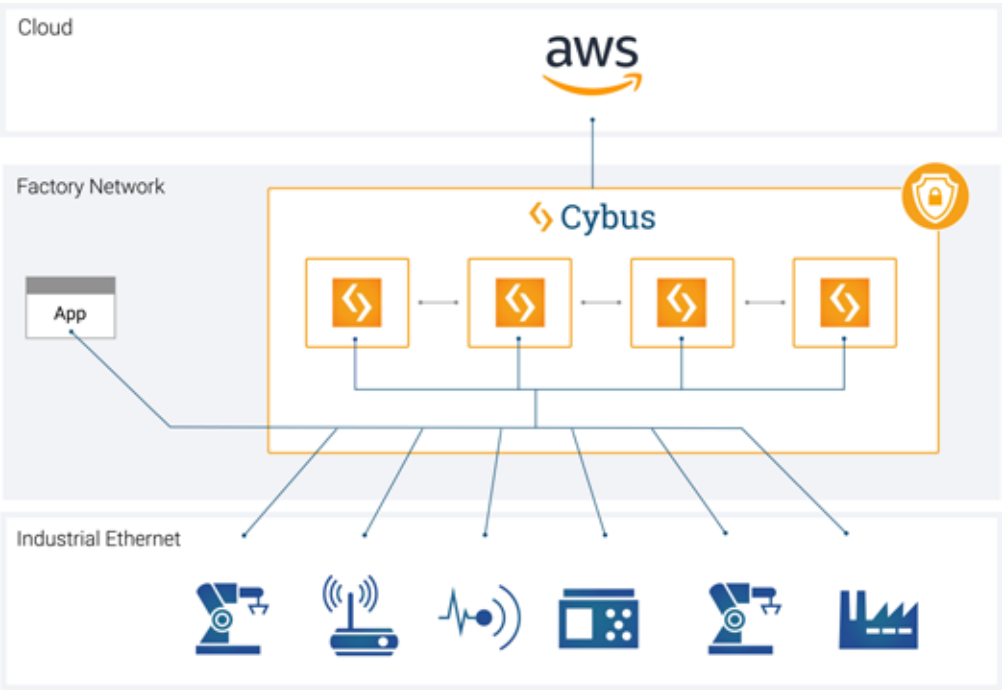
As copious amounts of advanced communications find their way into OT networks, vigilant attackers will be ready to penetrate with more advanced tools, techniques, and procedures.

Henry Martel, Field Applications Engineer, ***Antaira Technologies.***

Visit Website

Digital solutions in production by integrating OT and IT

Convergence of OT and IT systems is placing higher demands on network reliability and performance. As cybersecurity threats challenging these systems become more sophisticated and impacting, industrial network owners are looking to integrated solutions to ensure both holistic security and business continuity.



SOURCE: CYBUS GMBH

The scalable data infrastructure in the Porsche plants in Leipzig and Stuttgart-Zuffenhausen with the Manufacturing Data Platform from Cybus.

A COMMON DATA INFRASTRUCTURE AND universal cloud connectivity based on Cybus Connectware technology was implemented at the Porsche plants in Stuttgart-Zuffenhausen and Leipzig. The Industrial Cloud Community Partner Cybus provides a neutral technical framework with which a wide variety of digital solutions along the production chain can be implemented efficiently and in a compatible manner.

The digitization of production and logistics in the automotive industry takes place through many small solutions that are developed along the entire production chain. For a fast and effective development of compatible use cases, factory modernization requires a neutral technical framework that connects the shop floor and operational technology (OT) with the factory IT.

Porsche has taken up this challenge and developed an overarching data strategy together with the Industrial Cloud Community Partner Cybus.

The plants in Stuttgart-Zuffenhausen and Leipzig are pilot plants for the development of a solution that could be scaled to other locations in the Volkswagen Group in the future.

The neutral technical framework for factory modernization

With more than 1000 machines from different manufacturers in a single hall, the complexity of digitizing production sites becomes clear. Until now, almost every machine required a special digital solution or individual integration into the cloud in order to enable cross-plant analyzes and optimization measures.

In addition, the demands on an infrastructure are high: It must be high-performance, avoid downtime, allow flexibility and be able to handle a high data load. The sports car manufacturer is successfully meeting these challenges with a comprehensive data strategy. As a key component, the Manufacturing Data Platform from Industrial Cloud Community Partner Cybus creates a technology-neutral layer that seamlessly integrates OT and IT.

Manufacturing data platform breakthrough

Cybus' on-premises IoT solution collects operational data, which is harmonized and transmitted to the cloud. The central data infrastructure creates autonomy for applications, systems and environments and covers overarching security and specific data protocol requirements. As high-performance and easy-to-maintain software, Connectware runs 24 hours a day without downtime in the three-shift system of the production facilities. This is achieved through the use of Kubernetes clusters running Cybus Connectware - a breakthrough in production IT.

OT and IT are seamlessly connected

The implementation of Cybus' Industrial IoT Edge Layer enables the holistic management of data streams across OT and IT borders and realizes the high demands on IT infrastructure and security. As a pioneer in the Volkswagen Group, Porsche achieves full flexibility and scalability for its digital projects as well as a flexible transformation from petrol to hybrid to fully electric automobile production - and sets the course for the future of automobile production.

The first use cases in the areas of logistics, maintenance and production have already been implemented with the Manufacturing Data Platform from Cybus. Examples include the Industrial Computer Vision applications, which enable guided installation, documentation and quality control of signs and labels in production, and the Call Rocker Solution, which automates replenishment in SAP logistics systems.

"The use case is an example of how the Volkswagen Group is making great strides towards a scalable and future-proof production IT landscape. As a partner of the Industrial Cloud Community, Cybus is proud to support this," said Peter Sorowka, CEO of Cybus.

*Technology report by **Cybus**.*

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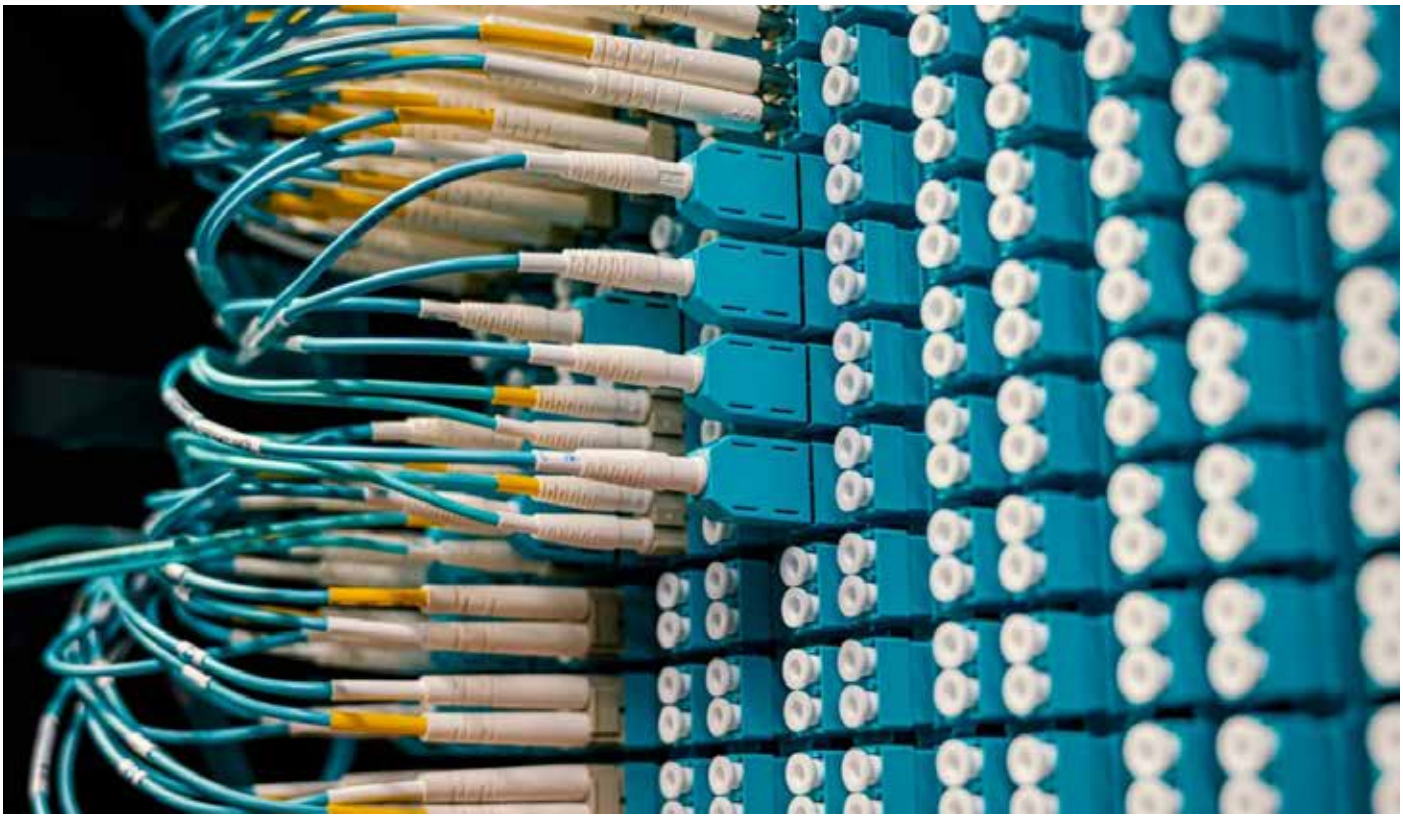
How to navigate digitization of the manufacturing sector

Digitization of manufacturing is a step towards the long-term sustainability of your firm. It will have a significant impact on your business a decade down the line. Level-headed decisions with a long-term perspective are the only sensible way to move forward.



SOURCE: ANTAIRA

Quality of service for today's industrial networks throughout the enterprise.

WE ARE WITNESSING A RADICAL SHIFT IN HOW the manufacturing sector works with Industry 4.0. Implementation of digital technology is the driving factor of this change. The transformation of the manufacturing industry, with the help of digital technologies, is popularly dubbed as digital transformation.

The major technologies involved in the digitization of the manufacturing sector are:

- Internet of Things (IoT)
- 5G/WiFi 6E connectivity
- Cloud computing
- Industrial edge technology
- Big data analytics

Digitally transformed businesses acquire many capabilities and advantages that were previously not accessible. Navigating your plant in the rapidly evolving digital landscape is not an easy task.

Embrace digitization

You might think it would be better to watch on the sidelines to see how this change will play out. Then, once the industry matures, adopt digitization - this is a flawed approach. By the time the digitization trend matures, businesses that have not transformed their systems and processes will be wiped out. To avoid such drastic consequences, you have to proactively adopt the digitization of your plant operations.

The benefits of digitization are innumerable. Some of the key benefits you can expect are:

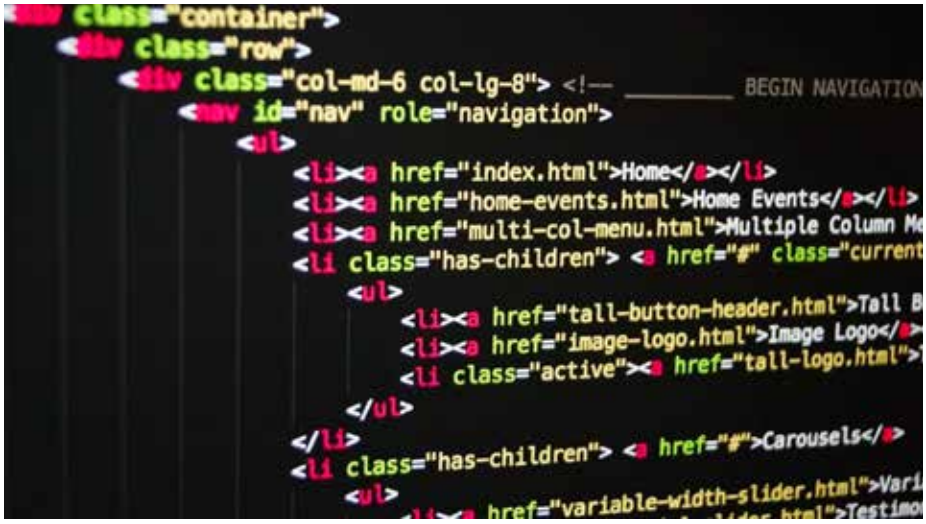
- Increased efficiency
- Decreased cost
- Quality improvement
- Improvement in turnaround time (TAT)
- Efficient inventory management
- Process improvement with analytics
- Dynamic production abilities

With these benefits, you will be able to supply goods to your consumers at a lower price with an overall better product. If you do not adopt digitization, your competitors will. Eventually, you will be priced out of the market by superior products at better prices. To stave off such an eventuality, you need to start thinking about and implementing digitization strategies as soon as possible.

How to digitize your operation?

Digitization of manufacturing is a step towards the long-term sustainability of your firm. It will have a significant impact on your business a decade down the line. Due to this, you cannot take a headless chicken approach towards digital transformation. Level-headed decisions with a long-term perspective are the only sensible way to move forward.

Cortizo, the European manufacturer of aluminum and PVC systems, builds systems for the architecture and manufacturing industries. Though they had some digital infrastructure, they had some challenges transforming to the modern industry paradigm. They had problems scaling digital systems with the rapid growth of the company. This also made collecting and processing large volumes of data a big challenge. In addition to these challenges,



Data is critical to the Industry 4.0 paradigm.

SOURCE: PEXELS

they also took it upon themselves to reduce business disruption with a smaller IT team.

First, they implemented IoT systems for machine monitoring and data collection. Once those systems were in place, they invested in digital infrastructure to process large amounts of data. This includes cloud infrastructure from Oracle and VMware. They also invested in UFFO storage for high-speed data transfer. All of this coupled with advanced machine learning and AI tools, powered analytics on cloud infrastructure. They also had the systems in place to realize the findings from analytics.

All this combined, reduced latency in decision-making by roughly 90%. The step-by-step strategic implementation helped them achieve impressive performance improvement and cost savings.

Strategy

You have to take cautious strategic steps towards digitization. The first exercise to do is to clarify the end goals of digitization. The expectations of your firm have to be penned down in black and white. You have to take stock of the current resources and capabilities of the firm.

Once a detailed evaluation of expectations and current capabilities is done, you have to create a road map for digitization. This road map should include the technologies, time frame, cost of implementation, and metrics to test successful implementation. Cortizo was able to implement their systems in the right sequence because of strategic evaluation. This gave priority to different technologies during their implementation.

Build digital capabilities

Factories in the existing paradigm run in silos. This will change with industry 4.0, it will bring cross-functional capabilities to one large interconnected system. This will range from supply chain management to customer feedback, which is only possible by a robust digital infrastructure. You have to acquire or develop the necessary digital capabilities before full-fledged implementation of digitization.

One aspect of gaining digital capability is having digital talent. Without a range of employees well-versed in technology, digital transformation efforts will not take flight. The other aspect is setting up digital governance. The existing governing structures of firms do not work with digital infrastructure. This has to be broken and remolded for a smooth transition to a digital native existence. Organizational structure also has to be reshaped to facilitate cross-functional integration.

Employee participation

The need for employee participation in change management is well-researched and documented. Digitization brings about a radical change in the way plants operate. Without the cooperation of employees, implementation becomes an insurmountable task. Raise employee confidence by addressing their concerns and doubts and transform them into active partners in digitization.

United States Navy decided to implement ERP systems towards the fag end of the last century. Top names in the space such as SAP, IBM, and Lloyd were supposed to be system integrators.

As with government projects, the decision-making happened top-down. The employees that had to use the systems were not consulted in the process - this meant that top-level officials were unaware of the nuances that had to be considered during implementation. Decades after implementation started, the project is not yet complete.

The navy also lost $1 billion in the process. More than 90,000 employees are also stuck with systems they cannot use. To avoid such a scenario, you have to take a bottom-up approach starting with the employees at the lower level.

Implementation

Implementation has to be done only after necessary digital capabilities are in place and employee participation is confirmed. Staggered implementation is the best way forward. Start with the digitization of one section or department. Then, assess how that performs compared to expectations. Fix any errors, if identified. Then move on to the next piece of the puzzle taking lessons from errors in the previous steps.

Gruppo Castelli is a large-scale cheese manufacturer in Italy. They wanted to digitize their functions to ensure business continuity - this ranged from PLC operations in their factories to customer feedback. At first, they transformed their industrial operations to suit digitization. Once that was successful, they moved on to the supply chain. After covering other functions of their business, sales and marketing were integrated with the rest of the digital infrastructure. This staggered approach took a relatively longer time frame, but avoided serious business disruption and implementation failure was limited to only a small function of the company.

Data management

Data is critical to the Industry 4.0 paradigm. There are many strategies for storing, managing, and processing data - it can be stored in data lakes, data warehouses, in the cloud, or on-premises. Data have different priorities and differing levels of sensitivity. Categorize data factoring in the security, access, and privacy needs of the organization.

Cybersecurity

The Colonial pipeline hack in 2021 made clear the need for cybersecurity in industrial systems. Hackers held the operations of the pipeline hostage for ransom. The critical infrastructure of the country was compromised due to a lack of focus on cybersecurity. You could also face such challenges if cybersecurity is considered an afterthought. Cybersecurity risks have to be addressed from the strategizing phase. You should only take on vendors who give a very high priority to cybersecurity.

Advance with a digital arsenal

It is obvious that you will not be able to survive the coming decade without building a strong digital infrastructure to support manufacturing operations. Employee participation and cross-functional collaboration are critical in digitization with industry 4.0. Take sensible small strides towards digitization than leaps; it's a more sustainable approach to digitizing your plant operations with Industry 4.0.

Bryan Christiansen, founder and CEO, ***Limble CMMS.***

Visit Website

Gaining an edge with Time Sensitive Networking (TSN)

SOURCE: PEXELS

John Browett, General Manager at the CC-Link Partner Association (CLPA), looks at how to reap the benefits of the Edge with advanced industrial communication solutions. For edge computing to work effectively, advanced network technologies are required to build the supporting network infrastructure.

EDGE COMPUTING IS KEY TO OPTIMISING data-driven activities, supporting the implementation of innovative digital technologies and ultimately the creation of the Connected Industries of the future. It allows data processing to take place close to the source, turning key data into actionable information. For Edge computing to work effectively, advanced network technologies are required to build the supporting infrastructure that is the backbone of successful enterprises.

Unique actionable insights

Unprecedently high volumes of data are being generated by smart applications and technologies, providing the foundation to create an in-depth understating of equipment status, processes and activities. This, in turn, can be translated into unique actionable insights to improve productivity, performance and efficiency.

Large datasets are another raw material required by competitive enterprises. But having a solid, reliable infrastructure to share process data, information and knowledge is equally important to succeed. Moreover, Edge computing is instrumental to creating frameworks that are capable of quickly and securely evaluating data.

This technology conducts analytics for real-time decision-making at the periphery of the network, close to where data is being created, while also supporting knowledge generation by filtering what should be sent to the Cloud or other higher-level systems. As a result, the Edge can reduce latency and network costs as well as optimise bandwidth usage, increase speed, security and scalability. Even more, enhanced transparency, flexibility and availability can also be achieved.

At the cutting edge of industrial networks

In order to take advantage of all the opportunities offered by Edge computing, it is important to set up a suitable network. More precisely, the ideal solution should be able to support the key aspects of this technology.

An ideal industrial communications system should support a converged architecture that allows real time process traffic and asynchronous process data to share the same network without compromising the overall function of the system. This is achieved with a foundation of determinism, ensuring that all data types flow across the network in a predictable manner to deliver the required performance.

SOURCE: ISTOCK/TOMML

Advanced network technologies are required to build the supporting infrastructure for successful Edge computing applications (Source: iStock/TommL)

The key to delivering this deterministic, converged architecture is Time-Sensitive Networking (TSN). This allows the critical data running the process to coexist with the equally critical but perhaps less time sensitive data about the process.

It is this latter data type that is the lifeblood of the Edge server. Using TSN means that these equally vital but very different streams of traffic can use a single network architecture, saving cost, simplifying maintenance and reducing project time.

Secondly, companies should look for an open solution that can provide maximum connectivity. This means supporting communications with different devices, whether on the shop floor or higher up in the automation hierarchy. Openness, interoperability and an integrated solution for effective factory automation on different levels are therefore essentials.

The CLPA has long been able to offer enabling network technologies for Edge applications. This began with CC-Link IE open gigabit Ethernet. By leveraging a token-passing method and 1 Gbit/s bandwidth, it could deliver deterministic performance and low latency, even with high data traffic loads. Also, the different versions of CC-Link IE networks, which supplement each other and cover different aspects of industrial communications, could connect the various parts of an enterprise needed to create Connected Industries.

The organisation's latest advancement, CC-Link IE TSN, goes even further in its ability to support Edge computing, enhancing and expanding the capabilities of this solution by adding Time-Sensitive Networking (TSN), to deliver advanced capabilities.

John Browett, General Manager, ***CC-Link Partner Association (CLPA).***

Visit Website

Six easy steps to secure your networking device

Whether your goal is to configure a new industrial factory automationnetwork or increase the security of an existing network, six simple steps to significantly increase security and reduce the risk from cyber threats. Being proactive enables administrators to prevent security breaches and if any incident does occur.

ENSURING THAT A DATA COMMUNICATIONS network is secure is a never-ending task, with new vulnerabilities being exposed every day. Methods to prevent unauthorised access and protect against a cybersecurity attack vary between industries. However, being proactive enables network administrators to prevent security breaches and be prepared if any incident does occur.

When choosing networking equipment, it is important to consider the level of protection you need, how easy is it to apply the security measures that are available, and what support the manufacturer provides in terms of addressing security vulnerabilities and providing software updates.

SOURCE: ISTOCK

Being proactive enables network administrators to prevent security breaches and be prepared if any incident does occur. (Source: iStock)

Change the default password

Retaining the device default password supplied by the manufacturer makes it very easy to perform maintenance, but this practice creates a significant network vulnerability. Replacing the default password and also moving away from the use of conventional, simple and short passwords reduces the possibility of an external threat guessing or using 'brute force' to work out the password and gain unauthorised access to the network. Passwords should use multi-character, mixed casing, special characters and numerals, with repetition or location names to be avoided.

Disable unused ports

Disabling unused ports on networking devices can prevent both authorised users from causing harm to the network by unintentionally plugging in too many cables, or an unauthorised user performing a malicious attack having managed to obtain physical access to the device. For additional security, link alarms can be configured on used ports to identify whether a cable has been removed.

Disable unused management services

Networking devices have HTTP enabled by default to allow users to browse the web interface in order to perform configuration steps. HTTP does not offer secure data transmission and should be disabled. Secure connections, such as HTTPS and SSH, are the recommended communication methods to access and configure a networking device. Both connections require the use of a password for authentication, which adds another layer of security.

Update to the latest firmware

Updating and securing an operating system is a continuous process. Cyber threats are constantly evolving, which exposes new vulnerabilities within an operating system, requiring manufacturers to perform deep inspection into the software code and the development and release of new updates that prevent exploitation. It is important to update your networking devices with the latest firmware to ensure your networking devices are secure against these new threats. Ideally, manufacturers should provide a software configuration tool that provides an easy method to perform primary, secondary and bootloader updates. These tools help to facilitate the regular practice of performing continuous updates that enhance network security.

Set your date and time

The system log is one of the most important resources available to network engineers and is very simple to use. The system log captures information that enables administrators to identify any authorised or unauthorised access to the network. It can also record when a firewall has been reconfigured. However, it is imperative that the date and time are set correctly, otherwise it can be challenging to determine from the system log the cause of an incident.

Report vulnerabilities

Manufacturers of networking devices and software that want to proactively react to cybersecurity threats and security vulnerabilities rely on input from users. Always report any security vulnerabilities to the manufacturer, enabling them to make their software as secure as possible, for everyone.

Industrial cybersecurity has matured but remains a challenging and dynamic domain. Whether you have already implemented cybersecurity strategies or are taking your first steps to secure your assets, Westermo is the ideal partner for protecting your critical network infrastructure.

Westermo will provide robust and reliable network technology powered by our WeOS operating system, which is continuously updated to comply with the latest cybersecurity guidelines. Using network management tools, you can build robust and straightforward processes for deploying proper cybersecurity measures that keep your systems, networks and connected devices protected from the latest cyber threats.

Ant Lane, Technical Training Manager, ***Westermo.***

Visit Website

Edge computing and its key role in the smart factory

Despite its capabilities, edge computing is not a replacement for centralised data storage methods, or an alternative to other data processing and management technologies. In fact, these architectures must work together to be truly beneficial. So, are edge devices just a new brand of the same technology? Not exactly.

ACCORDING TO GOOGLE TRENDS DATA, worldwide searches for 'edge computing' have increased tenfold in the last five years. Google alone boasts 340 million search results for the phrase — hardly simple revision for those curious about the technology. Among the noise — and the varying definitions of edge computing — the technology has become somewhat misunderstood.

Edge computing describes a distributed version of computation that brings data analysis closer to the source of data. In a factory setting, this could see data processing take place at the machine level. Unlike centralised models, where information would be sent to a data centre or the cloud, edge computing allows data capture, analysis, and action to be performed on the edge of a process — hence the name.

SOURCE: ISTOCK

While some processes do benefit from instant data analysis, smart factories cannot work in silos. The rise of the edge does not mark the downfall of other data management technologies.

Latency reduction

Edge devices are unique in the sense that they provide first-stage processing of data before sending this information elsewhere. Edge devices can also act on this data within the realms of the device itself, thanks to their intelligent capabilities. This can be achieved using forms of artificial intelligence (AI) and machine learning to help in decision making.

Because everything is taking place on the device, this method can significantly reduce latency, removing the time spent between sharing this information with distant data centres and awaiting feedback.

In practice, this could help a manufacturer to avoid critical failures and downtime. In an oil and gas application, for example, an edge device could detect dangerously high pressure in pipes. Rather than waiting for this data to be processed elsewhere and sent back to a site manager, the device could trigger instant shut offs or adaptations to avoid a disaster. Similarly, this same method can be used to make automated adjustments to a process to improve the outcome — this could be related to energy efficiency, accuracy or productivity.

The ability to effect change based on real-time data does exist in current software platforms. COPA-DATA's zenon, for instance, can be deployed across an entire facility to monitor operations. Compatible with most communication protocols, the software can pull data from a variety of equipment, sensors and vertical systems to provide operators with a real-time dashboard of facility-wide insights. Like our aforementioned example, this can alert users to disruptions in production and highlight potential problems.

Streamlining data

IIoT technologies have resulted in a huge increase in data across the industry. Today, it is not unusual for manufacturers to produce data on everything from energy efficiency and productivity, right through to operational insights and predictive maintenance. In fact, research suggests that the average smart factory produces five petabytes of data every week — that's five million gigabytes, or the equivalent of more than 300,000 16 gigabyte iPhones.

Manufacturing's big data has quickly become colossal, and edge computing provides a way to reduce the volume of data being sent to a centralised space.

For industries that rely on data integrity for compliance, deploying edge computing to manage some data analysis can become a vital part of a data management strategy. Pharmaceutical manufacturers, for example, must comply with the Food and Drug Administration (FDA) 21 CFR part 11 regulation. This standard applies to drug manufacturers and bio tech companies and requires these organisations to keep an accurate audit trail and electronic records. EU GMP Annex 11 is the European equivalent.

In these industries, on-edge analysis of some data can reduce the volume of information being sent to the cloud or data centre. Crucially, this ensures that time sensitive data is not lost in the flood of information.

Scaling the edge

While some processes do benefit from instant data analysis, smart factories cannot work in silos. The rise of the edge does not mark the downfall of other data management technologies. In fact, it reinforces their necessity.

Software platforms that can communicate with edge devices are essential for making edge technology scalable. Moreover, platforms that can collect, analyse, and visualise data from the edge — while compiling this with a variety of other types of equipment — are essential for constructing a holistic view of a factory's operations.

Realistically, most manufacturing facilities are not in a position for widespread deployment of edge devices, or edge platforms to converge these technologies. Instead, manufacturers need scalable options in their journey to digitalisation; independent software can be the glue that makes this possible.

Martyn Williams, Managing Director of industrial software expert, ***COPA-DATA UK.***

Visit Website

Industrial wireless router line

Rugged new devices available in PoE PSE and PoE PD versions are designed for industrial applications.

Antaira has announced the expansion of its wireless product line with the introduction of two new IEEE 802.11a/b/g/n/ac LAN access points offering router capabilities. Ideal for challenging industrial network infrastructures, the wireless devices allow a user to position their 2.4GHz/5GHz antennas for optimal coverage and signal strength.

The new ARS-7235-PSE-AC is an industrial-hardened dual-radio IEEE 802.11a/b/g/n/ac wireless LAN access point with added router capabilities boosting network robustness, stability, and a wide network coverage with a very low voltage input of 9V. It supports high-speed data transmission of up to 867Mbps, and is PoE PSE (Power Sourcing Equipment) compliant to supply up to 30W from one of its two Ethernet ports, allowing users to expand network connectivity to remote locations where a power source is not available.

It also comes embedded with the Qualcomm IPQ4029 SoC chipset that has dual Wi-Fi spectral bands of 2.4GHz and 5GHz to reliability handle increased network traffic.

Identical to the ARS-7235-PSE-AC, the ARS-7235-PD-AC version has PoE PD (Powered Device) on one its two ports rather than PoE PSE, giving users the ability to power it through the PD-capable Ethernet port.

SOURCE: ANTAIRA

ARS-7235-PSE-AC is an industrial-hardened dual-radio IEEE 802.11a/b/g/n/ac wireless LAN access point.

Standard versions of both devices are protected in an IP30-rated metal housing, and provide an operating temperature range of -10°C to 60°C, while extended temperature range models can be used in environments of -35°C to 70°C. Both are capable of operating in different modes, making them suitable for a variety of wireless applications including long-distance deployments.

Antaira

Learn More

Edge-as-a-Service solutions

Edge-as-a-service solutions connect legacy systems to the network edge and cloud.

Advantech announced a new partnership with Hivecell, an industry innovator in "edge as a service" technology solutions, for continued Artificial Intelligence of Things (AIoT) development. The combination of Advantech's rugged hardware and Hivecell's edge-as-a-service (EaaS) platform means easy access and deployment of end-to-end data solutions for customers. It has never been easier to connect legacy systems to IoT devices for scalable data collection and management.

Edge intelligence and EaaS solutions offer users device control, edge monitoring, and software management in order to facilitate successful, scalable digitalization. With a simplified path to application deployment, visualization, machine-learning operations (MLOps), and remote management for data-driven decision-making, customers can rapidly implement new applications. The speed of deployment and implementation maximizes benefits in operation optimization and business transformation.

The ability to extract actionable intelligence from real-time data can deliver gains across the board and Hivecell's EaaS solution combined with Advantech hardware makes it a reality. Hivecell's end-to-end EaaS connects legacy systems to gateways, edge computers, 5G routers, and other IoT devices for scalable data management.

SOURCE: ADVANTECH

Edge intelligence and EaaS solutions offer users device control, edge monitoring, and software management.

Collecting and processing data at the edge, the entire data flow improves as useless data is efficiently discarded on site. Only relevant data is sent back to headquarters and/or the cloud.

Advantech

Visit Website

High-voltage measurement

I/O terminal supports high-voltage measurement for renewable energy and EV technologies.

Designed for batteries, generators and motor applications up to 1,000 V, the new ELM3002-0205 EtherCAT Terminal enables extremely precise and reliable measurement.

The new ELM3002-0205 EtherCAT measurement terminal from Beckhoff delivers high-voltage measurement functionality for batteries, generators and motors. This feature-filled I/O terminal supports the four measurement ranges of ±60, ±120, ±500 and ±1,000 V, respectively, and is particularly suitable for applications in the fields of electric vehicles (EVs) and renewable energy.

In the renewable energy market, the ELM3002-0205 supports, for example, efficiency increases for wind turbines via direct converter control. A prerequisite for this is voltage measurement in the 1,000 V range directly on the generator. The EV segment has similar requirements in the rapidly increasing, large-scale production of high-quality EV batteries and accumulators globally.

With powerful oversampling functionality, the dual-channel measurement terminal achieves a maximum sampling rate of 50 ksps per channel. This high sampling rate in high-voltage applications enables deeper data insights in energy applications. In generator control, for example, faster response times are possible as a result. Moreover, high measurement accuracy enables more accurate frequency detection, which in turn improves frequency stabilization in power grids. In battery testing, load and quality tests can be reliably performed due to the high sampling rates. Specialized in extra-high voltages, the ELM3002-0205 is the newest member now comprises more than 30 high-precision and industrial-grade EtherCAT terminals.

SOURCE: BECKHOFF

EtherCAT measurement terminal delivers high-voltage measurement for batteries, generators and motors.

Beckhoff

Visit Website

5G industrial private network solution

Benetel and ASOCS provide industrial sector with technology needed for 5G private network installations.

OpenRAN radio specialist Benetel and networking software provider ASOCS have brought together their respective expertise to provide the industrial sector with the technology needed for 5G private network installations.

The two companies have agreed to enter into a joint global cooperation and are currently performing extensive interoperability testing. ASOCS will then integrate Benetel OpenRAN radio units (RUs) with its CYRUS® private 5G RAN software. This will be a major step forward in the progression of Industry 4.0, enabling the benefits of high data rates, low latency, and enhanced security functions of 5G to be realized, alongside the ease of installation associated with Wi-Fi.

Benetel's RAN550 radio units (RUs) are targeted at indoor usage, while the RAN650 RUs are intended for outdoor installation. Featuring a 4T4R antenna configuration, these OpenRAN RUs have a 7.2 functional split and can deliver 100MHz of instantaneous bandwidth. Versions are available that support the n78, n77u and n79 frequency bands. By using these RUs in combination with the highly flexible and scalable CYRUS® software from ASOCS, industrial customers will be able to build next generation networking infrastructure to support increased levels of automation. It will mean that entire sites can be addressed using one single multifaceted platform, with seamless transition from indoor to outdoor coverage.

SOURCE: BENETEL

Benetel's RAN550 radio units (RUs) are targeted at indoor usage, while the RAN650 RUs are intended for outdoor installation.

Benetel

Visit Website

Motor drive for advanced tension control

Improved control algorithms allow the new model to drive both SPM and IPM motors.

Delta's new advanced compact AC motor drive MH300 series offered in Europe, the Middle East, and Asia (EMEA) offer a power range of 0.4 to 75 kW and numerous tension control features, it's suitable for a wide range of constant torque applications, such as machine tools, extruding machines, bending machines, conveyer systems, and eventually also for cranes and hoists.

The MH300 product series also comes with a built-in EMC filter to limit electromagnetic emissions. Improved control algorithms allow the new model to drive both SPM and IPM motors. Zero speed holding torque with IPM motor in open loop control is possible out-of-the-box — there is no need to install an extra encoder.

The MH300 comes with the ability to calculate roll diameter using linear speed, material thickness, and distance. Two PID parameters allow industrial facilities to control tension at motor startup for small and large rolls at both high and low speeds. Since the amount of torque required to tension the web depends on the remaining diameter of the roll, the MH300 can also perform a tensor taper calculation. This automatically adjusts tension in line with roll diameter to avoid wrinkles and deformation of the web span during roll-to-roll processing. Friction and inertia are automatically compensated during winding and unwinding to keep the tension constant. The automatic roll change feature only needs an external signal, shutting down the machine is not necessary.

SOURCE: DELTA

Interfaces include PROFIBUS DP, DeviceNet, EtherCAT, EtherNet/IP, Modbus TCP, and PROFINET.

The overload capability of the new MH300 drive is 150% for a period of one minute or 200% over three seconds, making it suitable for constant torque applications.

Delta

Learn More

New amendment to IEC 61918

New edition of IEC 61918 regulates SPE cabling and installation for the automation world.

The new edition of IEC 61918:2018/AMD1:2022 Amendment1 is the installation standard for communication networks in industrial plants, machines and automation islands. Both cabling infrastructure and the components to be used, such as cables and connection technology, are clearly defined for all automation profiles. Cabling solutions using fiber optic cables, symmetrical copper cables and for wireless media are considered.

The amendment to IEC 61918 addresses new 1-pair cabling structures for Single Pair Ethernet and the associated remote power supply PoDL (Power over Data Line). This closes the gap between classic IT infrastructure and industry, IoT/IIoT. SPE has a special significance for industry and automation.

For the first time, it enables the universal application of TCP/IP-based automation protocols even for long distances, as in process automation or for the simple connection of sensors and actuators up to the industrial field level. Higher data rates, more power transmission and greater ranges than with classic fieldbuses pave the way for the IIoT and Industry 4.0.

SOURCE: HARTING

For PROFINET, EtherCAT or other protocols - the new IEC 61918 is a common denominator for automation profiles.

The new version of IEC 61918 now provides a clear and unambiguous normative description of how and with which components a sensor-to-cloud data infrastructure in industrial applications must look. The tools for the implementation of IIoT are now available; device suppliers can now start the development and production of SPE devices with internationally ensured compatibility and investment security.

HARTING

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100 Gigabit Ethernet in Real Time

Network communication with data rates of up to 100 gigabits per second can be implemented.

Kithara Software, specialist for industrial real-time software, has announced support for 100 Gigabit Ethernet. Starting with version 11.02 of the real-time operating system Kithara RealTime Suite (KRTS), network communication with data rates of up to 100 gigabits per second can be implemented.

KRTS now allows PCIe network cards with the Ethernet controller E810 by Intel to be used in a real-time context. Building on the previous support for 40 Gigabit Ethernet, whose hardware interface has a similar base structure, the 100 Gigabit mark has now been reached as well.

SOURCE: KITHARA SOFTWARE

Network communication with data rates of up to 100 gigabits per second can be implemented.

Continuous development process

"The implementation of new Ethernet technologies is a continuous development process for us, since many solutions of our real-time system are based on Ethernet and thus represent an essential pillar of the company. Furthermore, 100 Gigabit Ethernet is a crucial milestone, as demand for high data rates in industrial and research applications increases as well", explained Uwe Jesgarz, managing director of Kithara Software.

Real-time support for 100 Gigabit Ethernet, compared to 40 Gigabit Ethernet, also differs in the utilized type of QSFP (quad small form-factor pluggable), the optical transceiver modules.

Whereas 40 Gigabit Ethernet support uses the QSFP+ transceiver (4×10 Gbit/s), 100 Gigabit Ethernet employs the QSFP28 variant, which manages to get achieve up to 100 Gbit/s with four lanes of 25 Gbit/s each. Alternatively, QSFP28 ports can also be split into four independent 25 Gbit/s connections by using fanout cables

Kithara Software

Visit Website

Intelligent transportation applications

E1 Mark and EN 50121-4 compliant robust computers for intelligent transportation applications

Moxa has launched the V2403C Series, a new series of robust industrial computers that comply with the E1 Mark, ISO 7637-2, and EN 50121-4 standards for vehicular and wayside applications.

Drawing on Moxa's expertise in building robust computing platforms, the V2403C Series operates in a wide range of operating temperatures for deployments in harsh environments, which require high computing power and reliable wireless connectivity. As a field-ready solution, the V2403C computers are built around an Intel® Core™ i7/i5/i3 or Intel® Celeron® high-performance processor and come with up to 32 GB RAM, one mSATA slot, and two hot-swappable 2.5-inch SSDs for storage expansion. Embedded with two mPCIe slots for I/O expansion, the ultra-compact fanless computers support multiple displays in the control room for local monitoring of status and real-time control.

Wayside and vehicular applications require robust computers with expansion capabilities to connect sensors, cameras, and devices that use Wi-Fi and cellular technology. Furthermore, the design must handle "dirty power" during engine starts and shutdowns with a graceful shutdown mechanism in place to preserve system stability and lifespan of batteries. Compliance with E1 Mark, ISO 7637-2, and MIL-STD-810G requirements protects the V2403C computers from shocks and vibrations that are common in transportation applications.

SOURCE: MOXA

The V2403C Series operates in a wide range of operating temperatures for deployments in harsh environments, which require high computing power and reliable wireless connectivity.

Moxa

Visit Website

Ethernet-APL communications module

Softing introduces a hardware module for implementing Ethernet-APL field devices.

commModule APL, a new hardware module from Softing Industrial Automation, is designed to support device manufacturers in implementing Ethernet-APL field devices for the process industry quickly and reliably.

Ethernet Advanced Physical Layer (Ethernet-APL) is the new standard for end-to-end digital communication in the process industry and is also suitable for use in hazardous areas. Device manufacturers will have to prepare themselves for growing demand from end-users for this modern data transmission technology. They now face the challenge of developing and certifying new Ethernet-APL-capable devices within the shortest possible time-to-market - ideally without having to build up extensive specialist knowledge of Ethernet-APL.

SOURCE: SOFTING

commModule APL: a ready-to-use and pre-certified hardware for the implementation of Ethernet-APL field devices.

The hardware module provides connectivity to Ethernet-APL as well as an application software that can be easily configured to implement the required behavior of the respective field device. commModule-APL is delivered with a pre-installed PROFINET stack. It provides a configurable application data model and commands mapping to migrate existing HART and Modbus devices to Ethernet-APL. This does not require writing a single line of code. The assignment to HART or Modbus commands is done with the accompanying commScripter tool. commModule APL has already passed comprehensive EMC (electromagnetic compatibility) and environmental testing, as well as conformance testing for the Ethernet-APL Physical Layer and for the PROFINET protocol with PA Profile 4.02. It is also pre-certified in accordance with ATEX and IECEx.

Softing

Visit Website

New on-machine drives

Armor PowerFlex On-Machine drives help reduce design time, accelerate deployments and save costs.

New Allen-Bradley Armor PowerFlex AC variable frequency on-machine drives provide quicker installation, simple commissioning and predictive maintenance.

As an on-machine solution, the Armor PowerFlex drives move controls and hardware out of a cabinet and onto the machine, closer to the application. This can help industrial companies simplify machine designs and minimize costs and time to deploy.

The smart drives include an embedded EtherNet/IP dual-port switch, which provides fast collection of real-time data. The drives also monitor component life, allowing users to predict and schedule component replacements to help avoid costly unplanned downtime.

The Armor PowerFlex drives give users a motor control solution that replaces multiple components for easier integration into automation systems. The drives are available in standard and safety models.

Both options provide built-in, dual-port EtherNet/IP and CIP Security functionality, and the safety option provides advanced safety functionality.

SOURCE: ROCKWELL

The drives are also designed for harsh environments, where reducing installation time and cost are most critical.

The safety model of the drive is designed for applications that require functional safety. It offers integrated CIP Safety and supports integrated and hardwired safe-torque-off (STO) or safe-stop-1 (SS1) safety functions. With integrated STO or SS1, no additional external safety monitoring or control components are required. Additionally, using the Armor PowerFlex drive with Allen-Bradley GuardLogix PLCs and encoders enables advanced safe-speed functions.

Rockwell Automation

Visit Website

Power supply for drive controllers

STOBER offers a High Power supply module for drive controllers in multi-axis drive systems.

The SI6 is a drive controller in multi-axis drive system technology, suitable for uses including highly efficient multi-axis applications. Now, there is the new, decentralized PS6 High Power supply module: Just one of these powerful units can be used to supply multiple drive controllers. This gives engineers an extremely compact solution for extra dynamic applications. It saves space in the control cabinet, reduces the cabling effort and makes installation and commissioning faster.

At a slim 45 millimeters, the SI6 drive controller from the new Generation 6 is a highly dynamic drive component that works inconspicuously and reliably in the background, even during demanding movements. STO (Safe Torque Off) and SS1 (Safe Stop 1) functions are integrated.

In the SI6 series, these are certified for PL e, cat. 4 in accordance with EN 13849-1 and can be used without function tests that interrupt production. A single drive controller can control up to two axes. By stringing together several controllers, the number of axes to be controlled can be scaled as needed. The individual devices are fast and easy to connect with each other and to the PS6 central supply module using Quick DC-Link modules. As a single- or double-axis controller, it is available with a nominal output current up to 50 A. This highly dynamic series achieves short recovery times with fast set value changes and load jumps.

SOURCE: STOBER

At a slim 45 millimeters, the SI6 drive controller from the new Generation 6 is a highly dynamic drive component.

But in extra dynamic applications that require very high power, such as in metal and wood machine tools or presses, an increasing number of axes requires corresponding supply power. In response, STOBER has introduced the decentralized PS6 High Power supply unit.

STOBER

Visit Website

Predictive Service Analyzer

An AI-based service edge app from Siemens helps provide higher availability of drives.

The Predictive Service Analyzer indicates defects in the drive system at an early stage before they affect the entire production. As a result, production downtime can be avoided and maintenance times can be scheduled in good time, increasing plant availability by up to 30 percent. By scheduling maintenance and servicing activities based on actual demand, this increases productivity by up to 10 percent. The Predictive Service Analyzer's AI-based solution detects early signs of anomalies, such as those indicating mechanical damage in the motor, including bearing damage, imbalance, and misalignment, as well as critical operating conditions of the frequency converter. The app assesses the severity of the defect and the expected remaining runtime and can thus predict potential future failures.

The Predictive Service Analyzer is particularly suitable for applications with constant movements, as is the case with pumps, fans, and compressors or with motors that do not require speed control. In comparison to the MindSphere app Predicitve Service Assistant, which has already been launched on the market, the Edge App's analysis is based on the evaluation of very high data volumes in near real time. The edge-based solution also serves secure data handling in the plant and reduces costs for cloud data transfers. In combination with the Predictive Service Assistant, the app can preprocess data as needed, and used with the MindSphere App for further insights and recommendations for action.

SOURCE: SIEMENS

The app assesses the severity of the defect and the expected remaining runtime and can predict potential future failures.

Siemens

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Industrial Ethernet Book

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Industrial Networking & IIoT