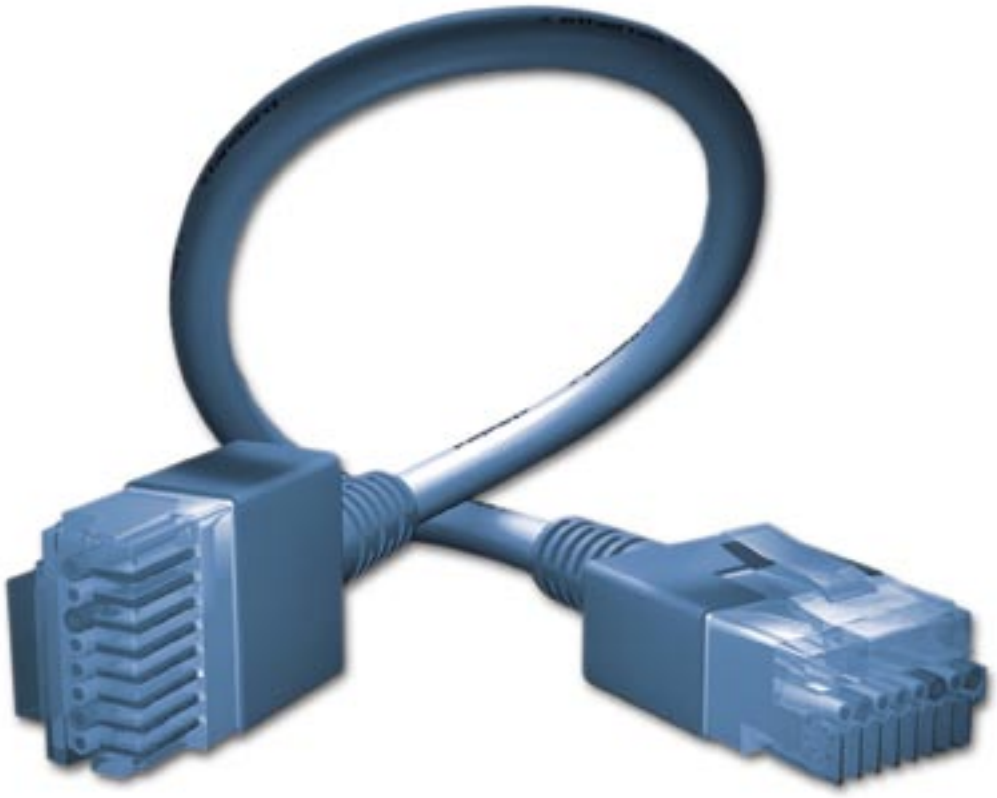
# ETHERNET Powerlink



Perfection in Automation

**www.br-automation.com**

Andreas Pfeiffer

Technology Marketing B&R
and Board Member of the
EPSG (ETHERNET Powerlink
Standardization Group)

The Industrial Ethernet market will grow at around 20% p.a. for at least the next 5 years according to leading automation analysts IMS Research. This is many times the growth of the automation industry in general and reflects an increase in networking generally and a shift to Ethernet based protocols, as users seek a universal networking technology.

When B&R introduced ETHERNET Powerlink to the market back in November 2001, nobody expected such enormuous growth rates of Industrial Ethernet. Today, ETHERNET Powerlink is still the only available Real-time Industrial Ethernet on the market in the microsecond performance range. It's proven in more than 40,000 nodes used in serial machinery and process automation all over the world.

At the time of its inception, it was interesting to hear from other industry vendors, that they do not see applications for such a performant system. I believe the vast growth of the Industrial Ethernet market and ETHERNET Powerlink applications in particular has proven them to be false. Day by day, many more industrial experts decide for using ETHERNET Powerlink and, there is a growing number of device and service vendors offering ETHERNET Powerlink enabled products and services.

This brochure is dedicated to innovative machine builders and process automation engineers who want to learn more about what is already possible today with ETHERNET Powerlink.

# What is ETHERNET Powerlink?

30 years ago, Ethernet was not developed to transfer real-time data between high-performance drives and leading-edge PLCs. There have been several approaches to overcome this obstacle which were all prototypes at best.

With ETHERNET Powerlink, Ethernet is ready for prime-time in automation. ETHERNET Powerlink the protocol solution managed by the open vendor and user group EPSG allows deterministic data transfer with implemented cycle times as low as 200$\mu$s and ultra precise timing precision better than 1$\mu$s. It is the only protocol with this performance not violating any Ethernet standards.

Besides its outstanding real-time capabilities, ETHERNET Powerlink offers ease-of-use in networking to suit industrial requirements. This is one of the reasons for the protocol's success in more than 40,000 nodes in serial applications. Furthermore, foundations have already been laid for future applications by current developments on machine safety, availability, reliability and engineering environments.

**True Real-Time for Standard Ethernet**
ETHERNET Powerlink provides a standard protocol for Fast Ethernet, which has proven its tough real-time characteristics in thousands of applications. The ETHERNET Powerlink Standardization Group (EPSG) ensures openness and continuous advancement. ETHERNET Powerlink as Standard Ethernet based system represents the second generation of fieldbus. This makes it possible to apply the full power of IT technologies to the automation world for the first time. ETHERNET Powerlink is especially suited for drives, I/Os, visualization and data exchange between PLC systems.

In automation further deployment of IT technologies like Ethernet and its IP-based protocols cannot be stopped anymore. Major advantages like increased bandwidth, data transparency, seamless integration and leveraging standard software and tools will lead to substitution of classical fieldbus systems.

# Why ETHERNET Powerlink ?



"ETHERNET Powerlink should become the fieldbus of the future."
*Ing. Deprato, Development Engineer Controls, Bystronic AG Switzerland*

"ETHERNET Powerlink is an ideal vehicle for injection molding.
You can run everything on one network."
*Dr. Kalis, Head of Development/Construction, Ferromatik Milacron*

"The more you move away from Standard Ethernet, the less you will be able to leverage its advantages. ETHERNET Powerlink is using standard components only, and can therefore be implemented in multiple environments. In the future even an order of magnitude faster with Gigabit Ethernet."
*Andreas Dreher, Development Manager, Hirschmann Electronics*

"ETHERNET Powerlink provides the basis for the synchronous drives which Lenze needs. All other approaches don't go far enough and won't be successful."
*Dr. Edwin Kiel, General Manager, R&D Lenze Drive Systems GmbH*

# Why ETHERNET Powerlink ?

**Open and Independent**
ETHERNET Powerlink is open for everybody. Further development and standardization is driven by the open vendors and users association EPSG (ETHERNET Powerlink Standardization Group).

**Market Oriented**
Enough room for differentiation. There is no single company dominating ETHERNET Powerlink. Everybody can influence its further development within the EPSG's working groups.

**No License Fees**
There are no license fees to pay in order to use ETHERNET Powerlink.

**Proven and Robust**
There is no risk to start using ETHERNET Powerlink. More than 40,000 nodes for more than three years in serial machine building and process automation make ETHERNET Powerlink the most mature Real-Time Industrial Ethernet.

**Available Now**
ETHERNET Powerlink is not just another concept. ETHERNET Powerlink is available now in many automation products like PLCs, drives, sensors, actuators and infrastructure components.

**Future Proof**
Already today, ETHERNET Powerlink is ready for future Ethernet standards. Due to its open and standard compliant architecture, ETHERNET Powerlink is well prepared for Gigabit Ethernet and other future extensions.



**No ASICs necessary**
There is no risk to run short of components. Any standard Ethernet silicon can run ETHERNET Powerlink. There are no dependencies from customized chips and vendors.

**Freedom of Implementation**
ETHERNET Powerlink enabled devices can be implemented with any standard Ethernet chip and processor architecture. There is maximum freedom for developing new devices or migrating exisiting products. Current ETHERNET Powerlink implementations are available on the following platforms:

- Altera FPGAs
- ARM
- Hilscher NetX
- Hyperstone
- Intel XScale
- Freescale ColdFire and HSC012
- Infineon 166
- NetSilicon

**Neutral Support**
Many experienced service companies around the world provide support for implementing ETHERNET Powerlink. No need to start from scratch – Evaluation kits, reference kits and turn-key software stacks provide a fast path to implementation.

**Maximum Performance**
ETHERNET Powerlink is the fastest, standard compliant Real-Time Industrial Ethernet system. Where other concepts need support through proprietary hardware components and chips, ETHERNET Powerlink reaches cycle times as low as 200$\mu$s with software.

**Precise Timing**
ETHERNET Powerlink guarantees the precise synchronisation of all connected devices. Current implementations offer timing precision and network jitter well below 1$\mu$s without special hardware support.

**Universal Interface**
ETHERNET Powerlink interface hardware can also run other Industrial Ethernet protocols, like Modbus TCP, Ethernet/IP or Profinet SRT.


# Why ETHERNET Powerlink ?

**Any Network Topology**
The network adapts to the needs of the application. ETHERNET Powerlink supports any network topology, like star, tree or daisy chain. Leverage Ethernet performance with fieldbus felxibility.

**Modularity Supported**
ETHERNET Powerlink can be extended on the fly. Hot plugging and maximum flexibility in network topology makes ETHERNET Powerlink the ideal backbone for modular machines.

**Directly Connected**
ETHERNET Powerlink devices talk directly with each other. Publish/subscribe and client /server relationship are always possiblew ithout detouring through a central PLC. This makes ETHERNET Powerlink highly efficient and ideal for multi-axis drive applications.

**Parameter and Diagnosis Data**
In the majority of applications, asynchronous data for parameterisation and diagnosis are as important as real-time process data. ETHERNET Powerlink always provides the optimum bandwidth mix for isochronous real-time and asynchronous non-real-time data.

**Simple Maintenance**
Device replacement made easy - No need to reconfigure the whole network or endless device configuration. ETHERNET Powerlink guarantees maximum up time.

**Easy to Learn and Use**
ETHERNET Powerlink is based on standards and therefore easy to learn and use for both networking and automation engineers. ETHERNET Powerlink has been designed for maximum ease-of-use.



**More than Just Another Fieldbus**
The automation world doesn't need just another faster fieldbus. ETHERNET Powerlink integrates fieldbus advantages with the benefits of mature IT networks and protocols.

**ETHERNET Powerlink is Ethernet**
Many other Real-time Ethernet concepts only use parts of standard Ethernet. ETHERNET Powerlink is Standard Ethernet. Thus the full range of Ethernet-based software, protocols and tools can still be used with ETHERNET Powerlink.

**Transparent Data Transfer**
Ethernet down to the sensor and actuator level. ETHERNET Powerlink offers highest real-time performance with transparent data transfer for parameterisation and diagnosis. Thus any Internet technology and protocol can be used with ETHERNET Powerlink.

**Standards Based**
ETHERNET Powerlink integrates best-of-breed standards in IT and automation. IEEE 802.3 Fast Ethernet, EN 50325-4 CANopen, IP-based protocols and other well established technologies are used for the leading Real-time Industrial Ethernet protocol.

**Setting the Standard**
ETHERNET Powerlink is based on worldwide standards and will become a standard itself. The EPSG is working with the IAONA, IEC and ISO to standardize ETHERNET Powerlink.

# ETHERNET Powerlink Insights

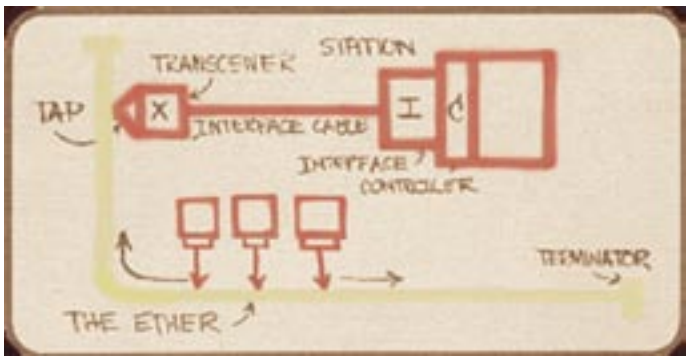
**Why Ethernet?**
To simplify development, maintenance and the supply chain, there is a strong demand from the automation industry to unify all levels of sufficient data communication to one network technology. With the Internet revolution, widely adopted networking and protocol standards from the IT world have reached pricing and robustness levels which make them attractive for communication networks in the automation industry.

- **The Future of Ethernet is Guaranteed**
  The basic concepts of Ethernet have been available for more than 30 years. The long life-cycles specific to the automation market demand a lasting base.

- **Ethernet Technology is Well Known**
  Ethernet and its accompanying protocols are considered common knowledge nowadays. The vast amount of available tools, programs and components further reduce the costs.

- **Ethernet Provides Transparency**
  The Ethernet standards bring together the IP-based data transfer protocols for diverse purposes. The integration of IT and automation by using Ethernet gives you real interoperability with Internet flexibility.

- **Ethernet is Real-time**
  With ETHERNET Powerlink, Ethernet also includes sensor and actuator levels, with cycle times as low as 200 $\mu$s and ultra precise timing precision better than one microsecond.



# Real-Time and Standard Ethernet



Regular Ethernet is not capable of handling data transfer in real-time. Additional measures like fully switched Ethernet and frame prioritization are not suitable either. Firstly, it does not fit the flexibility needs of automation network topologies. Secondly, deterministic data transfer and timing precision still cannot be guaranteed. And thirdly, it is quite complex to configure network utilization by selecting appropriate node and frame priorities. Multiple industry groups have therefore introduced various new mechanisms, like using non- CSMA/CD access mechanisms on Ethernet physics, introducing special time-based switching mechanisms, bit-stream decoding with ASICs or shortening Ethernet frames to lower transfer times. All these approaches have major drawbacks, either violating established worldwide standards, and/or forcing implementers to depend on proprietary ASICs.

Ethernet as an open standard demands openness when it comes to real-time data communication. Therefore, from the very beginning ETHERNET Powerlink always took the standard conform approach, extending IEEE 802.3 Ethernet with a mixed polling and time slicing mechanism to

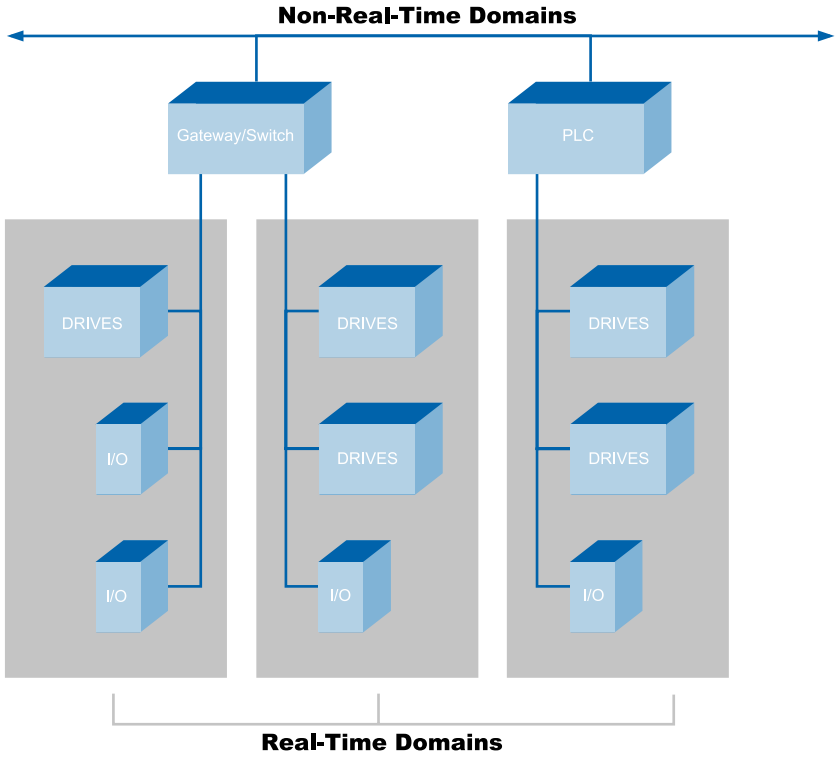
- guarantee transfer of time-critical data within very short and precise isochronous cycles with configurable timing.
- synchronize networked nodes with high precision in the microsecond range.
- transmit less time-critical data in a reserved asynchronous channel.

Current implementations have reached 200$\mu$s cycle time with a timing deviation (jitter) below 1$\mu$s. Until now, this was only possible with dedicated motion bus systems.
Due to its standard compliancy it is possible to leverage and continue using any standard Ethernet silicon, infrastructure component or test and measurement equipment with ETHERNET Powerlink. All IP-based protocols on higher layers, like TCP, UDP and above, can be further used without modifications. In particular, ETHERNET Powerlink conforms to the following international standards:

- IEEE 802.3 Fast Ethernet (incl. frame formats)
- IP-based protocols (TCP, UDP, etc)
- Standard device profiles according to CANopen EN50325-4
- Any Ethernet chip and hardware for implementation and operation - no ASICs and other non-standard hardware necessary
- IEEE 1588 for distributed real-time domain synchronization in one of the next extensions


# Network Structure

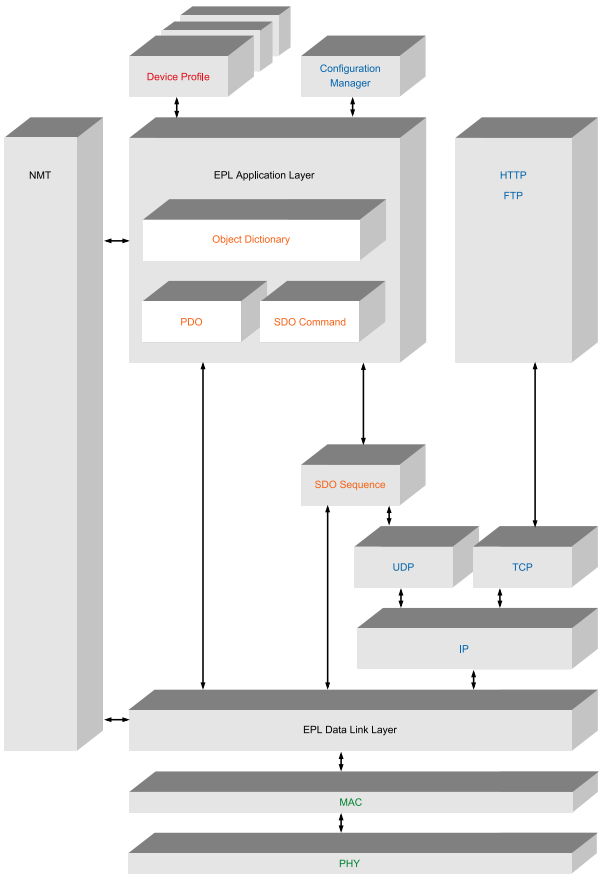
ETHERNET Powerlink distinguishes between real-time domains and non real-time domains. This separation matches typical machine and plant concepts. It also satisfies the increasing security demands to prevent hacker attacks at the machine level or harm through erroneous data communication on higher network hierarchies. True real-time requirements are met within the real-time domain. Less time critical data is routed transparently between the real-time domain and non-real-time domain using standard IP frames. A clear boundary between a machine and factory network prevents potential security flaws from the very beginning while keeping full data transparency.

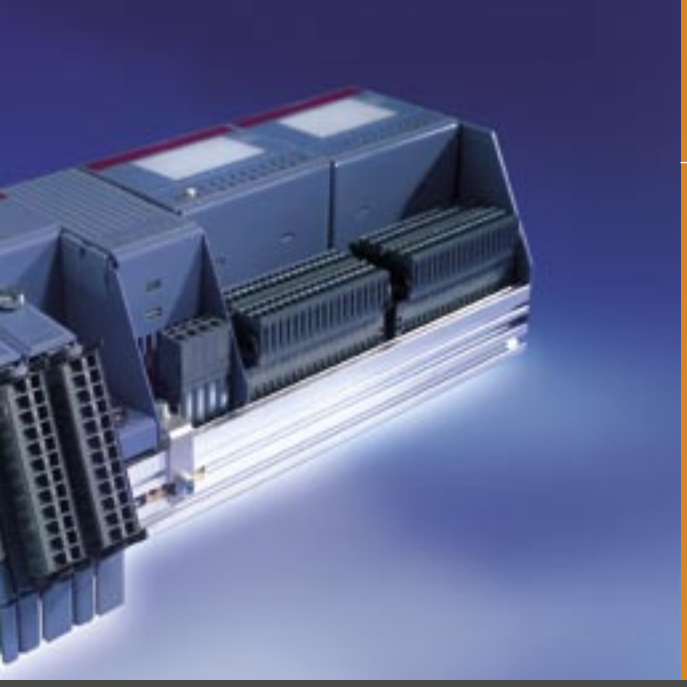


# Reference Model



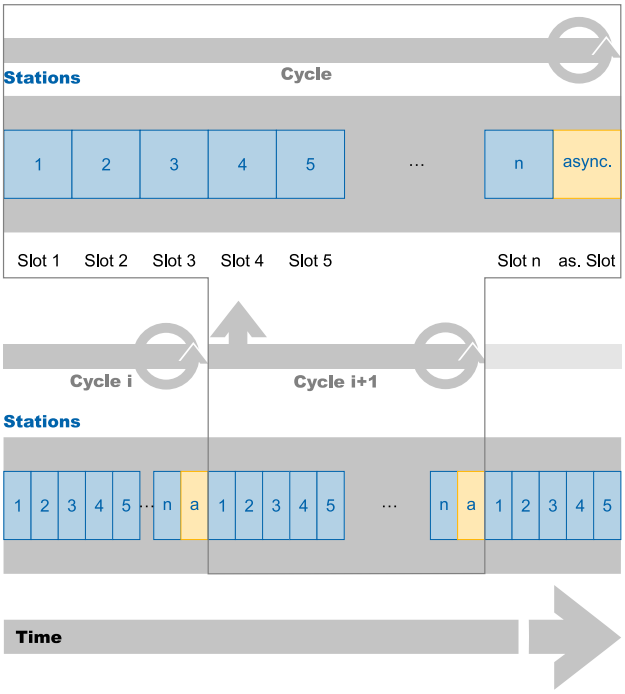
ETHERNET Powerlink is based on the ISO/OSI layer model and supports Client/Server and Producer/Consumer communication relationships. The protocol is based on the standard IEEE 802.3 layers. The current physical layer is 100BASE-X (see IEEE 802.3). In the future however, it could also be based on faster Ethernet variants such as Gbit Ethernet, if necessary. To minimize path delay and frame jitter it is recommended to use repeating hubs instead of switching hubs within the real-time domain. ETHERNET Powerlink references the IAONA Industrial Ethernet Planning and Installation Guide available for download from www.iaona-eu.org for proper wiring of industrial networks. Both RJ45 and M12 industrial Ethernet connectors are specified.





# Data Link Layer

Deterministic timing is achieved by applying a cyclic timing schedule for all connected nodes to access the physical layer. The schedule is divided into an isochronous phase and an asynchronous phase. During the isochronous phase, time-critical data is transferred, the asynchronous phase reserves bandwidth for non time-critical data. The Managing Node frees access to the physical medium via explicit messages. As a result, just one single node has access to the network at all times, thereby preventing collisions. The CSMA/CD mechanism, which causes non-deterministic Ethernet behavior, is not activated when ETHERNET Powerlink operates free of disturbances.




ETHERNET Powerlink's MAC-Addressing conforms to IEEE 802.3. It uses unique MAC-addresses for every device. In addition, nodes in the real-time domain are assigned an EPL Node ID. The respective node ID of a device can be selected by a node switch on the front side of the device. ETHERNET Powerlink also offers standard IP addressing when needed. This means that real-time devices can be accessed from anywhere in the world via the Internet. Local IP addresses are assigned to devices in a real-time domain. The local IP address for a particular device is derived from the respective node ID. The transition to the Internet is made via Network Address Translation (NAT), as it is when connecting to an Internet Service Provider.

# Application Layer



ETHERNET Powerlink has been integrated with the well known and widely deployed CANopen family of communication and device profiles. CANopen's DS301 and DS302 communication profiles have been adapted to ETHERNET Powerlink in a joint technical working group of both the EPSG and the CiA (CAN in Automation) group. Users and vendors of CANopen enabled devices are now able to easily migrate their applications from the well established CAN bus to an Ethernet environment which is a hundredfold faster. CAN bus and Ethernet networks can transparently be combined wherever needed.

CANopen

**Device Operating Modes**
An ETHERNET Powerlink capable device can handle the following operating states:

- Basic Ethernet Mode: The device is operated directly in the existing Ethernet networks, when real-time data transfer is not necessary. This is the default operating mode after switching on the device.
- Pre-Operational Mode: During the system start or after connecting the device to an existing network, the initialization and configuration data is loaded via the asynchronous channel.
- ETHERNET Powerlink Mode: After completing the boot procedure, the device enters real-time operation. The managing node checks the timing. The cycle time depends on the amount of isochronous and asynchronous data, as well as the number of nodes.

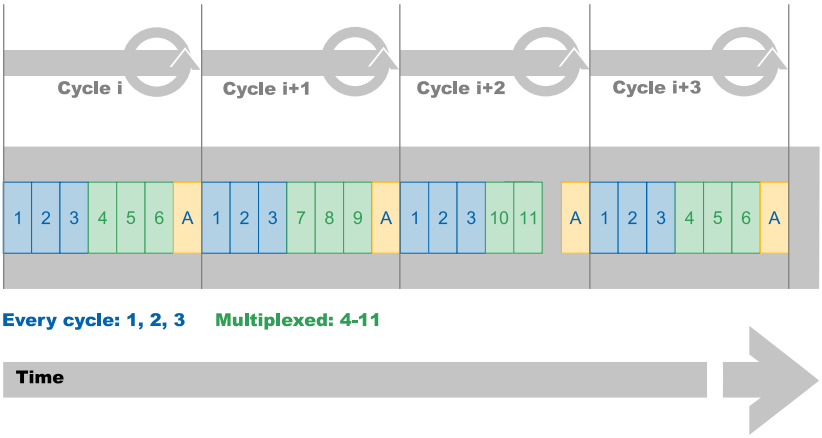
The basic cycle consists of the following phases:

- Start Phase: All networked nodes synchronize themselves to the managing node's clock
- Isochronous Phase: The managing node assigns a fixed time window to each node to transfer time-critical data. All other nodes can always listen to all data during this phase (publish/subscribe).
- Asynchronous Phase: The managing node grants the right to send ad-hoc data to one particular node. Standard IP-based protocols and addressing are used during this phase.

The quality of the real-time behavior depends on the precision of the overall basic cycle time. The length of individual phases can vary as long as the total of all phases remain within the basic cycle time boundaries. Adherence to the basic cycle time is monitored by the Managing Node. The duration of the isochronous and the asynchronous phase can be configured.

# Optimal Use of Bandwidth

In addition to transferring isochronous data during each basic cycle, multiple nodes are able to share common time slots for better bandwidth utilization. For that reason, the isochronous phase can distinguish between time slots dedicated to particular nodes which have to send their data every single basic cycle, and time-slots reserved for multiple slots to transfer their data one after the other.




Therefore less important yet still time-critical data can be transferred during longer cycles than the basic cycle. Assigning the time slots during each cycle is at the discretion of the managing node.

### Flexible Topologies

Ethernet networks installed in office buildings rely mostly on a star topology. This is not suitable for most machine networks. Field busses helped to reduce the wiring effort required while being able to adapt the network topology to the needs of the application. To help industrial Ethernet succeed at the lowest level, it must be possible to implement it with any network topology.

That's why individual ETHERNET Powerlink devices are equipped with several Ethernet ports which can handle lines and branches. Therefore any topology such as line, tree, star or mixed structures can be realized. Inside the device, a repeating hub ensures that the data stream continues on to its intended destination. In addition to greater flexibility when networking, this reduces the need for external infrastructure components such as switching or repeating hubs.

With ETHERNET Powerlink the physical and the logical topology of the network are separated. It is possible to connect a device to any port on the network without having to reconfigure it. This achieves a higher degree of freedom when designing and upgrading modular machine systems and prevents errors that may occur when the wrong cable is inserted.

# IP Address Assignment



Today, a DHCP server usually handles IP address assignment in an office. This server manages a pool of available addresses and assigns them automatically to devices upon request. However, this also means that devices on an office network never have permanent IP addresses. Instead, a device receives a new address from the pool each time it logs on to the network. If individual devices are contacted using an IP address on the machine level, it's important that any replacement device will have the same IP address again. In this case, the DHCP mechanism is not the right choice since a replaced device will no longer be accessible via the same address. With ETHERNET Powerlink, the device address is linked with the node selection switch on the front side of the device. This method is used to calculate the IP address itself, but it can still be overwritten by a network manager if needed. This guarantees that devices that are exchanged retain their IP addresses without them having to be entered manually.
Since the number of IP addresses available worldwide is limited, it's usually a company's IT department that is in charge of allocating them. An engineer using Ethernet for networking will probably need several IP addresses so that devices and modules in his machine can be reached by higher-level management. Series production can result in addresses being used even more quickly. Moreover, many IT departments underestimate the requirements for these types of services.

In addition to this, the manufacturer and user network environments are different, resulting in varying IP address ranges. ETHERNET Powerlink deals with this by assigning local IP addresses (RFC 1918 – Address Allocation for Private Internets) at the machine level, regardless if the machine is connected in the vendor's production network or at the final customer site. The same local IP addresses are always used on the machine. NAT (Network Address Translation) is used to assign global addresses to local internal addresses in the network where the machine is running. This method has already established itself in the Internet environment.
With ETHERNET Powerlink, it is used to cleanly separate manufacturer and end-user addresses without a lengthy reconfiguration process after delivery.

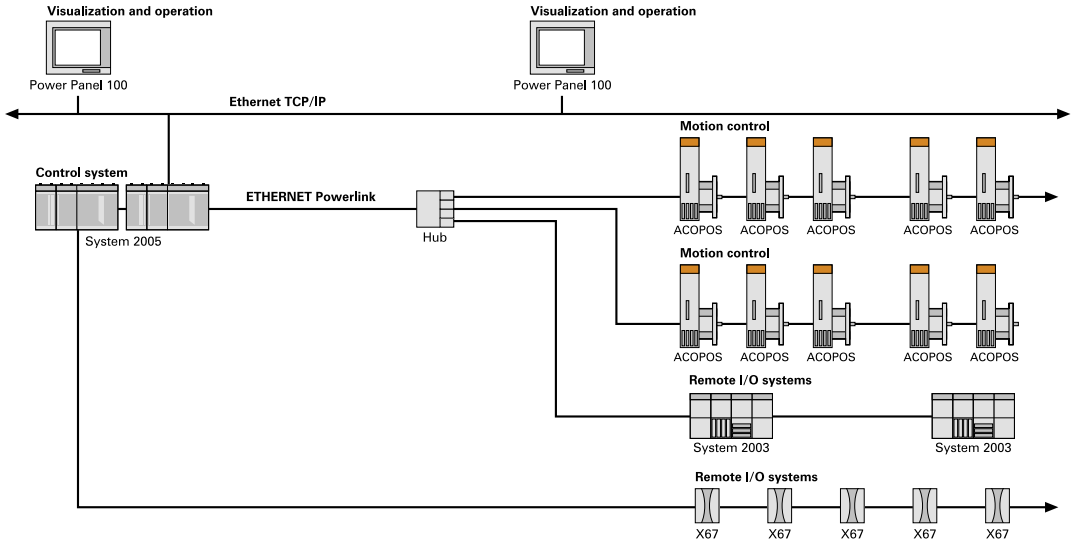
**Future Outlook**
Further deployment of IT technologies like Ethernet and its IP-based protocols cannot be stopped in automation anymore. Major advantages like increased bandwidth, data transparency, seamless integration and leveraging standard software and tools will lead to the substitution of classical fieldbus systems.
Besides its outstanding real-time capabilities, ETHERNET Powerlink offers ease-of-use in networking as demanded in the industry. This is one of the reasons for the protocol's success in currently more than 40,000 nodes in serial applications. Furthermore, already today the foundation has been secured towards future applications through current works on machine safety, availability, reliability and engineering environments.

**www.ethernet-powerlink.org**

# Embedded PC-based Automation

Large machines and systems place high demands on the functionality and performance of automation components. Flexibility, expandability and scalable performance classes allow the most modern machine concepts to be realized. High-performance PLC in PC architecture as controller, central and distributed expansions for I/O channels, open network standards and operator panels using the newest ergonomic designs. The example from the packaging industry combines decentralized operation, 50 drives, and 50 remote I/O systems as well as more then 60 I/O modules with IP67 protection distributed throughout the machine room.

- Scalable performance and I/O capacity
- Mixture of central and distributed architecture
- Clear concept and servicing
- Greatly reduced wiring

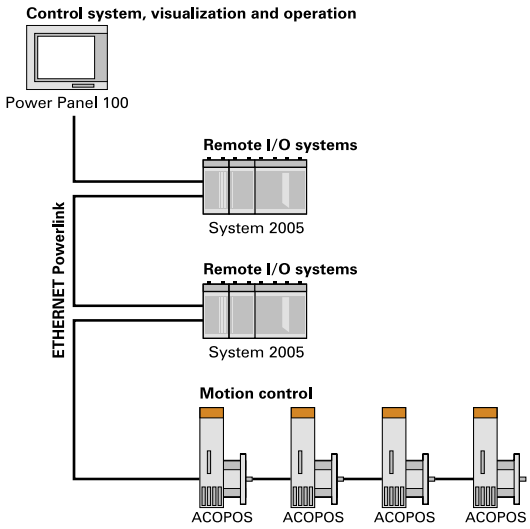


# Panel-based Automation



The operator panel is the central controller. All components, such as I/O systems and drives are connected via a high-performance network. With ETHERNET Powerlink™, the system is set up to handle the highest real-time demands.

- Modular and scalable machine modules
- Highest performance class for real-time applications
- Precise synchronization of multi-axis movements and I/O signals



# Members and Users

# An Open Platform

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# Benefits of Openess

Ethernet has succeeded in the IT world due to its openness. It is only consequent to continue with this openness when introducing Ethernet to realtime systems, like in automation. The market will accept open solutions only. In this context, openness not only means to have access to the technology itself, but to develop it further in an open environment with multiple ideas.The EPSG (ETHERNET Powerlink Standardization Group) has been founded in June 2003 as an association in Winterthur/Switzerland.

Originated from a group of leading automation companies its focus is to leverage the advantages of Ethernet also for networking high performance real-time systems. The fundament is the ETHERNET Powerlink real-time protocol, introduced by B&R end of 2001.

The EPSG ensures clear organisational structures and transparent decision making processes. It is organised in multiple working groups focusing on different tasks, like technology, marketing, certification and end users. Within these groups, each EPSG member has the opportunity to shape the future of ETHERNET Powerlink. The balance of demands from different directions leads to acceptable solutions which are implementable in a short timeframe. The success of this approach has just been proven by the recent co-operation between the EPSG and the CiA (CAN in Automation) group. In a joint technical working group, both associations managed to integrate ETHERNET Powerlink with CANopen communication and device profiles. The joint group started its work in July 2003 and introduced a mature 400page specification the same year in November. Multiple companies had the same goal and achieved a result which the group can be really proud of.

A lean organisation, transparent structures and efficient decision making processes guarantee the EPSG that goals can be achieved and practical solutions are developed. The openness to leverage existing standards wherever possible, to influence specifications, and to have access to the technology lead to a solid range of powerful solutions for future application challenges.

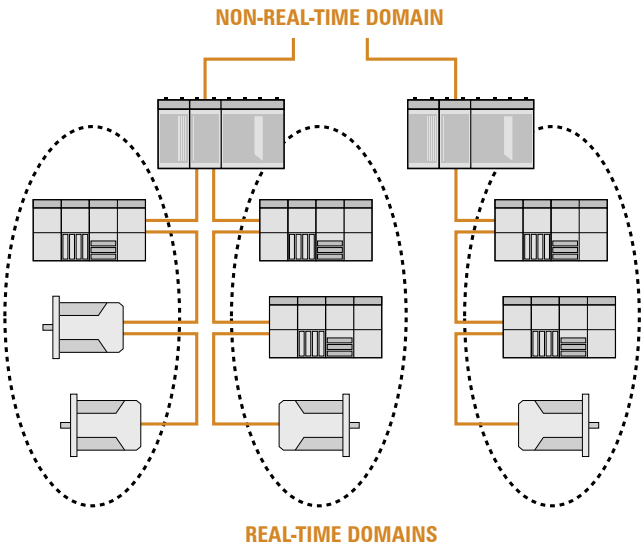
ETHERNET
POWERLINK
STANDARDIZATION GROUP


# ETHERNET Powerlink Security



**Securely Connected to the World**
One of the main reasons for using Industrial Ethernet is the transparency achieved when transferring data to standard applications such as data bases, process control systems, ERP systems, etc. System accessibility over the Internet also offers new possibilities for maintenance and service.

But where there's light, there are also shadows. Hackers, tired of just breaking into email systems, are looking forward to the time when a large number of machines are connected over global networks. The potential for loss due to production stoppages, quality reduction, or general damage is enormous.
For this reason, ETHERNET Powerlink provides clear dividing lines and access controls on the machine level from the very beginning. On the one hand, it is important to guarantee that external access to the machine network is only possible by authorized persons. On the other hand, it is important to guarantee that the timing of the real-time domain cannot be influenced by malicious attacks on the higher-level network. Time deviations in the microsecond range could cause reduced production quality and, in the worst case, could also damage machine parts. The separation between real-time and non-real-time domains in ETHERNET Powerlink ensures security in all aspects.

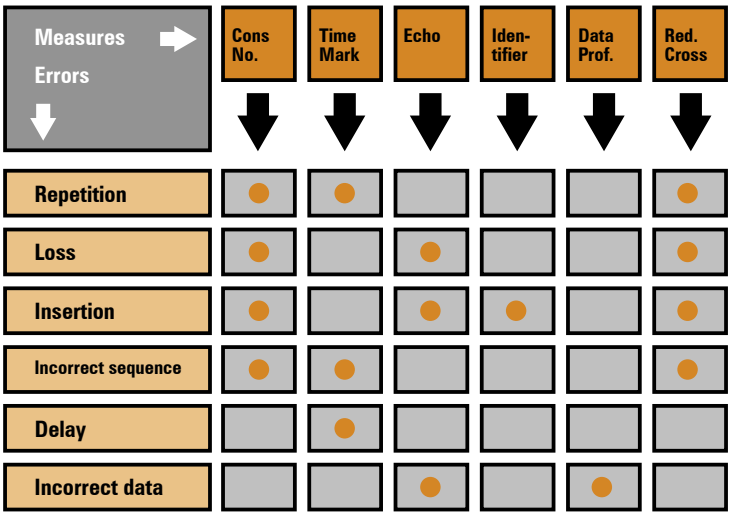



# ETHERNET Powerlink Safety

Safety related systems are needed when it is requested to protect personnel from potentially severe injuries through automated machines and processes. These systems have to guarantee that even erroneous interactions will not cause any damage or harm and, the machine will be switched over to a specific safe operation mode. In the past, this has been realized by using discrete wired electromechanical circuits. With the deployment of fieldbuses for networking automation components, this has to be done electronically.

The EPSG's safety working group is currently developing EPLsafety, the safety related extension of ETHERNET Powerlink. EPLsafety will become the first open and independent Ethernet based safety bus which will support cycle times down to 100$\mu$s. EPLsafety will cover applications in all areas like machine automation, process control and transport systems. There is even the potential in this system to satisfy reliability and availability demands of category SIL 4 according to IEC 61508. EPLsafety's concept certification is planned for end of 2004.

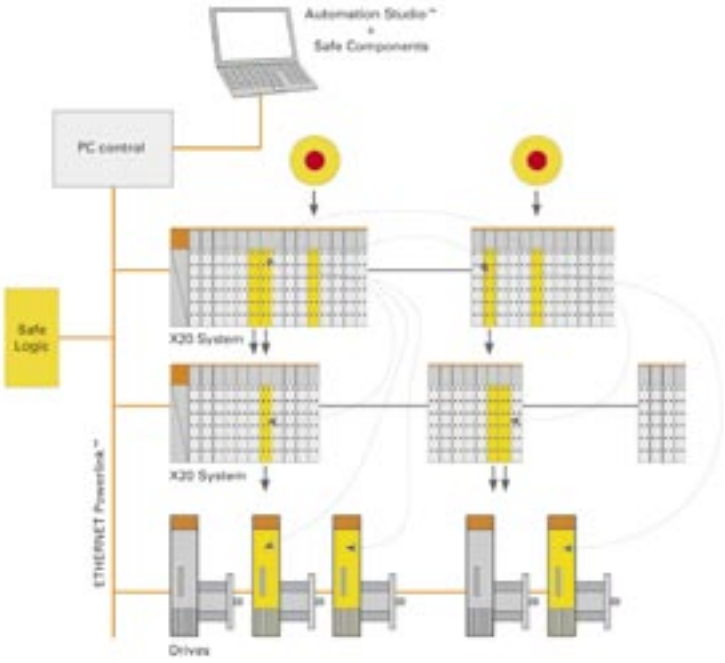
**IEC 61508**



# Safe Configuration and Programming



All logical functions are handled by the Safe Logic. This component defines all logical relationships between all safety devices with the help of a configuration tool. Logical programming of all safety functions is done with the help of graphical function blocks. Standardized pre-defined safety function blocks are under development at PLCopen. The regular PLC running the application can access all safety devices and variables via ETHERNET Powerlink.

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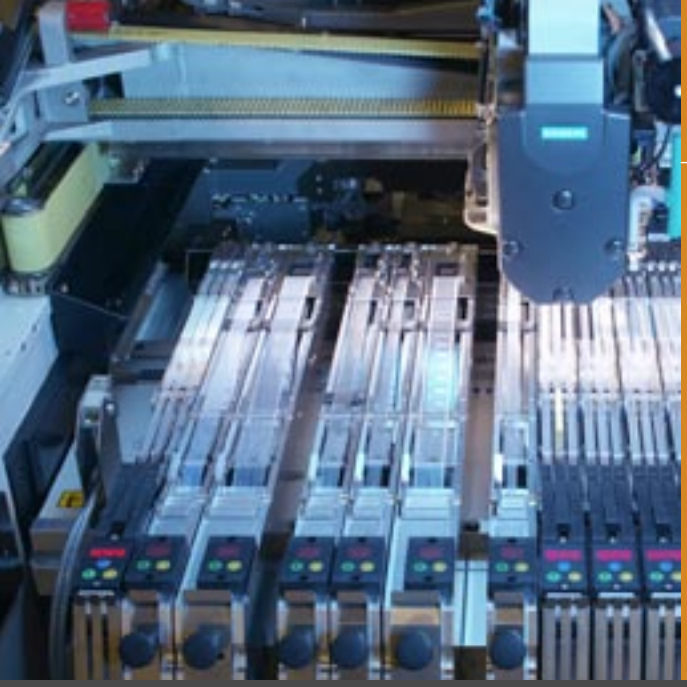


# Fast Track to Implementation

How complicated is it to integrate ETHERNET Powerlink into my device? This is one of the first questions asked by people interested in this technology. It is actually very easy, and there are many ways to achieve your goal. Which way is the most efficient depends on the individual requirements, guidelines and preferences. The EPSG and its members make sure that everyone can try out a fast and easy step-by-step approach to real-time communication via Ethernet.

**Initial Testing**
For the initial testing, you can try out the complete prefabricated evaluation boards. A device manufacturer can easily connect the hardware to ETHERNET Powerlink using commercial evaluation boards as the connection point. Well-documented functions and interfaces allow you to concentrate on linking into the network environment. Extensive programming and porting of protocol stacks is not necessary. Dedicated communication hardware ensures that the device is not loaded down with communication tasks so that full performance remains available. Evaluation boards can be obtained from various suppliers.

**Building on Proven Technology**
After successfully testing the function of a device in an ETHERNET Powerlink network with the evaluation board, the next step is to configure the entire device, including communication interface, in a way that meets the mechanical and electrical requirements of the manufacturer. The simplest way to guarantee a fast introduction on the market is to use a reference design in the manufacturer's device electronics.
The circuitry of some available ETHERNET Powerlink evaluation boards is open to the point that they can be simply integrated in the device. Hardware and software suppliers in the EPSG offer different sales and licensing models for this purpose. The manufacturer decides if a reference design is implemented 1:1 or only a part is used, i.e. porting is set up on custom architectures and depends on time-to-market and cost factors.
In any case, the reference designs are a good starting point.

**Optimized for the Quantities Needed**
If large quantities are needed, it makes sense to invest more for the integration and minimize manufacturing costs. It is necessary to check the extent to that the ETHERNET Powerlink stack can be implemented on the existing platform. Ideally, an Ethernet interface is already available on the device, and only the software has to be adjusted. One of the main advantages of Powerlink technology is the fact that it is open. Regardless of the processor architecture and whether it is applied to hardware or software ETHERNET Powerlink can be integrated into any standard Ethernet design.



**No proprietary ASIC needed.**
The device manufacturer is free to decide if the stack runs in the software on the preferred processor, a system-on-chip approach is used or an ASIC is developed. The properties of the technology are open, and experienced suppliers ensure that the optimal relationship between cost and performance can be found for each application. The software approach and open properties also make it possible to use a single hardware design for ETHERNET Powerlink and other Ethernet-based network systems. However you look at it: ETHERNET Powerlink allows the manufacturer to decide which implementation method is best. If time-to-market or price is important, an open, fully specified software solution provides more freedom and potential for optimization than rigid ASIC-based, real-time Ethernet approaches.

Very few manufacturers have the time and resources needed to obtain the know-how to set up and completely implement a communication protocol like ETHERNET Powerlink themselves in-house. More often, it's better to concentrate on the main areas of expertise in the device function and ensure a fast and high-quality network connection. Within the EPSG, well-known organisations offer customized services and components to put you on the fast track to implementing ETHERNET Powerlink:

ALTERA. IXXAT SND SMART NETWORK DEVICES hilscher MICREL z:w Zürcher Hochschule Winterthur Mitglied der Zürcher Fachhochschule port

Zürcher
Hochschule
Winterthur

Mitglied
der Zürcher
Fachhochschule

# Zurich University of Applied Science

**Communication runs high at this Institute of higher education**
The Zürcher Hochschule Winterthur is the largest multi-faculty Swiss University of Applied Sciences with some 2,500 students enrolled in various technical and business courses, from architecture right through to economics and linguistics. To ensure that our future engineers are equipped with the up-to-date skills required by industry and that Switzerland retains its position as a centre of innovative excellence, we carry out applied research in specialized institutes.

Prof. Thomas Müller founded the Institute of Embedded Systems (InES) in 2001 whose current research focus is on communication systems and protocols. The institute employs 8 lecturers, some 14 assistants and several trainees and apprentices.

InES successfully acquired and completed a large number of significant projects with industry leaders. The following is only one example of the problem solving capabilities in communications, albeit an untypical one, that InES can offer.

IDOCAS (Intelligent Distributed Obstacle & Collision Avoidance System www.idocas.ch) is a collision warning system for light aviation. Time and again pilots collide with other planes or stationary obstacles (cables, antennas ...) in unsupervised airspace. Due to the integrated GPS, the precise speed and position are known at all times. This data is broadcasted to all other flying objects from which the collision risk can be communicated to the pilot. In addition, an obstacles database warns the pilot of stationary hazards, such as ropes, cables or towers.

A major current focus of the Institutes' research is, however, industrial communication, in particular the ETHERNET Powerlink real-time communication protocol. InES, one of the five founding members of the EPSG and a driving force in establishing the specifications, also hosts the office of the association. The first stack complying with version 2 of the ETHERNET Powerlink protocol was presented in April this year at the HMI trade fair in Hanover. This was behind the EPSG multi-vendor application. Able to draw on this expertise, InES is in a unique position to be able to offer companies' unparallel support in implementing their ETHERNET Powerlink enabled products. This is what has happened with the two innovations being presented at the trade fair by the Institute together with its industrial partners TR-Electronic GmbH and Bihl+Wiedemann.

TR-Electronic GmbH is one of the leading suppliers of precision position transducers. The partnership with the InES enabled TR-Electronic transmitters to be enabled with ETHERNET Powerlink technology and so satisfy customers' demands for transducers with this communication technology. The Institute has carried out the same task for the ASi gateway specialists Bihl+Wiedemann. In this case the task was also combined with a with a Bachelors thesis.

# Implementing ETHERNET Powerlink



As a “bit slinger”, the AS interface is a perfect supplement to ETHERNET Powerlink networks, which, as a highly determinant “data pump”, tends to be used for networking more complex devices.

**Measuring and testing on the 100 Mbps Ethernet**
Especially in highly deterministic real time applications, every microsecond counts. Factors such as jitter and delay of a network component become highly important, characteristics that cannot be measured with typical networking-debugging tools. Recognising this, InES developed the Ethernet High Resolution Timing Analyser which measures with a high temporal resolution all events in the real-time network. The device can register the occurrence of specific, definable data packages and/or several external digital control signals with a time stamp. The well known Etherreal protocol analyser provides a familiar front-end, Powerlink-enabled” by an InES-developed plug-in, made available without charge to EPSG members on www.ethernet-powerlink.org.

If you have any questions concerning industrial communication, it will be worth your while contacting InES!

For further information please contact:
ZHW - InES (Institute of Embedded Systems) -
Technikumstrasse 9 - CH-8401 Winterthur
Tel. +41 (0) 52 267 75 25 - info@ines.zhwin.ch

Zürcher Hochschule Winterthur
Mitglied der Zürcher Fachhochschule

**www.ines.zhwin.ch**


SND
SMART NETWORK DEVICES

# Smart Network Devices

**Complete design service for Ethernet Powerlink**

Real-Time Ethernet is one of the most important topics in industrial automation today. But none of the different standards has reached the level of acceptance Ethernet Powerlink (EPL) has. Smart Network Devices (SND) has been instrumental in helping device manufacturers to expedite the propagation of EPL in the industry as time to market is increasingly important. This is why many manufacturers of PLCs and other industrial devices are looking for turnkey solutions, where hardware and software fits perfectly together and where the application programmer has to care about his process variables only. All complex aspects of the EPL protocol as well as all real-time requirements are guaranteed to be compliant to the specification if SND's Micro WebTargetTM CPU board family and the HyNetOSTM real-time network operation system are in play.
HyNetOS offers many more communication options apart form the actual EPL stack. A large variety of services such as a filing system, TCP/IP applications such as HTTP and FTP servers and various device drivers enable the user to keep the flexibility to make future adaptations and extensions. Also firmware updates can be done right over the real-time network with a single file upload from a central server (Fig. 1).

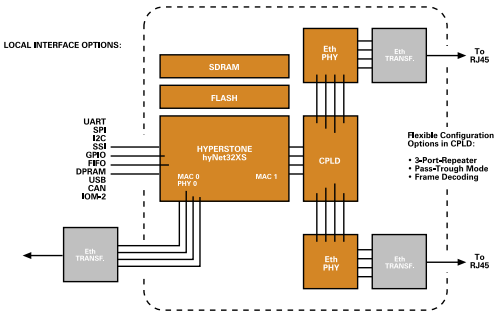



**Fig. 1: HyNetOS with EPL Stack**

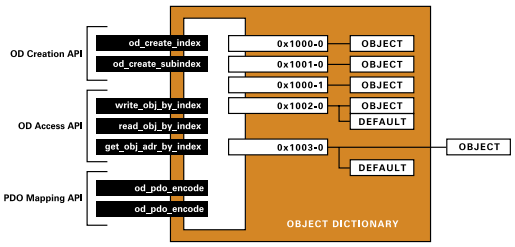



**Fig. 2: Object dictionary APIs**

The EPL stack in HyNetOS from SND is characterised by a very small memory footprint and a high efficiency. The complex parts of the protocol are hidden behind simple APIs. The interface to the application code, relying on the EPL V2.0 object dictionary structure just as in the CANopen standard, can be operated with a set of simple and easy-to-use functions (Fig 2).

Furthermore, the initialisation of an EPL node, including the actual firmware and the object dictionary is dynamic as the code and the settings are read from the flash filing system.
In such way one and the same node can either start as Controlled Node (CN, address 1-239) or as Managing Node (MN, adress 240) depending just on the position of the address selector switch at startup.



Also different device profiles can be configured just by placing different configuration files onto the device's flash disk. The structure of the object dictionary has furthermore been optimised for fast access speed and can be administrated through varios methods of SDO transfers from any remote location. It is also possible to save the configuration to the flash at any time.
As CPUs SND recommends the members of the 32-Bit RISC/DSP family from Hyperstone. The newest chip from this series is the hyNet32XS, offering 200 MHz clock and a large number of interfaces (e.g. Ethernet MAC und PHY) as well as a considerable amount of fast memory right on the chip. For smaller CN's this is just enough to run the EPL stack and some extensions which makes additional external SRAM or DRAM obsolete. This makes the design not only very compact but also extremely cost efficient. A fast CPU on the other hand ensures small cycle times (< 200 us) and a very small jitter (< 1 us) on the Managing Node (MN) and fast response times (< 2 us) on the Controlled Node (CN).
Also a hub-design is offered by SND, that can be integrated on the node itself. In such way a cost efficient line topology becomes possible. Furthermore the node can act as a gateway or router between real-time Ethernet and legacy Ethernet as a third optional Ethernet interface is available (Fig. 3). The CPU board from SND, the Micro WebTarget MWT3/RTE, is available as ready-to-go module solution or as hardware schematic, should the customer want to do the integration of the components on one of his boards.

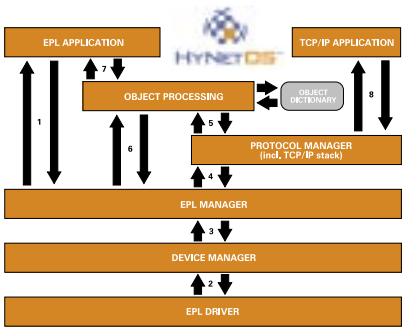



**Fig. 3: SND's Micro WebTarget Reference Design**

Anyone who chooses a hardware design based on the Hyperstone CPU today, is also ready for future extensions of the EPL standard. The clock synchronisation according to the IEEE 1588 standard is about to find ist way into the Ethernet Powerlink specification. With this respect the hyNet32XS has already the necessary hardware interface needed to guarantee a synchronisation jitter of less that 500 ns.
All together SND can offer a whole range of services and technologies with hardware and software solutions for current and future Ethernet Powerlink specifications. Additionally customer specific developments and adaptations are possible, so any customer can expect an optimised solution for his application.

**www.smartnd.com**


# IXXAT Automation GmbH

IXXAT Automation GmbH is a leading supplier for communication solutions in the automation and automotive area. At its headquarters in Weingarten, IXXAT has about 55 employees, of which more than 70% are R&D engineers. In addition, IXXAT Inc, a subsidiary located nearby Boston, MA., as the US sales office employing three professionals. IXXAT's activities are focussed on data communication based on CAN, CANopen, DeviceNet, ETHERNET Powerlink, Ethernet/IP, generic TCP/IP, LIN and FlexRay.

ETHERNET Powerlink (EPL) is seen as the most important migration technology for CAN evolving into the area of industrial Ethernet, because EPL is the only technology that guarantees hard real-time capabilities on generic Ethernet links. EPL is the natural path for CANopen applications shifting to Ethernet-based bus media due to its usage of CANopen communication mechanisms and device profiles within EPL V2.

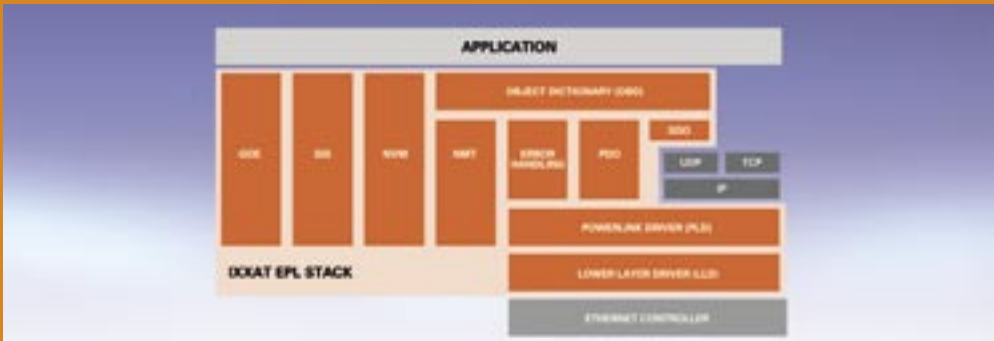
IXXAT is already offering several EPL products for some time: The already available EPL V2 protocol stack, which fully supports the CANopen mechanisms, allows to implement EPL V2 compliant devices with low efforts. The EPL V2 protocol stack is based on a software architecture that provides high performance as well as easy portability. For this reason it can easily be used with any CPU on different hardware platforms. A specific adaptation of the EPL V2 protocol stack is also available for a FPGA-based single chip solution. This enables cost-efficient development and volume production of EPL-devices.

IXXAT is currently developing a whole family of EPL products: The IXXAT EPL PCI Interface card allows control-applications (like soft-PLCs) or diagnosis and configuration software to access EPL systems. The already available CANopen Configuration Studio will be enhanced with a real-time-scheduler which makes it possible to use the CANopen Configuration Studio for CANopen as well as for EPL systems.
On top of this portfolio of standard products and services, IXXAT offers customer-specific hardware and software development as well as EPL technology seminars and application consulting.

**ETHERNET Powerlink Protocol Software**
The ETHERNET Powerlink software offered by IXXAT was developed in close cooperation with the companies Bernecker & Rainer, Lenze and Hirschmann and includes all protocols and mechanisms necessary for the development of Powerlink devices. Besides the basic EPL protocols which are transmitted by using Ethernet frames, the EPL protocol software includes also all CANopen mechanisms like Object Dictionary, PDO, SDO, Error Handling and Networkmanagement which are combined in the higher protocol layer.

The EPL software contains all necessary functions for the implementation of controlled nodes or managing nodes in accordance with the EPL V2 specification. IXXAT offers various options for the implementation of a TCP/IP stack into the EPL software. Beside the option of using TCP/IP stacks which are already included in operating systems, the IXXAT offers a commercial high performance TCP/IP stack as well as other 3rd party open source stacks. This is especially necessary if the operation of the SDO protocol via UDP is required. The EPL software is available in a generic version as hardware independent C source code, which can be ported to various target systems and platforms with or without an operating system.

# Implementing ETHERNET Powerlink






**Encapsulation of hard real-time tasks**
The lower layers of the EPL software are specifically designed to guarantee fast response times on real-time events on the EPL bus. Therefore, the access and the handling of the Ethernet controller is encapsulated within a separate module, the lower layer driver (LLD). For an adaptation of the EPL stack to a specific CPU or hardware platform, only this module needs to be modified. This abstraction between hardware-depending routines and the higher layers of the EPL software makes it possible to provide a high degree of scalability and adaptability. A central configuration file allows optimum adaptation of the EPL functionality provided by the protocol stack to the given application and thus enables effective use of available resources which guarantees an extremely resource-saving implementation.

**Object dictionary and programming interface**
The object dictionary is the interface between application and EPL communication. For each object dictionary entry, a reference to a variable with application data can be directly allocated. PDOs and SDOs access these application variables directly. Therefore, no modifications to an existing application are necessary in order to integrate an EPL protocol stack.
User-specific call-back functions can be linked to every application object. In the event of accesses to these objects, the respective (event-controlled) notification of the application will be performed. This mechanism allows a direct, application-specific reaction on the modification to the application data caused by a remote EPL bus device. In addition, save and restore of configured data is also supported.

**Operating system support**
The EPL stack can be used without an operating system. The software has an internal scheduler which ensures the optimal allocation of the available process time resources to the various stack functions. When using an operating system, the EPL stack is executed as a task. In this use-model, only basic operating system functions like semaphores and tasks are required. Because these functions are encapsulated by an abstraction layer, they can be easily adapted to the used operation system.

**Reference platform**
The provided „C“ source code can be used on ANY target system. Besides of the generic version, the delivered software package includes implementation samples, which work on Freescale Coldfire 523x/547x/548x based systems without the need of additional adaptation. Evaluation boards with wiring diagrams (reference schematics) are also available. On request, an adapted version for Netsilicon ARM9-based CPUs can be provided as well.
The ETHERNET Powerlink Protocol Software is delivered as „C“ source code, with software license, manual, technical support and maintenance contract.

IXXAT

www.ixxat.com


# ETHERNET Powerlink Configuration Tools

**PowerMAP for any Framework and any Device**
infoteam PowerMAP supports component based automation in Ethernet Powerlink fieldbus networks. Applications involving devices from different vendors may be easily distributed without the need for complicated communications programming. A graphical engineering tool with a fast select and connect method reduces engineering efforts dramatically. It focuses on configuration of devices and communication rather than on programming.
As an vendor independent tool infoteam PowerMAP comes either as part of the OpenPCS Automation suite or may be integrated with any other component based engineering framework. It features three different views of the network, each dedicated to a specific engineering task:

- PowerMAP / DTM creates electronic data sheets
- PowerMAP / IO maps distributed I/O to the controller
- PowerMAP / Link associates application objects across the network

**PowerMAP Device Type Manager**
Each device manufacturer has to set up configuration information detailing objects and data types accessible through the network. With PowerMAP/DTM setting up a ETHERNET Powerlink device is quite straight forward. It builds up the object dictionary for each device type and generates the appropriate electronics data sheets used during I/O configuration in a later phase.
Vendors of complex devices may need more flexibility than provided by a generic device type manager in spreadsheet like tables. infoteam Software therefore offers an additional generic class library, from which vendor specific DTM's may be derived. This library is fully compliant with the latest DTM style guide of the FTD joint interest group and eases the development of setup and maintenance software for Powerlink devices.

- Device configuration based on FTD/DTM technology
- Library for advanced interactive user interfaces
- Full featured operation of complex devices
- Handling of parameters and recipes

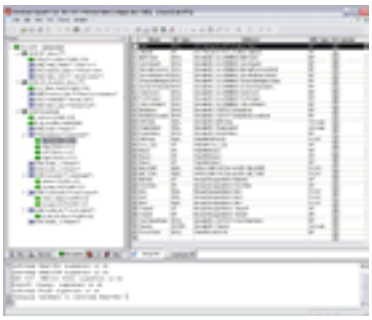
**PowerMAP I/O Configuration**
To set up an I/O configuration all device type information generated by the DTM is imported and all parameters are represented in a tree like structure. Browsing available objects from devices on the network, the application engineer defines the mapping of physical devices and their terminals to logical variables of the application program. Thus the independence of application programs written in one of the IEC 61131-3 languages from the IO assignment is preserved, greatly enhancing portability and reusability.

# Implementing ETHERNET Powerlink



An open interface based on DTM technology allows for vendor specific device descriptions and dynamically extends the capabilities of the device library:

- Browser for distributed ETHERNET Powerlink I/O
- Multi-vendor capability
- Portable application programs
- Fully compliant with IEC 61131-3



**PowerMAP Network Linking**
infoteam PowerMAP introduces a complete new method of network configuration. It clearly separates the fieldbus used for distributed I/O from the same network used for communication between intelligent devices. A graphical data flow editor enables the engineer to pick the different controllers from the configuration tree and place them on its worksheet to display its logical interfaces exposed for access by other controllers.

To define all necessary communication between those controllers, only the available interfaces need to be identified by a simple select and connect action. The dataflow is displayed automatically by coloured lines, specifying the different types of data transmitted. All the underlying details of the local or distributed I/O's are hidden freeing the engineer of all unnecessary technical information:

- Pick and place control objects from the configuration tree
- Select and connect their interface to specify the data flow

Online diagnostics and monitoring of data is part of the engineering environment. The complete communication between components of the machine or the process may be monitored using the same engineering tools. This makes maintenance easy and troubleshooting fast!

**www.infoteam.de**

# ETHERNET Powerlink FPGA Solution

**Maximum Performance at minimum Cost**

One of ETHERNET Powerlink's major advantages is that the protocol can be implemented on any standard Ethernet hardware and chip. ETHERNET Powerlink is the only Real-Time Industrial Ethernet solution with microsecond speed and precision which doesn't need support through proprietary hardware components like ASICs. Thus ETHERNET Powerlink can easily be integrated in many existing devices.

Vendors of sensors and actuators are now offered another solution based on Field Programmable Gate Arrays (FPGA). The solution has been developed by Altera, a leading FPGA vendor, and EPSG members and service providers.

The performance of modern FPGA generations and its drastic reduction of up-front costs allow a more flexible reaction to market dynamics. Reduced overall costs, shorter development cycles and faster time to market ensure a vendor's success on the market.

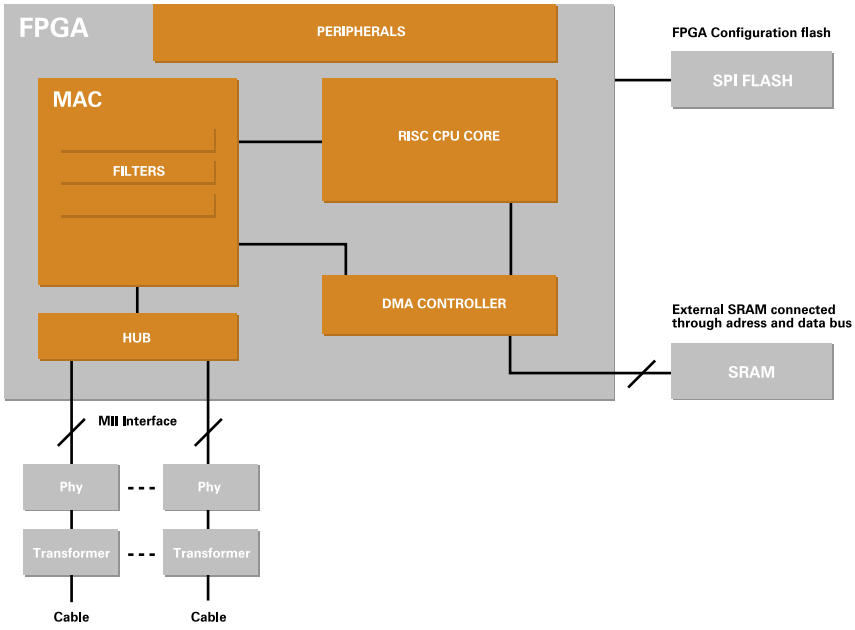
An optimized, license-free ETHERNET Powerlink interface, hub logic and a processor core can be realised on one single FPGA. With this solution, the cost per node have been reduced significantly below the 10 Dollar boundary, including the necessary processing infrastructure for the application.
Vendors of price-sensitive devices now have access to a universal, flexible architecture which adapts to the needs of the application.

- Universal Interface for ETHERNET Powerlink
- Reprogrammable Logic and Functions
- Optimized Frame Filter Mechanisms
- Minimized Costs
- Flexible Processor Core for Applications
- Configurable Peripherals and Interfaces

# Implementing ETHERNET Powerlink








"The FPGA solution has been developed by B&R and Altera, and will be supported by EPSG service providers like IXXAT Automation."

www.altera.com www.ixxat.com www.br-automation.com


# Products & Services

**AMK Arnold Müller GmbH & Co. KG**
www.amk-antriebe.de
PLC CONTROLLER SYMAC
SERVO Drives KE/KW

**Baldor**
www.baldor.com
NextMove ESB
multi-axis motion controller

**Bernecker+Rainer Industrie-Elektronik Ges.m.b.H.**
www.br-automation.com
System 2003 ETHERNET Powerlink Bus Controller Module EX481
System 2003 ETHERNET Powerlink Bus Controller Module EX484
System 2005 ETHERNET Powerlink Bus Controller Module EX282
System 2005 ETHERNET Powerlink Module IF686
X67 System ETHERNET Powerlink Bus Controller BC8321
System 2005 ETHERNET Powerlink Module IF782
System 2005 ETHERNET Powerlink Module IF786
System 2005 ETHERNET Powerlink Module IF787
System 2005 ETHERNET Powerlink Module IF789
Logic Scanner LS187
Logic Scanner LS189
ACOPOS Plug-in Module AC112
Industrial Ethernet Hub AC808
Industrial Ethernet IP67 Hub AC8005
EV081/EX081 ETHERNET Powerlink Evaluation Board

**Festo**
www.festo.com
Pneumatic manifolds

**Harting Electric GmbH & Co. KG**
www.harting.com
Ethernet Hub EHB 67-10 TP05
Infrastructure Components
Cabeling
Connectors

# ETHERNET Powerlink Product Directory



**Hirschmann Electronics GmbH & Co. KG**
www.hirschmann.de
- Industrial Fast Ethernet Hub RH2-TX
- Fiber Optics Transceivers
- ETHERNET Powerlink Gateway

**IXXAT Automation GmbH**
www.ixxat.de
- ETHERNET Powerlink V2 Protocol Stack

**Lenze**
www.lenze.com
- L-Force Servo Drives

**Smart Network Devices GmbH**
www.smartnd.com
- ETHERNET Powerlink Reference Boards
- ETHERNET Powerlink Implementation Services

**TR-Electronic**
www.tr-gruppe.de
- Rotary Encoder

**Posital**
www.posital.de
- Absolute rotary encoders with Web Server

**Zürcher Hochschule Winterthur**
**Institute of Embedded Systems**
www.ines.zhwin.ch
- Engineering-Kit: EPL Controlled Node Stack
- Engineering-Kit: EPL Managing Node Stack
- Evaluation: Interface-Kit
- Evaluation: Basic-Kit
- Evaluation: Test-Kit
- Evaluation: RTAI-Linux Complete-Kit
- Evaluation: Automation-Runtime-Complete-Kit
- Training: Boot-Training for Development Engineers
- Training: EPL-Manager for Development Engineers
- Tools: Ethernet High Resolution Timing Analyser

# System 2003 Bus Controller EX481

Remote I/Os can be connected to a ETHERNET Powerlink network using the ETHERNET Powerlink EX481 bus controller.

- Initialization - from power-on to active operation on the network
- Evaluating and sending input states
- Receiving and switching the outputs
- Defined error behavior for network crashes and local disturbances

| **Short Description** | **7EX481.50-1** |
|---|---|
| Bus Controller | ETHERNET Powerlink controlled note |
| **Peripherals** | **7EX481.50-1** |
| I/O Bus Interface | 9-pin DSUB socket |
| Station Number Dial | For setting the Powerlink station number |
| **Interfaces** | **7EX481.50-1** |
| Interface IF1 | |
| Fieldbus | ETHERNET Powerlink |
| Type | 100 Base-T (ANSI/IEEE 802.3) |
| Wiring | Shielded RJ45 port |
| Maximum Baud Rate | 100 MBit/sec |
| Cable Length | Max. 100 m between two stations (segment length) |
| **Power Supply** | **7EX481.50-1** |
| Design | Switching power supply with reverse polarity diode |
| Input Voltage | 24 VDC |
| Voltage Range | 18 VDC to 30 VDC |
| Power Input | 20.0 W |
| Output Power for I/O Modules and Screw-in Modules | 13.4 W |
| **General Information** | **7EX481.50-1** |
| Status Display | Module status |
| Diagnostics | |
| Module Status | Yes, with status LED |
| Certification | CE, C-UL-US, GOST-R |
| Operation on Module Slot | 1 |
| Maximum Number of Logical Module Slots | 16 |
| Maximum Number of Analog Module Slots | 8 |
| Possible Module Addresses for Analog Modules | 1 - 8, for description see section “Module Slot Rules” |
| Electrical Isolation | |
| PLC - IF1 | Yes |
| **Mechanical Characteristics** | **7EX481.50-1** |
| Dimensions | System 2003 single-width |
| Protection | IP20 |
| Operating Temperature | |
| Horizontal Installation | 0° C to +60° C |
| Vertical Installation | 0° C to +50° C |
| Storage Temperature | -20° C to +70° C |
| Humidity | 5 to 95% (non-condensing) |

# System 2003 Bus Controller EX484



Remote I/Os can be connected to a ETHERNET Powerlink network using the ETHERNET Powerlink EX484 bus controller.

- Initialization - from power-on to active operation on the network
- Evaluating and sending input states
- Receiving and switching the outputs
- Defined error behavior for network crashes and local disturbances
- Integrated 4x hub

| **Short Description** | **7EX484.50-1** |
|---|---|
| Bus Controller | ETHERNET Powerlink controlled note |
| **Peripherals** | **7EX484.50-1** |
| I/O Bus Interface | 9-pin DSUB socket |
| Station Number Dial | For setting the Powerlink station number |
| **Interfaces** | **7EX484.50-1** |
| Interface IF1 | |
| Fieldbus | ETHERNET Powerlink |
| Type | 100 Base-T (ANSI/IEEE 802.3) |
| Wiring | Internal 4x hub, 4 x shielded RJ45 port |
| Maximum Baud Rate | 100 MBit/sec |
| Cable Length | Max. 100 m between two stations (segment length) |
| **Power Supply** | **7EX484.50-1** |
| Design | Switching power supply with reverse polarity diode |
| Input Voltage | 24 VDC |
| Voltage Range | 18 VDC to 30 VDC |
| Power Input | 20.0 W |
| Output Power for I/O Modules and Screw-in Modules | 10.4 W |
| **General Information** | **7EX484.50-1** |
| Status Display | Module status |
| Diagnostics | |
| Module Status | Yes, with status LED |
| Certification | CE, C-UL-US, GOST-R |
| Operation on Module Slot | 1 |
| Maximum Number of Logical Module Slots | 16 |
| Maximum Number of Analog Module Slots | 8 |
| Possible Module Addresses for Analog Modules | 1 - 8, for description see section “Module Slot Rules” |
| Electrical Isolation | |
| PLC - IF1 | Yes |
| **Mechanical Characteristics** | **7EX484.50-1** |
| Dimensions | System 2003 single-width |
| Protection | IP20 |
| Operating Temperature | |
| Horizontal Installation | 0° C to +60° C |
| Vertical Installation | 0° C to +50° C |
| Storage Temperature | -20° C to +70° C |
| Humidity | 5 to 95% (non-condensing) |

# System 2005 Bus Controller EX282

The EX282 module is a ETHERNET Powerlink bus controller module. With it, the System 2005 can be operated as a remote I/O rack using ETHERNET Powerlink.
It is equipped with an internal hub with two RJ45 sockets.
The ETHERNET Powerlink bus controller is operated in an expansion slot on the PS456 power supply.

- ETHERNET Powerlink interface connection for I/O modules
- Integrated hub for efficient cabling
- Plug-in component for power-supply modules

| **Short Description** | **3EX282.6** |
|---|---|
| Bus Controller | ETHERNET Powerlink |
| **Controller** | **3EX282.6** |
| Fieldbus | ETHERNET Powerlink |
| Type | 100 Base-T (ANSI/IEEE 802.3) |
| Cable Length | Max. 100 m between two stations (segment length) |
| Maximum Baud Rate | 100 MBit/sec |
| Port Design | Internal 2 x hub |
| | 2 x shielded RJ45 port |
| **General Information** | **3EX282.6** |
| Status Display | Bus function, I/O module function |
| Diagnostics | |
| Bus Function | Yes, with status LED and software status |
| I/O Module Function | Yes, with status LED and software status |
| Certification | CE, C-UL-US, GOST-R |
| Electrical Isolation | |
| PLC - Powerlink | Yes |
| Power Consumption | |
| 5 VDC | 3.8 W |
| 24 VDC | - |
| Total | 3.8 W |
| **Mechanical Characteristics** | **3EX282.6** |
| Slot | Insert slot in PS465 power supply |
| Protection | IP20 |
| Operating/Storage Temperature | 0°C to +60°C / -20°C to +70°C |
| Humidity | 5 to 95% (non-condensing) |

# Interface Module IF686



- ETHERNET Powerlink to meet the highest real-time demands
- RJ45 connection
- Either manager or controller functionality

| **Short Description** | **3IF686.9** |
|---|---|
| Communication Module | 1 x ETHERNET Powerlink |
| **Interfaces** | **3IF686.9** |
| Interface IF1 | |
| Fieldbus | ETHERNET Powerlink |
| Type | 100 Base-T (ANSI/IEEE 802.3) |
| Wiring | Shielded RJ45 port |
| Maximum Baud Rate | 100 MBit/sec |
| Cable Length | Max. 100 m between two stations (segment length) |
| **General Information** | **3IF686.9** |
| Status Display | Status of Powerlink station, network activity, link/collision |
| Diagnostics | |
| Station Status | Yes, with status LED and software status |
| Bus Function | Yes, with status LED and software status |
| Certification | CE, C-UL-US, GOST-R |
| Electrical Isolation | |
| PLC - IF1 | Yes |
| Power Consumption | |
| 5 V | 1.76 W |
| 24 V | - |
| Total | 1.76 W |
| **Mechanical Characteristics** | **3IF686.9** |
| Slot | Insert for CP260, IF260, IF060 |
| Protection | IP20 |
| Operating/Storage Temperature | 0°C to +60°C / -20°C to +70°C |
| Humidity | 5 to 95% (non-condensing) |

# X67 Bus Controller BC8321

ETHERNET Powerlink is a standard protocol for Fast Ethernet which has proven its true real-time characteristics in thousands of applications. The ETHERNET Powerlink Standardization Group (EPSG, www.ethernet-powerlink.org) ensures that the standard remains open and is continually developed.

Powerlink represents the second fieldbus generation based on standard Ethernet. This makes it possible to apply the full power of IT technologies to the automation field for the first time.

**X67 ETHERNET Powerlink bus controller**

- ETHERNET Powerlink
- 8 digital channels that can be configured as inputs or outputs
- I/O configuration and firmware update via the fieldbus
- Integrated connection to the local expansion via X2X Link for 64 additional modules
- Configurable cycle time for local expansion from 400 $\mu$s

The BC8321 bus controller supports ETHERNET Powerlink V1. Additional X67 modules and other modules that are based on X2X Link can be attached using the integrated X2X Link connection. It is also possible to operate the X2X Link cycle synchronously 1:1 or synchronous to Powerlink using a prescaler.

Mechanically, ETHERNET Powerlink is connected via the new IP67 Ethernet Standard M12 connector with D-coding.

**Detailed information and support regarding selection, possible configurations, and combinations of digital and analog modules is available on the B&R Website: www.br-automation.com**



| **Brief Overview** | **X67BC8321** |
|---|---|
| Fieldbus Type | ETHERNET Powerlink |
| Cable Length | Max. 100 m between two stations (segment length) |
| Maximum Baud Rate | 100 MBit/s |
| Number of Channels | 8, software can be used to set as inputs or outputs |
| Rated Voltage | 24VDC |
| Input Filter | |
| Hardware | ≤10 µs (channel 1 - 4) / ≤70 µs (channel 5 - 8) |
| Software | Configurable between 0 and 25 ms |
| Input Circuit | Sink |
| Inputs | Event counting, gate measurement |
| Additional Functionalities | |
| Nom. Output Current | 0.5 A |
| Total Current | 4.0 A |
| Output Circuit | Source |
| Output Protection | Thermal cutoff for overcurrent and short circuit, integrated protection for switching inductances, reverse polarity protection of output supply |
| Outputs | None |
| Additional Functionalities | |
| Sensor Supply | 0.5 A total current |
| Electrical Isolation | |
| Fieldbus - X2X Link | Yes |
| Channel - Bus | Yes |
| Channel - Channel | No |
| Power Consumption | |
| Fieldbus | 3.5 W |
| I/O Internal | 2.0 W |
| X2X Link Supply | 4.8 W maximum power output for connected I/O modules |
| Power Output | 3.0 W X2X Link supply for I/O modules |
| **General Information** | **X67BC8321** |
| Status Display | I/O function for each channel, supply voltage, bus function |
| Diagnostics | |
| I/O Supply | Yes, with status LED and software status |
| Outputs | Yes, with status LED and software status |
| Certification | CE, C-UL-US, GOST-R |
| **Mechanical Characteristics** | **X67BC8321** |
| Dimensions (W x H x D) | 53 x 85 x 42 mm |
| Weight | 195 g |
| Protection | IP67 |
| Mounting Orientation | Any |
| Operating/Storage Temperature | 0°C to +60°C / -25°C to +85°C |

# aPCI Interface Module IF782

- ETHERNET Powerlink for real-time Ethernet Communication
- RS485 on multipoint connector

| **Brief Overview** | **3IF782.9** |
|---|---|
| Interface IF1 | |
| Type | RS485 |
| Wiring | 4-pin Multipoint Connector |
| Maximum Baud Rate | 115.2 kBit/s |
| Interface IF2 | |
| Fieldbus | ETHERNET Powerlink |
| Type | 100 Base-T (ANSI/IEEE 802.3) |
| Wiring | Shielded RJ45 port |
| Maximum Baud Rate | 100 MBit/s |
| Cable Length | Max. 100 m between two stations (segment length) |
| Electrical Isolation | |
| PLC - IFx | Yes |
| IF1 - IF2 | Yes |
| Power Consumption | |
| 3.3 V | 2.3 W |
| 5 V | 0.5 W |
| Total | 2.8 W |
| **General Information** | **3IF782.9** |
| Status Display | Send/receive data for IF1<br>Status of the Powerlink station, network activity, link/collision for IF2 |
| Diagnostics | |
| Data Transfer (IF1) | Yes, with status LEDs |
| Station Status (IF2) | Yes, with status LED and software status |
| Bus Function (IF2) | Yes, with status LED and software status |
| Certification | CE, GOST-R |
| **Mechanical Characteristics** | **3IF782.9** |
| Slot | Insert e.g. in CP360 |
| Protection | IP20 |
| Operating/Storage Temperature | 0°C to +60°C / -20°C to +70°C |
| Humidity | 5 to 95% (non-condensing) |
| Remark | Order 1 x TB704 terminal block separately |

# aPCI Interface Module IF786



- Multi-interface module
- ETHERNET Powerlink for real-time Ethernet Communication
- RS232 as online interface Parameters can be defined

| **Brief Overview** | **3IF786.9** |
|---|---|
| Interface IF1 | |
| Type | RS232 |
| Wiring | 9-pin DSUB plug |
| Maximum Baud Rate | 115.2 kBit/s |
| Interface IF2 | |
| Fieldbus | ETHERNET Powerlink |
| Type | 100 Base-T (ANSI/IEEE 802.3) |
| Wiring | Shielded RJ45 port |
| Maximum Baud Rate | 100 MBit/s |
| Cable Length | Max. 100 m between two stations (segment length) |
| Electrical Isolation | |
| PLC - IF1 | No |
| PLC - IF2 | Yes |
| IF1 - IF2 | Yes |
| Power Consumption | |
| 3.3 V | 2.0 W |
| 5 V | 0.5 W |
| Total | 2.5 W |
| **General Information** | **3IF786.9** |
| Status Display | Send/receive data for IF1<br>Status of the Powerlink station, network activity, link/collision for IF2 |
| Diagnostics | |
| Data Transfer (IF1) | Yes, with status LEDs |
| Station Status (IF2) | Yes, with status LED and software status |
| Bus Function (IF2) | Yes, with status LED and software status |
| Certification | CE, C-UL-US, GOST-R |
| **Mechanical Characteristics** | **3IF786.9** |
| Slot | Insert e.g. in CP360 |
| Protection | IP20 |
| Operating/Storage Temperature | 0°C to +60°C / -20°C to +70°C |
| Humidity | 5 to 95% (non-condensing) |

# aPCI Interface Module IF787

- Interface Module with CAN Bus and ETHERNET Powerlink

| **Brief Overview** | **3IF787.9** |
|---|---|
| Interface IF1 | |
| Type | CAN Bus |
| Wiring | 4-pin Multipoint Connector |
| Maximum Baud Rate | 500 kBit/s |
| Interface IF2 | |
| Fieldbus | ETHERNET Powerlink |
| Type | 100 Base-T (ANSI/IEEE 802.3) |
| Wiring | Shielded RJ45 port |
| Maximum Baud Rate | 100 MBit/s |
| Cable Length | Max. 100 m between two stations (segment length) |
| Electrical Isolation | |
| PLC - IFx | Yes |
| IF1 - IF2 | Yes |
| Power Consumption | |
| 3.3 V | 2.5 W |
| 5 V | 0.5 W |
| Total | 3.0 W |
| **General Information** | **3IF787.9** |
| Status Display | Send/receive data for IF1<br>Status of the Powerlink station, network activity, link/collision for IF2 |
| Diagnostics | |
| Data Transfer (IF1) | Yes, with status LED and software status |
| Station Status (IF2) | Yes, with status LED and software status |
| Bus Function (IF2) | Yes, with status LED and software status |
| Certification | CE, C-UL-US, GOST-R |
| **Mechanical Characteristics** | **3IF787.9** |
| Slot | Insert e.g. in CP360 |
| Protection | IP20 |
| Operating/Storage Temperature | 0°C to +60°C / -20°C to +70°C |
| Humidity | 5 to 95% (non-condensing) |
| Remark | Order 1 x TB704 terminal block separately |

# aPCI Interface Module IF789



- ETHERNET Powerlink
- Direct connection for high-speed I/O

| **Brief Overview** | **3IF789.9** |
|---|---|
| Interface IF1 | |
| Type | X2X Link Master |
| Design | 4-pin multipoint connector |
| Interface IF2 | |
| Fieldbus | ETHERNET Powerlink |
| Type | 100 Base-T (ANSI/IEEE 802.3) |
| Wiring | Shielded RJ45 port |
| Maximum Baud Rate | 100 MBit/s |
| Cable Length | Max. 100 m between two stations (segment length) |
| Electrical Isolation | |
| PLC - IFx | Yes |
| IF1 - IF2 | Yes |
| Power Consumption | |
| 3.3 V | 2.3 W |
| 5 V | 0.5 W |
| Total | 2.8 W |
| **General Information** | **3IF789.9** |
| Status Display | Send/receive data for IF1<br>Status of the Powerlink station, network activity, link/collision for IF2 |
| Diagnostics | |
| Data Transfer (IF1) | Yes, with status LED and software status |
| Station Status (IF2) | Yes, with status LED and software status |
| Bus Function (IF2) | Yes, with status LED and software status |
| Certification | CE, C-UL-US, GOST-R |
| **Mechanical Characteristics** | **3IF789.9** |
| Slot | Insert e.g. in CP360 |
| Protection | IP20 |
| Operating/Storage Temperature | 0°C to +60°C / -20°C to +70°C |
| Humidity | 5 to 95% (non-condensing) |
| Remark | Order 1 x TB704 terminal block separately |

# Logic Scanner LS187

- Interface module for CAN-bus and ETHERNET Powerlink

| **Brief Overview** | **5LS187.6** |
|---|---|
| Interface IF1 | |
| Type | CAN bus |
| Wiring | 4-pin multipoint connector |
| Maximum Baud Rate | 500 kBit/s |
| Interface IF2 | |
| Fieldbus | ETHERNET Powerlink |
| Type | 100 Base-T (ANSI/IEEE 802.3) |
| Wiring | Shielded RJ45 port |
| Maximum Baud Rate | 100 MBit/s |
| Cable Length | Max. 100 m between two stations (segment length) |
| Electrical Isolation | |
| PC - IFx | Yes |
| IF1 - IF2 | Yes |
| SRAM | 1 MByte, battery backed |
| Ready Relay | N.O. and N.C., max. 30 VDC, max. 10 A |
| Power Input | 4.0 W |
| **General Information** | **5LS187.6** |
| Status Display | Status of the Powerlink station, network activity, link/collision for IF2 |
| Diagnostics | |
| Data Transfer (IF1) | Yes, with software status |
| Station Status (IF2) | Yes, with status LED and software status |
| Bus Function (IF2) | Yes, with status LED and software status |
| Certification | CE, C-UL-US, GOST-R |
| **Mechanical Characteristics** | **5LS187.6** |
| Slot | Standard PCI half size module, ISA Plug & Play |
| Installation in | |
| B&R IPC Provit 5000 | Yes |
| Desktop PC | Yes |
| Protection | IP20 when installed |
| Operating/Storage Temperature | 0°C to +55 °C / -20°C to +70°C |
| Humidity | 0 to 95% (non-condensing) |
| Remark | Order 2 x TB704 terminal blocks separately<br>Lithium battery included in delivery |

# Logic Scanner LS189



- ETHERNET Powerlink
- X2X Link connection

| **Brief Overview** | **5LS189.6** |
|---|---|
| Interface IF1 | |
| Type | X2X Link Master |
| Design | 4-pin multipoint connector |
| Interface IF2 | |
| Fieldbus | ETHERNET Powerlink |
| Type | 100 Base-T (ANSI/IEEE 802.3) |
| Wiring | Shielded RJ45 port |
| Maximum Baud Rate | 100 MBit/s |
| Cable Length | Max. 100 m between two stations (segment length) |
| Electrical Isolation | |
| PC - IFx | Yes |
| IF1 - IF2 | Yes |
| SRAM | 1 MByte, battery backed |
| Ready Relay | N.O. and N.C., max. 30 VDC, max. 10 A |
| Power Input | 4.0 W |
| **General Information** | **5LS189.6** |
| Status Display | Status of the Powerlink station, network activity, link/collision for IF2 |
| Diagnostics | |
| Data Transfer (IF1) | Yes, with software status |
| Station Status (IF2) | Yes, with status LED and software status |
| Bus Function (IF2) | Yes, with status LED and software status |
| Certification | CE, C-UL-US, GOST-R |
| **Mechanical Characteristics** | **5LS189.6** |
| Slot | Standard PCI half size module, ISA Plug & Play |
| Installation in | |
| B&R IPC Provit 5000 | Yes |
| Desktop PC | Yes |
| Protection | IP20 when installed |
| Operating/Storage Temperature | 0°C to +55 °C / -20°C to +70°C |
| Humidity | 0 to 95% (non-condensing) |
| Remark | Order 2 x TB704 terminal blocks separately<br>Lithium battery included in delivery |


# ACOPOS
# ETHERNET Powerlink Interface AC112

- ETHERNET Powerlink interface for installation ACPOS servo-drives
- Integrated 2x hub for easy wiring
- For communication and configuration of the ACOPOS servo drives for complex and time-critical applications
- Node number can be set using switch

| **General Information** | **8AC112.60-1** |
|---|---|
| C-UL-US Listed | Yes |
| Module Type | ACOPOS plug-in module |
| Slot | Slot 1 |
| Power Input | Max. 2.5 W |
| **Powerlink Interface** | **8AC112.60-1** |
| Connection, Module Side | 2 x RJ45 socket |
| Indications | Status LEDs |
| Electrical Isolation | |
| ETHERNET - ACOPOS | Yes |
| Maximum Distance per Segment | 100 m [1] |
| Baudrate | 100 Mbit/s |
| Network Capable | Yes |
| Hub, 2x | Yes |
| Maximum Number of Hub Levels | 10 |
| Cabling Topology | Star or tree with level 2 hubs |
| Possible Station Operating Modes | Synchronous to ETHERNET Powerlink cycle |
| Watchdog Function | |
| Hardware | Yes (via ACOPOS servo drive) |
| Software | Yes (via ACOPOS servo drive) |

1) With a cycle time of 400 µs and 10 ACOPOS servo drives, the maximum total cable length is 200 m.

| **Operational Conditions** | **8AC112.60-1** |
|---|---|
| Environmental Temperature during Operation | --- [1] |
| Relative Humidity during Operation | --- [1] |

1) ACOPOS plug-in modules can be used in an ACOPOS servo drive; the corresponding values can be found in the technical data of the respective ACOPOS servo drive.

| **Storage and Transport Conditions** | **8AC112.60-1** |
|---|---|
| Storage Temperature | -25 to +55°C |
| Relative Humidity during Storage | 5 to 95% (non-condensing) |
| Transport Temperature | -25 to +70°C |
| Relative Humidity during Transport | 95% at +40°C |

# Ethernet Hub AC808



The AC808 Ethernet Hub is a stand alone device, which can be used universally as a Level 2 Hub in standard Ethernet networks or ETHERNET Powerlink networks. It is suitable for 100 Mbps (fast Ethernet) and 10 Mbps networks. The hub automatically recognizes the transfer speed for the channels. 1)

The Ethernet connections are made using RJ45 connectors. The pin assignments can be crossed for the first channel using a switch.

The hub can be installed horizontally or vertically on the mounting rail. It also has fastening possibilities on the sides for direct mounting.

| **Brief Overview** | **0AC808.9** |
|---|---|
| Type | 8x industrial hub (Layer 2) |
| Interface | Ethernet 10/100 Base-T (ANSI/IEEE 802.3) |
| Cable Length | Max. 100 m between two stations (segment length) |
| Transfer Rate | 10 or 100 MBit/s, Devices with 10/100 MBit/s autonegotiation are operated with 100 MBit/s 1). |
| Port Design | Shielded RJ45 ports |
| Power Supply | 24 VDC, max. 5.2 W, protection against reverse polarity |
| **General Information** | **0AC808.9** |
| Status Display | Network activity for each channel, Link/Collision for each channel, supply voltage |
| Diagnostics | |
| Bus Function | Yes, with status LED |
| Hub Supply | Yes, with status LED |
| Certification | CE, C-UL-US, GOST-R |
| **Mechanical Characteristics** | **0AC808.9** |
| Dimensions (W x H x D) | 115 x 43 (51 with mounting rail) x 86 mm |
| Protection | IP20 |
| Installation | Mounting rail installation and mounting rail adapter is included in the delivery |
| Mounting Orientation | Vertical or horizontal |
| Operating Temperature | |
| Horizontal installation | 0° C to +60° C |
| Vertical installation | 0° C to +50° C |
| Storage Temperature | -25° C to +70° C |
| Humidity | 5 to 95% (non-condensing) |

1) Note: If both devices are connected with 10 MBit/s and also 100 MBit/s, then there is no communication between these devices. Devices with 10/100 MBit/s autonegotiation are always operated with 100 MBit/s on the hub.

# ETHERNET Powerlink Applications

Real-time Ethernet is not theory anymore. Even true real-time requirements in the µs-range can be met today. For more than two years, more than 40,000 Ethernet Powerlink nodes have been successfully deployed in series machines and embedded systems. Those nodes are running reliably in rough environments, for example injection molding machines or packaging machines all over the world. Typical installations are comprised of 20-50 axes with controllers and a few hundred I/O peripherals running with 200µs to 2ms cycle times. An interesting benchmark application in the packaging industry is built with 50 axes and 2000 I/O points which are synchronised in 2.4ms. At the same time the video stream for a web camera is transmitted via the same real-time network.

Many industrial vendors are working on ETHERNET Powerlink compliant solutions. Ethernet as a well known networking technology with its worldwide acceptance reduces the risk of using this new real-time standard. Cost efficient tools are available and longterm availability of Ethernet is guaranteed. Ethernet is by far the most common networking technology in the world, thus Ethernet Powerlink will displace many proprietary realtime systems which are in use today. ETHERNET Powerlink is managed by the open vendor and end-user association EPSG (Ethernet Powerlink Standardization Group). Leading companies, like ABB, B&R, Tetra Pak, Baldor, Lenze or Hirschmann are working on further development and deployment. Together with the IAONA, the EPSG is submitting this method to the IEC for standardisation.

Further information about ETHERNET Powerlink, the technology, applications and the group can be found at

**www.ethernet-powerlink.org**

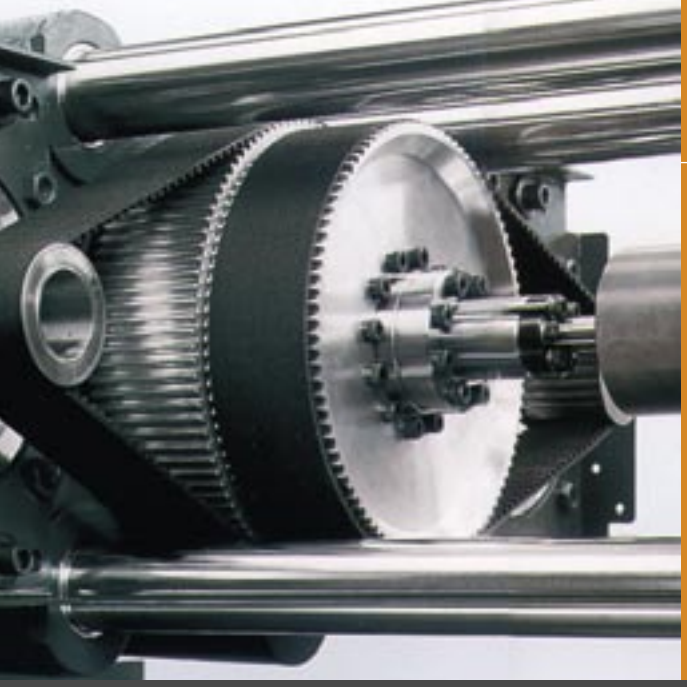
# Packaged with ETHERNET Powerlink



Is Ethernet, the dominant communication protocol for IT systems, also suitable for machine and system manufacturing? This is one of the most heated debates in automation technology today! However, the answer has been available for some time now: ETHERNET Powerlink, already available for a year as an open, manufacturer-independent, high-speed bus, has proven that it can stand up to real-world applications. More than 40.000 Powerlink devices are already in series operation all over the globe. Lemo Maschinenbau GmbH in Niederkassel-Mondorf is one of the more than 100 Powerlink users worldwide.

The world leader for plastic film welding machines has decided to use ETHERNET Powerlink for their newly developed smaller systems. In the Mondorf district of the city of Niederkassel, you can see a perfect example of how this has been working smoothly for some time now. The current world leader for plastic film welding machines has been in business for 50 years now: Lemo Maschinenbau GmbH, a company that belongs to Jagenberg AG, is located on the right bank of the Rhein where they develop and manufacture – in addition to other products – heavy duty, multifunction and specialized systems for plastic bags, pouches and sacks of all types. The machines are manufactured and distributed for all current trends in film technology. The latest Lemo innovation, which has just become ready for series production, is the DKT/CT packaging system with 19 positioning axes for welding plastic carrying bags in various formats. Powerlink controls all axes synchronously using the electronic cam profile function as well as the electronic gear function for two axes.

The cycle time is 800$\mu$s and the jitter is less than 1$\mu$s. This innovation, which was developed as a prototype for a German customer, is now ready for series production and has been marketed worldwide since the beginning of the year. All drives in the system, which allows various timing values, must move precisely in time with each other. This requires the highest degree of synchronism, angular precision and speed rigidity for all servo motors. They are controlled by 19 servo drives from B&R's Acopos product line. Dieter Baudach, assistant manager for development and responsible for electrical construction, described why Lemo has decided to use Powerlink for their brand new system: "We like the exceptionally low jitter and the extremely high data transfer speeds." This makes it possible to guarantee the highest film quality as well as extremely fast data exchange throughout the system. Most important, the synchronization of the axes can take place in true real-time. Dieter Baudach on this topic: "The machine can even be configured while it is running." In other words, a drive can be reconfigured by the operator relative to another drive even when a drive is turning – the electronic gear function is used for this operation. The speed of all servo motors can be controlled synchronously so that production speed can be adjusted. Baudach once again: "When processing plastic film, it is absolutely critical that the material transport takes place simultaneously and consistently for all drives. This is the only way to ensure that the form of film is not affected and that excessive stretching or straining does not occur." It is also important that the operation of the machine is kept "as simple as possible" and that the "possibility of errors is ruled out". This is done using B&R's Provit industrial PC system with a touch screen monitor. For example, as soon as the operator confirms an entry, the drives immediately move to the desired position. In general, a long list of advantages explains why Lemo has decided to use B&R and ETHERNET Powerlink not only for their largest systems, but also for their smaller designs.



# Plastics with Powerlink

Even in the plastics industry, the consistent use of the latest technologies guarantees the competitive edge during both development and production. Therefore, it's no surprise that many leading companies in this sector came into contact with ETHERNET Powerlink very early on. Numerous solutions – from individual machines to systems taking up entire rooms – would not have been possible in their respective performance classes without ETHERNET Powerlink. Both of the following examples demonstrate how ETHERNET Powerlink is able to solve problems which spring up in completely different areas.

At their location in Malterdingen, Germany, about 500 employees of Ferromatik Milacron Maschinenbau GmbH work on the development, production, and marketing of the most modern injection molding machines available. As a subsidiary of the American company Milacron, Ferromatik Milacron offers a wide selection of machines with clamping forces ranging from 300 to 30,000 kN and are pioneers in the area of fully-electric injection molding machines and the market leaders in Europe.

**Previously, all-electric machines were always positioned at the top end. This was also reflected in the price.**

Nearly maintenance-free due to the use of electromechanical drives, the ELEKTRA Evolution series of injection molding machines from Ferromatik Milacron is moving into price and performance categories that used to be reserved for hydraulic injection molding machines. With the ELEKTRA Evolution line, Milacron offers an all-electric machine in the price/performance class of classic hydraulic solutions. Important criteria in this regard include the mold installation area, ejector force, shot weight during injection, and the total system force. Many of these parameters have been difficult to handle using electrical machines from worldwide leading competitors in Japan. This goal was achieved using a suitably designed specification as well as the most modern development and production technology. Machine parts such as the extruder, ejector and injector, place high demands on the drive and control system in the areas of power, speed, and precision. For a precise production cycle, drives must be coupled together. The required precision can only be guaranteed with a high-speed bus system.



**Profibus DP and SERCOS are not alternatives to ETHERNET Powerlink concerning price and other technical aspects.**

"A theoretical transfer rate of 1 MBit/s on our traditional CAN bus and the need of three or four axes to be synchronized to a 2 ms cycle quickly brought us to very unpleasant downtimes," explains Dr. Kalis, head of development and construction at Ferromatik Milacron. The 100 MBit/s bandwidth, deterministic data transfer so important for drive coupling, and simple cabling were decisive factors. A great deal of injection molding know-how is incorporated in the positioning control loops used for the ELEKTRA Evolution series. The fully-electric solution allows the motor torque generated by the drive to be directly evaluated using ETHERNET Powerlink and taken into consideration when controlling the system. For reasons of quality assurance, it is also necessary to document the production process down to thesensor/actuator layer. In this regard, the universal capabilities of the Powerlink system guarantee maximum flexibility and transparent access to all layers. "With ETHERNET Powerlink, we are already prepared to link everything down to the drive level."

Brückner Maschinenbau GmbH, located in the Bavarian town of Siegsdorf, decided to use ETHERNET Powerlink for a completely different reason. With 450 employees, the company offers film production systems and is the world leader in computer-controlled film stretching lines. With the film stretching line, the raw material coming out of a plastic extruder is stretched in an oven until the desired film dimensions are reached. To achieve better film quality and strength, the Brueckner company developed and patented machines where the film could be stretched in two dimensions simultaneously. The latest generation of these machines, the LISIM® line, are fully-electric and driven by linear motors. The combination of flexible computer-supported control technology and mechanically independent drives allows a new level of freedom to be obtained when manufacturing high-quality films.

Although the motors are located in an environment heated to 250° C, they are only rated for operating temperatures between 150° C and 160° C. This represents a critical challenge for regulating the temperature of the system and its components. Potential thermal motor failures must be detected and handled in time to prevent production of faulty material and minimize machine downtime.

**The long distances on the machine can be easily handled with the Ethernet technology, unlike some other fieldbus systems.**

More than 1,000 temperature measurement points on the motors at approximately 200 EUR per measurement point would have totaled about 200,000 EUR just for temperature measurement. Working together with B&R, the implementation of optimized remote I/O systems and ETHERNET Powerlink networking reduced the cost to 25 EUR per measurement point. That amounts to a cost reduction of more than 87%. The bandwidth of ETHERNET Powerlink also allows large amounts of temperature data to be transferred efficiently to a CP360 CPU from the B&R 2005 controller family. In this way, Powerlink guarantees continual high quality throughout the entire spectrum, from plastic packaging to video tape.


# Powerlink Migration in Fiber Production

The system developed in-house by Lenzing Technik years ago is still able to meet today's demands for both data acquisition and output. However, recent advances in powerful control technology mean new innovations are possible in the areas of visualization, CPU speed, programming methods, and open interfaces. As a rule, every modification and readjustment results in system downtime. However, when using integrated production and system components which are independent of one another, it's important that production is not stopped and that downtimes are minimized. Extensive alterations in cabling and loops tests should be kept to an absolute minimum for revamped project solutions.

The first attempts at integrating the existing I/O layer into a new process control architecture using Profibus gateways were successful, but neither the necessary I/O transport speeds nor the required control cycles could be reached. As it turned out, directly integrating the existing I/O environment in real-time was only able to be achieved with ETHERNET Powerlink and a direct connection to a CP380 CPU module. The contractor for the migration project was Lenzing Technik, who developed a Gateway-CPU with Pentium architecture to route the I/O data and worked together with B&R to create the ETHERNET Powerlink firmware. The software development and the complete integration into the APROL process control system was supported by both the ETHERNET Powerlink PCI and the ETHERNET Powerlink library. The APROL process control system is able to take the I/O signals from Lenzing's system, configure them conveniently with the integrated 3rd-party connection editor, and process them in the system like they were B&R variables. Features which were able to be implemented included bumpless downloads, automatic configuration of the Lenzing CPU, and real-time processing in all layers.

In their conversation with automotion, the men responsible for the project at Lenzing, masters engineer Christoph Ramsauer and graduate engineer Robert Emminger, were more than satisfied with the results they achieved.



**Existing hardware must be used when expanding the system.**

The most important factor taken into consideration when the different process control systems were evaluated was the possibility of migrating external systems. For this reason, APROL was also selected as the system for processing pulp (RGS and viscose). A substantial advantage was the fact that both the peripherals and the entire cabling to the I/O points could be left as they were, and no initiators had to be swapped out. When the existing system expands to the point of I/O resource exhaustion, or when more computer power is needed, updates can be carried out on the new system, even for existing assembly components.

Since both systems – the Lenzing Technik system and the B&R solution – can exist together, the integration and migration criteria were fully met. The only other things necessary for the new system were powerful I/O cards and processors. We know that a "purebred" system would always be faster than a migrated solution. However, it was our goal to use ETHERNET Powerlink to achieve an optimal combination.

**Profitability through maximum protection against breakdowns**

The lifespan of the control systems is generally not planned in advance at Lenzing. Instead, a standard should be gradually implemented which can produce without fear of failure or breakdown. In the medium-term, the entire system should be updated. Of much more importance is the long-term availability of all necessary components. Last but not least, each innovation must also be profitable. However, this isn't just guaranteed by absolute performance. It is also ensured when downtime is kept to an absolute minimum. A stable system allows the controller to be better configured, thus preventing reduced quality caused by disturbances and restart times.

**Error-free parallel operation proves that migration works.**

As a client, it's always important that everything is produced on time. To improve clarity, dates were defined for completing the hardware, completing the drivers, establishing the communication to the lower level, as well as total implementation into the project or test system. This system has only been in service for three months. In that time, the migration has been successful, and ETHERNET Powerlink has worked without any problems since the very first day.

There are currently two systems running: Line 2 – the existing assembly with the "old" system – with a capacity of six tons and Line 1 with the B&R-migrated solution, currently handling 22 tons. Both systems are monitored in a control room by the same personnel. The technical changes necessary to increase the capacity were relatively easy to implement in the new system.

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