

Drives and Motion with PROFINET

In combination with PROFIdrive, PROFINET becomes a drive bus for the most stringent requirements that is also suitable without limitation for all other automation engineering control tasks.

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INDEX

| | |
|---|----|
| 1. Summary | 3 |
| 2. Drive technology | 3 |
| 3. PROFINET | 8 |
| 4. PROFIdrive and Encoder device profile | 10 |
| 5. PROFINET for drive technology | 16 |
| 6. Performance and benefits | 17 |
| 7. Information for device manufacturers | 19 |
| 8. Information for plant and machine owners | 21 |
| 9. Support from PROFIBUS & PROFINET International | 22 |
| 10. Terms | 23 |
| 11. Appendix | 26 |



1. Summary

PROFINET, the "Industrial Ethernet" communication system based on standard Ethernet, combines with the **PROFIdrive** drive profile, which has already been used successfully with PROFIBUS for decades, as well as other technologies such as device and application profiles, to form the basis for an extremely high-performance and future-proof drive technology.

This "**Drive Technology with PROFINET**" has a comprehensive range of applications, scalable performance with cycle times as short as a few μs , and user-friendly, cost-effective implementation. This makes it the ideal solution for all drive tasks.

All of the technologies used originated from, and are supported by, working groups of **PROFIBUS & PROFINET International (PI)**, the world's largest community of manufacturers and users of automation technology.

2. Drive technology

For the past two decades, electric **drive technology** has gone through a significant innovation phase and, as a result, has contributed to various optimizations in the production and process industries, including achievement of ambitious targets for energy saving. The importance of this is underscored by the fact that electric drives for machines, conveyor belts, pumps, compressors, etc., are responsible for up to 70% of total industrial power consumption. The object of this white paper is to present the combining of the **PROFINET** communication technology developed and supported by PROFIBUS & PROFINET International (PI) with the PI **PROFIdrive** device profile (and additionally the **PROFI-safe** and **PROFIenergy** profiles) to form a high-performance, flexible, and scalable drive technology. This will result in the ability to operate PROFINET drives of different manufacturers with or without device profiles with scalable communication (Standard Ethernet, RT, or IRT). With that, the PROFINET universal bus will also prove itself as a high-performance drive bus (Figure 1).

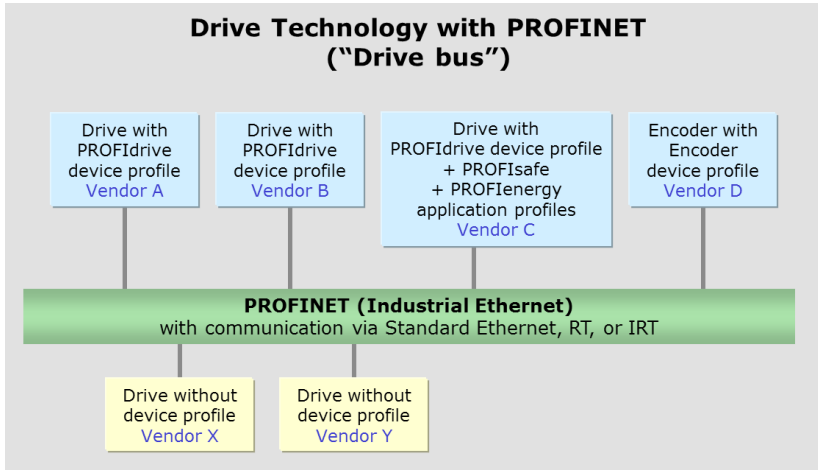


Figure 1: PROFINET used as drive bus

- **PROFINET** is the world’s leading standard Ethernet-based Industrial Ethernet communication network, which has been standardized in IEC 61158 and IEC 61784.
- **PROFIdrive** is the PI drive profile, which has been standardized in IEC 61800-7 and used successfully for 20 years, that forms a uniform, vendor-neutral application interface for drives. With its six application classes, PROFIdrive provides seamless, scalable solutions for all drive technology applications.
- **PROFIenergy** is the PI application profile for energy management applications, whose objective is to minimize energy use.
- **PROFIsafe** is the PI application profile for running safety-related applications and “standard” applications on the same cable.
- **Encoder** is the PI device profile for uniform operation of encoders on PROFIBUS and PROFINET. The Encoder profile is a subset of the PROFIdrive profile for stand-alone encoders.

Two “drives” for drive technology

The rapid development of modern drive technology during the past 25 years is based primarily on two driving forces.

- First, starting in the early 1990s, drive technology took advantage of *advances in industrial communication technologies* in the form of new serial fieldbuses. The ability of variable-speed drives to communicate became

a selling point, and new fieldbus systems such as PROFIBUS DP provided the necessary communication platform. By speeding up processes, the opportunities for production optimization, especially for factory automation applications, made a quantum leap! From the outset, PROFIBUS DP played a leading role in this and, with the addition of application-oriented functions in Version DP V1, laid the foundation for its current position as the global market leader with over 40 million installed nodes. The next big leap in drive technology is currently underway with the use of the Industrial Ethernet-based PROFINET fieldbus technology.

- The second driving force was the reliance of drive technology on *internationally-standardized, vendor-neutral drive interfaces (drive profiles)* for devices. This facilitated implementation of interfaces and enabled joint operation, uniform behavior, and the ability to combine devices from different manufacturers on the bus (see Section 4). The PROFIdrive drive profile was available for this early on. Today, the ability to expand this profile using the PROFIsafe and PROFIenergy profiles will provide a state-of-the-art profile that is tailor-made to the current requirements of users.

Drive technology before the fieldbus era

The earliest interface for drive systems was the discrete analog interface, which used I/O terminals to transfer control commands and status messages and voltage or current signals to deliver setpoints to the frequency converter. With the changeover of closed-loop control and signal processing in converters to digital technology, serial interfaces such as RS422 and RS232 found their way into drive technology in the 1980s. Initially, they were used mainly to connect a PC for parameter assignment or commissioning purposes. A second interface enabled connection to a controller or an overall control system. Finally, a third interface was used to quickly forward analog process variables to the downstream drive. *These three communication paths co-existed side by side for many years.*

Drive technology around and after 2000

- “Drive technology” was generally understood to mean a frequency converter or servo amplifier that controlled a motor according to a preassigned speed setpoint. All components required for this (motor, converter, encoder, and closed-loop controller) were parts of the drive (Figure 2), while only setpoint setting and actual value monitoring were handled by the controller using fieldbus communication. From a technological perspective, therefore, a vertical 1:1 relationship existed between the controller and drive without any possibility, for example, for direct com-

munication between network nodes. Additional functionalities such as safety engineering and standby management had to be implemented using separate additional monitoring and control systems.

- The effect of the new fieldbus communication technology was first seen on the interface to the automation system, where it enabled distributed I/O signals to be read into the control system and output from there using cyclic communication. Many fieldbuses added acyclic communication shortly thereafter, which also replaced the previous interface for parameter assignment and commissioning. Following introduction of direct data exchange in PROFIBUS, it was possible to replace the third interface between the drives, as well, with a single interface on the drive.

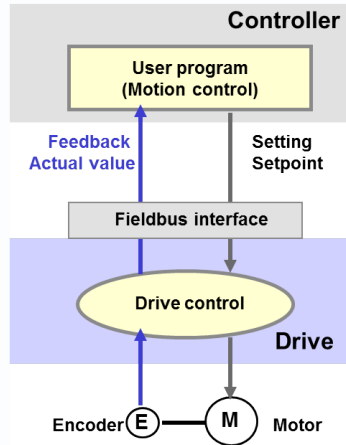


Figure 2: Drive technology (technological perspective) around 2000

- For servo drives in motion control applications, however, the standardized fieldbus systems were generally too slow or lacked real-time capability. In particular, the synchronization between the strictly cyclical motion control application in the control system and the equally cyclical closed-loop position and speed control in the drive required isochronous communication capability, i.e., clock synchronization. Many drive manufacturers developed special communication systems for this, which are still available on the market today.
- The mechanical shafts and cams customarily used up to that point were increasingly replaced by electric drive functions. This was particularly evident in PROFIBUS. In order to operate even greater numbers of drives within an acceptable cycle time in the range of 1-10 ms, the transmission rate was increased from 1.5 to 12 Mbps. At the same time, isochronous communication and clock synchronization were added for motion control applications. This enabled PROFIBUS to replace special-purpose bus systems and to realize all applications of standard drives up to and including machine tools with a single system.

Drive technology in 2012

- A characteristic feature of drive technology in 2012 is the combining of typical drive and technology functions with additional and increasingly important applications such as *safety engineering* and *energy management in the drive* (Figure 3). The drive is thus evolving into a platform for various drive-related automation functions. Accordingly, the former “single” fieldbus interface of the drive is upgraded to a “multifunctional communication node point” between the automation functions distributed among the drive and controller.
- Another advancement is the increasing replacement of conventional fieldbuses with *industry-compatible Ethernet systems*, such as PROFINET, as the automation bus. This has boosted performance in many ways, and not just as a result of the shorter cycle times and simplified networking with higher levels. Details regarding this can be found in Section 6.

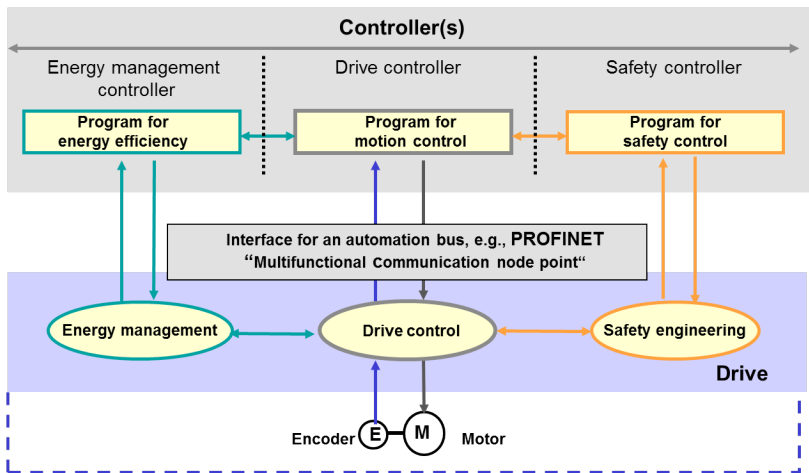


Figure 3: Drive technology (technological perspective) in 2012

- The technological perspective (Figure 3) of the indicated advancements shows – compared to Figure 2 – several vertical and horizontal relationships between one or more controllers with different functions. On the control side, there is not only the drive controller but also controllers for energy management and/or safety. On the drive side, there are energy management and safety engineering functions in addition to the drive functions.

3. PROFINET

Ethernet – in its Industrial Ethernet version – has long been accepted by industry for networking of controllers and visualization stations and for integrating instrumentation and controls into the corporate level.

A different situation exists at the level of the drives and field devices. Here, until recently fieldbus technology – including all its variants, e.g., PROFIBUS DP – was and still is the state of the art. And, special-purpose systems are occasionally still used for sequence and drive controllers. However, a change can be seen here, as well. Industrial Ethernet-based solutions, such as PROFINET, are finding increasing interest and use at the drive level, because of their significantly increased performance and the additional user benefits resulting from their integrated approach and communication infrastructure.

PROFINET at a glance

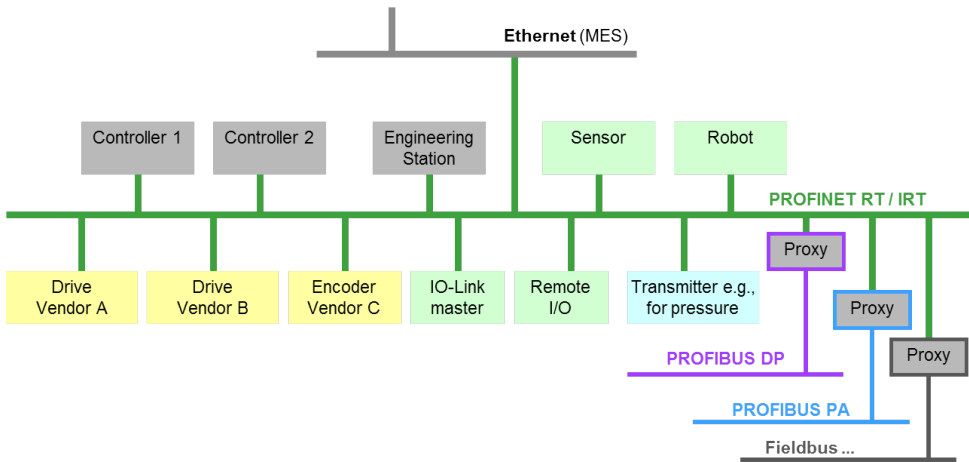


Figure 4: PROFINET - the Industrial Ethernet universal communication network

- PROFINET is the universal Ethernet-based communication network that makes the well-established Ethernet standard from the office world accessible to all areas of automation engineering (Figure 4), while building on the experience gained over decades in the industrial fieldbus environment with PROFIBUS. PROFINET realizes fast vertical and horizontal data

exchange at all levels and is thus the basis for efficient machine and plant concepts, including integration into the corporate level.

- Thanks to its scalable cycle time (Figure 5) and the subdivision of its functions into conformance classes and options (see figure 14 in appendix), PROFINET can be adapted flexibly to the task at hand and is thus both a “generalist for all situations” as well as an “expert in special disciplines” such as drive engineering, safety engineering, and industrial wireless applications.
- PROFINET supports fast communication of I/O process data with a high level of determinism (Real Time RT and Isochronous Real Time IRT) and – independently, simultaneously, and on the same cable - standard TCP/IP communication (Figure 6) and is thus open for utilization of IT services and Web tools in the network and for communication with network components, e.g., for parameter assignment purposes. This saves time, for example, when commissioning large plants, if the drive parameters can be assigned and the drives commissioned even though the controller program is not yet fully ready.
- PROFINET was developed by PROFIBUS & PROFINET International (PI), the world’s largest fieldbus organization, and standardized in IEC 61158. This means openness and a wide product selection for the user, as well as assurance of a future-proof solution as a result of standardization and capacity for innovation.
- PROFINET is aimed at supporting users with the most economical solution possible for their specific tasks. PROFINET achieves this through its outstanding flexibility based on application-oriented solutions and scalable performance, its efficiency resulting from optimal user of existing resources, and its performance due to increased productivity.

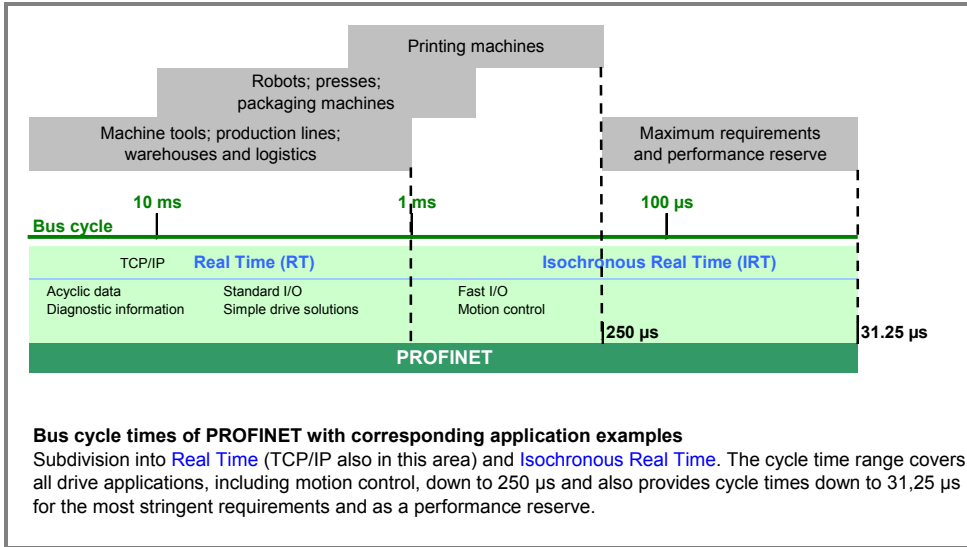


Figure 5: Scalable cycle times (RT and IRT) of PROFINET

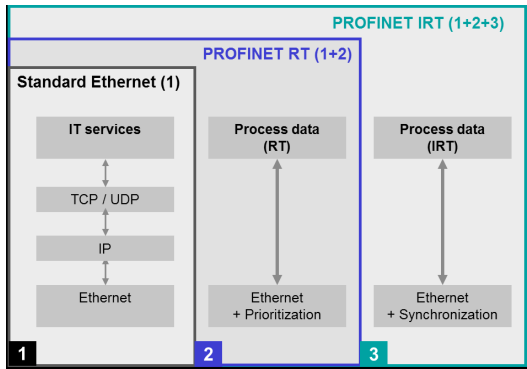


Figure 6: Three communication channels of PROFINET

4. PROFIdrive and Encoder device profiles

Device profiles

“Device profiles” describe device- and application-specific properties that have been jointly specified by a number of manufacturers for uniform implementation in devices of a particular device class, such as drives, pressure transducers, flow transducers. From this it follows that, irrespective of the manufacturer, devices with the same profile will exhibit uniform behavior on a bus system with respect to the specified functions. Today’s “drive profiles” are not just confined to specifications for data exchange but rather also specify the meaning of drive-specific data and parameters across vendors. Users of “profile devices” can then use existing program sections of a PLC without modification and thus reduce their engineering effort significantly. Users also benefit from a larger device selection and the greater ease of device replacement, commissioning, and diagnostics, for example. However, in spite of intensive efforts towards standardization, a number of drive profiles have emerged on the market for the respective communication systems, such as **PROFIdrive** for PROFIBUS and PROFINET, **AC/DC profile** for CIP Motion, and **DSP-402** for CANopen-based networks.

Viewed in a different way, a profile also establishes the cross-vendor digital interface for communication between the automation system and the device level by means of explicit specifications regarding the functionality and parameters of the respective device class. The importance of this interface is constantly increasing in light of the enormous data quantities that are being exchanged as the degree of automation advances.

PROFIdrive – the drive profile of PI

PROFIdrive is the modular device profile for drive devices developed by PROFIBUS & PROFINET International (PI), which has enabled fieldbus-based drive solutions using PROFIBUS DP as the communication system since the 1990s. Since that time, technological advances and increasing user requirements have led to continuous further development of PROFIdrive, while at the same time preserving its basic functionality. This effort has been undertaken by a working group of PI with participants from numerous device manufacturers.

Milestones of PROFIdrive

| | |
|------|--|
| 1991 | Start of profile work as VDE-GMA project |
| 1997 | Profile Version 2.0 |
| 2002 | Profile Version 3.1 with expanded communication technology for use with PROFIBUS DP-V2 |
| 2005 | Use also possible with PROFINET |
| 2005 | Safety amendment to PROFIdrive for the safety controller on the drive using the PROFIsafe profile |
| 2007 | International standardization in IEC 61800-7 |
| 2009 | Option for energy management through joint use with the PROFInergy application profile |
| 2011 | Community Project for joint further development and free of charge use of the PROFIdrive source code |

Six application classes provide complete coverage of automation technology drive tasks

One of the essential requirements when developing PROFIdrive was to ensure that the profile covered all of the extremely diverse applications of drive technology, but without having to bring along unneeded functions as ballast in the case of simple applications. This challenge was met by defining six application classes within the PROFIdrive profile in agreement with leading user organizations, such as OMAC (Organization for Machine Automation and Control). A drive device can span one or more of these classes, depending on the market segment and device implementation. At the same time, the technology functions for all classes, except AK 1, are distributed among the controller and drives.

With this modular structure, PROFIdrive allows flexible and cost-effective configuration of drive devices, which is very beneficial for device manufacturers and users alike. Figure 7 shows an overview of the application classes and their typical application ranges.

This clearly shows the systematic assignment of classes to

- non-isochronous or isochronous operation (second line from the top) as well as to
- converters or drives (third line from the top).

The relative vertical position of the various classes is a qualitative indicator of the proportion of automation functions within the drive. For example, this proportion is highest in AK 3.


| Performance features of PROFIdrive application classes (AK1 - AK6) | | | |
|--|--|--|---|
| | | Non-isochronous operation | Isochronous operation |
| | | Converters <u>without</u> servo motor | Drives <u>with</u> servo motor |
| High  Automation proportion in the drive Low | Same as AK 1, but with distribution of automation among several drives AK 2 | Closed-loop drive control with open-loop single-axis positioning control AK 3 | Same as AK 4/5, except for decentralized automation, e.g., for clocked processes and electronic shaft AK 6 |
| | Standard drive with closed-loop speed control AK 1 | | Servo drive with isochronous closed-loop speed and position control with central motion control AK 4/5 |
| | Applications | Pumps, fans, compressors Conveyor belts, elevators, etc. | Single-axis positioning Simple handling of caps Paper machines |

Figure 7: Performance scope (application classes) of PROFIdrive

Application class 1

For standard drives with closed-loop speed control, e.g., for frequency converters for pumps or compressors.

Application class 2

For standard drives according to AK 1, but with additional technology function, e.g., for closed-loop pressure or flow control, as well as distribution of functions among the controller and multiple drives; used for, e.g., setpoint cascades with continuous webs.

Application class 3

For drives with closed-loop drive and position control as well as an additional open-loop positioning control, e.g., for twisting bottle caps on and off. The drive acts as an autonomous single-axis positioning drive.

Application classes 4/5

For servo drives with central motion control in multiple axes, e.g., for machine tools or robots with a closed-loop speed control in the drive and closed-loop position control in the controller. The position control loop is closed via the bus, requiring clock synchronization of communication.

Application class 6

For servo drives for decentralized automation, e.g., for electronic shafts or clocked machines with synchronized master and slave drives.

Optional additional functions

The application classes are extended by functions, such as

- Support of up to three position encoders whose data are transmitted via standard frames of the controller (application classes 4 and 5)
- "Dynamic Servo Control" closed-loop control concept for optimizing dynamic closed-loop control properties of mechanically-rigid drive systems (application class 4).

Application classes and interface functions

The realization of particular application classes in a drive requires implementation of the corresponding interface functions. The modular structure of these functions is very instrumental for this. Figure 8 shows the relationships.

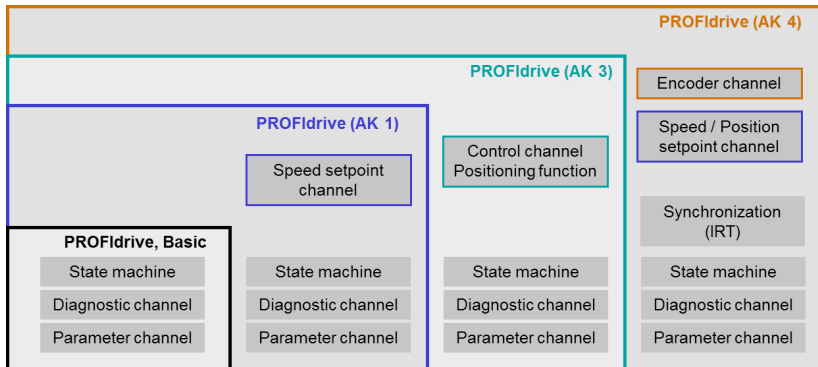


Figure 8: Modular structure of the drive application classes from interface functions

All application classes require the following three basic functions: parameter channel, diagnostic channel, and state machine. AK 4 additionally requires the synchronization basic function. Depending on the application class to be realized, specific functions such as speed setpoint (AK 1) or positioning function (AK 3) are added to the basic functions. The same principle applies to the other application classes as well as to the optional additional functions (not shown in Figure 8).

Encoder device profile

The Encoder device profile defines a uniform interface on PROFIBUS and PROFINET, in which four encoder classes are differentiated depending on the possible uses (Figure 9). Classes 1 and 2 include simpler encoders that do not supply isochronous position or speed signals to the controller. Classes 3 and 4 include high-performance, isochronous encoders that provide a PROFIdrive encoder channel and thus can also be used with standard motion control controllers or fast digital control loops.

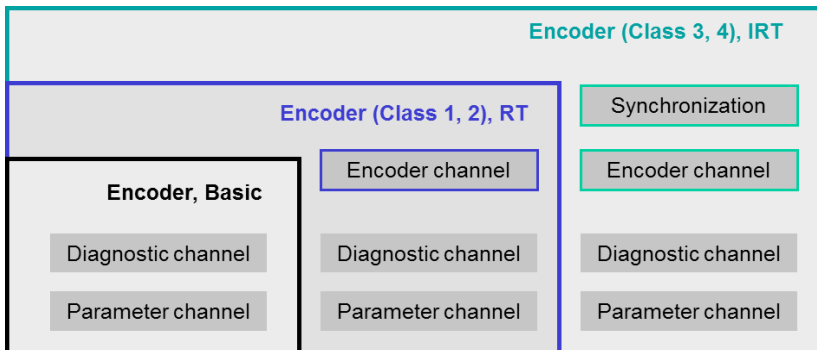


Figure 9: Generic structure of the Encoder profile from interface functions

5. PROFINET for drive technology

The Industrial Ethernet version of Ethernet has long been roundly accepted by industry for networking controllers and visualization stations and for integrating instrumentation and controls into the corporate level.

The optimal solution: PROFINET with PROFIdrive

The above-mentioned development steps guaranteed the PROFIdrive drive profile a leading position among the various drive profiles in the past. With the current step toward Industrial Ethernet, a further performance increase is now available.

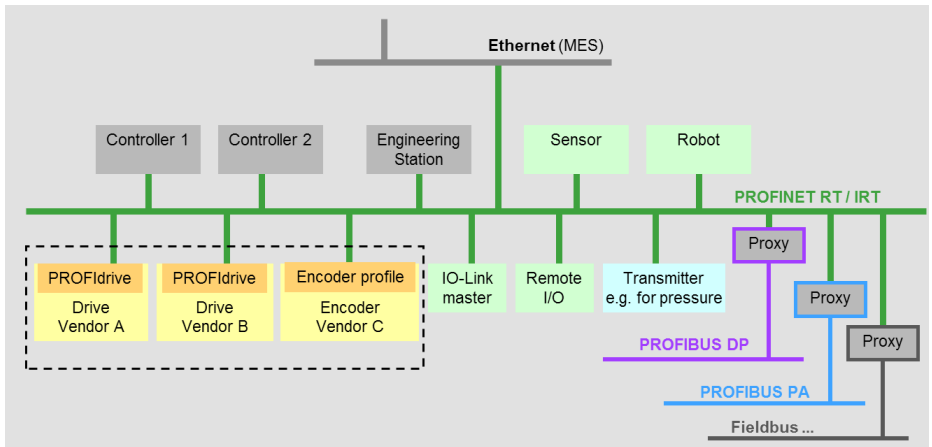


Figure 10: PROFINET as drive bus and universal bus of the automation technology

- In combination with PROFINET, the PROFIdrive drive profile becomes a **high-performance Ethernet-based technology for comprehensive drive solutions** with minimum cycle times, maximum determinism, parallel standard TCP/IP communication, and many other performance characteristics demanded by today's users. For details on this, see Section 6 Performance and benefits.
- Conversely, in combination with PROFIdrive, PROFINET becomes a **drive bus for the most stringent requirements** that is also suitable without limitation for all other automation engineering control tasks (Figure 10), such as communication with directly-connected remote I/O or sensors or via proxy-integrated systems such as PROFIBUS DP or PROFIBUS PA.

6. Performance and benefits

More flexibility

Competitive edge based on pace of innovation: Shorter and shorter innovation and product life cycles are forcing all industry sectors to quickly adapt to machine and plant structures. To increase competitiveness, fast reaction times are essential! Drive Technology with PROFINET provides the flexibility required for this.

- The openness of PROFINET forms the basis for an integrated, uniform automation network in machines and plants with the additional option to connect standard Ethernet devices.
- The topology structures possible with PROFINET (line, star, tree, and ring) offer complete freedom when designing a new plant or when adapting to existing structures. The ease in which network infrastructures can be expanded, including during operation, is very useful when modifying or expanding plants.
- PROFINET is “100 percent Ethernet” and supports TCP/IP and thus the unhindered use of Web technologies.
- With additional use of the PROFIsafe and/or PROFIenergy profiles, safety-related communication paths as well as energy management can be configured.
- In addition to drives with PROFIdrive profile, other drive devices with a PROFINET interface as well as process instrumentation, e.g., for measuring pressure or temperature, can be operated on the same network.

More performance

In drive technology, performance means capabilities such as exact motion control and deterministic device synchronization. These are requirements for maximum product quality and competitiveness. For this, Drive Technology with PROFINET provides performance data with ample reserve for future requirements.

- The scalable cycle times of PROFINET, which are as short as 100 μs , open the way for all drive technology and motion control applications, no matter how demanding. The productivity of machines and plants is thereby increased.
- For highly specific applications and as a reserve for the future, further development has taken place, with the result that Version V2.3 will provide for a cycle time of 31.25 μs with exact deterministic behavior and without any limitation on the openness of the TCP/IP communication.
- Communication via PROFINET is deterministic (use of synchronized clock pulse generators) with a jitter < 1 μs and thus ensures maximum precision of the executed functions and the product quality.

- PROFINET provides for the best-possible plant availability through its media redundancy via integrated interfaces or external switches.
- The number of nodes on a PROFINET network is virtually unlimited.

More efficiency

Economical handling of resources is having a rapidly increasing effect on a company's success – especially in the manufacturing sector. Factors contributing to this that the user can influence include plant availability, effective diagnostics and maintenance concepts, and easy engineering. Drive Technology with PROFINET provides effective support to users for all of these factors.

- PROFINET requires only a single cable for both transmission of machine data and simultaneous IT communication. This reduces material costs and work time for installation and maintenance.
- With PROFINET the plant topology poses no restrictions. Line, ring, and star structures are supported, as are copper or fiber-optic cable solutions. The topology detection provides users a fast, graphical overview.
- PROFINET does not require time-consuming entry of IP addresses. Instead it performs addressing automatically based on the device name or, in the case of a fixed topology, using neighborhood detection.
- High machine availability represents real money, and this requires fast error detection. The powerful device and network diagnostics of PROFINET gives users the tool they need. The use of switches in field devices serves the same purpose as it prevents local disturbances from influencing the overall network and thus assures plant availability.
- When a device is replaced, the new device is automatically assigned the name of its predecessor. The device replacement occurs without the use of an engineering tool.
- Machine and plant optimization measures are increasingly focused on improving energy efficiency. PROFINET has the tool for this with its PROFenergy profile. Individual loads or whole production units can be selectively switched off during idle times and then switched back on again.

7. Information for device manufacturers

Interface implementation

The method used to implement an interface depends largely on the design and performance scope of the device, the expected quantities, and particulars of the business model, such as time to market. That is then the basis for up-front decisions such as

- Development in-house or by a service provider
- Use of ready-made modules or a customized design
- Execution in a fixed design as ASIC or in a reconfigurable design using FPGA technology (FPGA: Field Programmable Gate Array, see below)

This decision and the subsequent implementation is aided by the fact that the relevant technologies for this, i.e., PROFINET, PROFIdrive, PROFIsafe, and PROFIenergy, are all supported by PROFIBUS & PROFINET International. Its member companies offer a comprehensive range of hardware and software components as well as services that device manufacturers can utilize for implementation.

Externally arranged couplers (protocol converters)

The use of a protocol converter external to the device is appropriate when the field device has a serial interface and integration of the PROFINET connection in the device is either undesirable or infeasible. In this case, the converter is connected to the serial interface of the field device and converts its protocol to PROFINET. This solution requires no interventions in the hardware or software of the device. An in-house development is not required.

Ready-to-install communication modules

Ready-to-install communication modules are available for implementing the PROFINET interface internally in the device with minimum in-house work. The entire protocol runs on them independently, unaided by and, thus, without burdening the device processor. This type of module typically comprises all hardware components of the PROFINET interface, including a 2-port switch. The in-house development work is limited to connecting the module to the device electronics.

Use of a single chip interface

For compact field devices for which large quantities are planned, an in-house development using a single chip interface with standard Ethernet controller is appropriate.

Alternative 1: ASICs

- ERTEC is a universal Ethernet controller based on a 32-bit ARM 946 processor with integrated switch in a 2-port (ERTEC 200) or 4-port (ERTEC 400) design.
- TPS 1 is an Ethernet controller designed especially for compact input/output devices and drives. It allows simple and cost-effective integration of a PROFINET interface for all communication channels of PROFINET 2.3 at the cost of a fieldbus interface.

Alternative 2: FPGA technology

FPGAs are reusable, programmable silicon chips that can be configured in such a way that they implement particular hardware functions without contact wafers. FPGAs are reconfigurable and can assume a new “characteristic” by compiling a different circuit function. FPGAs allow the creation of flexible, scalable, and compact solutions.

Optimal support for the implementation is provided by the video Your way to PROFIdrive - Free standard implementation (source code) of PROFIdrive: <http://youtu.be/NBqqsRei5cl>

Community project “Reference implementation of PROFIdrive profile”

Recently, an extremely cost- and time-efficient solution for profile implementation has been made available to device manufacturers in order to promote as widespread use as possible of the PROFIdrive profile in combination with PROFIBUS and PROFINET. In January 2011, the PI PROFIdrive working group and the “IndustrialNETworX Community” jointly established the “Reference Implementation of PROFIdrive Profile” community project with the participation of numerous manufacturers of drive devices and technology components.

www.industrialnetworx.com/profidrive-profile

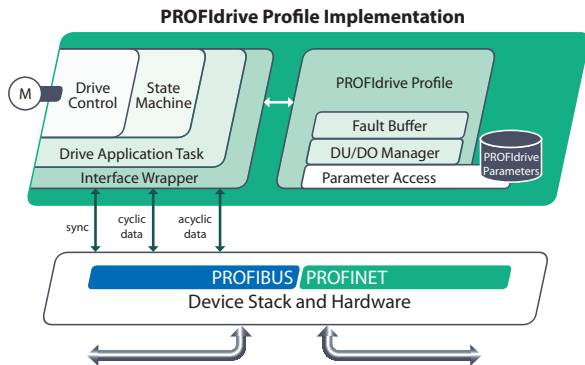


Figure 11: Scope of the standard implementation of PROFIdrive

Project objective

The objective of the community project is to support the development work of drive device manufacturers by making available the source code of a standard implementation of PROFIdrive free of charge and to jointly develop this further into a quasi-standard implementation on the netX technology. In addition, the community is providing support to manufacturers for the source code integration up to and including device certification. The scope of the standard implementation is shown in Figure 10. This will enable device manufacturers to implement PROFIdrive much more quickly and cost-effectively. The participating manufacturers of technology components and development kits are integrating the source code into their products and can thus provide additional support for device manufacturers.

8. Information for plant and machine owners

Changing from PROFIBUS to PROFINET

Starting with Version 4.0 of the PROFIdrive drive profile published in 2005, the profile can be used with PROFIBUS as well as with PROFINET without any reprogramming of the application. This advancement meets the machine building industry's demand for an easy, low-cost way of operating drives on both communication systems without having to change the profile implementation.

This dual use is possible because the architecture of PROFIdrive is strictly separated between the communication-independent functions (primarily the application) and the communication system used. This enables an application to be run with PROFIBUS as well as PROFINET.

Figure 12 shows the correspondences in each case.

| PROFIdrive | PROFIBUS | PROFINET |
|-----------------------|----------------------------|---------------------|
| PROFIdrive Controller | PROFIBUS DP Master Class 1 | PROFINET Controller |
| PROFIdrive P-Device | PROFIBUS DP Slave | PROFINET Device |
| PROFIdrive Supervisor | PROFIBUS DP Master Class 2 | PROFINET Supervisor |

Figure 12: Correspondences of the bus nodes

Figure 12 shows the correspondences in each case.

P-Device and Supervisor are terms for the drive device and engineering station that were introduced in the object model of PROFIdrive.

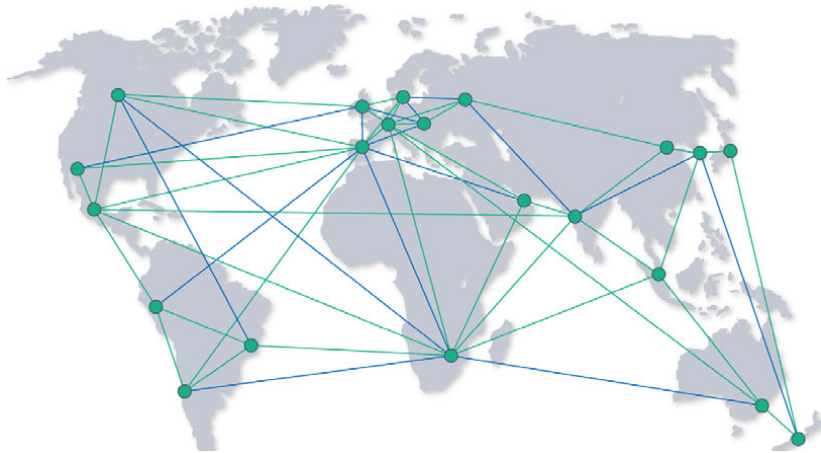
9. Support from PROFIBUS & PROFINET International

Comprehensive, global support

PROFIBUS & PROFINET International is the most influential interest group in the field of industrial communication with an international network of manufacturers and users spanning all industry sectors. At the same time, it has significant regional engagement thanks to its representatives and institutions in numerous countries. This is the ideal basis for providing comprehensive support that is in-depth and regionally accessible.

- 27 regional representatives are expert local contact persons responsible for the regional organization and member support.
- 48 competence centers provide consulting and concrete support for all technical issues.
- 26 training centers are available to share their technical know-how and practical experience with manufacturers and users.
- 11 test labs are experienced partners for easy, cost-effective certification of devices.

All figures refer to 2012; further information is available at <http://www.profibus.com/>



Support generates competitive advantages

As PI members, device manufacturers and users profit from this unique network and the profound experience of over 1400 member companies and their countless "PROFINetworkers". At the same time, they have access to all technical documentation and are given the opportunity to participate in developing future technologies and solutions. This provides an ideal basis for achieving significant competitive advantages.

10. Terms

Ethernet

is a communication technology that specifies the protocols and hardware (cables, distributors, etc.) for wired data networks and that was originally intended for local data networks (LANs). Ethernet enables exchange of data packets between the devices connected in the data network with transmission rates of 10 Mbps, 100 Mbps (Fast Ethernet), 1000 Mbps (Gigabit Ethernet), and 10 Gbps.

The Ethernet specification comprises definitions for cable types and connectors as well as packet formats and other transmission formats. Ethernet conforms to IEEE 802.3 and comprises layer 1 (physical layer) and a portion of layer 2 (data link layer) in the OSI model.

Ethernet often serves as the basis for network protocols like TCP/IP that operate in higher layers.

Industrial Ethernet

is the generic term for all efforts to strengthen the Ethernet standard for use in industrial environments. For example, switches suitable for industrial environments have been created, a mounting rail system has been introduced, the EMC interference immunity and degrees of protection against dust and splashing water have been increased, and special measures have been taken for increased availability. Particularly important is the realization of short, and extremely short, cycle times, simultaneously with a high level of determinism and synchronous behavior, as well as the development of powerful diagnostic mechanisms.

IEEE 802.3

Ethernet was developed in the 1970s at the Palo Alto Research Center of Xerox. In cooperation with DEC and Intel, Ethernet later became an open standard.

Subsequently, a number of standards were developed for Ethernet for which the **Institute of Electrical and Electronics Engineers (IEEE)** and its **Working Group 802.3** (Technology for local area networks) are responsible. Since this working group was set up, the name Ethernet has become the synonym for all specifications proposed and standardized by it. Ethernet is standardized in IEEE 802.3 and builds on IEEE 802.1 (Internet Working) and IEEE 802.2 (Logical Link Control, LLC).

IEEE 802.3 currently comprises a number of different technologies for which individual standards are included.

ISO/OSI model

In 1977, ISO developed a reference model for the vendor-neutral and open architecture description of communication workflows between partners (computer and application) in data networks. This OSI (Open System Interconnection) reference model divides the overall communication functions into 7 logical layers, each of which assumes a portion of these functions. The seven layers are the same for senders and receivers.

Each layer uses its internal processes to generate a layer-specific output, which serves as input for the processes of the next higher layer. This distribution allows the processes of a layer to be modified and optimized without having to adapt the whole system immediately. Only the service functions relative to the adjacent layers (interface specifications) still have to be met.

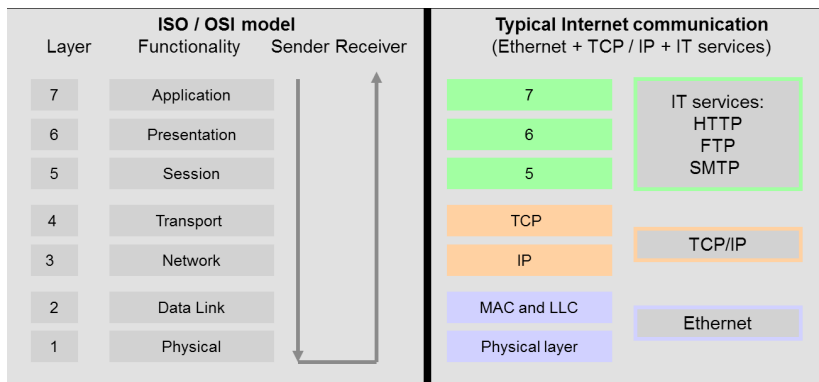


Figure13: ISI/OSI model

Layer 1 (Physical)

Specification of the mechanical, electrical, and optical properties of the transmission media.

Layer 2 (Data Link)

Secures the access to the transmission medium and ensures error-free transmission. For this, the data stream is disassembled into frames and provided with a check number that is used to check for error-free transmission. Layer 2 is further subdivided into MAC (Media Access Control, borders on Layer 1) and LLC (Logic Link Control, borders on Layer 3).

Layer 3 (Network)

Structures the communication connection, including routing between the network nodes. For communication on the Internet, IP (Internet Protocol) is the basic protocol on layer 3. Each computer that wants to participate in the communication requires an IP address.

Layer 4 (Transport)

Transports the data between sender and receiver and provides a uniform access for the user-oriented layers 5-7.

The TCP protocol (Transfer Control Protocol) is on layer 4. It uses the property of IP that allows sending of individual packets between applications. The TCP and IP protocols are often referred to in combination as TCP/IP.

Layer 5 (Session)

Organizes the connection between the connected terminals via control and checking mechanisms. Examples of protocols on this layer are HTTP and SMTP.

Layer 6 (Presentation)

Converts system-dependent characters to an independent format for data exchange between different systems.

Layer 7 (application)

Provides services such as e-mail or Internet communication services.

11. Appendix

Scalable scope of functions of PROFINET (conformance classes and options; see Section 3, page 9)

| | Conformance classes | | | Options (for all CCs) |
|--|---------------------|------|------|--------------------------|
| | CC-A | CC-B | CC-C | |
| Cyclic data exchange, Real-Time (RT) | | | | |
| Acyclic data exchange, Non-Real-Time via standard TCP/UDP | | | | |
| Access to IT services via standard TCP/UDP | | | | |
| Reading out of identification information of devices (I&M function) | | | | |
| Diagnosis of device states (tiered alarm model) | | | | |
| Same device model as for PROFIBUS DP facilitates technology switch | | | | |
| Model for integrating PROFIBUS and other fieldbuses | | | | |
| Diagnostics for monitoring and maintenance of network components | | | | |
| Topology detection for simple device replacement, etc. | | | | |
| Topology display for easy plant documentation | | | | |
| Isochronous real-time communication (IRT) | | | | |
| Further optimized IRT communication for the most stringent requirements | | | | |
| Use of PROFIdrive profile for drive technology and motion control | | | | |
| Use of PROFIsafe profile for safety-related communication | | | | |
| Use of PROFIenergy profile for energy efficiency optimization | | | | |
| Access by multiple controllers to one device input (shared input) | | | | |
| Distribution of device functions to various controllers (shared devices) | | | | |
| Access to devices without plant shutdown (Configuration in Run) | | | | |
| Time stamping for alarms and status messages | | | | |
| Redundancy mechanisms for high plant availability | | | | |
| Extended I&M functions (see item 4) | | | | |
| Industrial Wireless communication via WLAN and Bluetooth | | | | |
| Call-up of a specific engineering tool (of a device) | | | | |

| Application areas of conformance classes of PROFINET | CC-A | CC-B | CC-C |
|--|------|------|------|
| Building automation, process automation | | | |
| Drive technology, machine control | | | |
| Isochronous applications, motion control | | | |

Figure 14: Conformance classes for PROFINET



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