PROFIBUS

Technical Overview

Open Solutions for the World of Automation

Policy

We are and will remain the world's leading organization in the field of digital networking for industrial and process automation, serving our customers, our members and the press with the best solutions, benefits and information.

We are committed to setting and protecting the standards for open communication and control in the automation and process market.

Introduction

From the very outset, the field of automation has been subject to continuous change. Not so many years ago, it was limited to the production area of a company. In this respect, the implementation of fieldbus technology has meant a considerable innovation, enabling the migration from central to decentral automation systems. This has now been the PROFIBUS objective for more than 10 years.

PROFIBUS has since become the world market leader in the area of fieldbus technology. In spite of the outstanding successes of recent years, development work at PROFIBUS continues with undiminished enthusiasm and energy. While in the initial years, the focus was on communication technology, current activities center around aspects of system integration and engineering and, in particular, the subject of application profiles. The latter has made PROFIBUS the only fieldbus that provides comprehensive coverage of both factory and process automation.

Furthermore, information technology (IT) with its principles and standards increasingly determines what's happening in the world of modern automation. Modern fieldbus systems have adopted these principles, thus achieving greater consistency with the office world of corporate management level. In this respect, industrial automation is following the development trends of the office world, where IT has long since left its mark, radically transforming structures, systems and processes. The integration of information technology in the world of automation opens up whole new prospects for global data communication between automation systems. In pursuit of this objective, PROFIBUS is flanked by the Ethernet-based communication standard PROFInet.

The use of standards and open solutions in place of proprietary solutions ensures long-term compatibility and expandability - in other words - protection of existing investment. This is a matter of key importance to the PROFIBUS User Organization. The continuous further development of PROFIBUS technology provides members with a long-term perspective.

Contents

This "Technical Overview of PROFIBUS" takes into account the level of technology at the end of 2001 and its objective is to provide a comprehensive description of the world's leading fieldbus system PROFIBUS, without becoming too engulfed in specific details.

The brochure not only offer sufficient information to those readers interested in an overview, but also introduces experts to more extensive specialized literature. In this context, we would like to point out that - in spite of the care that has been taken in the preparation of this overview - only the PROFIBUS documents available on the Internet are definitive and binding.

Chapters 1 and 2
offer an introduction to the principles of fieldbus technology and their implementation with PROFIBUS.

Chapters 3 to 6
deal with the core aspects of PROFIBUS, whereby any repetition of subject matter dealt with in the brief summary in chapter 2 is intentional for reasons of completeness.

The structure emulates the modular layout of PROFIBUS, from communication technology through application profiles to system profiles.

Chapters 7 to 10
are more practically orientated; they deal with subjects such as device management, implementation and certification and also offer a brief overview of PROFInet.

Chapters 11 and 12
round off the brochures with details of the PROFIBUS User Organization and its range of services and an index.

Contents

1. Communication in automation

The communication capability of devices and subsystems and consistent information routes are indispensible components of future-pointing automation concepts. Communication is increasingly taking place horizontally at field level as well as vertically through several hierarchical levels simultaneously. Graduated and coordinated industrial communication systems, such as PROFIBUS with downward interfacing to AS-Interface and upward interfacing to Ethernet (over PROFInet) (see Figure 1), offer the ideal preconditions for transparent networking in all areas of the production process.

1.1 Industrial communication

At sensor-actuator level

Signals of the binary sensors and actuators are transmitted over a sensor actuator bus. This allows a particularly simple and cost-effective installation technology with which data and the power supply of the terminals can be transmitted over a shared medium. AS-Interface offers a suitable bus system for this field of application.

At field level

Distributed peripherals, such as I/O modules, transducers, drive units, analysis devices, valves or operator terminals, communicate with the automation systems over a powerful, real time communication system. Transmission of the process data is cyclic, while additional interrupts, parameters and diagnostic data are transmitted acyclically as required. PROFIBUS fulfills these criteria and offers a universal and consistent solution for both factory and process automation.

At cell level

programmable controllers, such as PLCs and IPCs communicate with each other and with IT systems of the office world using standards, such as Ethernet, TCP/IP, Intranet and Internet. The information flow requires large data packets and a range of powerful communication functions.

As well as PROFIBUS, the Ethernet-based open and multi-vendor automation concept PROFInet also offers a trendsetting solution for this purpose.

The following offers a detailed description of PROFIBUS as the central link for the information flow in automation. Please refer to the relevant literature for a description of AS-Interface. A brief description of PROFInet is also provided in Chapter 8.

Fieldbuses

are industrial communication systems that can use a range of media, such as copper cable, fibre optic or wireless with bit-serial transmission for coupling widely distributed field devices (sensors, actuators, drives, transducers,...) to a central control or management system. Fieldbus technology was developed in the 80's with the aim of replacing the previously commonly used central parallel wiring and prevailing analog signal transmission (e.g. 4-20 mA- or +/- 10V interface) by digital technology. Due to the different industry-specific demands of users and the preferred proprietary solutions of large manufacturers, several bus systems with varying properties are currently established on the market. The key systems are now included in the recently adopted standards IEC 61158 and IEC 61784. PROFIBUS is an integral part of these standards.

Recently, Ethernet-based communication systems have also been specified for use in industrial automation. They offer wide-ranging options for consistent communications between the levels of industrial automation and the office world. PROFInet is an example of one such Ethernet-based communication system.

A need for the coordinated development and distribution of these fieldbus systems on the market has seen the emergence of a range of *User Organizations* comprising manufacturers, users and institutes, such as the PROFIBUS User Organization (PNO) and its umbrella organization PROFIBUS International (PI) for PROFIBUS and PROFInet technologies.

User benefits

are the motivation for the emergence and continuous further development of fieldbus technology. This ultimately manifests itself as a reduction of the "total cost of ownership", as well as an increase in "performance" and "quality improvement" during the setup and operation of automation plants. The benefits are achieved through configuration, cabling, engineering, documentation, assembly and commissioning, as well as through the plant goods production. A further benefit is achieved through the reduction of the "total cost of life cycle" in the form of easy modification and high availability due to regular diagnostics information, preventive maintenance, simple parameter assignment, consistent data flows and asset management, to cite just a few examples.

Fieldbuses increase the productivity and flexibility of automated processes compared to conventional technology and create the basic prerequisite for the configuration of distributed automation systems.

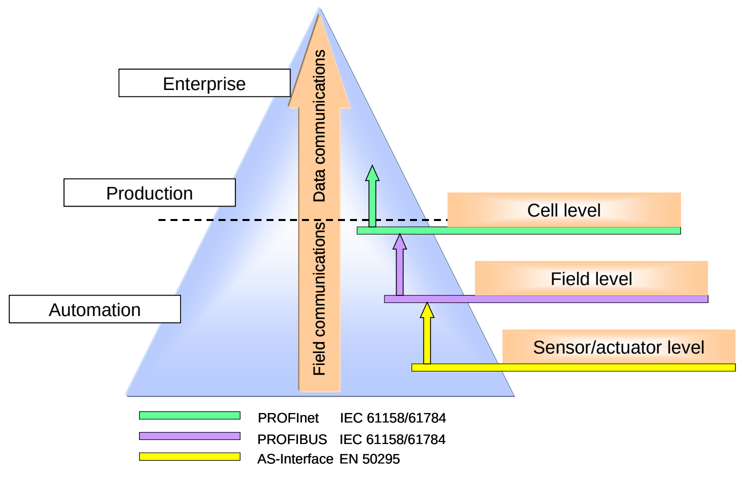

Fig. 1: Communication in automation technology

Sender		Receiver	Designation and function of the layers	
7		7	Application layer	Interface to application program with application-oriented commands (read, write)
6		6	Presentation layer	Representation (coding) of data for analysis and interpretation in the next layer
5		5	Session layer	Establishing and clearing temporary station connections; synchronization of communicating processes
4		4	Transport layer	Controlling data transmission for layer 5 (transport errors, breaking down into packets)
3		3	Network layer	Establishing and clearing connections, avoiding network congestion
2		2	Data-link layer	Description of bus access protocol (Medium Access Control, MAC) including data security
1		1	Physical layer	Definition of the medium (hardware), coding and speed of the data transmission
Transmission medium				

Fig. 2: The OSI reference model

Thanks to its universal characteristic, PROFIBUS can be used in virtually all areas of automation, in factory automation and process automation (chemistry, process engineering) in particular, but also in traffic engineering, power generation and power distribution.

1.2 Terms of fieldbus technology

The ISO/OSI reference model

describes the communication between the stations of a communication system. In order for it to run effectively and unequivocally, defined rules and transfer interfaces need to be used for the communications protocol. In 1983, the International Organization for Standardization (ISO) developed the OSI reference model ("Open Systems Interconnection Reference Model") for just this purpose. This defines all the elements, structures and tasks required for communication and arranges them into seven *layers or levels* according to the chronological communication process with each layer building upon the level beneath (Fig. 2). Each layer has to fulfill specified functions within the communication process. If a communication system does not require specific functions, the corresponding layers have no purpose and are bypassed. PROFIBUS uses the layers 1, 2 and 7.

Communications protocols

define how two or more stations exchange data using message frames. A data frame contains different fields for messages and control information. The actual data field is *preceded* by the header information (source and destination address and details of the subsequent message) and *followed* by the data security part containing check information with regard to the correctness of the transmission (fault recognition).

A feature of fieldbuses is that they enable optimum transmission of small, time-critical data volumes. Thus, they limit the data volume and simplify the transmission process.

Bus access control

(**MAC**, **M**edium **A**ccess **C**ontrol) is a specific procedure that determines at which point in time a station can send data. While *active* stations can start the exchange of information, *passive* stations may only begin communication when prompted by an active station.

A distinction is made between controlled, *deterministic* access procedure with real-time capability (e.g. master-slave with PROFIBUS) and random, *stochastic* access procedure (e.g. CSMA/CD with Ethernet).

Addressing

is necessary in order to be able to selectively address a station. For this purpose, station addresses are assigned either over the address switch ("hard addresses") or during parameter assignment during commissioning ("soft addresses").

Communication services

fulfill communication tasks of the station (e.g. cyclic or acyclic user data communication). The number and type of these services are a criterion for the application area of a communications protocol. A distinction is made between *connection-oriented* services (sender and receiver are directly linked by using their addresses) and *connectionless* services (with no direct link of sender and receiver). The second group includes multicast and broadcast messages that are sent either to a specific group or to all stations.

Profiles

are used in automation technology to define specific properties and behavior for devices, device families or entire systems in such a way that this determines their largely unique characterization. Only devices and systems with the same vendor-independent profile provide "interoperability" on a fieldbus, thus fully exploiting the advantages of fieldbuses for the user.

IEC 61158 document	Contents	OSI layer
IEC 61158-1	Introduction	
IEC 61158-2	Physical layer specification and service definition	1
IEC 61158-3	Data-link service definition	2
IEC 61158-4	Data-link protocol specification	2
IEC 61158-5	Application layer service definition	7
IEC 61158-6	Application layer protocol specification	7

Table 1: Breakdown of IEC 61158

Profile set	Data link	Physical layer	Implementation
Profile 3/1	IEC 61158 subsets; asynchronous transmission	RS485 Plastic fiber Glass fiber PCF fiber	PROFIBUS
Profile 3/2	IEC 61158 subsets; synchronous transmission	MBP	PROFIBUS
Profile 3/3	ISO/IEC8802-3 TCP/UDP/IP/Ethernet	ISO/IEC 8802-3	PROFInet

Table 2: Properties of the Communication Profile Family CPF 3 (PROFIBUS)

Application profiles refer primarily to devices (field devices, controls and tools of integration) and comprise both an agreed selection of bus communication and the specific device application. This type of profile serves manufacturers as a specification for the development of profile-conform and thus interoperable devices. *System profiles* describe classes of systems, which include functionality, program interfaces and integration tods.

1.3 International standardization

The international standardization of a fieldbus system is decisive for its acceptance, establishment and thus its benefits. PROFIBUS achieved national standardization in 1991/1993 in the DIN 19245, Part I-III and Europe-wide standardization in 1996 in the EN 50170.

Together with other fieldbus systems, PROFIBUS has been standardized in the IEC 61158 since 1999. 2002 saw the completion of activities to update the IEC 61158. In the course of these activities, the latest PROFIBUS und PROFInet developments were incorporated in this standard.

IEC 61158
bears the title "Digital data communication for measurement and control – fieldbus for use in industrial control systems“ and is broken down into 6 parts that are designated 61158-1, 61158-2 etc. The contents of Part 1 deal with introductory subjects, while the subsequent parts are orientated towards the OSI reference model (layers 1, 2 and 7); see Table 1.

The various parts of the IEC 61158 define, among other things, the numerous "services and protocols“ for the communication between stations, which is regarded as the total available set, from which a specific selection (subset) is made for specific fieldbus systems.

The fact that a wide range of different fieldbus systems are available on the market is acknowledged in the IEC 61158 by the definition of 10 "fieldbus protocol types“ with the designation Type 1 to Type 10. PROFIBUS is Type 3 and PROFInet Type 10.

The IEC 61158 comments on the fact that bus communication (by definition) is only possible between devices that belong to the same protocol type.

IEC 61784
bears the title "Profile sets for continuous and discrete manufacturing relative to fieldbus use in industrial control systems“. Assignment to IEC 61158 is established through the following introductory comment: "This international standard (i.e. IEC 61784) specifies a set of protocol specific communication profiles based on IEC 61158, to be used in the design of devices involved in communications in factory manufacturing and process control“.

The 61784 depicts which subsets of the total available set specified in the 61158 (and other standards) are used by the "services“ of a specific fieldbus system for communication. The fieldbus-specific "communication profiles“ determined in this manner are summarized in the "**C**ommunication **P**rofile **F**amilies (**CPF**)“ according to their implementation in the individual fieldbus systems.

The profile sets implemented with **PROFIBUS** are summarized under the designation "Family 3“ with subdivisions 3/1, 3/2 und 3/3. Table 2 shows their assignment to PROFIBUS and PROFInet.

2. PROFIBUS at a glance

PROFIBUS is a consistent, open, digital communication system with a wide range of applications, particularly in the fields of factory and process automation. PROFIBUS is suitable for both fast, time-critical applications and complex communication tasks.

PROFIBUS *communication* is anchored in the international standards IEC 61158 and IEC 61784. The *application and engineering aspects* are specified in the generally available guidelines of the PROFIBUS User Organization. This fulfills user demand for manufacturer independence and openness and ensures communication between devices of various manufacturers without the need to adapt the devices.

2.1 History

The history of PROFIBUS goes back to a association venture project supported by the public authorities, which began in 1987 in Germany. Within the framework of this venture, 21 companies and institutes joined forces and drew up a strategic "fieldbus" project. The aim was the realization and establishment of a bit-serial fieldbus, the basic requirement of which was the standardization of the field device interface. For this purpose, the relevant member companies of the ZVEI (Central Association for the Electrical Industry) agreed to support a mutual technical concept for factory and process automation.

A first step saw the specification of the complex communications protocol PROFIBUS FMS (Fieldbus Message Specification), which was tailored to demanding communication tasks. A further step in 1993 saw completion of the specification for the more simply configured and thus considerably faster PROFIBUS DP protocol (decentralized peripherals). This protocol is now available in three functionally graded versions; DP-V0, DP-V1 and DP-V2.

Building on these two communications protocols, and with the development of numerous application-oriented profiles and a fast growing number of available devices, PROFIBUS began its triumphant advance, initially in factory automation and, since 1995, in process automation. Today, PROFIBUS is fieldbus world market leader with more than a 20% share of the market, approx. 400,000 equipped plants and more that 4 million nodes of more than 2000 available PROFIBUS products from a wide range of manufacturers.

2.2 Organization

The success of PROFIBUS stems in equal measures from its progressive technology and the success of its non-commercial PROFIBUS User Organisation e.V. **(PNO)**,the trade body of manufacturers and users founded in 1989. Together with the 22 other regional PROFIBUS associations, since founded in countries all over the world, and the international umbrella organization PROFIBUS International **(PI)** founded in 1995, this organization now boasts more than 1,100 members worldwide. Objectives are the continuous further development of PROFIBUS technology and increased acceptance worldwide.

The development and establishment of technology takes place within the framework of 5 Technical Committees, which are made up of more than 35 working groups with more than 300 experts.

As well as the wide range of measures for the development of technology and its acceptance, PI also undertakes additional tasks for the worldwide support of members (users and manufacturer) with advice, information and measures for quality assurance, such as the standardization of technology in international standards.

PI forms the largest fieldbus user association in the world. This re-

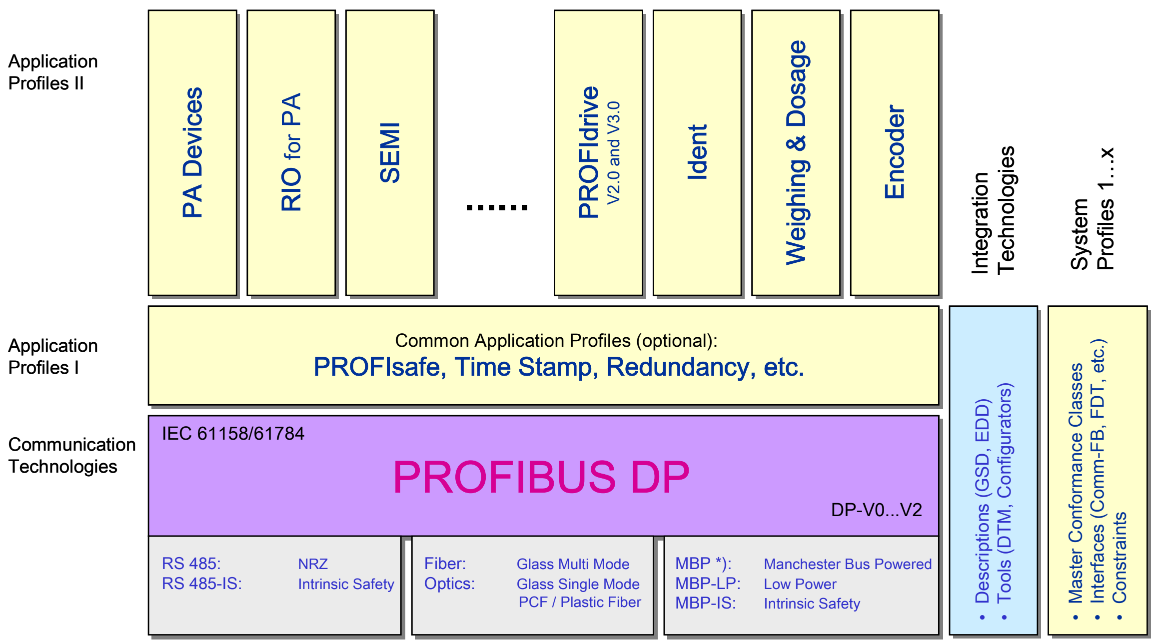

Fig. 3: Technical system structure PROFIBUS

represents future opportunities and responsibility in equal measure, *opportunity* to continue creating and establishing leading technologies that are useful to users and *responsibility* for those at the head of these user associations to be unflagging in their endeavors to target openness and investment protection for PROFIBUS in the future. This obligation serves as the guiding principle for all concerned.

2.3 PROFIBUS as "modular system"

PROFIBUS has a modular design and offers a range of communication technologies, numerous application and system profiles, as well as device management tools. Thus PROFIBUS covers the diverse and application-specific demands from the field of factory and process automation in equal measure. The number of installed PROFIBUS plants are proof of the high acceptance of this fieldbus technology.

From the technological standpoint
the lower level (communications) of the system structure of PROFIBUS (see Fig. 3) is based on the aforementioned ISO/OSI reference model. This intentionally gave a purely abstract description of the communication steps without providing details of content/practical implementation. Fig. 3 contains the implementation of the OSI model (layers 1, 2 and 7) in PROFIBUS with details of how the layers are individually implemented/specified.

Specifications agreed between manufacturers and users on specific device applications are arranged above layer 7 in application profiles I and II.

From the user standpoint
PROFIBUS presents itself in the form of different application-typical versions that are not specifically defined but have proven useful as a result of frequent applications. Each version results from a typical (but not specifically defined) combination of modular elements from the groups "transmission technology", "communications protocol" and "application profiles". The following examples explain this principle using the best known PROFIBUS versions (Fig. 4).

PROFIBUS DP
is the version for factory automation; it uses RS485 transmission technology, one of the DP communications protocol versions and one or more application profile(s) typical of factory automation, such as *Ident Systems or Robots/NC*.

PROFIBUS PA
is the version for process automation, typically with MBP-IS transmission technology, the communications protocol version DP-V1 and the application profile *PA Devices*.

Motion Control with PROFIBUS
is the version for drive technology using RS485 transmission technology, the communications protocol version DP-V2 and the application profile *PROFIdrive*.

PROFIsafe
is the version for safety-relevant applications (used in various industries), using RS485 or MBP-IS transmission technology, one of the available DP versions for communication and the application profile *PROFIsafe*.

Across several layers, the modular system as shown in Fig. 3 has the following:

- Functions and tools for device description and integration (umbrella term: Integration Technologies, see Chapter 7) and
- A range of standards (interfaces, master profiles; umbrella term: system profiles) that primarily serve the realization of uniform, standardized systems, see Chapter 6.

2.3.1 Communication

Communication technology covers *transmission* and *connection technology* (layer 1 or physical layer, i.e. connectors, cables, signal levels,...) and the *communications protocols* with bus access, utilities for data transmission, protective functions, etc., required for the transmission of data.

There is a whole range of connection technologies available for PROFIBUS.

With its versions DP-V0 - DP-V2, PROFIBUS with **DP** now offers a broad spectrum of options at protocol level, which enable optimum communication between different applications. Historically speaking, FMS was the first PROFIBUS communications protocol.

Communications protocols

FMS
(Field Message Specification)
is ideally designed for communication at cell level, in which programmable controllers, such as PLCs and PCs primarily communicate with each other. It can be seen as the forerunner of DP.

DP
(Decentralized Peripherals)
stands for simple, fast, cyclic and deterministic process data exchange between a bus master and the assigned slave devices. This function version, designated DP-V0, has been expanded by a version DP-V1. Comprising acyclic data exchange between master and slave. A further version DP-V2 is also now available, which enables upwardly compatible direct slave-to-slave communication that allows isochronous bus cycle.

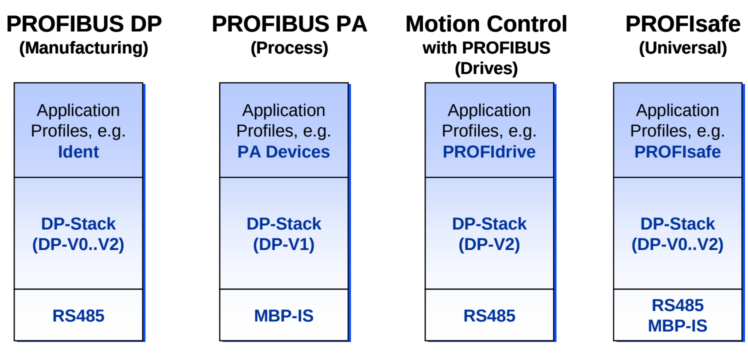

Fig. 4: Typical, application-oriented features of PROFIBUS

Bus access protocol

As *bus access protocol* (layer 2 or data-link layer), PROFIBUS knows the master-slave procedure, supplemented by the token passing procedure for coordination of several masters on the bus. The tasks of layer 2 also include functions, such as data security and the handling of frames.

Application layer

Layer 7 defines the *application layer* and forms the interface to the application program. It offers various cyclic and acyclic utilities for data exchange.

2.3.2 Transmission technologies

RS485 is the most frequently used transmission technology. It uses a shielded twisted pair cable and enables transmission rates of up to 12 Mbit/sec.

The version RS485-IS has also now been newly specified as a 4-wire medium in protection type EEx-i for use in potentially explosive areas. The specified level of voltage and current refer to the safety-relevant maximum values that must not be exceeded in either individual devices or during interconnection in the system. In contrast to the FISCO model (see Chapter 3.1.2), which only has one intrinsically safe source, in this case all stations represent active sources.

The *MBP* transmission technology *(**M**anchester Coded, **B**us **P**owered*, previous designation "IEC 1158-2 - Physics", see Chapter 3.1) is available for applications in process automation with a demand for bus powering and intrinsic safety of devices. Compared to the previously used procedure, the "Fieldbus Intrinsically Safe Concept" (FISCO, see Chapter 3.1.2), which was specially developed for interconnection of intrinsically safe fieldbus devices, considerably simplifies planning and installation.

Fiber-optic transmission is suitable for use in areas with high electromagnetic interference or where greater network distances are required.

2.3.3 Profiles

Profiles are the specifications defined by manufacturers and users regarding specific properties, performance features and behavior of devices and systems. Profile specifications define the parameters and behavior of devices and systems that belong to a profile family due to "profile-conform" development, thus facilitating device interoperability and, as far as possible, device interchangeability on a bus. Profiles take into account application and type-specific special features of field devices, controls and means of integration (engineering). The term profile ranges from just a few specifications for a specific device class through to comprehensive specifications for applications in a specific industry. The generic term for all profiles is *application profiles*.

A distinction is then drawn between ***general application profiles*** with implementation options for different applications (this includes, for example, the profiles PROFIsafe, redundancy and time stamp), ***specific application profiles***, which are developed especially for a specific application, such as PROFIdrive, SEMI or PA Devices, and ***system and master profiles**,* which describe specific system performances that are available to field devices. Thus, these are the opposite of the application profiles.

PROFIBUS offers a wide range of such application profiles, which allow application-oriented implementation.

2.4 PROFIBUS - the keys to success

The success of **PROFIBUS** through to world market leader is determined by many factors:

- PROFIBUS offers the plant manufacturers and operators an industry-wide, universal, consistent and open technology.
- PROFIBUS is a key factor in noticeably reducing costs in the field of machine and plant engineering.
- PROFIBUS has consistently and logically expanded its application area while taking into account the demands of the respective application fields. This ensures optimum support of industry-specific applications.
- PROFIBUS means optimum integration in many automation and engineering systems for users due to its high acceptance and widespread use worldwide.
- PROFIBUS consistently and logically pursues the stabilization and broad acceptance of communication platforms, the further development of application profiles and the connection of industrial automation to the IT world of corporate management level.

3. PROFIBUS communication technology

3.1 Transmission technology

In the ISO/OSI reference model, layer 1 defines the method of "physical" data transmission, i.e. electrical or mechanical. This includes the type of encoding and the transmission standard used (e.g. RS485). Layer 1 is called the physical layer.

PROFIBUS provides different versions of layer 1 as transmission technology (see Table 4). All versions are based on international standards and are assigned to PROFIBUS in both IEC 61158 und IEC 61784.

Transmission Rate [KBit/s]	Range per segment [m]
9.6	1200
19.2	1200
45.45	1200
93.75	1200
187.5	1000
500	400
1500	200
3000, 6000, 12000	100

The values refer to cable type A with the following properties:

Impedance	135...165 Ω
Capacity	< 30 pf/m
Loop resistance	110 Ω/km
Wire diameter	0.64 mm
Core cross-section	> 0.34 mm²

Table 3: Transmission rate and range for cable type A

3.1.1 RS485 transmission technology

RS485 transmission technology is simple and cost-effective and primarily used for tasks that require high transmission rates. Shielded, twisted pair copper cable with one conductor pair is used.

The RS485 transmission technology is easy to use. No expert knowledge is required for installation of the cable. The bus structure allows addition or removal of stations or the step-by-step commissioning of the system without influencing other stations. Subsequent expansions (within defined limits) have no effect on stations already in operation.

Physical layer	Short designation	Note
RS485	RS485 RS485-IS	Correct designation: ANSI TIA/EIA RS-485-A; optional IS
FO (Fiber Optics)	Glass, multi mode	
	Glass, single mode	
	PCF fiber	
	Plastic fiber	
MBP (Manchester and Bus Powered)	MBP MBP-IS MBP-LP	Previously: "IEC 1158-2-Physics" IS: Intrinsic Safety LP: Lower Power

Table 4: Transmission technology (physical layer) for PROFIBUS

One new option is the ability of the RS485 to also operate in intrinsically safe areas (RS485-IS, see explanation at the end of this section).

Characteristics of RS485

Various *transmission rates* can be *selected* between 9.6 Kbit/s and 12 Mbit/s. One uniform speed is selected for all devices on the bus when commissioning the system. Up to *32 stations* can be connected, the maximum permissible *line length* depends on the transmission rate. These and other properties are summarized in Table 5.

Installation instructions for RS485

Network topology

All devices are connected in a bus structure (line). Up to 32 stations (masters or slaves) can be connected in a single segment. The beginning and end of each segment is fitted with an active *bus terminator* (Fig. 5). Both bus terminators have a permanent power supply to ensure error-free operation. The bus terminator is usually switched in the devices or in the bus terminator connectors.

If more than 32 stations are implemented or there is a need to expand the network area, *repeaters* must be used to link the individual bus segments.

Cable, connection technology

Different cable types (type designation A - D) for different applications are available on the market for connecting devices either to each other or to network elements (e.g. segment couplers, links and repeaters). When using RS485 transmission technology, we recommend the use of *cable type A* (see data in Table 3).

"PROFIBUS" cable is offered by a wide range of manufacturers; we particularly recommend the fast-connect system which, when used with a suitable cable and special stripping tool, allows fast, reliable and extremely simple wiring.

When connecting the stations, always ensure that the data lines are not reversed. Always use a shielded data line (type A is shielded) to ensure high interference immunity of the system against electromagnetic emissions. The shield should be grounded on both sides where possible and large-area shield clamps used for grounding to ensure good conductivity.

Network topology	Line, active bus terminator at both ends, spur lines: max. overall line length depends on transmission rate
Medium	Shielded, twisted pair cable
No. of stations	Without repeater : 32 stations per segment With repeater : up to 126 stations
Connector	Preferably 9-pin D-sub connector for IP 20 M12, HAN-BRID or Hybrid connector for IP 65/67

Table 5: Characteristics of RS485 transmission technology

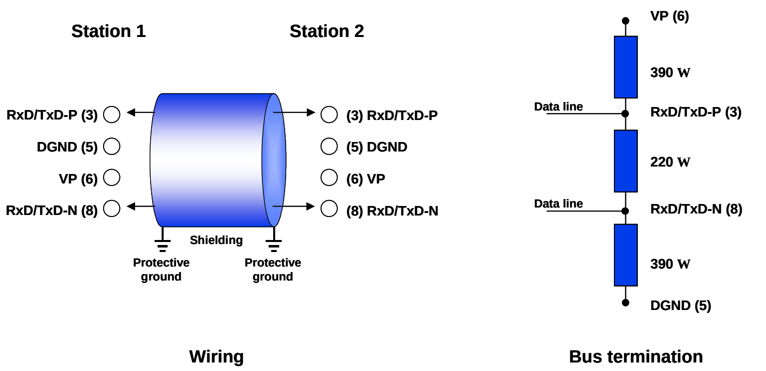

Fig. 5: Wiring and bus termination for RS485 transmission technology

tivity. Furthermore, always ensure that the data line is laid separately and, where possible, away from all power cables. Never use spur lines for transmission rates ≥ 1.5 Mbit/s. Commercially available connectors support direct connection of the incoming and outgoing data cable in the connector. This dispenses with the need for spur lines and the bus connector can be connected and disconnected at the bus at any time without interrupting data communications. The type of *connector* suitable for RS485 transmission technology depends on the degree of protection. A 9-pin D-Sub connector is primarily used for protection rating IP 20. There are three common alternatives for protection rating IP 65/67:

- M12 circular connector in accordance with IEC 947-5-2
- Han-Brid connector in accordance with DESINA recommendation and
- Siemens hybrid connector

The Han-Brid connector system also provides a version for the transmission of data using fibre optics and 24 V working voltage for peripherals over copper cable in a shared hybrid cable.

Problems with transmission technology in PROFIBUS networks can usually be attributed to incorrect wiring and installation. These problems can often be solved using *bus test devices,* which are able to detect many typical wiring errors even before commissioning.

For the *suppliers' addresses* of the many different connectors, cables, repeaters, bus test devices mentioned here, please refer to the PROFIBUS Product Catalog (www.profibus.com).

RS485-IS

There has been great demand among users to support the use of RS485 with its fast transmission rates in intrinsically safe areas.

The PNO has addressed this task and worked out a guideline for the configuration of intrinsically safe RS485 solutions with simple device interchangeability.

The specification of the interface stipulates the level for current and voltage that must be adhered to by all stations in order to ensure safe functioning during interconnection. An electric circuit permits maximum currents at a specified voltage. When interconnecting active sources, the sum of the currents of all stations must not exceed the maximum permissible current.

An innovation of the RS485-IS concept is that, in contrast to the FISCO model, which only has *one* intrinsically safe source, *all* stations now represent active sources. The continuing investigations of the testing agency lead us to expect that, as with the standard version, it will be possible to connect up to 32 stations to the intrinsically safe bus circuit.

3.1.2 Transmission in accordance with MBP

The term MBP

MBP stands for transmission technology with the following attributes

- "**M**anchester Coding (M)", and
- "**B**us **P**owering", (BP).

This term replaces the previously common terms for intrinsically safe transmission "Physics in accordance with IEC 61158-2", "1158-2" etc. The reason for this change is the fact that, in its definitive version, the IEC 61158-2 (physical layer) describes several different connection technologies, i.e. including MBP technology, so that the previous designation is not unambiguous.

MBP is *synchronous transmission with a defined transmission rate of 31.25 Kbit/s and Manchester coding*. This transmission technology is frequently used in process automation as it satisfies the key demands of the chemical and petrochemical industries for *intrinsic safety* and *bus powering using two-wire technology*. The characteristics of this transmission technology are summarized in Table 6. This means that PROFIBUS can also be used in potentially explosive areas with the attribute intrinsically safe.

Installation instructions for MBP

Connection technology

The intrinsically safe transmission technology MBP is usually limited to a specific segment (field devices in hazardous areas) of a plant, which are then linked to the RS485 segment (control system and engineering devices in the control room) over *segment coupler* or *links*.

Segment couplers are signal converters that modulate the RS485 signals to the MBP signal level. These are transparent from the bus protocol standpoint.

In contrast, ***links*** have their own intrinsic intelligence. They map all the field devices connected to the MBP segment as a single slave in the RS485 segment. There is no limit to the transmission rate in the RS485 segment when using links, so that fast networks can also be implemented using field devices with MBP connection, e.g. for control tasks.

Network topologies with MBP

Tree or line structures (and any combination of the two) are network topologies supported by PROFIBUS with MBP transmission.

In a *line structure,* stations are connected to the trunk cable using tee adapters. The *tree topology* is comparable to the classic field installation method. The multi-core master cable is replaced by the two-wire bus master cable, the field distributor retains its function of connecting the field devices and detecting the bus terminator impedance. When using a tree topology, all field devices connected to the fieldbus segment are wired in parallel in the field distributor. In all cases, the maximum permissible spur line lengths must be taken into account when calculating the overall line length. In intrinsically safe applications, a spur line has a max. permissible length of 30 m.

Transmission medium

A shielded two-wire cable is used as transmission medium, see Fig. 5. The bus trunk cable has a passive line terminator at each end, which comprises an RC element connected in series with R = 100 Ω and C = 2 µF. The bus terminator is already integrated in the segment coupler or link. When using MBP technology, incorrect connection of a field device (i.e. polarity reversal) has no effect on the functionality of the bus as these devices are usually fitted with an automatic polarity detection function.

No. of stations, line length

The number of stations that can be connected to a segment is limited to 32. However, this number may be further determined by the protection type selected and bus powering (if any).

In intrinsically safe networks, both the maximum feed voltage and the maximum feed current are defined within strict limits. But the output of the supply unit is limited even for nonintrinsically safe networks.

As a rule of thumb for determining the max. line length, it suffices to calculate the power requirements of the connected field devices, and to specify a supply unit and the line length for the selected cable type. The required current (=Σ power requirements) is derived from the sum of the basic currents of the field devices connected in the respective segment plus, where applicable, a reserve of 9 mA per segment for the operating current of the FDE (Fault Disconnection Electronics). The FDE prevents faulty devices permanently blocking the bus.

Data transmission	Digital, bit-synchronous, Manchester coding
Transmission rate	31.25 Kbit/s, voltage mode, DC voltage-free
Data security	Preamble, error-protected start/end delimiter, CRC (Cyclic Redundancy Check)
Cable	Shielded twisted pair wire
Remote feeding	Optionally available over signal wire
Protection type	Intrinsic safety (EEx ia/ib) and casing (EEx d/m/p/q)
Topology	Line and tree topology; also in combination
No. of stations	Up to 32 stations per segment; total sum of max. 126
No. of repeaters	Expandable with maximum 4 repeaters

Table 6: Characteristics of MBP transmission technology

Joint operation of bus-powered and externally fed devices is permissible. Please note that externally fed devices also consume a basic current over the bus terminator, which must be taken into account accordingly when calculating the max. available feed current.

The FISCO model considerably simplifies the planning, installation and expansion of PROFIBUS networks in potentially explosive areas.

3.1.3 Fiber optic transmission technology

Some fieldbus application conditions place restrictions on wire-bound transmission technology, such as those in environments with very high electromagnetic interference or when particularly large distances need to be covered. Fiber optic transmission over fiber optic conductors is suitable in such cases. The PROFIBUS guideline (2.021) for fiber optic transmission specifies the technology available for this purpose. When determining these specifications, great care was naturally taken to allow problem-free integration of existing PROFIBUS devices in a fibre optic network without the need to change the protocol behavior of PROFIBUS (layer 1). This ensures *downward compatibility with existing PROFIBUS installations.*

The supported *fibre optic types* are shown in Table 7. The transmission characteristics support not only *star and ring topology structures,* but also *line structures*.

In the simplest case, a fiber optic network is implemented using electrical/optical transformers that are connected to the device and the fiber optics over a RS485 interface. This allows you to switch between RS485 and fiber optic transmission within a plant, depending on the circumstances.

Fiber type	Core diameter [µm]	Range
Multimode glass fiber	62.5/125	2-3 km
Singlemode glass fiber	9/125	> 15 km
Plastic fiber	980/1000	< 80 m
HCS® fiber	200/230	approx. 500 m

Table 7: Characteristics of optical fibers

3.1.4 The FISCO model

The FISCO model considerably simplifies the planning, installation and expansion of PROFIBUS networks in potentially explosive areas.

This model was developed in Germany by the **PTB** (**P**hysikalisch **T**echnische **B**undesanstalt - German Federal Technical Institute) and is now internationally recognized as the basic model for the operation of fieldbuses in potentially explosive areas.

The model is based on the specification that a network is intrinsically safe and requires no individual intrinsic safety calculations when the relevant four bus components (field devices, cables, segment couplers and bus terminators) fall within predefined limits with regard to voltage, current, output, inductance and capacity. The corresponding proof can be provided by certification of the components through authorized accreditation agencies, such as PTB and BVS (Germany) or UL and FM (USA).

If FISCO-approved devices are used, not only is it possible to operate more devices on a single line, but the devices can be replaced during runtime by devices of other manufacturers or the line can be expanded - all without the need for time-consuming calculations or system certification. So you can simply plug & play - even in hazardous areas! You merely need to ensure adherence to the aforementioned rules (see "Installation instructions for MBP) when selecting supply unit, line length and bus terminator.

Boundary conditions for the application of FISCO

All stations must be approved in accordance with FISCO

- The cable length must not exceed 1000 m (ia) / 1900 m (ib)
- The cable must satisfy the following values (cable type A):
  R´= 15 ... 150 Ω/km
  L´= 0.4 ... 1mH/km
  C´= 80 ... 200 nF/km
- Whatever combination is used, always ensure that the permissible input variables of the field devices matches the maximum output variables of the relevant supply unit:
  $U_i \geq U_o$
  $I_i \geq I_o$
  $P_i \geq P_o$

User benefits of FISCO

- Plug & Play supported, even in hazardous areas
- No system certification
- Interchangeability of devices or expansion of plant without time-consuming calculations
- Maximization of the number of connected devices

Transmission according to MBP and the FISCO model is based on the following principles:

- No power is fed to the bus when a station is sending.
- Each segment has only *one* source of power, the supply unit.
- Each field device consumes a constant basic current of at least 10 mA in steady state.
- The field devices act as a passive current sink.
- Passive line termination is implemented at both ends of the bus trunk line.
- Networks in line, tree and star topology are supported.

With bus powering, the basic current of at least 10 mA per device serves to supply power to the field device. Communication signals are generated by the sending device, which modulates ± 9 mA to the basic current.

Fig. 6: PROFIBUS configuration with active masters and slaves

3.2 Communications protocols

PROFIBUS offers two communications protocols:

PROFIBUS DP
(**D**ecentralized **P**eripherals) with versions DP-V0, DP-V1 and DP-V2 as a fast protocol for communication between programmable controllers and field devices and

PROFIBUS FMS
(**F**ieldbus **M**essage **S**pecification) with particularly powerful functions, preferably for peer-to-peer communication (PLC - PLC).

3.2.1 PROFIBUS DP

The communications protocol DP has been designed for *fast data exchange at field level*. This is where central programmable controllers, such as PLCs, PCs or process control systems, communicate with distributed field devices, such as I/O, drives, valves, transducers or analysis devices, over a fast serial connection. Data exchange with the distributed devices is primarily cyclic. The communication functions required for this are specified through the DP basic functions (version DP-V0). Geared towards the special demands of the various areas of application, these basic DP functions have been expanded step-by-step with special functions, so that DP is now available in three versions; DP-V0, DP-V1 and DP-V2, whereby each version has its own special key features (see Fig. 7). This breakdown into versions largely reflects the chronological sequence of specification work as a result of the ever-increasing demands of applications. Versions V0 and V1 contain both "characteristics" (*binding* for implementation) and options, while version V2 only specifies options.

The key contents of the three versions are as follows:

Version *DP-V0*
provides the basic functionality of DP, including cyclic data exchange, station, module and channel-specific diagnostics and four different interrupt types for diagnostics and process interrupts, and for the pulling and plugging of stations.

Version *DP-V1*
contains enhancements geared towards process automation, in particular acyclic data communication for parameter assignment, operation, visualization and interrupt control of intelligent field devices, parallel to cyclic user data communication. This permits online access to stations using engineering tools. In addition, DP-V1 has three additional interrupt types: status interrupt, update interrupt and a manufacturer-specific interrupt.

Version *DP-V2*
contains further enhancements and is geared primarily towards the demands of drive technology. Due to additional functionalities, such as isochronous slave mode and lateral slave communication (DXB) etc., the DP-V2 can also be implemented as a drive bus for controlling fast movement sequences in drive axes.

The various versions of DP are specified in detail in the IEC 61158. The following explains the key characteristics.

3.2.1.1 Basic functions DP-V0

The central control (master)

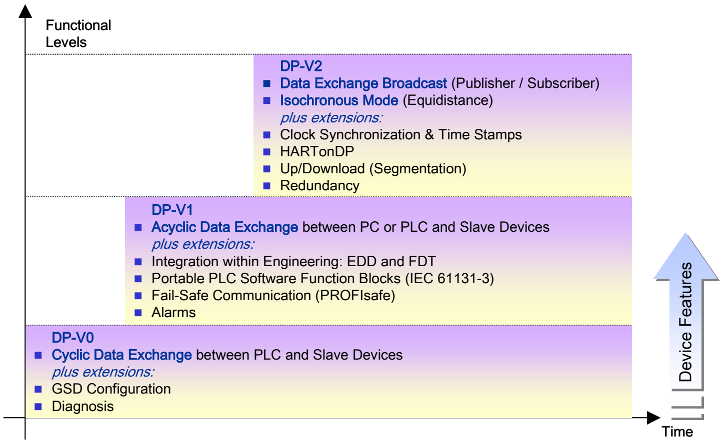

Fig. 7: Functionality of the PROFIBUS DP version with key features

- reads input information from the slaves cyclically and
- writes output information to the slaves cyclically.

The bus cycle time should be shorter than the program cycle time of the central automation system, which is approx. 10 ms for many applications. However, a faster data throughput alone is not enough for successful implementation of a bus system. Simple handling, good diagnostic capabilities and interference-proof transmission technology are also key factors. DP provides an optimum combination of these characteristics.

Speed
DP only requires approx. 1 ms at 12 mbit/s for the transmission of 512 bits of input and 512 bits of output data distributed over 32 stations.
Fig. 8 shows typical DP transmission times, depending on the number of stations and the transmission rate. When using DP, input and output data are transmitted in a *single* message cycle. With DP, user data is transmitted using the **SRD Services** (**S**end and **R**eceive **D**ata **S**ervice) of layer 2.

Diagnostic functions
The comprehensive diagnostic functions of DP enable the fast location of faults. The diagnostic messages are transmitted over the bus and collected at the master. These messages are divided into three levels:

Device-specific diagnostics
Messages on the general readiness for service of a station, such as "Overheating", "Undervoltage" or "Interface unclear".

Module-related diagnostics
These messages indicate whether a diagnosis is pending within a specific I/O subdomain of a station (e.g. 8-bit output module).

Channel-related diagnostics
These messages indicate the cause of a fault related to an individual input/output bit (channel), such as "Short-circuit at output".

System configuration and device types

DP supports implementation of both mono-master and multi-master systems. This affords a high degree of flexibility during system configuration. A maximum of 126 devices (masters or slaves) can be connected to a bus. The specifications for system configuration define the following:

- no. of stations
- assignment of station addresses to the I/O addresses,
- data integrity of I/O data,
- the format of diagnostic messages and
- the bus parameters used.

Device types
Each DP system is made up of different device types, whereby a distinction is made between three types of devices:

DP master class 1 (DPM1)
This is a central controller that cyclically exchanges information with the distributed stations (slaves) at a specified message cycle. Typical

DPM1 devices are programmable logic controllers (PLCs) or PCs. A DPM1 has active bus access with which it can read measurement data (inputs) of the field devices and write the setpoint values (outputs) of the actuators at fixed times. This continuously repeating cycle is the basis of the automation function.

DP master class 2 (DPM2)
Devices of this type are engineering, configuration or operating devices. They are implemented during commissioning and for maintenance and diagnostics in order to configure connected devices, evaluate measured values and parameters and request the device status. A DPM2 does not have to be permanently connected to the bus system. The DPM2 also has active bus access .

Slaves
A slave is a peripheral (I/O devices, drives, HMIs, valves, transducers, analysis devices), which reads in process information and/or uses output information to intervene in the process. There are also devices that solely process input information or output information. As far as communication is concerned, slaves are passive devices, they only respond to direct queries. This behavior is simple and cost-effective to implement (in the case of DP-V0 it is already completely included in the hardware).

In the case of **mono-master systems,** only *one* master is active on the bus during operation of the bus system. Figure 9 shows the system configuration of a mono-master system. The PLC is the central control component. The slaves are decentrally coupled to the PLC over the transmission medium. This system configuration enables the shortest bus cycle times.

In **multi-master operation** several masters are connected to one bus. They represent either independent subsystems, comprising one DPM1 and its assigned slaves, or additional configuration and diagnostic devices. The input and output images of the slaves can be read by all DP masters, while only one DP master (the DPM1 assigned during configuration) can write-access the outputs.

Bus access	• Token passing procedure between masters and master-slave procedure between masters and slaves • Mono-master or multi-master system option • Master and slave devices, max. 126 stations on one bus
Communication	• Peer-to-peer (user data communication) or multicast (control commands) • Cyclic master-slave user data communication
Operating states	• Operate Cyclic transmission of input and output data • Clear Inputs are read, outputs remain in fail-safe state • Stop Diagnostics and parameter assignment, no user data transmission
Synchronization	• Control commands enable the synchronization of inputs and outputs • Sync mode Outputs are synchronized • Freeze mode Inputs are synchronized
Functionality	• Cyclic user data transfer between DP master and slave(s) • Dynamic activation/deactivation of individual slaves; checking of slave configuration • Powerful diagnostic functions, 3 levels of diagnostic messages • Synchronization of inputs and/or outputs • Optional address assignment for slaves over the bus • Maximum 244 bytes of input/output data per slave
Protective functions	• Message transmission at hamming distance HD=4 • Watchdog control of DP slaves detects failure of assigned master • Access protection for inputs and outputs of slaves • Monitoring of user data communication with adjustable monitoring timer in master
Device types	• DP master class 1 (DPM1) e.g. central programmable controllers, such as PLCs, PCs. • DP master class 2 (DPM2) e.g. engineering or diagnostic tools • DP slave e.g. devices with binary or analog inputs/outputs, drives, valves

Table 8: Overview of DP-V0

System behavior

In order to ensure a high degree of device interchangeability among devices of the same type, the *system behavior* of the DP has also been standardized. This behavior is determined primarily by the operating state of the DPM1.

This can be controlled either locally or over the bus from the configuration device. There are three main states:

Stop
No data communication between the DPM1 and the slaves.

Clear
The DPM1 reads the input information of the slaves and keeps the outputs of the slaves in a fail-safe state ("0" output).

Operate
The DPM1 is in the data transfer phase. In cyclic data communication, inputs are read from the slaves and output information written to the slaves.

The DPM1 cyclically sends its status to all its assigned slaves at configurable intervals using a multicast command.

The reaction of the system to a fault during the data transfer phase of the DPM1, e.g. the failure of a slave, is determined by the "**auto clear**" configuration parameter.

If this parameter is set to *True,* the DPM1 switches the outputs of all assigned slaves to a fail-safe state the moment a slave is no longer ready for user data transmission. The DPM1 subsequently switches to the clear state.

If this parameter is set to *False,* the DPM1 remains in the operate state even in the event of a fault and the user can control the reaction of the system.

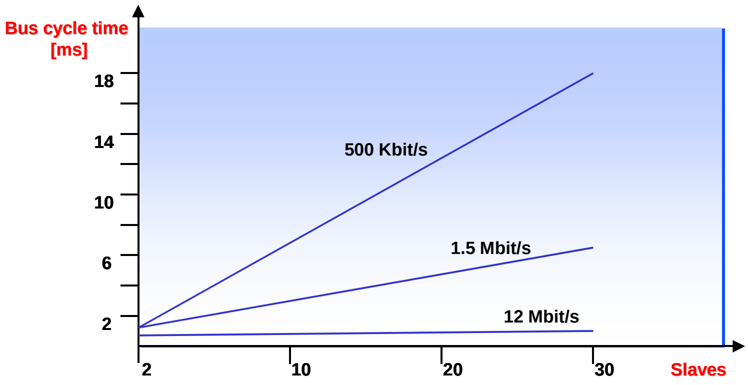

Fig. 8: Bus cycle times of a DP mono-master systems. Boundary conditions: each slave has 2 bytes of input and output data

Cyclic data communication between the DPM1 and the slaves

Data communication between the DPM1 and its assigned slaves is automatically handled by the DPM1 in a defined, recurring sequence (see Fig. 11). The user defines the assignment of the slave(s) to the DPM1 when configuring the bus system. The user also defines which slaves are to be included/excluded in the cyclic user data communication.

Data communication between the DPM1 and the slaves is divided into three phases: parameterization, configuration and data transfer. Before the master includes a DP slave in the data transfer phase, a check is run during the parameterization and configuration phase to ensure that the configured setpoint configuration matches the actual device configuration. During this check, the device type, format and length information and the number of inputs and outputs must also correspond. This provides the user with reliable protection against parameterization errors. In addition to user data transfer, which is automatically executed by the DPM1, the user can also request that new parameterization data are sent to the slaves.

Sync and freeze mode

In addition to the station-related user data communication, which is automatically handled by the DPM1, the master can also send control commands to all slaves or a group of slaves simultaneously. These control commands are transmitted as multicast commands and enable sync and freeze modes for *event-controlled synchronization* of the slaves.

The slaves begin **sync mode** when they receive a sync command from the assigned master. The outputs of all addressed slaves are then frozen in their current state. During subsequent user data transmission, the output data are stored at the slave while the output states remain unchanged. The stored output data are not sent to the outputs until the next sync command is received. Sync mode is terminated with the "unsync" command.

In the same way, a freeze command causes the addressed slaves to enter **freeze mode**. In this mode, the states of the inputs are frozen at their current value. The input data are not updated again until the master sends the next freeze command. Freeze mode is terminated with the "unfreeze" command.

Protective mechanisms

For safety reasons, it is necessary to ensure that DP has effective protective functions against incorrect parameterization or failure of transmission equipment. For this purpose the DP master and the slaves are fitted with monitoring mechanisms in the form of time monitors. The monitoring interval is defined during configuration.

At the DP master

The DPM1 uses a Data_Control_Timer to monitor the data communication of the slaves. A separate timer is used for each slave. The time monitor is tripped if no correct user data transfer is executed within the monitoring interval. In this case, the user is notified. If the automatic error handling (Auto_Clear = True) is enabled, the DPM1 exits the operate state, switches the outputs of the assigned slaves to the fail-safe state and shifts to the clear mode.

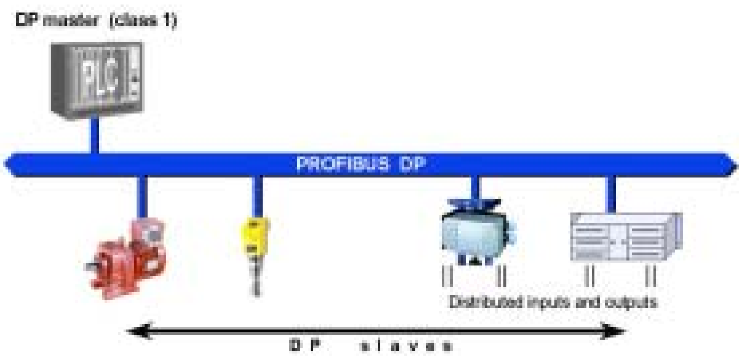

Fig. 9: PROFIBUS DP mono-master system

At the slave

The slave uses the watchdog control to detect errors of the master or transmission. If no data communication with the master occurs within the watchdog control interval, the slave automatically switches its outputs to the fail-safe state.

In addition, access protection is required for the inputs and outputs of the slaves operating in multi-master systems. This ensures that only the authorized master has direct access. For all other masters, the slaves provide an image of their inputs and that can be read without access rights.

3.2.1.2 Version DP-V1

Acyclic data communications

The key feature of version DP-V1 is the extended function for acyclic data communication. This forms the requirement for parameterization and calibration of the field devices over the bus during runtime and for the introduction of confirmed alarm messages. Transmission of acyclic data is executed parallel to cyclic data communication, but with lower priority. Figure 13 shows some sample communication sequences. The master class 1 has the token and is able to send messages to or retrieve them from slave 1, then slave 2, etc. in a fixed sequence until it reaches the last slave of the current list (MS0 channel); it then passes on the token to the master class 2. This master can then use the remaining available time ("gap") of the programmed cycle to set up an acyclic connection to *any* slave (in Figure 13 slave 3) to exchange records (MS2 channel); at the end of the current cycle time it returns the token to the master class 1. The acyclic exchange of records can last for several scan cycles or their "gaps"; at the end, the master class 2 uses the gap to clear the connection. Similarly, as well as the master class 2, the master class 1 can also execute acyclic data exchange with slaves (MS1 channel).

The additionally available services are shown in Table 9.

Extended diagnostics

As a further function, the device-specific diagnostics of the DP-V1 have been enhanced and divided into the categories alarms and status messages (see Fig. 10).

3.2.1.3 Version DP-V2

Slave-to-slave communications

This function enables direct and thus time-saving communication between slaves using broadcast communication without the detour over a master. In this case the slaves act as "publisher", i.e., the slave response does not go through the coordinating master, but directly to other slaves embedded in the sequence, the so-called "subscribers" (see Fig. 13). This enables slaves to directly read data

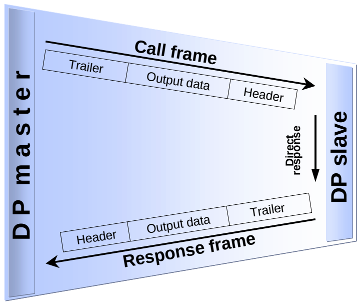

Fig. 11: Cyclic user data transmission in DP

from other slaves and use them as their own input. This opens up the possibility of completely new applications; it also reduces response times on the bus by up to 90 %.

Isochronous mode

This function enables clock synchronous control in masters and slaves, irrespective of the bus load. The function enables highly precise positioning processes with clock deviations of less than a microsecond. All participating device cycles are synchronized to the bus master cycle through a "global control" broadcast message. A special sign of life (consecutive number) allows monitoring of the synchronization. Fig. 14 shows the available times for data exchange (DX, green), access of a master class 2 (yellow) and reserve (white). The red arrow identifies the route from the actual data acquisition (T_I) over control (R_x) through to the setpoint data output (T_O), which usually extends over two bus cycles.

Clock management

This function (a real-time master sends time stamps to all slaves over the new connectionless MS3 services) synchronizes all stations to a system time with a deviation of less than a millisecond. This allows the precise tracking of events. This is particularly useful for the acquisition of timing functions in networks with numerous masters. This facilitates the diagnostics of faults as well as the chronological planning of events.

Upload and download

This function allows the loading of any size of data area in a field device with a single command. This enables, for example, programs to be updated or devices replaced without the need for manual loading processes.

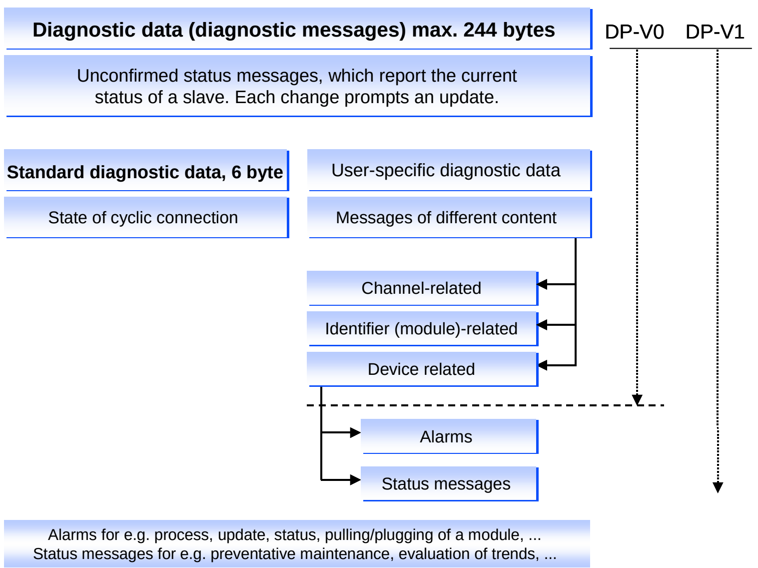

Fig. 10: Configuration of diagnostic messages in DP-V0 and DP-V1

3.2.1.4 Addressing with slot and index

When addressing data, PROFIBUS assumes that the physical structure of the slaves is *modular or* can be structured internally in logical functional units, so-called *modules*. This model is also used in the basic DP functions for cyclic data communication, where each module has a constant number of input/output bytes that are transmitted in a fixed position in the user data telegram. The addressing procedure is based on identifiers, which characterize a module type as input, output or a combination of both. All identifiers combined produce the configuration of a slaves, which is also checked by the DPM1 when the system starts up.

The acyclic services are also based on this model. All data blocks enabled for read/write access are also regarded as assigned to the modules and can be addressed using slot number and index. The **slot number** addresses, the module and the **index** addresses the data blocks assigned to a module. Each data block can be up to 244 bytes (see Fig. 15). In the case of modular devices, the slot number is assigned to the modules. The modules begin at 1 and are numbered in ascending contiguous sequence. The slot number 0 is for the device itself.

Compact devices are regarded as a unit of virtual modules. These can also be addressed with slot number and index.

Through the length specification in the read/write request it is also possible to read/write parts of a data block. When access to the data block was successful, the slave sends a positive read/write response or may otherwise be able to classify the problem by means of its negative response.

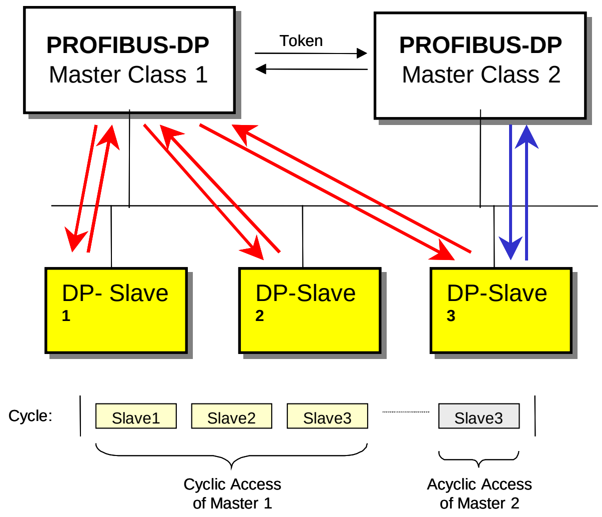

Fig. 13: Cyclic and acyclic communication in DP-V1

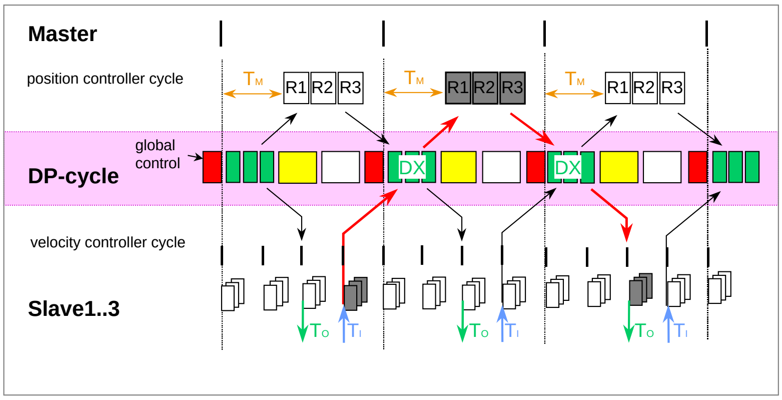

Fig. 14: Isochronous mode

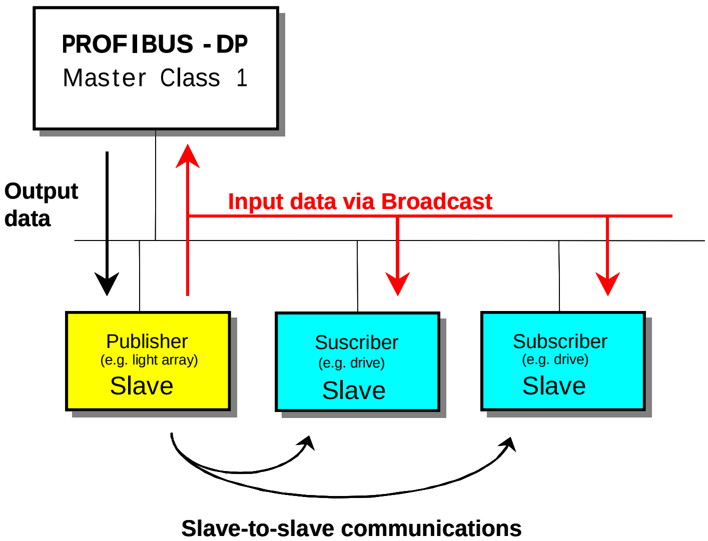

Fig. 12: Slave-slave data exchange

Acyclic services between the DPM1 and slaves	
MSAC1_Read	The master reads a data block from the slave
MSAC1_Write	The master writes a data block to the slave
MSAC1_Alarm	An alarm is transmitted from the slave to the master, which explicitly acknowledges receipt. The slave can only send a new alarm message after it has received this acknowledgment; this prevents any alarms being overwritten.
MSAC1_Alarm_Acknowledge	The master acknowledges receipt of an alarm to the slave
MSAC1_Status	A status message is transmitted from the slave to the master. There is no acknowledgment.
Data transmission is connection-orientated over a MSAC1 connection. This is set up by the DPM1 and is closely linked to the connection for cyclic data communication. It can be used by the master that has parameterized and configured the respective slave.	

Acyclic services between the DPM2 and slaves	
MSAC2_Initiate MSAC2_Abort	Setup and clear down of a connection for acyclic data communication between the DPM2 and the slave
MSAC2_Read	The master reads a data block from the slave
MSAC2_Write	The master writes a data block to the slave
MSAC2_Data_Transport	The master can write application-specific data (specified in profiles) acyclically to the slave and, if required, read data from the slave in the same cycle.
Data transmission is connection-orientated over a MSAC2 connection. This is set up before the start of the acyclic data communication by the DPM2 using the Initiate service. The connection is then available for Read, Write and Data_Transport services. The connection is cleared down correspondingly. A slave can maintain several active MSAC2 connections simultaneously. However, the number of connections is limited by the resources available in the respective slave.	

Table 9: Services for acyclic data communication

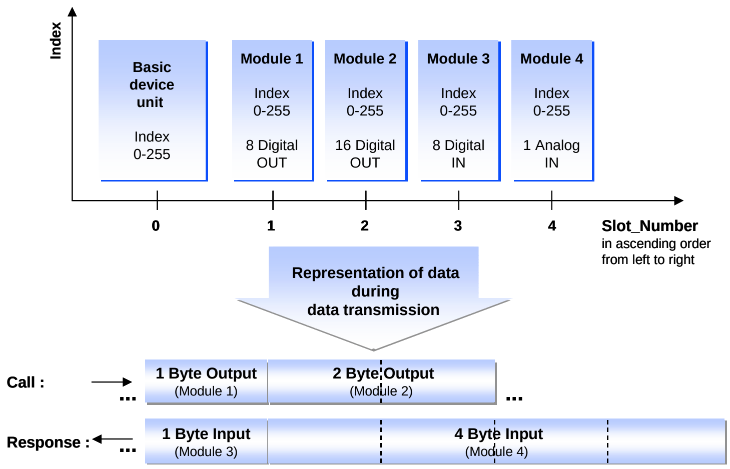

Fig. 15: Addressing with slot and index

4. General application profiles

General application profiles describe the functions and characteristics that relate to the whole range of applications. They can be used in conjunction with *specific* application profiles.

4.1 PROFIsafe

For considerable time, the distributed fieldbus technology for factory and process automation was subject to the restriction that safety tasks could only be solved using conventional technology in a second layer or distributed over special buses. With PROFIsafe, PROFIBUS has now created a comprehensive, open solution for safety-relevant applications that satisfies all known user scenarios.

PROFIsafe defines how fail-safe devices (emergency stop pushbuttons, light arrays, overfill cutouts, etc.) can communicate over PROFIBUS with fail-safe controllers so safely that they can be used for safety-related automation tasks up to KAT4 compliant with EN954, AK6 or **SIL3** (**S**afety **I**ntegrity **L**evel). It implements safe communications over a profile, i.e. over a special format of user data and a special protocol.

The specification has been jointly drawn up by manufacturers, users, standardization committees and inspectorates (TÜV, BIA). It is based on the relevant standards, primarily the IEC 61508, which address the concerns of software development in particular.

PROFIsafe takes into account a number of error possibilities that can occur in serial bus communications, such as the delay, loss or repetition of data, incorrect sequences, addressing or corrupt data.

There are a range of remedial measures, the following of which have been selected for PROFIsafe:

- Consecutive numbering of safety telegrams.
- Timeout for incoming message frames and their acknowledgment.
- Identifier between sender and receiver ("password").
- Additional data security (**C**yclic **R**edundancy **C**heck, **CRC**).

By skillfully combining these remedial measures in connection with a patented "SIL monitor" (monitoring of the frequency of failed messages) PROFIsafe achieves safety classes up to SIL 3 and beyond.

PROFIsafe is a single-channel *software solution*, which is implemented in the devices as an additional layer "above" layer 7 (see Fig. 15); the standard PROFIBUS components, such as lines, ASICs or protocols, remain unchanged. This ensures redundancy mode and retrofit capability.

Devices with the PROFIsafe profile can be operated in coexistence with standard devices without restriction on one and the same bus (cable).

PROFIsafe uses acyclic communication and can be used with RS485, fiber optic or MBP transmission technology. This ensures both fast response times (important for the manufacturing industry) and intrinsically safe operation (important for process automation).

In process technology, it is only necessary to provide and prepare *one* standard device type for fail-safe or normal operation, as the fail-safe functionality can be configured during application (SIL2 for operational reliability).

As a generic software driver, PROFIsafe is available for a wide range of development and runtime environments. The specification can be found in the document "PROFIsafe, Profile for Safety Technology", Order No. 3.092.

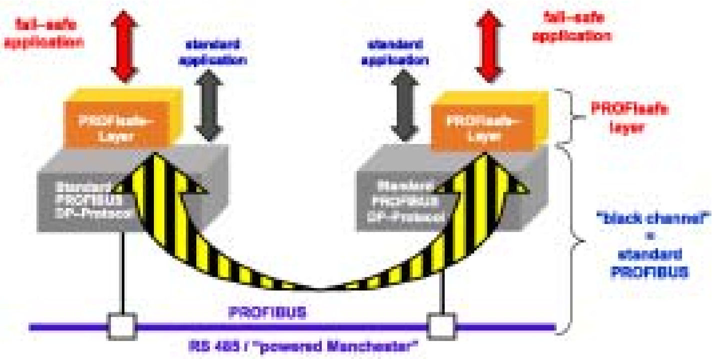

Fig. 15: Fail-safe mode with PROFIsafe

4.2 HART

In view of the large number of HART devices installed in the field, the integration of these devices in existing or new PROFIBUS systems is of key importance to most users.

The PROFIBUS "HART" specification offers an open solution for this problem. It combines the benefits of the PROFIBUS communication mechanisms without any changes required to the PROFIBUS protocol and services, the PROFIBUS **PDUs** (**P**rotocol **D**ata **U**nit**s**) or the state machines and functional characteristics.

This specification defines a profile of PROFIBUS that is implemented in the master and slave above layer 7, thus enabling mapping of the HART client-master-server model on PROFIBUS. The cooperation of the HART Foundation on the specification work ensures complete conformity with the HART specifications.

The HART-client application is integrated in a PROFIBUS master and the HART master in a PROFIBUS slave (see Fig. 16), whereby the latter serves as a multiplexer and handles communication to the HART devices.

For the transmission of HART messages, a communication channel has been defined that operates independently of the MS1 and MS2 connections. An **HMD** (**H**ART **M**aster **D**evice) can support several clients. The number of clients depends on the implementation.

HART devices can be connected with the HMD to PROFIBUS over different components (PROFIBUS Guideline "PROFIBUS Profile for HART“ Order No. 3.102).

4.3 Time stamps

When recording timing functions in networks, particularly those such as diagnostics or fault location, it is useful to be able to provide certain events and actions with a time stamp, which enables precise time assignment.

For this purpose, PROFIBUS offers the *time stamp* profile. Precondition is a time-of-day management in the slaves through a time-of-day master over MS3 services. An event can be given a precise system time stamp and read out accordingly. A concept of graded messages is used. The message types are summarized under the term *"Alerts"* and are divided into high-priority "alarms" (these transmit a diagnostics message) and low-priority "events". In both cases, the master acyclically reads (using the MS1 services) the time-stamped process values and alarm messages from the alarm and event buffer of the field device (see Fig. 17). Please refer to the corresponding document, the PROFIBUS Guideline "Time Stamp", Order No. 2.192.

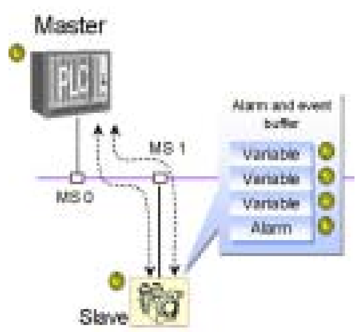

Fig. 17: Time stamp and alarm messages

4.4 Slave redundancy

The installation of field devices with redundant communication behavior is desired in many applications. For this reason, PROFIBUS has drawn up the specification for a *slave-redundancy mechanism* that describes the following device characteristics (see Fig. 18):

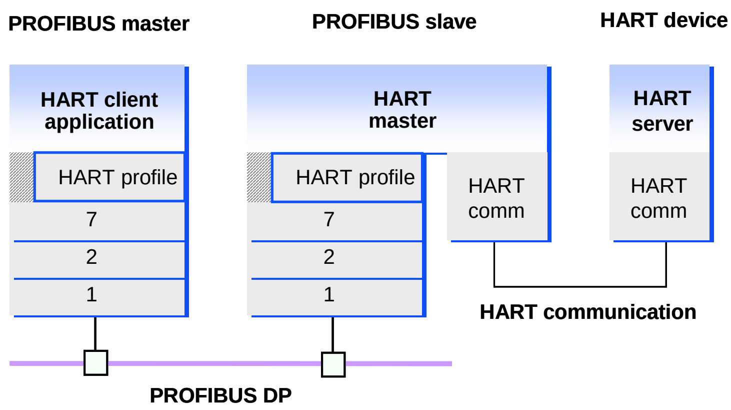

Fig. 16: Operation of HART devices over PROFIBUS

- Slave devices contain two different PROFIBUS interfaces that are called *primary* and *backup* (slave interface). These may be either in a *single* device or distributed over *two* devices.
- The devices are equipped with two independent protocol stacks with a special *redundancy expansion*.
- The **redundancy communication (RedCom)** runs between the protocol stacks, i.e. within a device or between two devices, that is independent of PROFIBUS and whose performance capability is largely determined by the redundancy reversing times.

In normal mode, communications are sent exclusively over the primary slave; only this slave is configured, it also sends the diagnostic data of the backup slave. In the event that the primary slave fails the backup slave takes over its functions, either because it has detected the failure itself or because requested to do so by the master. In addition, the master monitors all slaves and trips a diagnostics message as soon as the backup slave fails and there is no further redundancy.

A redundant slave device can be operated on one PROFIBUS line or, in the event of an additional line redundancy, on two PROFIBUS lines. The advantages of this redundancy solution for the user are as follows:

- Only one device version required to implement different redundancy structures.
- Master, line and slave redundancy are available independently of one another.
- No additional configuration of the backup slave required, thus no need for complex tools.
- Complete monitoring of both slave parts possible.
- The slave device has no influence on the bus load and therefore on the dynamic response of PROFIBUS.

The redundancy of PROFIBUS slave devices provides high availability, short reversing times, no data loss and ensures fault tolerance. Please refer to the corresponding document, the PROFIBUS Guideline "Specification Slave Redundancy", Order No. 2.212.

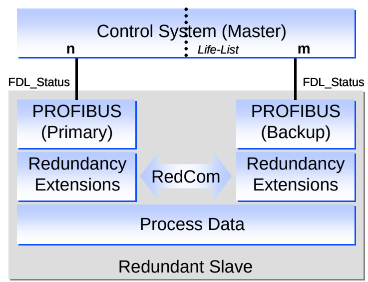

Fig. 18: Slave redundancy in PROFIBUS

5. Specific application profiles

PROFIBUS stands out from other fieldbus systems primarily due to its extraordinary breadth of application options. The PROFIBUS concept has set new standards. Not only has it developed specific profiles that take into account key industry-specific user demands - it has also successfully united all key aspects across all applications in a standardized and open fieldbus system, thus ensuring full protection of existing investment.

Table 10 shows all current specific PROFIBUS application profiles as well as those pending.

5.1 PROFIdrive

The profile PROFIdrive defines device behavior and the access procedure to drive data for electric drives on PROFIBUS, from simple frequency converters through to highly dynamic servo-controls.

The integration of drives in automation solutions is highly dependent on the task of the drive. For this reason, PROFIdrive defines six application classes, which cover the majority of applications.

With **standard drives (class 1),** the drive is controlled by means of a main setpoint value (e.g. rotational speed), whereby the speed control is carried out in the drive controller.

In the case of **standard drives with technological function (class 2),** the automation process is broken down into several subprocesses and some of the automation functions are shifted from the central programmable controller to the drive controllers. PROFIBUS serves as the technology interface in this case.

Slave-to-slave communication between the individual drive controls is a requirement for this solution.

The positioning drive (class 3) integrates an additional position controller in the drive, thus covering an extremely broad spectrum of applications (e.g. the twisting on and off of bottle tops). The positioning tasks are passed to the drive controller over PROFIBUS and started.

The **central motion control (classes 4 and 5)** enables the coordinated motional sequence of multiple drives. The motion is primarily controlled over a central numeric control (CNC). PROFIBUS serves to close the position control loop as well as synchronize the clock (Fig. 20). The position control concept (Dynamic Servo Control) of this solution also supports extremely sophisticated applications with linear motors.

Distributed automation by means of clocked processes and electronic shafts **(class 6)** can be implemented using slave-to-slave communication and isochronous slaves. Sample applications include "electrical gears", "curve discs" and "angular synchronous processes".

PROFIdrive defines a device model as functional modules that operate together internally and which reflect the intelligence of the drive system. These modules are assigned objects that are described in the profile and defined with regard to their functions. The overall functionality of a drive is described by the sum of its parameters.

In contrast to other drive profiles, PROFIdrive only defines the ac-

Designation	Profile contents	Current status of PNO guideline
PROFIdrive	The profile specifies the behavior of devices and the access procedure to data for variable-speed electrical drives on PROFIBUS.	V2 3.072 V3 3.172
PA devices	The profile specifies the characteristics of devices of *process engineering in* process automation on PROFIBUS.	V3.0 3.042
Robots/NC	The profile describes how *handling and assembly robots* are controlled over PROFIBUS.	V1.0 3.052
Panel devices	The profile describes the interfacing of simple *human machine interface devices (HMI)* to higher-level automation component s.	V1.0D 3.082
Encoders	The profile describes the interfacing of rotary, angle and linear *encoders* with single-turn or multi-turn resolution.	V1.1 3.062
Fluid power	The profile describes the control of hydraulic drives over PROFIBUS. In cooperation with VDMA.	V1.5 3.112
SEMI	The profile describes characteristics of devices for semiconductor manufacture on PROFIBUS (SEMI standard).	3.152
Low-voltage switchgear	The profile defines data exchange for low-voltage switchgear (switch-disconnectors, motor starters, etc.) on PROFIBUS DP.	3.122
Dosage/weighing	The profile describes the implementation of weighing and dosage systems on PROFIBUS DP.	3.162
Ident systems	The profile describes the communications between devices for identification purposes (bar codes, transponders).	3.142
Liquid pumps	The profile defines the implementation of liquid pumps on PROFIBUS DP. In cooperation with VDMA.	3.172
Remote I/O for PA devices	Due to their special place in bus operations, a different device model and data types are applied to the remote I/Os compared to the PROFIBUS PA devices.	3.132

Table 10: The PROFIBUS specific application profiles

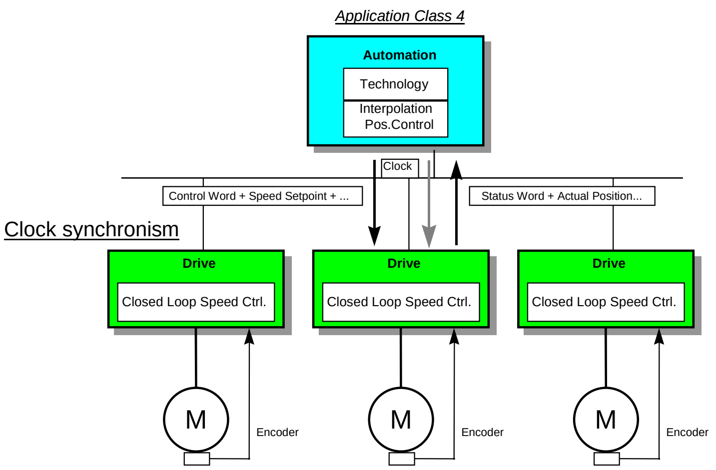

Fig. 20: PROFIdrive, positioning with central interpolation and position control

cess mechanisms to the parameters and a subset of approx. 30 *profile parameters,* which include e.g. fault buffers, drive controllers, device identification, etc.

All other parameters (which may number more than 1,000 in complex devices) are *manufacturer-specific*, which provides drive manufacturers great flexibility when implementing control functions. The elements of a parameter are accessed acyclic over the so-called DP-V1 parameter channel.

PROFIdrive V3 uses the version DP-V2 as its communications protocol with its innovative slave-to-slave communication and isochronous mode, see Chapter 3.2.

Both application profiles are available on the Internet: "Profiles for variable speed drives", V2, Order-No.: 3.072; "PROFIdrive Profile Drive Technology", V3, Order-No.: 3.172.

5.2 PA devices

Modern process devices are intrinsically intelligent and can execute part of the information processing or even the overall functionality in automation systems. The PA devices profile defines all functions and parameters for different classes of process devices that are typical for signal flow - from process sensor signals through to the preprocessed process value which is read out at the control system together with a measured value status. The various steps of information processing (signal chain) and the status forming process are shown in Fig. 21.

The PA devices profile is documented in a *general data sheet* containing the currently valid specifications for all device types and in *device data sheets* containing the agreed specifications for specific device classes. The PA device profile can be found in version 3.0 and contains device data sheets for the following:

- Pressure and differential pressure
- Level, temperature and flow rate
- Analog and digital inputs and outputs
- Valves and actuators
- Analyzers

The block model

In process engineering it is common to use *blocks* to describe the characteristics and functions of a sensor or actuator and to represent an automation application through a combination of these types of blocks. The specification of PA devices uses this function block model to represent functional sequences as shown in Fig. 22.

The following *three block types* are used:

Physical Block (PB)
A PB contains the characteristic data of a device, such as device name, manufacturer, version and serial number, etc. There can only be one physical block in each device.

Transducer Block (TB)
A TB contains all the data required for processing an unconditioned signal delivered from a sensor for passing on to a function block. If no processing is required, the TB can be omitted.

Multifunctional devices with two or more sensors have a corresponding number of TBs.

Function Block (FB)
An FB contains all data for final processing of a measured value prior to transmission to the control system, or on the other hand, for processing of a setting before the setting process.

The following function blocks are available:

Analog Input Block (AI)
An AI delivers the measured value from the sensor/TB to the control system after further processing (input in the sense of "input on the bus").

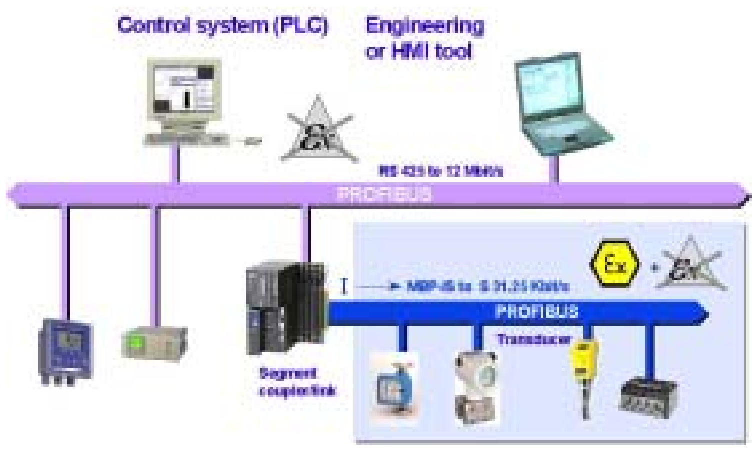

Fig. 19: Plant topology and bus powering of field devices using MBP transmission technology

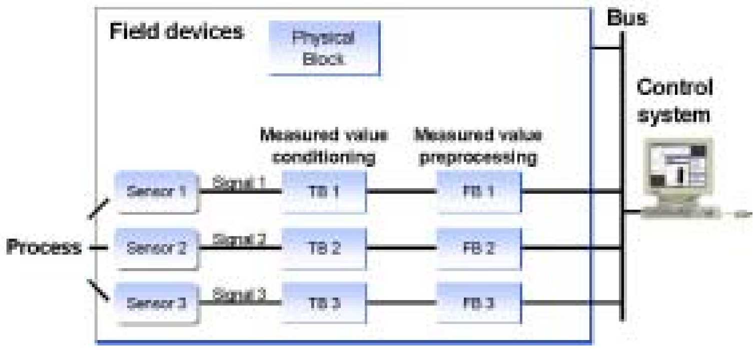

Fig. 22: Block structure of a field device (with multifunctionality)

Analog Output Block (AO)
An AO provides the device with the value specified by the control system

Digital Input (DI)
A DI provides the control system with a digital value from the device.

Digital Output (DO)
A DO provides the device with the value specified by the control system.

The blocks are implemented by the manufacturers as software in the field devices and, taken as a whole, represent the functionality of the device. As a rule, several blocks work together in an application, see Fig. 22, which shows a simplified block structure of a multifunctional field device.

The configuration corresponds to the division of a signal chain in two subprocesses:

The functionality of the first subprocess "measuring/actuating principle" (Fig. 21, above) is in the ***transducer blocks***, the functionality of the second subprocess "preprocessing measured values/postprocessing settings" (Fig. 21, below) is in the ***function blocks***.

Specifications in the PA device profile

It is only possible to show a selection of the specifications in brief. For further details, please refer to the specification or the relevant literature, e.g. "PROFIBUS PA" (Ch. Diedrich/ Th. Bangemann, Oldenbourg-Industrieverlag).

Illustration of the signal chain

The PA devices profile gives a detailed definition of the functions and parameters for each step of the signal chain depicted in Fig. 21 . By way of an example, Fig. 23 and Table 11 provide further details of the step "calibration" and Fig. 24 shows the step "limit-value check".

Addressing parameters

Blocks are determined by means of their start address and parameters through a relative index within the block; as a rule, these can be freely selected by the device manufacturer. For access to the parameters (e.g. using an operator tool) the device-specific block structures are stored in the directory of the device.

Batch parameter sets

For implementation of field devices in batch processes, the profile allows storage of several parameter sets even during the commissioning phase. The current batch process is then switched to the assigned parameter set during runtime.

Modular devices

With PROFIBUS a distinction is made between compact and modular devices, whereby a function block is a "module" in this context. The PA device profile offers a selection of function blocks for this purpose. Devices with a configured modularity are described as multivariable devices

Devices with several process variables

Process devices increasingly offer several process variables, e.g. over several sensors or in the form of derived variables. This is taken into account in the transducer blocks of the profile by differentiating between **P**rimary **V**alue (**PV**) and **S**econdary **V**alue (**SV**).

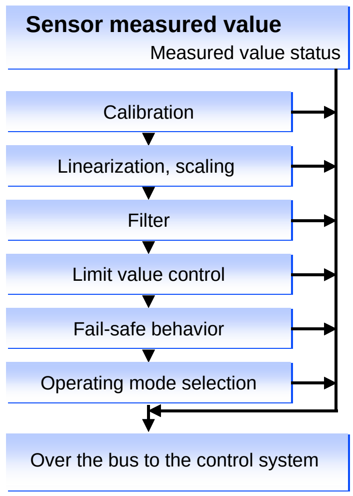

Fig. 21: Signal chain in the PA device profil

Limit-value check

Part of the information processing transferred to the device is the limit-value check. For this purpose, PA devices offer corresponding mechanisms for signalling when warning/alarm limits are exceeded or fallen below (see Fig. 24).

Value status

A value status information item is added to the measured value, which delivers a statement of the quality of the measured value. There are three quality levels *bad*, *uncertain* and *good* and additional information is provided on a substatus that is assigned to each quality level.

Parameter	Parameter description
LEVEL_HI	Range of measured filling level
LEVEL_LO	
CAL_POINT_HI	Section from the sensor measuring range with which the level range is mapped.
CAL_POINT_LO	

Table 11: Parameters for the calibration function

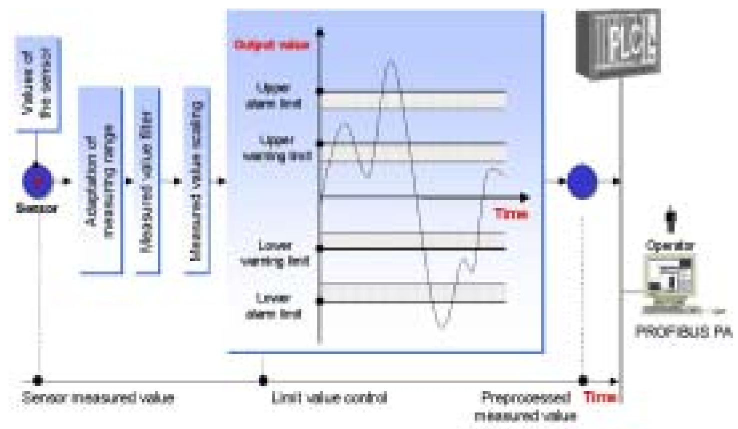

Fig. 24: Specification of the limit-value check function

Fail-Safe behavior

The PA device profile also provides fail-safe characteristics. If a fault has occurred in the measuring chain, the device output is set to a user-definable value. Users can select between three different fail-safe behavior types.

Please refer to the relevant document, the PROFIBUS Guideline "Profile for Process Control Devices", Order No. 3.042.

5.3 Fluid power

This describes data exchange formats and parameters for proportional valves, hydrostatic pumps and drives and is based closely on the PROFIdrive definitions. Either a parameter channel on DP-V0 or acyclic communication over DP-V1 are used for supplying device parameters. Work on the profile was completed in October 2001.

Please refer to the corresponding document, the PROFIBUS Guideline "Profile Fluid Power Technology", Order No. 3.112.

5.4 SEMI

Some of the devices for the process industry are also implemented in semiconductor production, e.g. vacuum pumps, flow-rate meters, etc. There are already deviating specifications for device models in this "SEMI", which we aim to harmonize with this profile, which we are still currently working on. A basic profile is already available. Additional data sheets are currently being prepared for further devices.

5.5 Ident systems

Ident systems is a profile for barcode readers and transponder systems. These are primarily intended for extensive use with the DP-V1 functionality. While the cyclic data transmission channel is used for small data volumes to transfer status/control information, the acyclic channel serves the transmission of large data volumes that result from the information in the barcode reader or transponder. The definition of standard function blocks has facilitated the use of these systems and paves the way for the application of open solutions on completion of international standards, such as ISO/IEC 15962 and ISO/IEC18000.

5.6 Remote I/Os for PA

Due to their largely (fine) modular design, remote I/O devices are difficult to bring in line with the "ideal" PA device model. For this reason, they have a special place in the field of distributed process automation. Furthermore, economic sensitivity also strongly influences the selected device configurations (modules, blocks, ...), resources (memory, records, ...) and functions (e.g. acyclic access). For this reason a simplified device model has been defined and the quantity framework restricted. The aim is to offer maximum support on the basis of cyclically exchanged data formats.

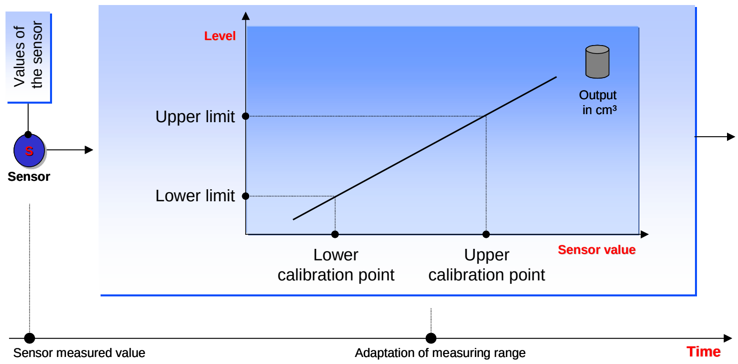

Fig. 23: Specification of the calibration function

6. System profiles

Profiles in automation technology define specific characteristics and behavior for devices and systems so that these are uniquely characterized (in classes or families) and are vendor-independent, thus supporting device interoperability and interchangeability on a bus.

Master profiles for PROFIBUS
describe classes of controller, each of which support a specific "subset“ of all the possible master functionalities, such as

- Cyclic communications
- Acyclic communications
- Diagnostics, interrupt handling
- Time-of-day management
- Slave-to-slave communication, isochronous mode
- Safety

System profiles for PROFIBUS
go a step further and describe classes of systems including the possible functionality of *Standard Program Interfaces* (FB in accordance with IEC 61131-3, safety layer and FDT) and *integration options* (GSD, EDD and DTM). Fig. 25 shows the standard platforms available for the application profiles.

In the PROFIBUS system, the master and system profiles provide the much needed counterpart to the application profiles (Fig. 26):

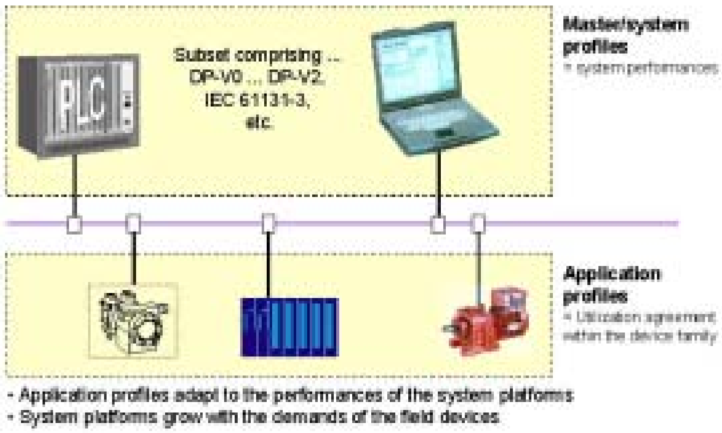

Fig. 26: System and application profiles (in correlation)

- Master and system profiles describe specific system performances that are made available to the field devices, while
- in order to define specific characteristics within a device family, application profiles require specific system performances to implement these.

The *device manufacturers* can alternately focus on existing or specified system profiles and the *system manufacturers* on their platforms (taking into account the increasing demands of the devices) or extend these application profiles.

PROFIBUS is already working on a number of system profiles based on tried and tested applications in the field, (see Fig. 25). These are expected to be stipulated in specifications in the near future and extended by further profiles in keeping with future demands.

Standardized function blocks (Communication Function Blocks)
While application programmers can usually access cyclic communication data (MS0 channel) over the process image of a control system, in the past there was no system-neutral program interface for acyclic data. In view of the wide range of manufacturers and devices, standards needed to be established in this area as well to enable integration of different field devices without specific communication knowledge in the application programs of different control systems. For this purpose, the PNO has now specified its guideline "Communication and Proxy Function Blocks according to IEC 61138-3". This guideline specifies function blocks in a " combinations of standards " that are based on the widely used standard IEC 61131-3 (programming languages) and also use the PROFIBUS-defined communication services of the IEC 61158.

The guideline defines communications blocks for master classes 1 and 2 as well as slaves and several auxiliary functions. The technological functionality of a field device can be addressed under a compact identification, which is used consistently by all blocks. All blocks also have a common concept for displaying errors with coding in accordance with IEC 61158-6.

The *PLC manufacturers* of the corresponding system classes/profiles offer these standard communication blocks ("Comm-FBs") in PLC-specific "IEC libraries", the *field device manufacturers* can respond by creating uniform proxy function blocks, which can be used with all control systems.

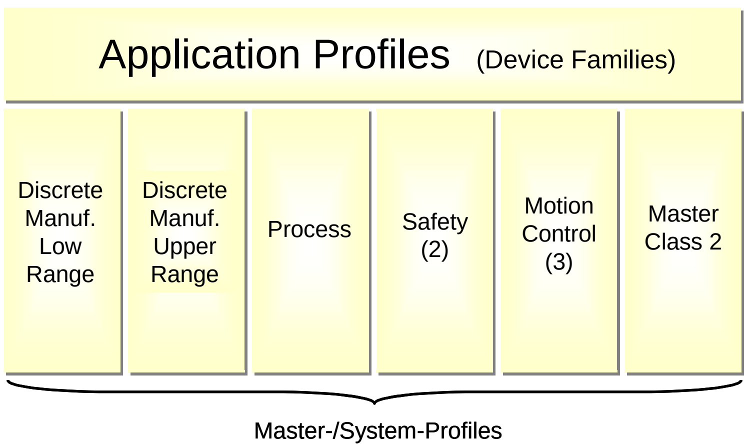

Fig. 25: Master/system profiles for PROFIBUS

Proxy function blocks

Proxy function blocks represent a technological device function by providing all the necessary input and output parameters at the block interface. These proxy function blocks are usually created once by the field device manufacturers and can be implemented in the control systems of the relevant system classes/profiles without any special adjustment (see Fig. 28).

Application Programmer´s Interface (API)

In order to make it as easy as possible for application programmers to use the communication services, the respective standard programming language blocks or function calls are available in the libraries. Together with the FDT interface, the PROFIBUS "Comm-FBs" expand the Application Programmer's Interface as shown in Fig. 27.

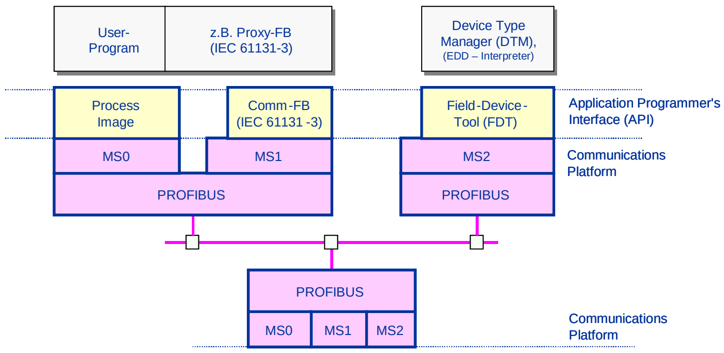

Fig. 27: Application Programmer´s Interface, API

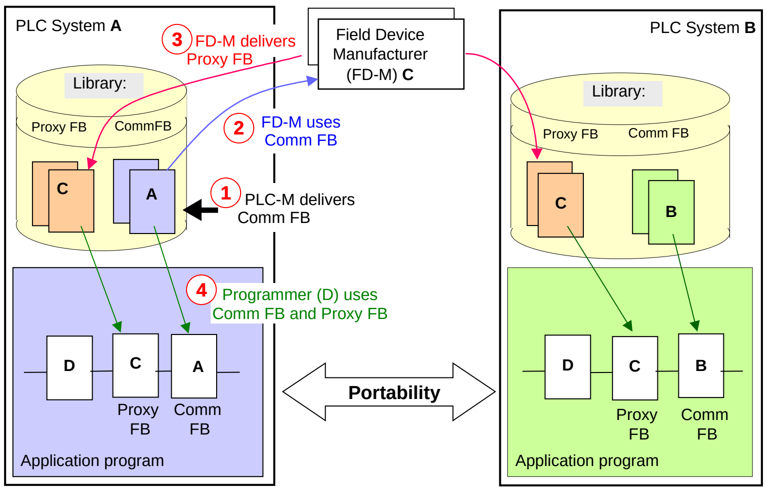

Fig. 28: Portable function blocks

7. Device management

Modern field devices provide a wide range of information and also execute functions that were previously executed in PLCs and control systems. To execute these tasks, the tools for commissioning, maintenance, engineering and parameterization of these devices require an exact and complete *description of device data and functions,* such as the type of application function, configuration parameters, range of values, units of measurement, default values, limit values, identifications, etc. The same applies to the controller/control system, whose device-specific parameters and data formats must also be made known (integrated) to ensure error-free data exchange with the field devices.

PROFIBUS has developed a number of methods and tools ("integration technologies") for this type of device description which enable standardization of device management. The performance range of these tools is optimized to specific tasks, which has given rise to the term *scaleable device integration*.

Methods of device description:

The ***communication features*** of a PROFIBUS device are described in a device master data file (**G**eneral **S**lave **D**ata, **GSD**) in a defined data format; the GSD is created by the device manufacturer and is included in the delivery of the device.

The ***application features*** of a PROFIBUS device (device characteristics) are described by means of a universal **E**lectronic **D**evice **D**escription **L**anguage (**EDDL**) developed and specified by the PNO. The file **(EDD)** created in this manner is also provided by the device manufacturer.

For ***complex applications*** there is also the solution of mapping all device-specific functions, including the user interface for parameterization, diagnostics, etc., as *software components* in a so-called **D**evice **T**ype **M**anager (**DTM**). The DTM (which, in contrast to the GSD and EDD, is a software) then acts as the "driver" of the device opposite the standardized FDT interface, which is implemented in the engineering tool or in the control system.

7.1 GSD

A GSD is a readable ASCII text file and contains both general and device-specific specifications for communication. Each of the entries describes a feature that is supported by a device. By means of keywords, a configuration tool reads the device identification, the adjustable parameters, the corresponding data type and the permitted limit values for the configuration of the device from the GSD. Some of the keywords are *mandatory*, e.g. Vendor_Name, others are *optional*, e.g. Sync_Mode_ supported. A GSD replaces the previously conventional manuals and supports automatic checks for input errors and data consistency, even during the configuration phase.

Structure of a GSD

A GSD is divided into three sections:

General specifications

This section contains information on vendor and device names, hardware and software release versions, as well as the supported transmission rates, possible time intervals for monitoring times and signal assignment on the bus connector.

Master specifications

This section contains all the master-related parameters, such as the maximum number of connectable slaves or upload and download options. This section is not available in slave devices.

Slave specifications

This section contains all slave-specific information, such as the number and type of I/O channels, specification of diagnostic texts and information on the available modules in the case of modular devices.

It is also possible to integrate bitmap files with the symbols of the devices. The format of the GSD is designed for maximum flexibility. It contains lists, such as the transmission rates supported by the device, as well as the option to describe the modules available in a modular device. Plaintext can also be assigned to the diagnostic messages.

There are two ways to use the GSD:

- The GSD for compact devices whose block configuration is already known on delivery. This GSD can be created completely by the device manufacturer.
- The GSD for modular devices whose block configuration is not yet conclusively specified on delivery. In this case, the user must use the configuration tool to configure the GSD in accordance with the module configuration.

By reading the GSD into the configuration tool (see Fig. 29), e.g. into a PROFIBUS configurator, the user is able to make optimum use of the special communication features of the device.

Certification with GSD

The device manufacturers are responsible for the scope and quality of the GSD of their devices. Submission of a GSD profile (contains the information from the profile of a device family) or an individual device GSD (device-specific) is essential for certification of a device.

PNO support

To support device manufacturers, the PROFIBUS Web site has a special GSD editor/checker available to download, which facilitates the creation and checking of GSD files.

The specification of the GSD file formats is described in the following PROFIBUS guidelines:

DP devices : No. 2.122
FMS devices : No. 2.101/2.102

The standard-compliant GSD files of PROFIBUS devices can be downloaded free of charge from the PNO Web site in the GSD library at www.profibus.com

New development stages

of the communication functions of PROFIBUS are continually integrated in the GSD by the PNO. Thus, the keywords for DP-V1 can be found in the GSD Revision 3 and those for DP-V2 in the GSD Revision 4.

Manufacturer ID

Every PROFIBUS slave and every master class 1 must have an *ID number*. This is required so that a master can identify the types of connected devices without the need for extensive protocol overheads. The master compares the ID number of the connected devices with the ID numbers specified in the configuration data by the configuration tool. Transfer of the user data is not started until the correct device types with the correct station addresses are connected to the bus. This ensures optimum protection against configuration errors.

For an ID number for each device type, device manufacturers must apply to the PROFIBUS User Organization who also handle administration of the ID numbers. Application forms can be obtained from any regional agency or from the PROFIBUS Web site on the Internet.

Profile ID

A special range of ID numbers (generic ID numbers) have been reserved for field devices for process automation and drives respectively: 9700h - 977Fh or 3A00h - 3AFFh. All field devices corresponding exactly to the specifications of the PROFIBUS PA profile version 3.0 or higher, or PROFIdrive version 3, may use ID numbers from this special range. The specification of these profile ID numbers has further increased the interchangeability of these devices. The ID number to be selected for the respective device depends on various factors e.g. in the case of PA on the type and number of existing function blocks. The ID number 9760H is reserved for PA field devices that provide several different function blocks (multivariable devices). Special conventions also apply to the designation of the GSD files of these PA field devices. These are described in detail in the profile for PA field device.

The first profile ID number reserved for PROFIdrive (3A00h) is used during the DP-V1 connection buildup to check that the master and slave are using the same profile. Slaves that positively acknowledge this identifier support the DP-V1 parameter channel described in the PROFIdrive profile.

All further profile ID numbers serve to identify vendor-independent GSD files. This enables the interchangeability of devices of different manufacturer without the need for new bus configurations. For example, the VIK-NAMUR mode with vendor-independent PROFIdrive GSD is defined as a component of the PROFIdrive profile for the chemical industry.

7.2 EDD

The GSD is inadequate for describing *application-related* parameters and functions of a field device (e.g. configuration parameters, ranges of values, units of measurement, default values, etc.). This requires a more powerful description language, which has been developed in the form of the universally applicable **E**lectronic **D**evice **D**escription **L**anguage (**EDDL**), currently available as version 1.1. Above all, the EDDL provides the language means for the description of the functionality of field devices. This also contains support mechanisms to

- integrate existing profile descriptions in the device description,
- allow references to existing objects so that only supplements require description,
- allow access to standard dictionaries and
- allow assignment of the device description to a device.

Using the EDDL device manufacturers can create the relevant **EDD file** for their devices which, like the GSD file, supplies the engineering tool and then subsequently the device information to the control system (see Fig. 29).

New development stages

As with the GSD, the EDDL will also be subject to expansions that keep it in step with the continuous further development of advancing device technology. Work is currently underway on a unique specification for dynamic semantics and for the description of hardware modular slaves.

The specification of the EDDL is an integral component of the international standard IEC 61804. It is included in the PROFIBUS guideline 2.152.

7.3 FDT/DTM concept

The existing description languages for the configuration and parameterization have their limits. This becomes clear when, for example

- complex, non-standardized characteristics of intelligent field devices including the diagnostic capabilities are to be made useable for the plant operator or
- in the "Optimization of assets" field, functions for preventative maintenance or for maintenance procedures are to be supported.
- for reasons of answerability, the operation of devices needs to be "encapsulated" in software (safety technology, calibration, etc).

These complex task areas, require an "auxiliary tool" that allows device manufacturers to provide users with expanded and also very specific characteristics of their field devices in standardized form and which at the same time allows the manufacturers of automation systems to integrate these field device characteristics in the control system over standardized interfaces.

The solution to this is the fieldbus-independent interface concept **FDT/DTM** (see Fig. 29), which was developed in a working group of the PNO and the ZVEI (Central Association for the Electrical Industry) and made generally available.

The FDT interface

The definition of a universal interface provides the ability to implement suitable created software components on all engineering or other integration platforms of automation systems fitted with this interface.

Such an interface has been specified by the aforementioned working group and designated **FDT** (**F**ield **D**evice **T**ool). The FDT specification is currently available as version 1.2.

The specification of FDT is contained in the PROFIBUS guideline 2.162.

Device as software component

The specific functions and dialog of a field device for parameterization, configuration, diagnostics and maintenance, complete with user interface, are mapped in a *software component*. This component is called the **DTM** (**D**evice **T**ype **M**anager) and is integrated in the engineering tool or control system over the FDT interface.

A DTM uses the routing function of an engineering systems for communicating across the hierarchical levels. Furthermore its project data management with version. It works in field devices as a "driver", similar to a printer driver, which the printer supplier includes in delivery and must be installed on the PC by the user.

The DTM is generated by the device manufacturer and is included in delivery of the device.

DTM generation

There are various options for generating the DTM:

- Specific programming in a higher programming language.
- Reuse of existing component or tools through their encapsulation as DTM.
- Generation from an existing device description using a compiler or interpreter.
- Use of the DTM toolkit of MS VisualBasic.

With DTMs it is possible to obtain direct access to all field devices for planning, diagnostics and maintenance purposes from a central workstation . A DTM is not a stand-alone tool, but an ActiveX component with defined interfaces.

User benefits of FDT/DTM

The FDT/DTM concept is protocol-independent and, with its mapping of device functions in software components, opens up interesting new user options. This draws the "driver" principle, well-known from the office world, into the world of automation technology.

The concept incorporates integration options where they are most useful: in the areas of engineering, diagnostics, service and asset management - liberated from the specific communication technologies of the various fieldbuses and the specific engineering environment of automation systems.

The FDT standard provides a basis for integrated solutions from the field through to tools and methods of corporate management.

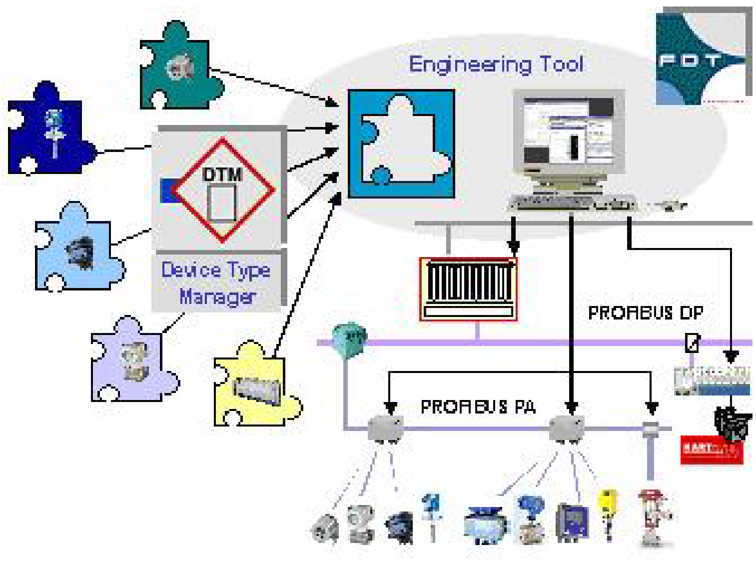

Fig. 29: FDT/DTM concept

8. PROFInet

PROFInet is a comprehensive automation concept that has emerged as a result of the trend in automation technology towards modular, reusable machines and plants with distributed intelligence. With its comprehensive design (uniform model for engineering, runtime and migration architecture to other communication systems, such as PROFIBUS and OPC) PROFInet fulfills all the key demands of automation technology for

- consistent communications from field level through to corporate management level using Ethernet,
- a vendor-independent plant-wide engineering model for the entire automation landscape,
- openness to other systems,
- implementation of IT standards and
- integration capability of PROFIBUS segments without the need to change them.

PROFInet is available as a *specification* and as an operating system-independent *source software*. The specification describes all aspects of PROFInet: the object and component model, the runtime communication, the proxy concept and the engineering. The PROFInet software covers all runtime communications. This combination of specification and software as source code enables simple and efficient integration of PROFInet in the broadest range of device operating system environments. The chosen path of preparing a source software upon which all product implementations are built presents an outstanding opportunity to ensure the consistent quality of the PROFInet interface in products. The procedure ensures that any interoperability problems are reduced to a minimum.

PROFInet components

The basic approach of PROFInet is the application of the object model, already tried and tested in the software world, on automation technology. For this purpose, machines, plants and their parts are divided into technological modules, each of which comprises mechanics, electrics/electronics and application software. The functionality of the technological module is encapsulated in PROFInet components, which can be accessed over universally defined "interfaces". The components can be combined over their interfaces according to the modular principle and interconnected to applications.

In this context "components" means an encapsulated, reusable software unit. For the implementation of this component model, PROFInet uses the model most common in the PC world, the Microsoft Component Object Model (COM), in its expansion for distributed systems (DCOM). In this case, all the objects of a system are equal and, to all outward appearances, identical.

This type of distributed automation system enables the modular design of plants and machines and supports reusability of plant and machine parts.

8.1 The PROFInet engineering model

A vendor-independent engineering concept has been defined to enable user-friendly configuration of a PROFInet system. It is based on an engineering object model which enables the development of configuration tools as well as the specification of manufacturer/customized functional expansions by means of so-called facets.

The PROFInet engineering mode distinguishes between the *programming* of the control logics of the individual technological modules and the *configuration* of the overall plant for an application.

As previously, programming of the individual devices and their configuration and parameterization is carried out by the manufacturer with manufacturer-specific tools. The software created during programming is then encapsulated in the form of a PROFInet component using the componer interface that is also to be integrated in the tool. The Componer interface generates the component description in the form of an XML file whose configuration and contents are defined in the PROFInet specification.

The plant is configured by interconnecting the PROFInet components to an application using the PROFInet engineering tool (configuration editor). To do this, the generated PROFInet components are transferred to the configuration editor by importing their XML files and the relationship established over graphical lines.

This allows plant-wide combination of distributed applications (of different manufacturers) to an overall application (see Fig. 30). The decisive advantage of this is the fact that the communication no longer needs to be programmed. Instead, the communication relationships between the components are established over lines, so-called interconnections.

The interconnection information is then downloaded to the device with a simple mouse click. This means that each device knows its communication partners and relationships and the information to be exchanged.

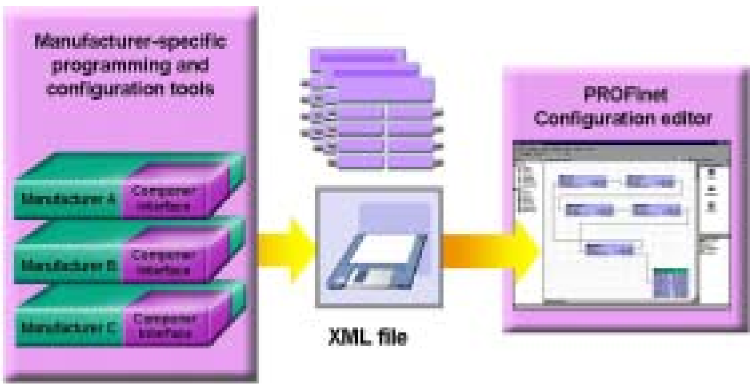

Fig. 30: Creation and interconnection of components

8.2 The PROFInet communications model

The PROFInet communications model defines a vendor-independent standard for communication on Ethernet with conventional IT mechanisms (runtime communications). It uses TCP/IP and COM/DCOM, the most common standards of the PC world. It provides direct access from the office world through to automation level and vice versa (vertical integration).

With PROFInet, the DCOM wire protocol, together with the aforementioned standards, defines the data exchange between the components of different manufacturers over Ethernet. Alternatively, there is also an optimized communication mechanism for application areas with hard real time.

Devices that are operated on the Ethernet require the implementation of communication mechanisms in accordance with the PROFInet-standard (see Fig. 31). The connection technology required for the link to Ethernet is available in protection classes IP 20 and IP65/67 in the form of a guideline.

8.3 The PROFInet migration model

The integration of PROFIBUS segments in PROFInet is implemented using proxies (see Fig. 32). These assume a proxy function for all the devices connected to PROFIBUS. This means that when rebuilding or expanding plants, the entire spectrum of PROFIBUS devices, including products of PROFIdrive and PROFIsafe can be implemented unchanged, thus providing users with maximum investment protection. Proxy technology also allows integration of other fieldbus systems.

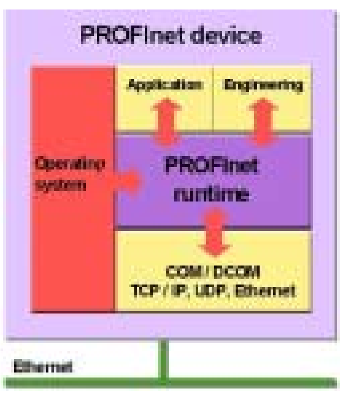

Fig. 31: Device structure of PROFInet

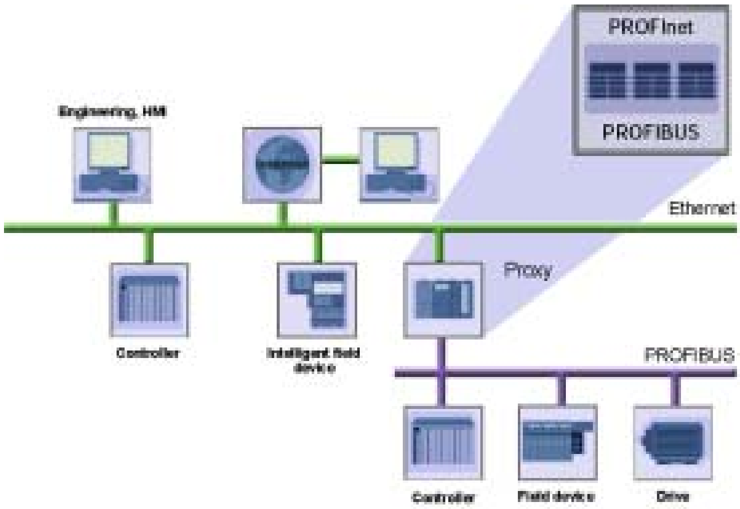

Fig. 32: PROFInet migration model

8.5 XML

XML (E**X**tensible **M**arkup **L**anguage) is a flexible data description language based on a simple ASCII code. XML documents can be exchanged with applications in a number of ways, e.g. on diskette, by e-mail, using TCP/IP or with HTTP over the Internet.

XML is important in automation technology for, among other things, parameter descriptions in FDT, as import and export format for field device parameters in engineering tools or as a means of vertical integration (data exchange independent of the operating system used).

8.6 OPC and OPC DX

OPC (OLE for Process Control) is a standard interface introduced in 1996 for access to Windows-based applications in automation. The implementation of OPC enables the flexible, manufacturer-independent selection of components and their interconnection without the need for programming. OLE, and thus OPC, are based on the Microsoft DCOM model .

Since 2000, OPC data and OPC services are mapped in XML, which means that OPC data can even be exchanged between non-Windows platforms by means of readable XML documents.

OPC DX (Data Exchange) is being developed within the framework of the OPC Foundation with the aim of developing a protocol for the exchange of non-time-critical user data between automation systems of different manufacturers and types (PLC, DCS, PC).

OPC DX is based on the existing specification OPC **DA** (**D**ata **A**ccess). At the same time an engineering interface has been defined, which enables configuration of the connected systems. In contrast to PROFInet, OPC DX is not object-orientated, but tag-orientated, i.e. the automation objects do not exist as COM objects but as (tag) names.

OPC DX will enable the connection of different automation systems in a plant at Ethernet level. However, it is not possible to access field level, so that existing fieldbus systems and PROFInet are not influenced in any way.

9. Certification

In order for PROFIBUS devices of different types and manufacturers to correctly fulfill tasks in the automation process, it is essential to ensure the error-free exchange information over the bus. The requirement for this is a standard-compliant implementation of the communications protocol and application profiles by device manufacturers.

To ensure that this requirement is fulfilled, the PNO has established a *quality assurance procedure* whereby, on the basis of test reports, certificates are issued to devices that successfully complete the test .

The *aim of the certification* is to provide users the necessary security for error-free functionality during the common operation of devices of different manufacturers. To achieve this, the device undergoes rigorous practical testing in independent test laboratories. This enables early detection of any misinterpretations of the standards by developers, thus allowing remedial action by manufacturers before devices are implemented in the field. Interoperability of the device with other certified devices is also part of the test. On successful completion of the test, the manufacturer can apply for a device certificate.

Basis for the certification procedure (see Fig. 34) is the standard EN 45000. The PROFIBUS User Organization has approved manufacturer-independent *test laboratories* in accordance with the specifications of this standard. Only these test laboratories are authorized to carry out device tests, which form the basis for certification.

The test procedure and sequence for certification are described in the guidelines No. 2.032 (DP slaves), No. 2.062 (PA field devices) and No. 2.072 (DP master).

9.1 Test procedure

A precondition for the test is the conferred ID number and a GSD file, as well as an EDD for the device where applicable.

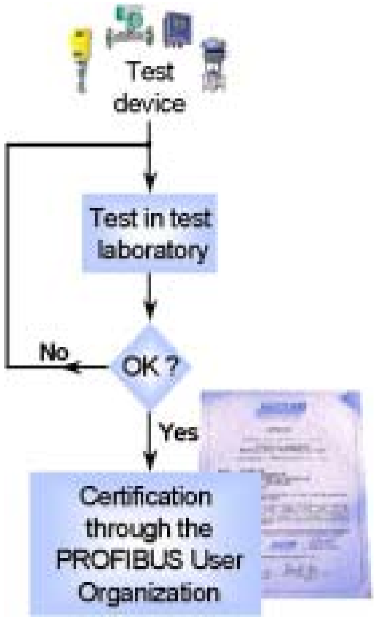

Fig. 34: Device certification procedure

The test procedure, which is the same for all test laboratories, is made up of several parts:

A *GSD/EDD check*
ensures that the device description files comply with the specification.

The hardware test
tests the electric characteristics of the PROFIBUS interface of the test specimen for compliance with the specifications. This includes terminating resistors, suitability of the implemented drivers and other modules and the quality of line level.

The function test
examines the bus access and transmission protocol and the functionality of the test device. The GSD is used to parameterize and customize the test system. The black-box procedure is used during testing, which means that no knowledge is required of the internal structure of the implementation. The reactions generated in the test specimen and their time ratios are recorded on the bus monitor. If necessary, the outputs of the test device are monitored and logged.

The *conformity test*
forms the main part of the test. The object is to test conformity of the protocol implementation with the standard. Essentially, the test deals with the:

Status machine: the PROFIBUS protocol is defined in the form of a status machine. All externally visible state transitions are tested. The target behavior is summarized in programmable sequences. The actual behavior is analyzed, compared with the target behavior and the result is written to the protocol file.

Behavior in the case of fault: this simulates bus faults, such as interruptions, short-circuits of the bus line and power failure.

Addressability: the test device is addressed under three arbitrary addresses within the address range and tested for error-free functioning.

Diagnostic data: the diagnostic data must correspond to the entry in the GSD and the standard. This requires external tripping of the diagnostics.

Mixed operation: combination slaves are checked for correct functifunctioning with an FMS and DP master.

Interoperability test: the test device is checked for interoperability with the PROFIBUS devices of other manufacturers in a multivendor plant. This checks that the functionality of the plant is maintained when the test device is added. Operation is also tested with different masters.

Each step of the test is carefully documented. The test records are made available to the manufacturer and the PROFIBUS User Organization. The test report serves as the basis for the issuing of a certificate.

9.2 Issue of a certificate

Once a device has successfully passed all the tests, the manufacturer can apply for a certificate from the PROFIBUS User Organization. Each certified device contains a certification number as a reference. The certificate is valid for 3 years but can be extended after undergoing a further test.

The addresses of the test laboratories can be obtained from the PROFIBUS Web site on the Internet.

10. Implementation

This chapter contains instructions on how to implement the communications protocol and the interfaces in automation/field devices.

For the device development or implementation of the PROFIBUS protocol, a broad spectrum of standard components (PROFIBUS ASICs, PROFIBUS stacks, monitor and commissioning tools) and services are available that enable device manufacturers cost-effective development. Table 12 contains a list of commonly available products. The table is based on manufacturer data. A corresponding overview is also available in the product catalog of the PROFIBUS User Organization (www.profibus.com/productguide.html). If you require further details, please refer to our trade literature offering expert advice available from the PROFIBUS Competence Center.

During implementation of the PROFIBUS protocol, please note that the certification refers to the overall device. Standard components are not subject to the certification process as this does not provide a guarantee for the end product device. However, as well as the quality of the PROFIBUS interface, the quality of the standard components also plays an important role in the successful certification of devices.

10.1 Standard components

Interface module

The complete PROFIBUS interface module is ideal for a low/medium number of items. These credit card size modules implement the entire bus protocol. They are fitted on the master board of the device as an additional module.

Protocol chips

In the case of high numbers of devices, an individual implementation on the basis of commercially available PROFIBUS protocol chips offers a practical solution. Table 12 offers an overview of the currently available basic technology components, whereby a distinction is made between

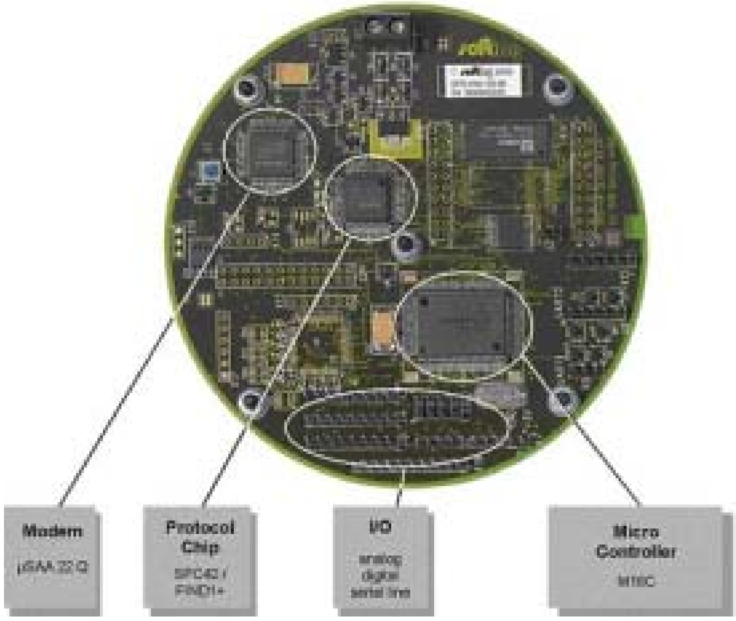

Fig. 35: Example for the implementation of a PROFIBUS slave

- ***Single chips***, in which all protocol functions are integrated on the chip,
- ***Communications chips***, which implement smaller or larger parts of the protocol on the chip and also require an additional controller and
- ***Protocol chips*** with integrated microcontroller.

The type of implementation version to select largely depends on the complexity of the field device, and the performance and functionality required. The following offers some examples.

Implementation of simple slaves

The implementation of single-chip ASICs is ideal for simple I/O devices. All protocol functions are already integrated on the ASIC. No microprocessors or software are required. Only the bus interface driver, the quartz and the power electronics are required as external components.

Examples are the LSPM2 and SPM2 ASICs from Siemens, the IX1 chip from M2C and the VPC LS ASIC from profichip.

Implementation of intelligent slaves

In this form of implementation, the time-critical parts of the PROFIBUS protocol are implemented on a protocol chip and the remaining protocol parts implemented as software on a microcontroller. This applies to the chips DPC31, SPC3 and VPC3+, in which all cyclic protocol parts have been implemented.

The DPC31 chip from Siemens is a combination of protocol chip and microcontroller. The ASICs SPC3 and SPC 4-2 from Siemens, VPC3+ from profichip and IX1 from M2C are currently available as pure protocol chips.

These ASICs offer a universal interface and operate together with common microcontrollers. A further option is offered by microprocessors with an integrated PROFIBUS core.

Implementation of complex masters

In this form of implementation, the time-critical parts of the PROFIBUS protocol are also implemented on a protocol chip and the remaining protocol parts implemented as software on a microcontroller. The ASICs ASPC2 from Siemens, the AGE platform from AGE and PBM from IAM are currently available for the implementation of complex master devices. They can be operated in combination with many common microprocessors.

Hersteller	Chip	Typ	Merkmale	FMS	DP	zus. m controller	zus. Protokoll-software	Max. Übertragungs-rate
AGE	AGE Plattform	Master/Slave	FPGA-basierter, universeller Protokollchip	—	●	●	●	12 MBit/s
IAM	PBM	Master	Protokollbaustein	●	●	●	●	3 MBit/s
M2C	IX1	Master/Slave	Single Chip oder Protokollbaustein	●	●	—/●	—/●	3 MBit/s
profichip	VPC3+	Slave	Protokollbaustein	—	●	●	●	12 MBit/s
profichip	VPC LS	Slave	Low Cost Single Chip, 32 E/A direkt an Chip anschließbar	—	●	—	—	12 MBit/s
profichip	VPC 16	Slave	Multi-Feldbus-Protokollchip mit integriertem Microcontroller	—	●	—/●	●	12 MBit/s
Siemens	SPC4-2	Slave	Protokollbaustein	●	●	●	●	12 MBit/s
Siemens	SPC3	Slave	Protokollbaustein	—	●	●	●	12 MBit/s
Siemens	DPC31	Slave	Protokollchip mit integriertem Microcontroller	—	●	—/●	●	12 MBit/s
Siemens	ASPC2	Master	Protokollbaustein	●	●	●	●	12 MBit/s
Siemens	SPM2	Slave	Single Chip, 64 E/A direkt an den Chip anschließbar	—	●	—	—	12 MBit/s
Siemens	LSPM2	Slave	Low Cost Single Chip, 32 E/A direkt an Chip anschließbar	—	●	—	—	12 MBit/s
Synergetic	DSTni-LX	Master	Protokollbaustein mit Microcontroller	●	●	●	●	12 MBit/s

Table 12 : Available PROFIBUS protocol chips

10.2 Implementation of interfaces

MBP transmission technology

When implementing a bus-powered field device with MBP transmission technology, particular attention must be paid to low power consumption.

As a rule, only a feed current of 10-15 mA over the bus cable is available for these devices, which must supply the overall device, including the bus interface and the measuring electronics.

Special modem chips, e.g. from Siemens (SIM 1), Smar (PA-ASIC), Yokogawa (µSAA 22 Q) and Ship-Star (FCHIP1), are available to meet these requirements. These modems take the required operating energy for the overall device from the MBP bus connection and make it available as feed voltage for the other electronic components of the device. At the same time, the digital signals of the connected protocol chip are converted into the bus signal of the MBP connection modulated to the energy supply. A typical configuration with a commercially available roundboard is shown in Fig. 35.

For further details on how to implement the bus connection for field devices with MBP transmission technology, please refer to the technical PNO guideline No. 2.092.

RS485 transmission technology

For field devices that cannot be powered over the bus it is possible to use the standard RS 485 interface. This increases flexibility when implementing the device as this can then be connected to a PROFIBUS DP segment without a coupler or link.

Key features of RS 485 technology are its low interface costs and ruggedness. Data rates of 9.6 Kbit/s to12 Mbit/s are supported without the need to implement any changes.

As a further enhancement, the RS 485 IS has been developed, which offers an intrinsically safe version of the RS 485.

The RS485 modules are available from various manufacturers.

11. The PROFIBUS User Organization

In order to ensure its maintenance, further development and market dominance, open technology requires a company-independent institute as a working platform. In 1989, the **PROFIBUS User Organization e.V. (PNO)** was founded to promote PROFIBUS technology in this very manner. It is a nonprofit trade body of manufacturers, users and institutes. The PNO is a member of the international umbrella organization **PROFIBUS International (PI)** founded in 1995, which now boasts 23 regional user organizations (**R**egional **P**ROFIBUS **A**ssociations, **RPA**) and more than 1,100 members who represent the largest trade body in the field of industrial communications worldwide.

Tasks

The key tasks of PI are as follows:

- Maintenance and further development of PROFIBUS technology.
- Extending worldwide acceptance and use of PROFIBUS technology.
- Investment protection for users and manufacturer through influencing control of standardization.
- Representation of members' interests before standardization committees and associations.
- Worldwide technical support of companies through the Competence Centers.
- Quality assurance through device certification.

Organization

PI has handed over the development of PROFIBUS technology to PNO Germany. The advisory committee of PNO Germany now controls the development activities. The development teams are organized in 5 **T**echnical **C**ommittees (**TCs**) with more than 35 permanent **W**orking **G**roups (**WGs**). In addition to this, there are also a changing number of ad hoc WGs that handle specific subjects limited to certain time periods. The WGs draw up new specifications and profiles, deal with quality assurance and standardization, work in standardization committees and undertake effective marketing measures (trade fairs, presentations) for expanding PROFIBUS technology. The **B**usiness **O**ffice coordinates all ongoing events.

Membership

Membership in the PNO is open to all companies, associations, institutes and persons who would like to play a constructive role in the development and acceptance of PROFIBUS technology. The mutual efforts of members who are often very different and come from a broad spectrum of industries (particularly in the WGs) produce a considerable synergy effect and generate a rigorous exchange of information. This leads to innovative solutions, effective use of resources and last but not least, a significant market edge.

Working groups

The WGs with their 300 honorary members make a key contribution to the success of PROFIBUS. Fig. 36 shows how the 5 TCs are broken down to deal with different areas. The further division into more than 35 WGs allows very focussed development work on specific technologies and industries.

All members are entitled to participate in the working groups and are thus able to take a proactive stance on further development. All new work results are submitted to members for further comment before they are released by the advisory committee.

Competence Centers

PI has approved 21 Competence Centers worldwide as well as 7 test laboratories for certification work. These facilities offer all manner of advice and support to users and manufacturers as well as carrying out tests for the certification of devices. Current addresses can be found on the PI Web site.

Documentation

By way of further support, the PNO offers all users and manufacturers a wide and very comprehensive range of documentation. This is provided in English and divided into the following categories:

PROFIBUS standard
contains the basic PROFIBUS specification and a selection of other documents.

PROFIBUS guidelines
contains specifications on e.g. implementations, test procedures, installations, description languages, as well as application-oriented specifications, such as Time Stamp or PROFInet.

PROFIBUS profiles
contains all approved profile specifications.

Technical overviews and catalogs
The key themes of PROFIBUS are presented in numerous technical overviews from a marketing standpoint. The product catalog, containing more than 2000 PROFIBUS products and services, offers an excellent overview of the performance capability of the member companies of PROFIBUS.

The documents are available in

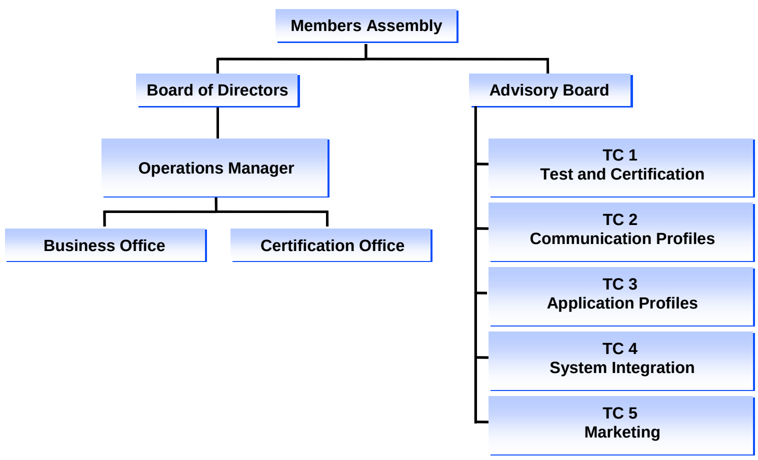

Fig. 36: Structure of the PROFIBUS User Organization

PDF format on the PROFIBUS Web site. If required you can also obtain the documentation on CD-ROM.

A list of all available documentation can also be obtained from the PNO or on the PROFIBUS Web site.

International support

23 regional PROFIBUS User Organizations, including organizations in the USA, China and Japan, are available to offer users and manufacturers worldwide support with their technology, training and marketing services. They are organized under the umbrella organization "PI" and represent the interests of their members, organize trade shows and information events, as well as ensuring that any new demands on the markets are taken into account in any further developments.

The addresses of the regional PI units can be found on the back page of this technical overview or on our Web site at www.profibus.com.

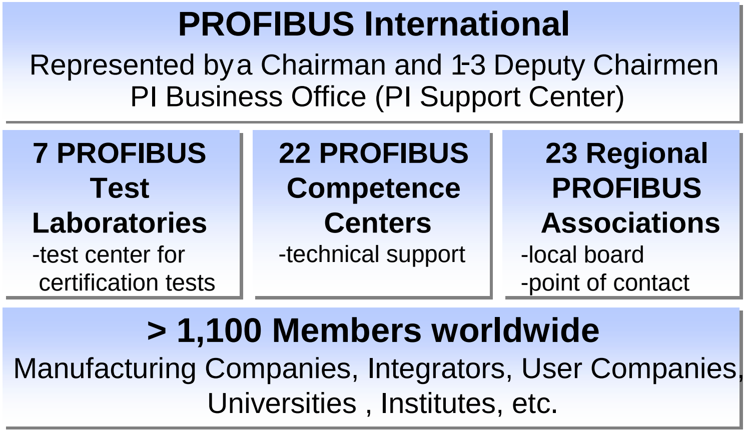

Fig. 37: PI Organization

12. Index

Australia and New Zealand
PROFIBUS User Group (ANZPA)
c/o OSItech Pty. Ltd.
P.O. Box 315
Kilsyth, Vic. 3137
Phone ++61 3 9761 5599
Fax ++61 3 9761 5525
australia@profibus.com

PROFIBUS Belgium
August Reyerslaan 80
1030 Brussels
Phone ++32 2 706 80 00
Fax ++32 2 706 80 09
belgium@profibus.com

Association PROFIBUS Brazil
c/o Siemens Ltda IND1 AS
R. Cel. Bento Bicudo, 111
05069-900 Sao Paolo, SP
Phone ++55 11 3833 4958
Fax ++55 11 3833 4183
brazil@profibus.com

Chinese PROFIBUS User Organisation
c/o China Ass. for Mechatronics Technology
and Applications
1Jiaochangkou Street Deshengmenwai
100011 Bejing
Phone ++86 10 62 02 92 18
Fax ++86 10 62 01 78 73
china@profibus.com

PROFIBUS Association Czech Republic
Karlovo nam. 13
12135 Prague 2
Phone ++420 2 2435 76 10
Fax ++420 2 2435 76 10
czechrepublic@profibus.com

PROFIBUS Denmark
Maaloev Byvej 19-23
2760 Maaloev
Phone ++45 40 78 96 36
Fax ++45 44 65 96 36
denmark@profibus.com

PROFIBUS Finland
c/o AEL Automaatio
Kaarnatie 4
00410 Helsinki
Phone ++35 8 9 5307259
Fax ++35 8 9 5307360
finland@profibus.com

France PROFIBUS
4, rue des Colonels Renard
75017 Paris
Phone ++33 1 45 74 63 22
Fax ++33 1 45 74 03 33
france@profibus.com

PROFIBUS Nutzerorganisation
Haid-und-Neu-Straße 7
76131 Karlsruhe
Phone ++49 7 21 96 58 590
Fax ++49 7 21 96 58 589
germany@profibus.com

Irish PROFIBUS User Group
c/o Flomeaco Endress + Hauser
Clane Business Park
Kilcock Road, Clane, Co. Kildare
Phone ++353 45 868615
Fax ++353 45 868182
ireland@profibus.com

PROFIBUS Network Italia
Gall. Spagna, 28
35127 Padova
Phone ++39 049 870 5361
Fax ++39 049 870 3255
pni@profibus.com

Japanese PROFIBUS Organisation
TFT building West 9F
3-1 Ariake Koto-ku
Tokyo 135-8072
Phone ++81 3 3570 3034
Fax ++81 3 3570 3064
japan@profibus.com

Korea PROFIBUS Association
#306, Seoungduk Bldg.
1606-3, Seocho-dong, Seocho-gu
Seoul 137-070, Korea
Phone ++82 2 523 5143
Fax ++82 2 523 5149
korea@profibus.com

PROFIBUS Nederland
c/o FHI
P.O. Box 2099
3800 CB Amersfoort
Phone ++31 33 469 0507
Fax ++31 33 461 6638
netherlands@profibus.com

PROFIBUS User Organisation Norway
c/o AD Elektronikk AS
Haugenveien 2
1401 Ski
Phone ++47 909 88640
Fax ++47 904 05509
norway@profibus.com

PROFIBUS User Organisation Russia
c/o Vera + Association
Nikitinskaya str, 3
105037 Moscow, Russia
Phone ++7 0 95 742 68 28
Fax ++7 0 95 742 68 29
russia@profibus.com

PROFIBUS Slovakia
c/o Dept. of Automation KAR FEI STU
Slovak Technical University
Ilkovièova 3
812 19 Bratislava
Phone ++421 2 6029 1411
Fax ++421 2 6542 9051
slovakia@profibus.com

PROFIBUS Association South East Asia
c/o Endress + Hauser
1 Int. Bus. Park #01-11/12 The Synergy
609917 Singapore
Phone ++65 566 1332
Fax ++65 565 0789
southeastasia@profibus.com

PROFIBUS User Organisation Southern Africa
P.O. Box 26 260
East Rand
Phone ++27 11 397 2900
Fax ++27 11 397 4428
southernafrica@profibus.com

PROFIBUS i Sverige
Kommandörsgatan 3
28135 Hässleholm
Phone ++46 4 51 49 460
Fax ++46 4 51 89 833
sweden@profibus.com

PROFIBUS Nutzerorganisation Schweiz
Kreuzfeldweg 9
4562 Biberist
Phone ++41 32 672 03 25
Fax ++41 32 672 03 26
switzerland@profibus.com

The PROFIBUS Group U.K.
Unit 6 Oleander Close
Locks Heath, Southampton, Hants, SO31 6WG
Phone ++44 1489 589574
Fax ++44 1489 589574
uk@profibus.com

PROFIBUS Trade Organization, PTO
16101 N. 82nd Street, Suite 3B
Scottsdale, AZ 85260 USA
Phone ++1 480 483 2456
Fax ++1 480 483 7202
usa@profibus.com

PROFIBUS International
Support Center
Haid-und-Neu-Straße 7
76131 Karlsruhe
Phone ++49 721 96 58 590
Fax ++49 721 96 58 589
info@profibus.com
www.profibus.com