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**Adjustable speed electrical power drive systems –
Part 7-303: Generic interface and use of profiles for power drive systems –
Mapping of profile type 3 to network technologies**

**Entraînements électriques de puissance à vitesse variable –
Partie 7-303: Interface générique et utilisation de profils pour les entraînements
électriques de puissance – Mise en correspondance du profil de type 3 avec les
technologies de réseaux**



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ADJUSTABLE SPEED ELECTRICAL POWER DRIVE SYSTEMS –

**Part 7-303: Generic interface and use
of profiles for power drive systems –
Mapping of profile type 3 to network technologies**

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EP844542	[SI]	Numerical control method and control structure for controlling of movement of objects whereby speed control is effected at a higher rate than position control	1998-274369	EP844542-A1 27.05.1998; DE59603496-G 02.12.1999; EP844542-B1 27.10.1999

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This bilingual version (2013-04) corresponds to the monolingual English version, published in 2007-11.

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FDIS	Report on voting
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Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

The French version of this standard has not been voted upon.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 61800 series, under the general title *Adjustable speed electrical power drive systems*, can be found on the IEC website.

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INTRODUCTION

The IEC 61800 series is intended to provide a common set of specifications for adjustable speed electrical power drive systems.

IEC 61800-7 describes a generic interface between control systems and power drive systems. This interface can be embedded in the control system. The control system itself can also be located in the drive (sometimes known as "smart drive" or "intelligent drive").

A variety of physical interfaces is available (analogue and digital inputs and outputs, serial and parallel interfaces, fieldbuses and networks). Profiles based on specific physical interfaces are already defined for some application areas (e.g. motion control) and some device classes (e.g. standard drives, positioner). The implementations of the associated drivers and application programmers interfaces are proprietary and vary widely.

IEC 61800-7 defines a set of common drive control functions, parameters, and state machines or description of sequences of operation to be mapped to the drive profiles.

IEC 61800-7 provides a way to access functions and data of a drive that is independent of the used drive profile and communication interface. The objective is a common drive model with generic functions and objects suitable to be mapped on different communication interfaces. This makes it possible to provide common implementations of motion control (or velocity control or drive control applications) in controllers without any specific knowledge of the drive implementation.

There are several reasons to define a generic interface.

For a drive device manufacturer

- Less effort to support system integrators
- Less effort to describe drive functions because of common terminology
- The selection of drives does not depend on availability of specific support

For a control device manufacturer

- No influence of bus technology
- Easy device integration
- Independent of a drive supplier

For a system integrator

- Less integration effort for devices
- Only one understandable way of modeling
- Independent of bus technology

Much effort is needed to design a motion control application with several different drives and a specific control system. The tasks to implement the system software and to understand the functional description of the individual components may exhaust the project resources. In some cases, the drives do not share the same physical interface. Some control devices just support a single interface which will not be supported by a specific drive. On the other hand, the functions and data structures are often specified with incompatibilities. This requires the system integrator to write special interfaces for the application software and this should not be his responsibility.

Some applications need device exchangeability or integration of new devices in an existing configuration. They are faced with different incompatible solutions. The efforts to adopt a solution to a drive profile and to manufacturer specific extensions may be unacceptable. This will reduce the degree of freedom to select a device best suited for this application to the selection of the unit which will be available for a specific physical interface and supported by the controller.

IEC 61800-7-1 is divided into a generic part and several annexes as shown in Figure 1. The drive profile types for CiA 402¹, CIP Motion^{TM2}, PROFIdrive³ and SERCOS interface^{TM4} are mapped to the generic interface in the corresponding annex. The annexes have been submitted by open international network or fieldbus organizations which are responsible for the content of the related annex and use of the related trademarks.

The different profile types 1, 2, 3 and 4 are specified in IEC 61800-7-201, IEC 61800-7-202, IEC 61800-7-203 and IEC 61800-7-204.

This part of IEC 61800-7 specifies how the profile type 3 (PROFIdrive) is mapped to the network technologies PROFIBUS⁵ and PROFINET⁶.

IEC 61800-7-301, IEC 61800-7-302 and IEC 61800-7-304 specify how the profile types 1, 2 and 4 are mapped to different network technologies (such as CANopen⁷, EtherCAT^{TM8}, Ethernet Powerlink^{TM9}, DeviceNet^{TM10}, ControlNet^{TM11}, EtherNet/IP^{TM12}, and SERCOS interface).

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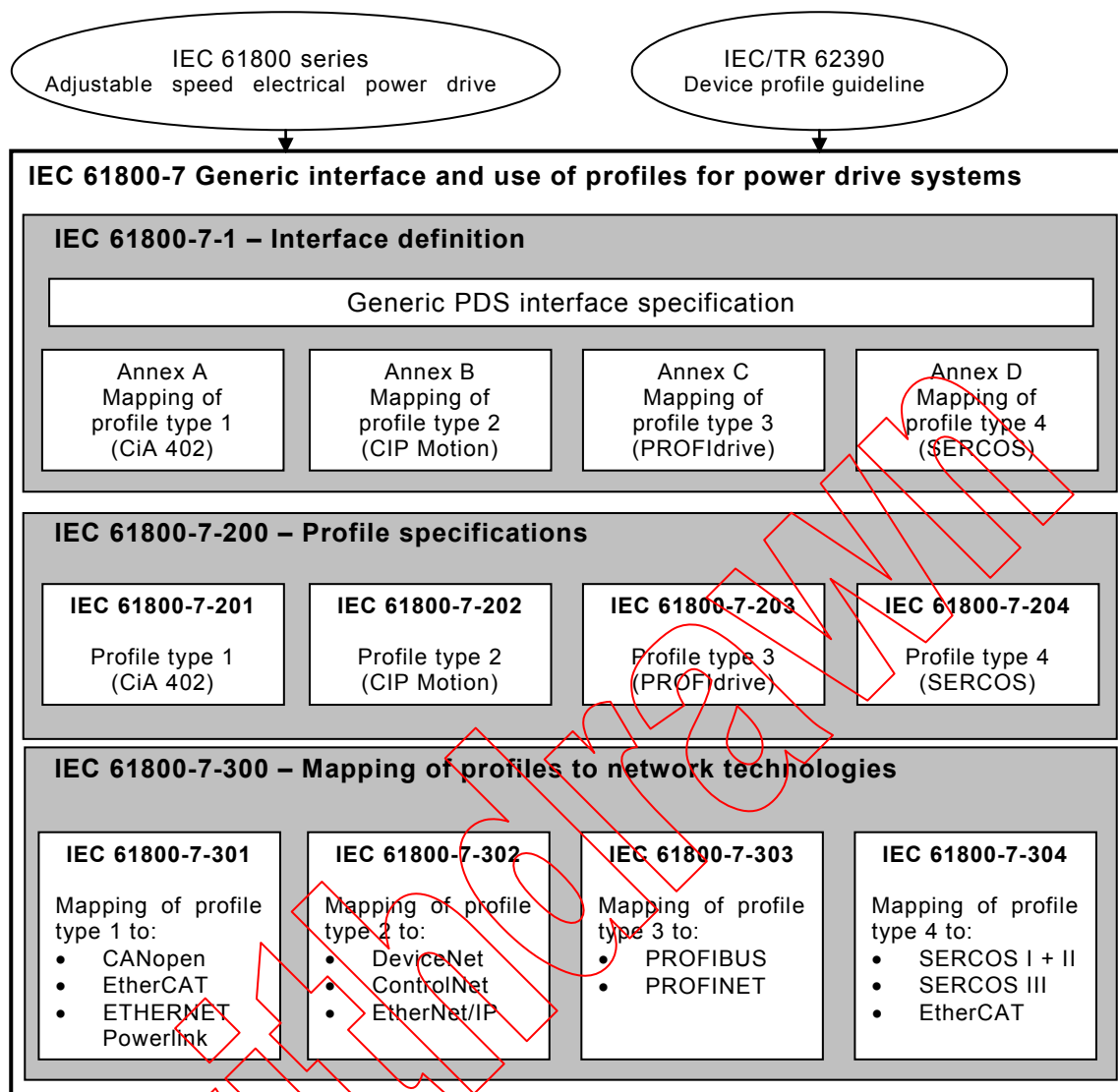


Figure 1 – Structure of IEC 61800-7

ADJUSTABLE SPEED ELECTRICAL POWER DRIVE SYSTEMS –

Part 7-303: Generic interface and use of profiles for power drive systems – Mapping of profile type 3 to network technologies

1 Scope

IEC 61800-7 specifies profiles for Power Drive Systems (PDS) and their mapping to existing communication systems by use of a generic interface model.

The functions specified in this part of IEC 61800-7 are not intended to ensure functional safety. This requires additional measures according to the relevant standards, agreements and laws.

This part of IEC 61800-7 specifies how the profile type 3 (PROFIdrive) specified in IEC 61800-7-203 onto different network technologies.

- PROFIBUS DP, see Clause 4,
- PROFINET IO, see Clause 5.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61158 (all parts), *Industrial communication networks – Fieldbus specifications*

IEC 61158-5-3, *Industrial communication networks – Fieldbus specifications – Part 5-3: Application layer service definition – Type 3 elements*

IEC 61158-5-10, *Industrial communication networks – Fieldbus specifications – Part 5-10: Application layer service definition – Type 10 elements*

IEC 61158-6-3, *Industrial communication networks – Fieldbus specifications – Part 6-3: Application layer protocol specification – Type 3 elements*

IEC 61158-6-10, *Industrial communication networks – Fieldbus specifications – Part 6-10: Application layer protocol specification – Type 10 elements*

IEC 61784-1, *Industrial communication networks – Profiles – Part 1: Fieldbus profiles*

IEC 61784-2, *Industrial communication networks – Profiles – Part 2: Additional fieldbus profiles for real-time networks based on ISO/IEC 8802-3*

IEC 61800-7, (all parts), *Adjustable speed electrical power drive systems – Generic interface and use of profiles for power drive systems*

IEC 61800-7-203, *Adjustable speed electrical power drive systems – Part 7-203: Generic interface and use of profiles for power drive systems – Profile type 3 specification*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1

actual value

value of a variable at a given instant

[IEV 351-21-02]

3.1.2

algorithm

completely determined finite sequence of operations by which the values of the output data can be calculated from the values of the input data

[IEV 351-21-37]

3.1.3

application

software functional element specific to the solution of a problem in industrial-process measurement and control

NOTE An application may be distributed among resources, and may communicate with other applications.

[IEC/TR 62390:2005, 3.1.2, modified]

3.1.4

attribute

property or characteristic of an entity

[IEC/TR 62390:2005, 3.1.3]

3.1.5

class

description of a set of objects that share the same attributes, operations, methods, relationships, and semantics

[ISO/IEC 19501, modified]

3.1.6

clock cycle synchronous application

synchronization of sampling and cycle times in the closed-loop control software in digital drives and control systems

3.1.7

commands

set of commands from the application control program to the PDS to control the behaviour of the PDS or functional elements of the PDS

NOTE 1 The behaviour is reflected by states or operating modes.

NOTE 2 The different commands may be represented by one bit each.

3.1.8

control

purposeful action on or in a process to meet specified objectives

[IEV 351-21-29]

3.1.9

control device

physical unit that contains – in a module/subassembly or device – an application program to control the PDS

3.1.10

data type

set of values together with a set of permitted operations

[ISO/IEC 2382-15:1999, 15.04.01, modified]

3.1.11

device

field device

networked independent physical entity of an industrial automation system capable of performing specified functions in a particular context and delimited by its interfaces

[IEC 61499-1:2005, 3.30, modified]

entity that performs control, actuating and/or sensing functions and interfaces to other such entities within an automation system

[ISO 15745-1:2003, 3.11]

3.1.12

device profile

representation of a device in terms of its parameters, parameter assemblies and behaviour according to a device model that describes the device's data and behaviour as viewed through a network

NOTE This is a definition from IEC/TS 61915 which is extended by the addition of the device functional structure.

[IEC/TR 62390:2005, 3.19, modified]

3.1.13

DO IO Data

collection of all Input Data and Output Data (cyclic transmission) of a Drive Object (drive axis)

3.1.14

Drive Object

functional element of a Drive Unit

3.1.15

Drive Unit

logical device which comprises all functional elements related to one central processing unit

3.1.16**functional element**

entity of software or software combined with hardware, capable of accomplishing a specified function of a device

NOTE 1 A functional element has an interface, associations to other functional elements and functions.

NOTE 2 A functional element can be made out of function block(s), object(s) or parameter list(s).

[IEC/TR 62390:2005, 3.1.12]

3.1.17**Input Data**

data to be sent cyclically from the device to the controller

3.1.18**interface**

shared boundary between two entities defined by functional characteristics, signal characteristics, or other characteristics as appropriate

[IEV 351-21-35, modified]

3.1.19**IO Data**

Input Data and Output Data of a device

3.1.20**Isochronous Mode**

communication system service for clock cycle synchronism which generates a constant (timing) bus cycle with a clock cycle signal at the start of the cycle

3.1.21**model**

mathematical or physical representation of a system or a process, based with sufficient precision upon known laws, identification or specified suppositions

[IEV 351-21-36]

3.1.22**operating mode**

characterisation of the way and the extent to which the human operator intervenes in the control equipment

[IEV 351-31-01]

3.1.23**Output Data**

data to be sent cyclically from the controller to the device

3.1.24**parameter**

data element that represents device information that can be read from or written to a device, for example through the network or a local HMI

NOTE 1 Adapted from IEC/TS 61915.

NOTE 2 A parameter is typically characterized by a parameter name, data type and access direction.

[IEC/TR 62390:2005, 3.1.22, modified]

3.1.25

Process data

data related to the control process, for example gain factor and state variables, typically mapped to parameters

3.1.26

profile

representation of a PDS interface in terms of its parameters, parameter assemblies and behaviour according to a communication profile and a device profile

3.1.27

setpoint

value or variable used as Output Data of the application control program to control the PDS

3.1.28

status

set of information from the PDS to the application control program reflecting the state or mode of the PDS or a functional element of the PDS

NOTE The different status information may be coded with one bit each.

3.1.29

technological functions

closed-loop controls and sequence controls for automation of application-specific processes

3.1.30

type

hardware or software element which specifies the common attributes shared by all instances of the type

[IEC/TR 62390:2005, 3.1.25]

3.1.31

variable

software entity that may take different values, one at a time

[IEC/TR 62390:2005, 3.1.27]

NOTE The values of a variable as well as of a parameter are usually restricted to a certain data type.

3.2 Abbreviated terms

AC x	Application Class x, where x is the number of the AC
AP	Application Process
API	Application Process Identifier
AR	Application Relationship
ASE	Application Service Element
CM	Context Management
CO	Communication Object
CR	Communication Relationship
C-LS	Controller's Sign-Of-Life
DO	Drive Object
DO-LS	Drive Object Sign-Of-Life
DP	Decentralised (distributed) Periphery
DSC	Dynamic Servo Control

DU	Drive Unit
DX	Data_Exchange
DXB	Data-eXchange-Broadcast
f	frequency
FDL	Fieldbus Data Link (Layer 2)
GAP	Area between own station address and the next one (attempt to include new active stations)
GC	Global Control Telegram
GSD	Device Data File (device description, input for a bus configuring tool)
HW	Hardware
ID	Identifier
IO AR	IO Application Relationship
IOCS	IO Consumer Status
IOPS	IO Producer Status
IO Data	IO Data; is transmitted cyclically
IP	Internet Protocol
IRT	Isochronous Realtime Ethernet
I/O	Input/Output
LS	Sign-Of-Life
MAP	Module Access Point
MSG	Acyclic services (Message)
M CR	Multicast CR
MS0 AR	PROFIBUS MS0 AR (cyclic data exchange between master (class1) and slave)
MS1 AR	PROFIBUS MS1 AR (acyclic data exchange between master (class1) and slave)
MS2 AR	PROFIBUS MS2 AR (acyclic data exchange between master (class2) and slave)
NAMUR	Standards Working Group for Instrumentation and Control in the Chemical Industry
NC	Numerical control system with a numeric control command set
OP	Operator Panel
Pxxx	Parameter (identified by number xxx)
PAP	Parameter Access Point
PC	Personal Computer
PDS	Power Drive System
P-Device	Peripheral Device (PROFIdrive Base Model)
PDU	Protocol Data Unit
PG	Programming device
PLC	Programmable Logic Controller without a Motion Control command set
PLL	Phase Locked Loop (phase control loop)
PNO	PROFIBUS User Organization
PNU	Parameter Number
PROFIBUS	Process Field Bus (see IEC 61158 Type 3 elements and IEC 61784-1)

PROFINET	Process Field Bus (see IEC 61158 Type 10 and IEC 61784-2)
RES	Reserve
RT	Realtime Ethernet
SAP	Service Access Point
SW	Software
SYNC	Synchronization
SYNCH	Synchronization Telegram (global control)
T _{BASE_DP}	Time base of TDP
T _{BASE_IO}	Time base of TI, TO
t _{BIT}	Bit-Time
TCA_Min	Lacktime for the Controller application process
TCA_Valid	Time for Input Data available
T _{DC} , T _{DC}	Data-Cycle-Time
T _{DP}	DP-Cycle-Time
T _{DP_MAX}	Maximum of TDP
T _{DP_MIN}	Minimum of TDP
T _{DX}	Data_Exchange-Time
T _J	Jitter-Time
T _I	Input-Time
T _{I_MIN}	Minimum of TI
T _{ID1}	Idle-Time 1
T _{ID2}	Idle-Time 2
T _{input_valid}	Lack time for the acquisition process
T _{IO_Input}	Time for <i>actual value</i> acquisition
T _{IO_InputMin}	Lack time for the acquisition process
T _{IO_Output}	Time for setpoint transfer
T _{IO_OutputMin}	Lack time for the setpoint transfer process
T _{IO_OutputValid}	Time for Output Data available
T _M	Master-Time
T _{MAPC}	Master_Application_Cycle-Time
T _{MLS}	Master_Life_Sign-Time
T _O	Output-Time
T _{O_MIN}	Minimum of (TO-TDX)
T _{PLL_D}	PLL-Delay
T _{PLL_W}	PLL-Window
T _{SAPC}	Slave_Application_Cycle-Time
T _{SC}	Speed Controller Sampling Time
T _{SDR}	Station_Delay_Responder Time
T _{TR}	Target_Rotation-Time
T _{WD}	Watchdog-Time
UUID	Universal Unique Identifier
TOK	Token passing
VIK	Association of the Industrial Customers and Industrial Power Producers

ZSW

Status Word

4 Mapping to PROFIBUS DP

4.1 General

This clause defines the mapping of the PROFIdrive Base Model on the PROFIBUS DP Communication System (see IEC 61158 Type 3 elements).

4.2 Mapping to PROFIBUS data types

Table 1 shows the mapping of the PROFIdrive standard data types to the PROFIBUS DP specific data types.

Table 1 – Mapping of data types

Data types used in Profile PROFIdrive	Equivalent data types in PROFIBUS DP	Reference to the definition
Boolean	Boolean	IEC 61158-5-3
Integer8	Integer8	IEC 61158-5-3
Integer16	Integer16	IEC 61158-5-3
Integer32	Integer32	IEC 61158-5-3
Unsigned8	Unsigned8	IEC 61158-5-3
Unsigned16	Unsigned16	IEC 61158-5-3
Unsigned32	Unsigned32	IEC 61158-5-3
FloatingPoint	FloatingPoint	IEC 61158-5-3
VisibleString	VisibleString	IEC 61158-5-3
OctetString	OctetString	IEC 61158-5-3
TimeOfDay (with date indication)	TimeOfDay (with date indication)	IEC 61158-5-3
TimeDifference	TimeDifference	IEC 61158-5-3
Date	Date	IEC 61158-5-3
TimeOfDay without date indication	TimeOfDay without date indication	IEC 61158-5-3
TimeDifference with date indication	TimeDifference with date indication	IEC 61158-5-3
TimeDifference without date indication	TimeDifference without date indication	IEC 61158-5-3

4.3 Base Model at PROFIBUS DP

4.3.1 Communication Devices

When using PROFIBUS DP as Communication Network, the PROFIdrive Devices are mapped to the following PROFIBUS DP objects:

Controller

The PROFIdrive Controller is represented by the PROFIBUS **DP-master (class 1)**. For example, this may be a PLC, NC or PC.

P-Device

The PROFIdrive P-Device is represented by the PROFIBUS **DP-slave**. The P-Device is related to one or more Axis of the automation system.

Supervisor

The PROFIdrive Supervisor is represented by the PROFIBUS **DP-master (class 2)**. For example this may be a PG or OP.

Figure 2 shows the topology of a typical PROFIdrive drive system using PROFIBUS DP as Communication Network.

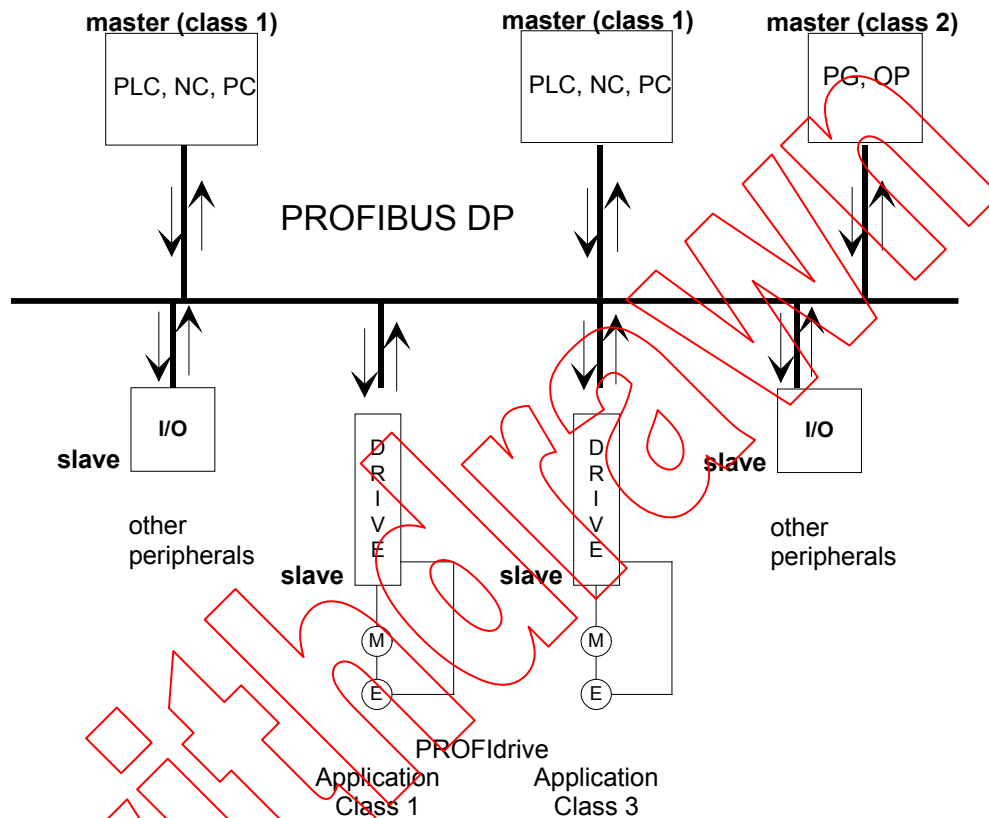


Figure 2 – PROFIBUS DP Devices in a PROFIdrive drive system

4.3.2 Communication Relationship

The PROFIdrive Communication Relationships between the Devices are mapped to PROFIBUS DP in the following way:

Controller – P-Device

Relationship is represented by **MS0 AR plus MS1 AR**

Supervisor – P-Device

Relationship is represented by **MS2 AR**

P-Device – P-Device

Relationship is represented by **cyclic data exchange between DP-slaves (DXB)**

Figure 3 shows the PROFIdrive Devices and their relationships on PROFIBUS DP.

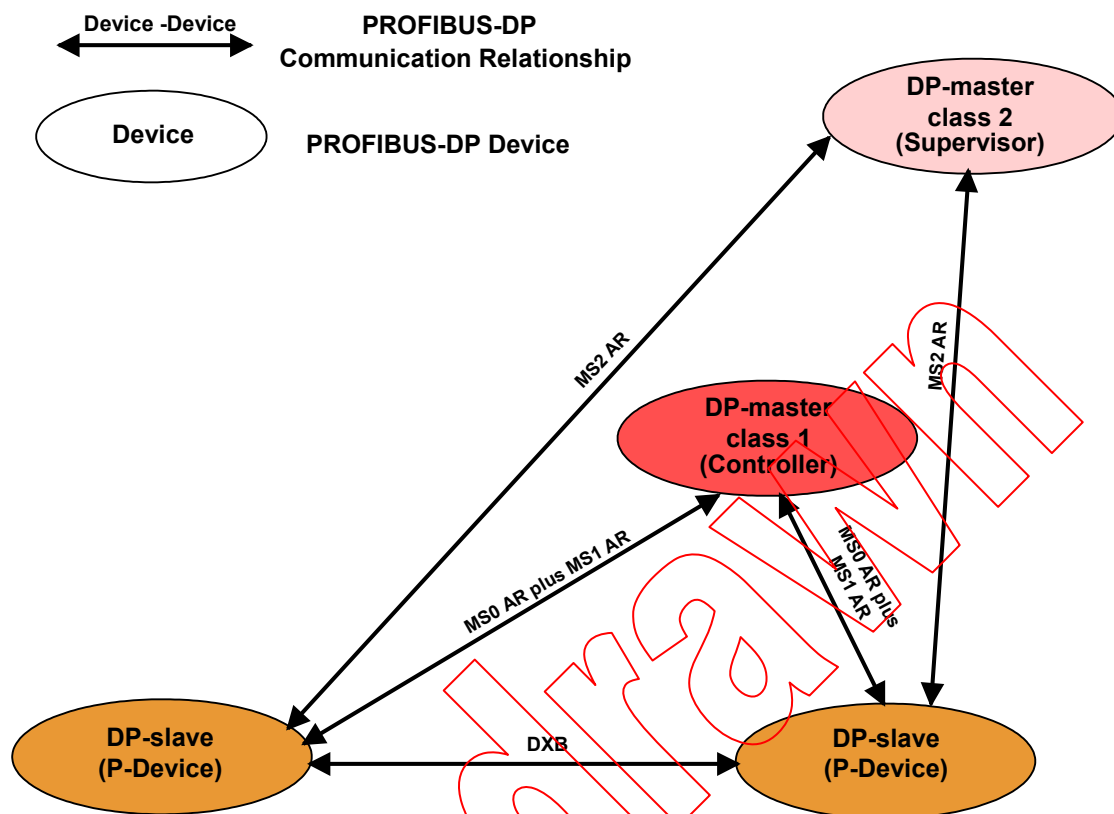


Figure 3 – PROFIdrive Devices and their Relationship for PROFIBUS DP

4.3.3 Communication Network

For PROFIBUS DP as Communication System for PROFIdrive, the PROFIdrive General Communication Model is shown in Figure 4. With PROFIBUS DP, having different Network Interfaces (master- or slave-Interface) means also having different Stations. Therefore, the Station and Device Objects in the General Communication Model are the same.

With PROFIBUS, a maximum of 126 devices – that is, masters or slaves – may be connected to one bus in single- or multi-master operation. Thus, PROFIdrive P-Devices with different Drive Objects as well as other peripherals (such as I/O) may be operated on one bus.

Therefore, the PROFIdrive Device at PROFIBUS DP is precisely defined by the following address information:

- Network (PROFIBUS bus/domain)
- Device (PROFIBUS node address)

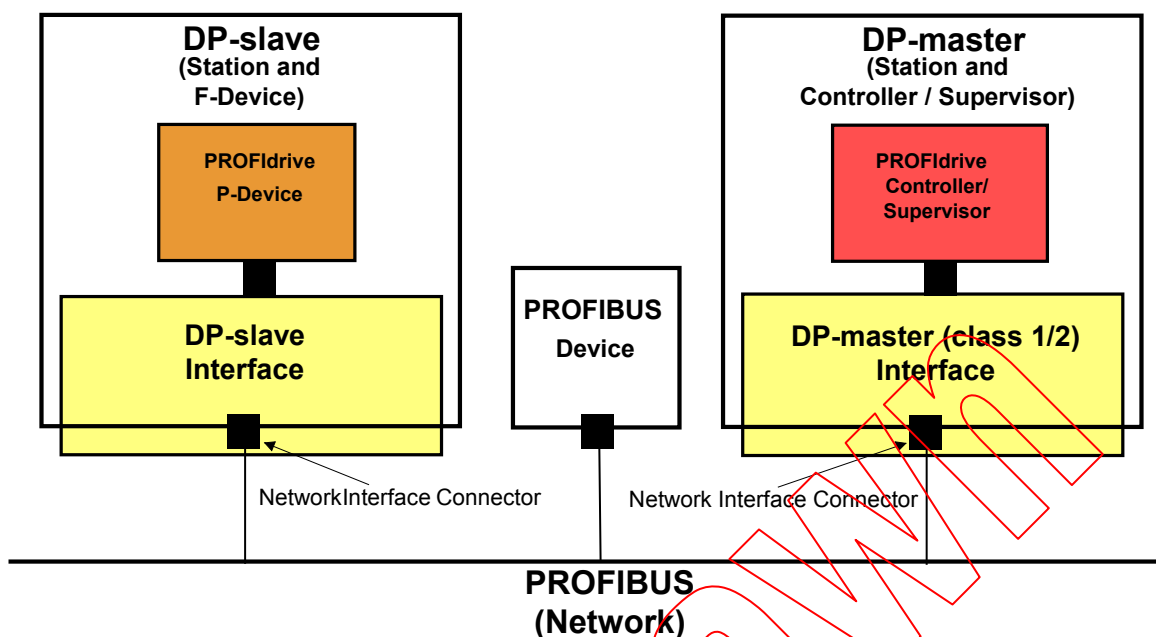


Figure 4 – General Communication Model for PROFIdrive at PROFIBUS DP

4.3.4 Communication Services

4.3.4.1 General

The PROFIdrive Base Model Communication Services are provided by the following PROFIBUS DP mechanisms:

4.3.4.2 Cyclic Data Exchange

The Cyclic Data Exchange service for PROFIBUS DP is realised by two different PROFIBUS DP communication mechanisms, depending on the communication relationship.

- For the master/slave (Controller/P-Device) relationship, the Cyclic Data Exchange is realised by use of simple transfer of user data via the Data_Exchange telegram (DX).
- For the slave/slave (P-Device/P-Device) relationship, the Cyclic Data Exchange is realised by use of the cyclic data exchange between DP-slaves (DXB) mechanism. The so-called Publisher-Subscriber-Model is based on a publisher (passive station) which provides its actual values not only to the DP master but also to all other stations (subscribers), so that the other slaves may access and process this data. Therefore, by the configuration of the PROFIBUS DP system, the DXB relationships between the DP slaves are configured and contain the information on which subscriber accesses to which publisher data. The DXB communication is coupled to the cyclic user data exchange of DP. Figure 5 shows the mechanism of the DXB communication.

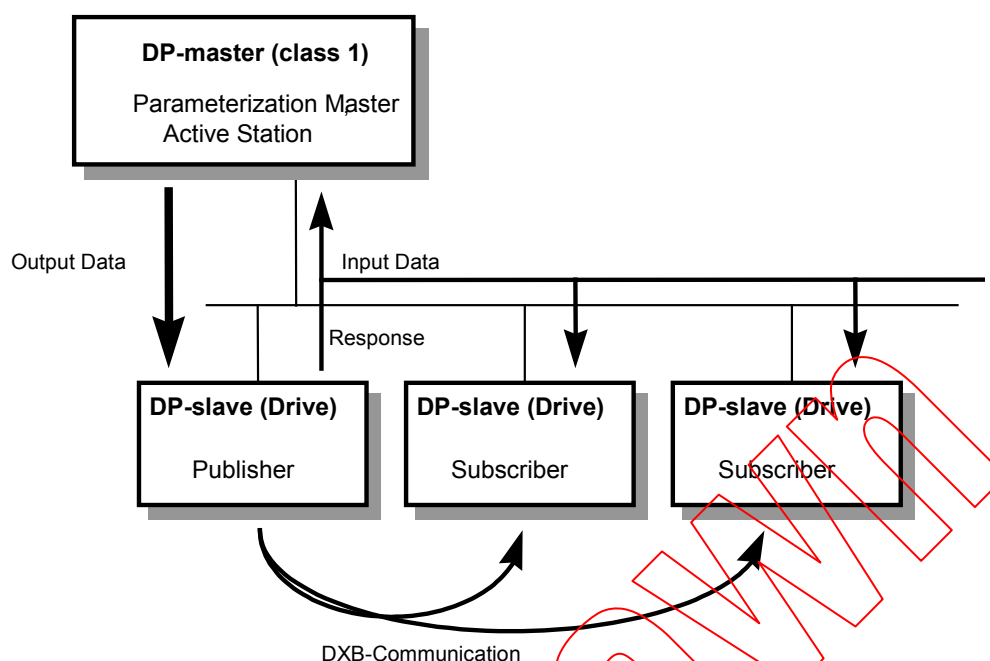


Figure 5 – PROFIBUS DP DXB communication designations

4.3.4.3 Acyclic Data Exchange

The Acyclic Data Exchange service is realised by the MS1 AR or MS2 AR of PROFIBUS DP.

Acyclic communication uses the MS1 AR and MS2 AR mechanism READ and WRITE of data block.

This allows start-up tools to be connected as DP-master (class 2) on PROFIBUS DP and a series of functions, for example reading out the DO IO Data normalisation through the control.

4.3.4.4 Alarm Mechanism

With PROFIdrive on PROFIBUS DP, the Alarm Mechanism is not used. Diagnosis and Fault management is done by use of PROFIdrive mechanism based on standard Parameter Access and the cyclic PROFIdrive control and status words.

4.3.4.5 Clock Synchronous Operation

Clock Synchronous Operation at PROFIBUS DP is done by using the PROFIBUS DP-V2 Isochronous Mode. Clock cycle synchronous operation in the PROFIBUS DP Isochronous Mode is implemented by using an isochronous clock signal. This cyclic, isochronous clock signal is transmitted as Global Control telegram from the DP-master (class 1) to all PROFIBUS slaves. Thus, the slaves supporting isochronous operation may synchronise their applications (internal/Slave Clock) with the Master Clock (see IEC 61158 Type 3 elements).

Special error mechanisms in each station make stable communication possible, even if there is a sporadic failure of the Master Clock.

For PROFIdrive, the PROFIBUS Isochronous Mode is the basis for drive synchronization. Not only message interchange on the bus system is implemented in an isochronous time frame, but also the internal control algorithms – such as closed loop speed and current controllers in the drive, or the controller in the higher level automation system – are synchronised (see Figure 6).

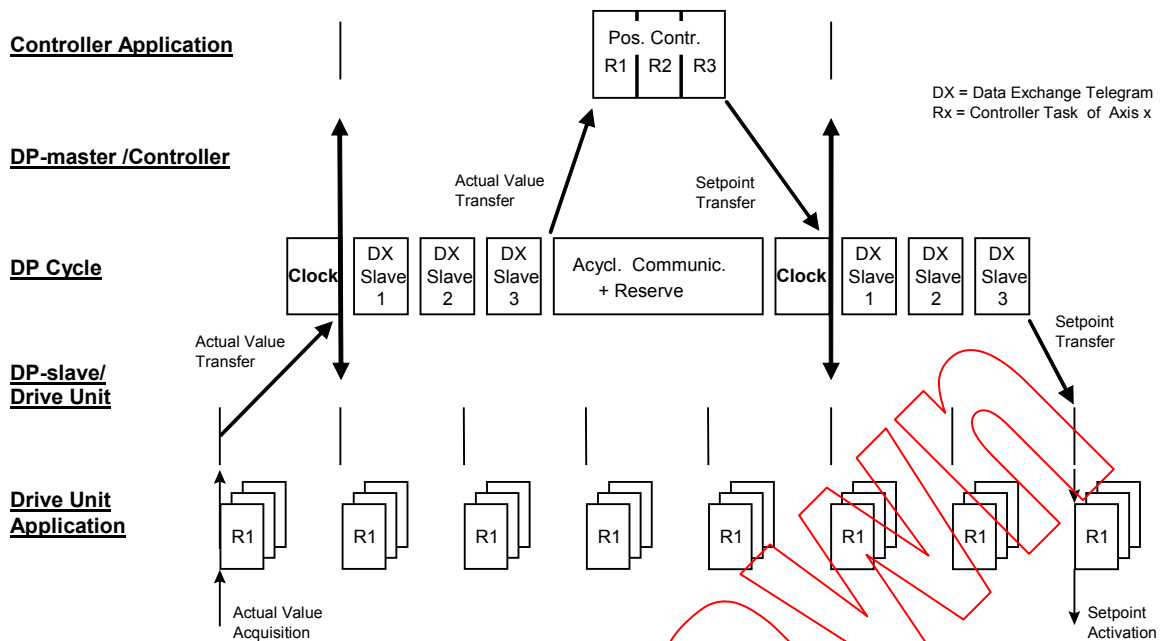


Figure 6 – Synchronous communication for PROFIdrive at PROFIBUS DP

4.3.5 P-Device Communication Model

Figure 7 shows the P-Device Communication Model when PROFIBUS DP is used as Communication System.

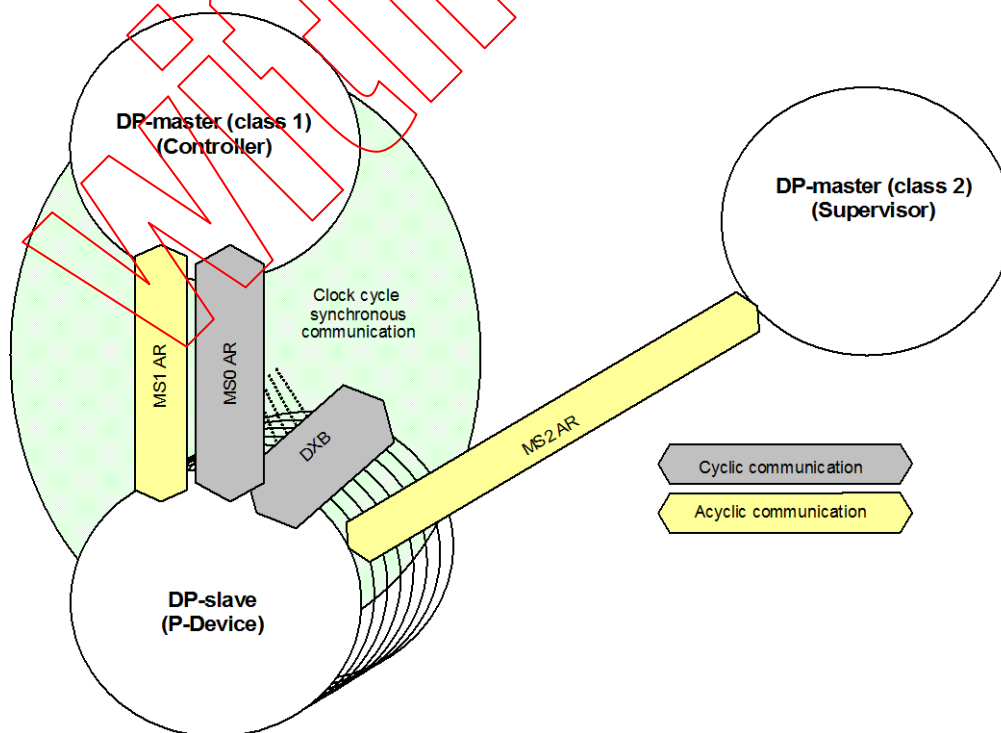


Figure 7 – Overview about the P-Device Communication Model on PROFIBUS

The type of PROFIBUS DP clock pulse generation (refer to 4.9.5) permits only one synchronous DP-master (class 1) on the bus. Additional masters on this bus may only be non synchronous DP-masters (class 1 or class 2). DP-masters class 2 are subordinated to the DP-master (class 1) with respect to the distribution of the cycle time, and thus increase the minimal DP cycle time T_{DP} (refer to 4.9).

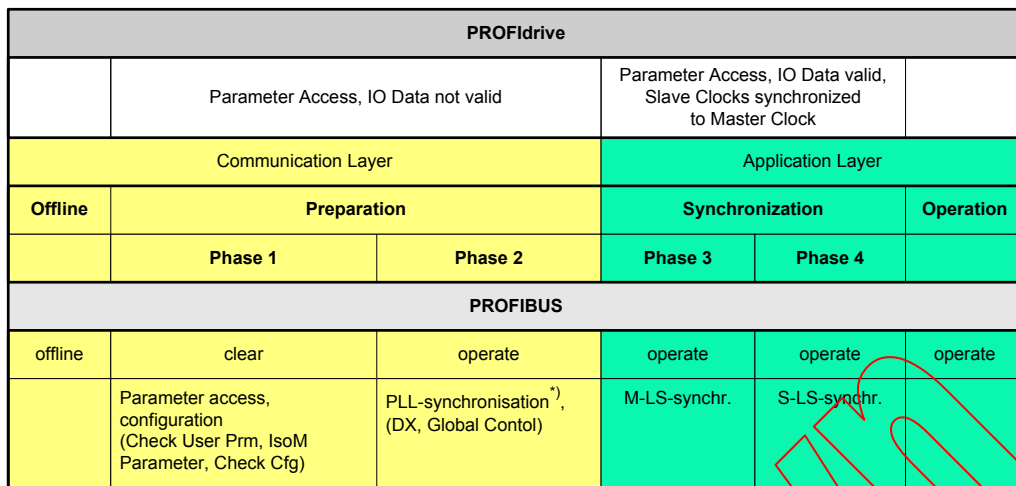
The following restrictions to bus topology are recommended when using the synchronous operation:

- A Class 1 Master may use all the available services without restrictions; other communication partners on the bus should be limited to maximum two MS2 AR channels (Services: Initiate, Read, Write, Data transport).
- A DP-master (class 2) has to be certified for the cycle synchronous applications (Token Hold Time).

4.3.6 Base Model State Machine

For PROFIdrive at PROFIBUS, the States of the PROFIdrive Base Model State Machine are mapped to the PROFIBUS states according to Figure 8. The actions to be carried out in the different phases and the corresponding PROFIBUS states are described in the following list:

- Offline: In the Offline state, no Communication Service is available. No data passes between the Devices.
- Phase1: This state is the PROFIBUS Clear state and part 1 of the PROFIdrive Preparation state. In Phase 1, the acyclic data transfer is working. Therefore Controller and Supervisor may perform a Parameter Access to the P-Device. The P-Device may also signal exceptions via the Alarm Mechanism to the Controller.
Typically in this mode, the Controller tries to parameterise the P-Devices (slaves) assigned to it, to configure them, and to prepare for start of IO Data exchange. In this state, Input and Output Data (DO IO Data) are not valid.
- Phase2: This state is part 2 of the PROFIdrive Preparation state, where the PROFIBUS is already in the operate state and the P-Devices (slaves) try to synchronise their local clocks to the Master Clock according to the specification of the Isochronous Mode. In this Phase, the Cyclic Data Exchange is active and the Global Control Telegram is sent by the DP-master (class 1). Also, the other Communication System services (MS1 AR, MS2 AR, Alarm Mechanism) are active and running.
- Phase3: This state is part 1 of the PROFIdrive Synchronization state, where the PROFIBUS is already in the operate state (Input and Output Data are valid), all Slave Clocks are synchronised to the Master Clock and the PROFIdrive Application Layer tries to synchronise their Tasks by use of the Life Sign mechanism. In this first part, the Master Life Sign (M-LS) is synchronised (see also IEC 61800-7-203, 6.3.12).
- Phase4: This state is part 2 of the PROFIdrive Synchronization state, where the PROFIBUS is already in the operate state (Input and Output Data are valid), all Slave Clocks are synchronised to the Master Clock and the PROFIdrive Application Layer tries to synchronise their Tasks by use of the Life Sign mechanism. In this second part the Slave Life Sign (S-LS) is synchronised while the Master Life Sign is already synchronised (see also IEC 61800-7-203, 6.3.12).
- Operation: In the Operation state, all Communication Services are available and active, also the Functional Objects on the Application Layer are synchronised and the whole PROFIdrive application is ready to operate.



^{*)} if clock synchronous operation is required

Figure 8 – Mapping of the Base Model State Machine at PROFIBUS DP

4.3.7 Definition of the CO

For PROFIdrive, the PROFIBUS Slot is defined as common CO. The CO/Slot should be used as Communication Object for IO Data Parameter Access.

4.4 Drive Model at PROFIBUS DP

4.4.1 P-Device

Figure 9 shows the PROFIdrive P-Device mapped on a PROFIBUS slave device. The logical address elements for the Drive Object in the PROFIBUS system are:

- PROFIBUS domain
- Node-Address
- Drive Unit
- DO-ID

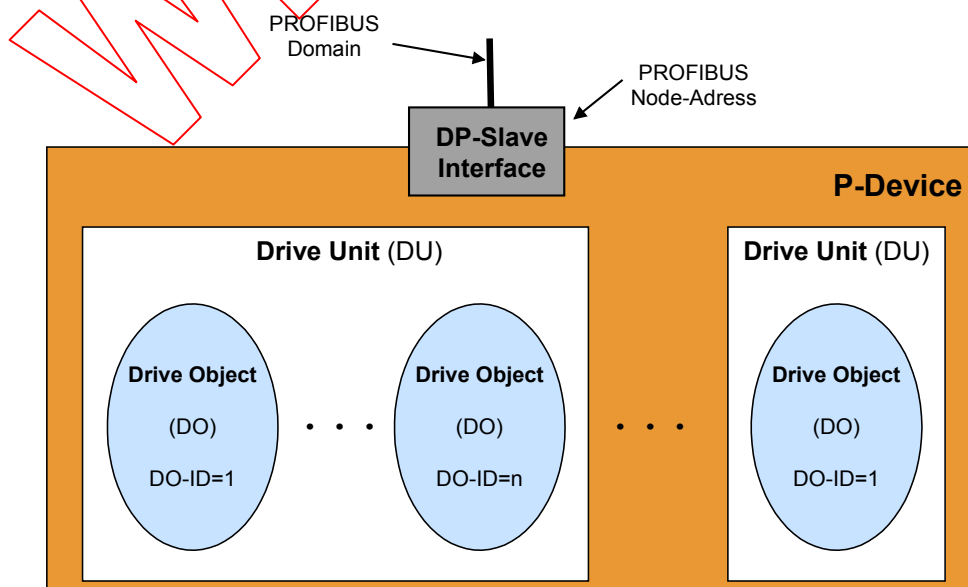


Figure 9 – PROFIBUS DP specific Logical P-Device model (multi axis drive)

4.4.2 Drive Unit

Figure 9 shows the PROFIdrive DOs inside a P-Device clustered in Drive Units (DU). The affiliation of the DOs to the DUs is relevant for the determination of the validity range of global PROFIdrive parameters. Here, the PROFIBUS slots belonging to one DU are merged to one block of consecutive slotnumbers. Mixing of slots of different DUs is not allowed.

The Identification of the DUs inside a P-Device can be done by evaluation of the global PROFIdrive parameter PNU 964.5 (number of DO) for all slots of the P-Device. The presence of PNU964 identifies the slot as a slot belonging to a PROFIdrive DO (important within heterogeneous P-Devices). Evaluation of the number of axis and correlation with the axis separator slots shows the start and the end slot of every DU.

4.5 DO IO Data

4.5.1 COs for DO IO Data configuration

Within PROFIBUS, the Slot consists of Input and/or Output Data. With PROFIdrive, the IO Data of one or more PROFIBUS Slots is mapped to setpoint values and actual values of the DO.

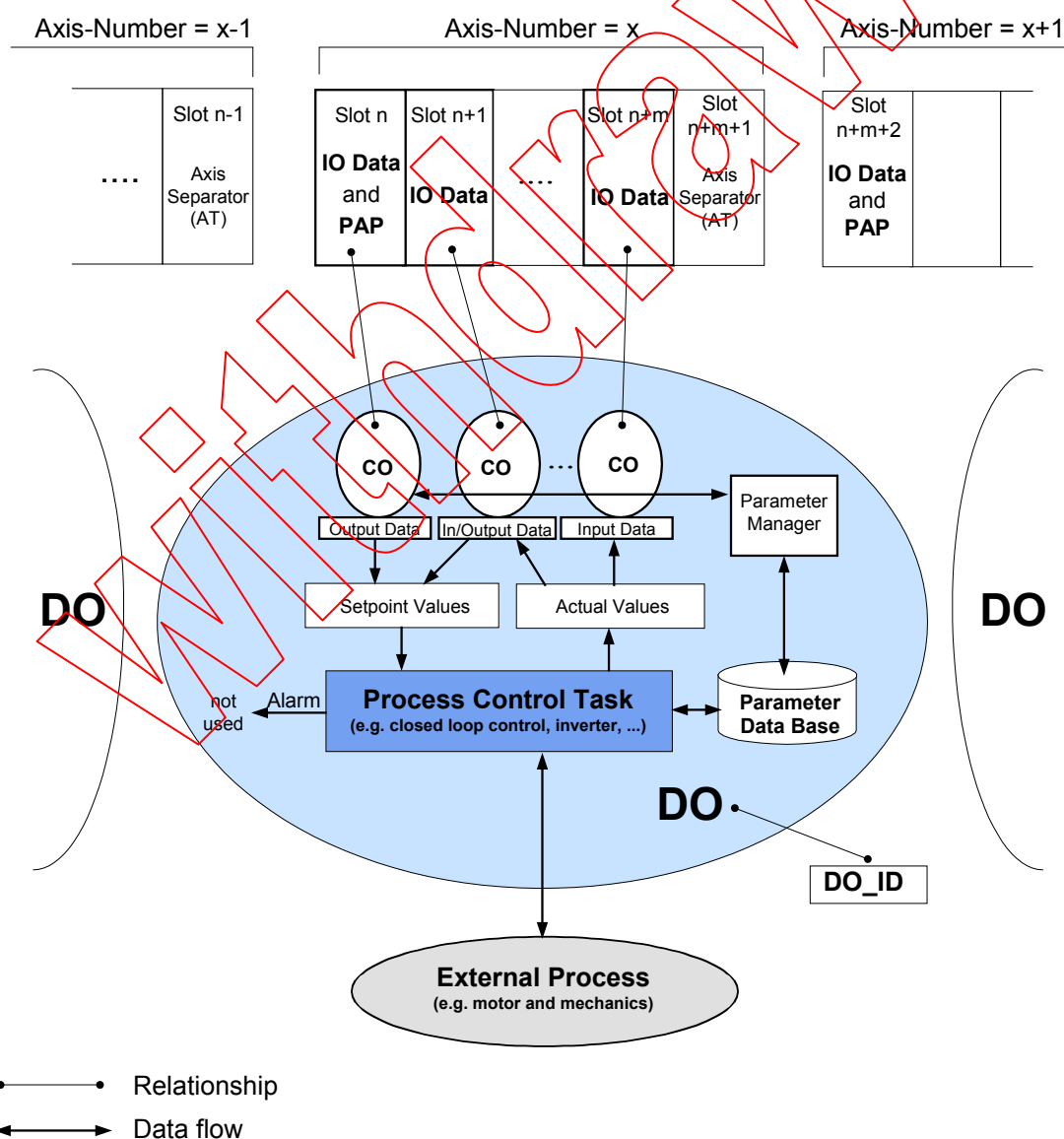


Figure 10 – Mapping of PROFIBUS Slot to the PROFIdrive DO

The mapping for a typical DO in a Multi-Axis or Modular Drive Unit is shown in Figure 10. A single axis DU consists at least out of one Slot/CO (Input/Output IO Data). In a Multi-Axis or Modular Drive Unit, the slots related to one DO are separated to the slots of the next DO by a special "Axis Separator" slot. The Axis Separator slot is empty and therefore does not comprise any IO Data.

For PROFIdrive at PROFIBUS, the following Slot types are defined:

- Standard DP-Slot (standard configuration identifier/DP ID):
 - Used for Input IO Data or Output IO Data
- Profile-specific Slots (special configuration identifier/PROFIdrive ID):
 - Axis Separator (empty/ no IO Data)
 - PROFIdrive Standard telegram (Input plus Output IO Data)
 - DXB (DXB Output IO Data)

A group of Slots belonging to one DO are identified by the Axis-Number. The Axis-Number starts with the number 1 and comprises at least one Slot. Note that the Drive Unit may consist of more DOs than the highest Axis-Number because of additional DOs without IO Data.

4.5.2 Standard telegram configuration

Every telegram type supported by the Drive Object shall be described by associated IDs. Telegrams which the master sends to the slave are interpreted as Output Data, and those telegrams which the master receives from the slave are interpreted as Input Data.

Recommendations for the DP IDs and the PROFIdrive IDs to transfer the PROFIdrive standard telegrams (defined in IEC 61800-7-203, 6.3.4.3) are shown in Table 2. The recommendations of the DP ID are given for data transfer with consistency over the complete length.

Table 2 – DP IDs and PROFIdrive IDs of the standard telegrams

Standard telegram	brief description of the standard telegrams	DP IDs		PROFIdrive IDs It is recommended to use the special configuration identifiers
		Setpoint direction	Actual value direction	
1	Speed setpoint (16 bit), no sensor, no Sign-Of-Life	IO Data component Output module 2 words 1110 0001 = 0xE1	IO Data component Input module 2 words 1101 0001 = 0xD1	2 words output, 2 word input 0xC3 0xC1 0xC1 0xFD 0x00 0x01
2	Speed setpoint (32 bit), no sensor, additional control word	IO Data component Output module 4 words 1110 0011 = 0xE3	IO Data component Input module 4 words 1101 0011 = 0xD3	4 words output, 4 words input 0xC3 0xC3 0xC3 0xFD 0x00 0x02
3	Speed setpoint (32 bit), additional control word, with one sensor	IO Data component Output module 5 words 1110 0100 = 0xE4	IO Data component Input module 9 words 1101 1000 = 0xD8	5 words output, 9 words input 0xC3 0xC4 0xC8 0xFD 0x00 0x03
4	Speed setpoint (32 bit), additional control word, with two sensors	IO Data component Output module 6 words 1110 0101 = 0xE5	IO Data component Input module 14 words 1101 1101 = 0xDD	6 word output, 14 word input 0xC3 0xC5 0xCD 0xFD 0x00 0x04

Standard telegram	brief description of the standard telegrams	DP IDs		PROFIdrive IDs It is recommended to use the special configuration identifiers
		Setpoint direction	Actual value direction	
5	Speed setpoint (32 bit), additional control word, with one sensor, DSC	IO Data component Output module 9 words 1110 1000 = 0xE8	IO Data component Input module 9 words 1101 1000 = 0xD8	9 words output, 9 words input 0xC3 0xC8 0xC8 0xFD 0x00 0x05
6	Speed setpoint (32 bit), additional control word, with two sensors, DSC	IO Data component Output module 10 words 1110 1001 = 0xE9	IO Data component Input module 14 words 1101 1101 = 0xDD	10 words output, 14 word input 0xC3 0xC9 0xCD 0xFD 0x00 0x06
7	Positioning interface (transferring traversing blocks)	IO Data component Output module 2 words 1110 0001 = 0xE1	IO Data component Input module 2 words 1101 0001 = 0xD1	2 words output, 2 words input 0xC3 0xC1 0xC1 0xFD 0x00 0x07
8	Position setpoint, speed setpoint, additional control word	IO Data component Output module 5 words 1110 0100 = 0xE4	IO Data component Input module 5 words 1101 0100 = 0xD4	5 words output, 5 words input 0xC3 0xC4 0xC4 0xFD 0x00 0x08
9	Positioning interface (with target position and velocity)	IO Data component Output module 6 words 1110 0101 = 0xE5	IO Data component Input module 5 words 1101 0100 = 0xD4	6 words output, 5 words input 0xC3 0xC5 0xC4 0xFD 0x00 0x09
20	Speed setpoint (16bit) n _{set} interface for the process technology See also IEC 61800-7-203, 6.5.5	IO Data component Output module 2 words 1110 0001 = 0xE1	IO Data component Input module 6 words 1101 0101 = 0xD5	2 words output, 6 words input 0xC3 0xC1 0xC5 0xFD 0x00 0x14
NOTE 1 For coding of the DP IDs, see IEC 61158-6-3.				
NOTE 2 The IO Data may be distributed over several modules in the master configuration for the IO Data component.				
NOTE 3 PROFIdrive IDs: The telegrams which are actually configured may be looked up in parameter P922 "telegram selection".				

Examples of configuration telegrams using DP IDs or PROFIdrive IDs for standard telegram 3 with one axis, two axis, and DXB communication are given in Table 3, Table 4 and Table 5.

Table 3 – 1 Drive Axis, standard telegram 3

Slot	1	2
DP ID	0xE4 (output)	0xD8 (input)
PROFIdrive ID	0xC3 0xC4 0xC8 0xFD 0x00 0x03	

Table 4 – 2 Drive Axes, standard telegram 3

Drive Axis	1			2		
Slot	1	2	3	4	5	6
DP ID	0xE4 (output)	0xD8 (input)	0x01 0xFE (axis separator)	0xE4 (output)	0xD8 (input)	0x01 0xFE (axis separator)
Slot	1		2	3		4
PROFIdrive ID	0xC3 0xC4 0xC8 0xFD 0x00 0x03		0x01 0xFE (axis separator)	0xC3 0xC4 0xC8 0xFD 0x00 0x03		0x01 0xFE (axis separator)

Table 5 – 2 Drive Axes, standard telegram 3, per axis one DXB link each with 2 words

Drive Axis	1				2			
Slot	1	2	3	4	5	6	7	8
DP ID	0xE4 (output)	0xD8 (input)	0x81 0xC1 0xF9 (1 DXB Link)	0x01 0xFE (axis separa- tor)	0xE4 (output)	0xD8 (input)	0x81 0xC1 0xF9 (1 DXB Link)	0x01 0xFE (axis separa- tor)
Slot	1		2	3	4	5		6
PROFIdrive ID	0xC3 0xC4 0xC8 0xFD 0x00 0x03		0x81 0xC1 0xF9 (1 DXB Link)	0x01 0xFE (axis separator)		0xC3 0xC4 0xC8 0xFD 0x00 0x03		0x81 0xC1 0xF9 (1 DXB Link)

NOTE The coding of an empty slot (0x01 0x00 0xF9) instead of the coding of a DXB-slot (0x81 0xC1 0xF9) in the configuration telegram is also valid.

An example of the configuration telegram using DP IDs or PROFIdrive IDs for standard telegram 20 with one axis is given in Table 6.

Table 6 – 1 Drive Axis, standard telegram 20

Slot	1	2
DP ID	0xE1 (output)	0xD5 (input)
PROFIdrive ID	0xC3 0xC1 0xC5 0xFD 0x00 0x14	

4.5.3 Cyclic Data exchange between DP-Slaves (DXB)

NOTE In the subsequent text, only DXB communication will be referred to. Cyclic data exchange between DP-slaves and Data-eXchange Broadcast (DXB) are synonymous. The service used for cyclic data exchange between DP-slaves of PROFIBUS DP is Data-eXchange Broadcast.

4.5.3.1 Overview

Cyclic data exchange between DP-slaves (DXB) allows DP nodes to also read the Input Data (actual values) of DP slaves either completely or in part, and use them as Output Data (setpoint values). Thus, the possible uses of PROFIBUS are expanded, particularly in the area of distributed applications in drive engineering.

Via DXB, signals may be transmitted from drive to drive; for example:

- Speed setpoint values for setting up a setpoint cascade in paper, foil, wire-drawing machines and as well as fiber stretching plants.

- Torque setpoint values for load distribution controllers of drives that are coupled mechanically or via the material, such as longitudinal line-shaft drives for a printing machine, or S-drum drives.
- Acceleration setpoint values (dv/dt) for acceleration pre-control of multiple motor drives.
- Position setpoint values, for example for an electronic shaft.

The essential features of DXB are:

- General
 - All nodes which transfer data via DXB are located in **one** PROFIBUS network.
 - All data which is transferred using DXB is exchanged in **one** DP cycle.
 - Data is transferred via DXB **cyclically** in every DP cycle.
 - The DXB relationships (links) are steady-state. This means that they cannot be re-configured during runtime without having to re-parameterise the master and the DP-slaves.
 - Every DXB communication link shall be configured using the bus configuration tool.
 - The DXB communication links are target-oriented configured for each DP-slave which receives data via DXB (Subscriber).
 - The descriptive data of the configured DXB communication links (subscriber table) is distributed to the subscribers at start-up (parameterisation).
- DP-master
 - A DP-master which may initiate DXB communication is required so that the DP-slaves may communicate with each another.
 - The DP-master receives all of the data sent from publishers as Input Data without requiring any special configuring.
 - Data in the subscriber, which is controlled from the publishers, is not sent as Output Data from the associated DP-master.
- DP-slave
 - A DP-slave may publish data via DXB (publisher function) as well as receive data (subscriber function). A drive with DXB communication which is in conformance with PROFIdrive should be able to receive data from at least one node and publish all of its Input Data.
 - The DP-slave shall also be able to operate with a standard DP-master without DXB communication. The DXB communication may be switched-on/off by an appropriately parameterised bus.
- Publisher
 - A publisher shall support the "DXB request" and "DXB response" PROFIBUS functions.
 - A publisher shall support the "Publisher_supp" key word in the GSD file.
- Subscriber
 - A subscriber shall support the key word "Subscriber_supp" in the GSD file.
 - A subscriber shall support the block structure of parameterisation data in order to load the subscriber table.
 - The Subscriber shall support a supervision mechanism (DXB-Timer) for each DXB-Link.

4.5.3.2 Application example

Figure 11 shows an example of DXB communication in a segment of a foil coating plant.

Segment of a foil coating plant

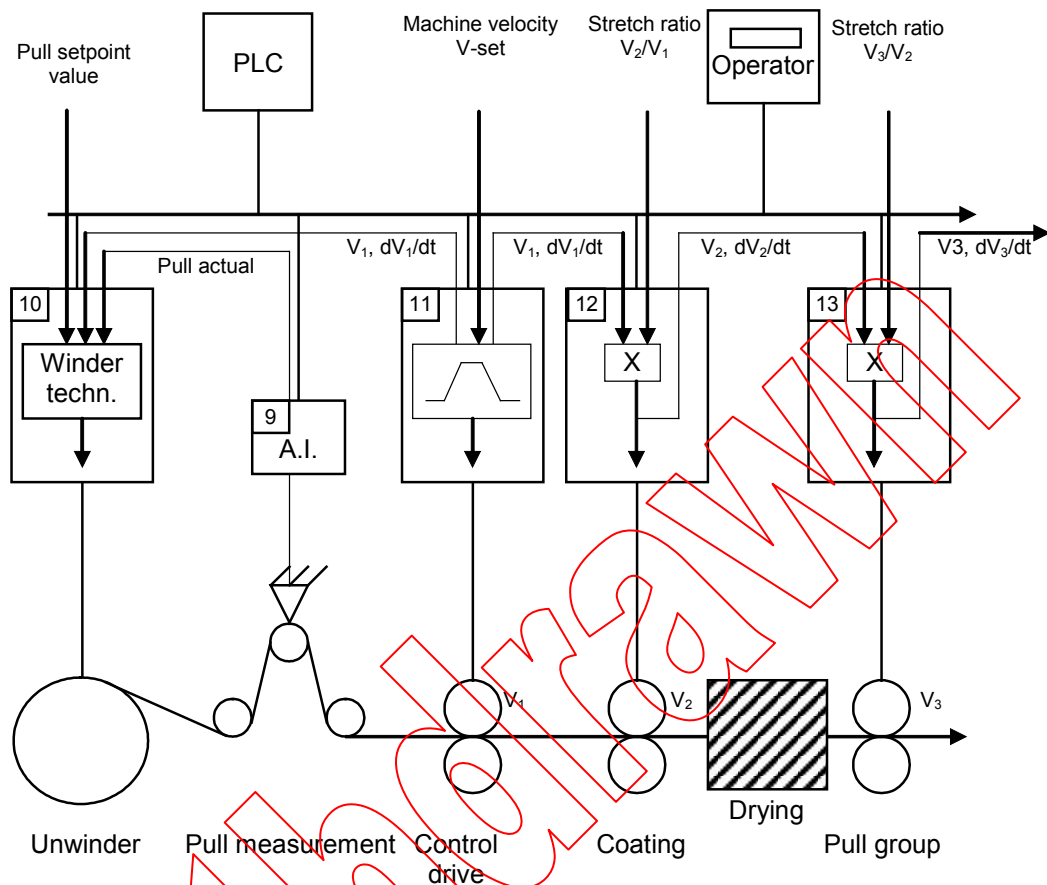


Figure 11 – Application example of DXB communication

The PLC is the PROFIBUS DP master (Class 1). All drives and distributed I/O are networked with the PLC as passive nodes (DP-slaves). The control drive receives the machine setpoint V-set from the DP-master system. The other drives receive their individual stretching ratios or the tension setpoint from the DP-master. These values are almost steady-state or changed extremely slowly.

The drives, coupled by the DXB communication of PROFIBUS form an autonomous setpoint cascade, automatically follow the speed setpoint of the central ramp-function generator computed in the control drive. The winder senses the tension actual value (also via DXB communication) from the distributed analog input of the tension measuring device. The command variables are quickly and automatically transferred from drive to drive without any computation required from the master system.

This means that the master system is relieved of time-critical (fast) setpoint calculations during acceleration and deceleration. All of the dynamic command variables are computed in a decentralised manner and distributed to the following drives via the bus.

4.5.3.3 User model and configuration

Publisher and Subscribers are modelled just like conventional DP-slaves.

Subscribers receive additional descriptive objects for the DXB communication relationships.

The bus is configured in two steps:

- First step – all of the DP-slaves are configured with their Input and Output Data.
- Second step – the DXB communication relationships are configured for each subscriber.

Configuration identifier for DXB communication in the configuration telegram:

An ID using the special configuration identifier format shall be set in the configuration string for every DXB communication link.

ID for DXB communication: 0x81; 0xCy-1; 0xF9 (y = length of link data in words)

The configuration for DXB communication is described using the example from 4.5.3.2.

The Control drive configuration is shown in Table 7:

Table 7 – Slave No.11 (Publisher)

Module	ID	I/O offset	Technological significance
1	2 words-output data	0	Control word 1
		1	
		2	V-set
		3	(machine velocity)
2	3 words-input data	0	Status word 1
		1	
		2	V1
		3	(velocity of the control drive)
		4	dV1/dt
		5	(material web acceleration)

The Configuration of the sequential drive (coating) is shown in Table 8:

Table 8 – Slave No.12 (Publisher and Subscriber)

Module	ID	I/O offset	Technological significance
1	2 words-Output Data	0	Control word 1
		1	
		2	V2/V1
		3	
2	3 words-Input Data	0	Status word 1
		1	
		2	V2
		3	
		4	dV2/dt
		5	

The sequential drive (coating) provides for the subsequent drive of the setpoint cascade V2 and dV2/dt as publisher data is shown in Table 9.

Table 9 – Configuration of the DXB communication link of the coating drive

Link	Publisher No.	I offset ^a Publisher	Length	O offset ^b Subscriber	Technological significance
1	11	2	4	4	V1
				5	(velocity of the control drive)
				6	dV1/dt
				7	(material web acceleration)
^a Offset (starts with 0 in byte) in the publisher Input Data, from which point on the subscriber should access data. ^b Offset (starts with 0 in byte) in the Output Data of the subscriber, in which the publisher data are mapped.					

The Unwinder configuration is shown in Table 10 and Table 11:

Table 10 – Slave No.10 (Subscriber)

Module	ID	I/O offset	Technological significance
1	2 word	0	Control word 1
	output	1	
	data	2	Tension setpoint
		3	
2	2 word	0	Status word 1
	Input Data	1	
		2	Tension actual value
		3	

Table 11 – Configuration of the DXB communication links of the unwinder

Link	Publisher No.	I offset ^a Publisher	Length	O offset ^b Subscriber	Technological significance
1	11	2	4	4	V1
				5	(velocity of the control drive)
				6	dV1/dt
				7	(material web application)
2	9	0	2	8	Tension actual values
				9	
^a Offset (starts with 0 in byte) in the publisher Input Data, from which point on the subscriber should access data. ^b Offset (starts with 0 in byte) in the Output Data of the subscriber, in which the publisher data are mapped.					

4.5.3.4 Device internal data mapping

With the definition of Links from the Publisher to a Subscriber, the subscriber device is capable of filtering the link data out of the relevant broadcast telegrams. Because of the axis modular structure of a PROFIdrive Device, a mapping of the link data to the axis Input Data is necessary (see Figure 12). The information for the DXB filtering and the related mapping of the filtered data to the Input Data field of the PROFIdrive Axis is combined in the DXB-Subscriber table. The structure and handling of the Subscriber Table is described in 4.5.3.5.

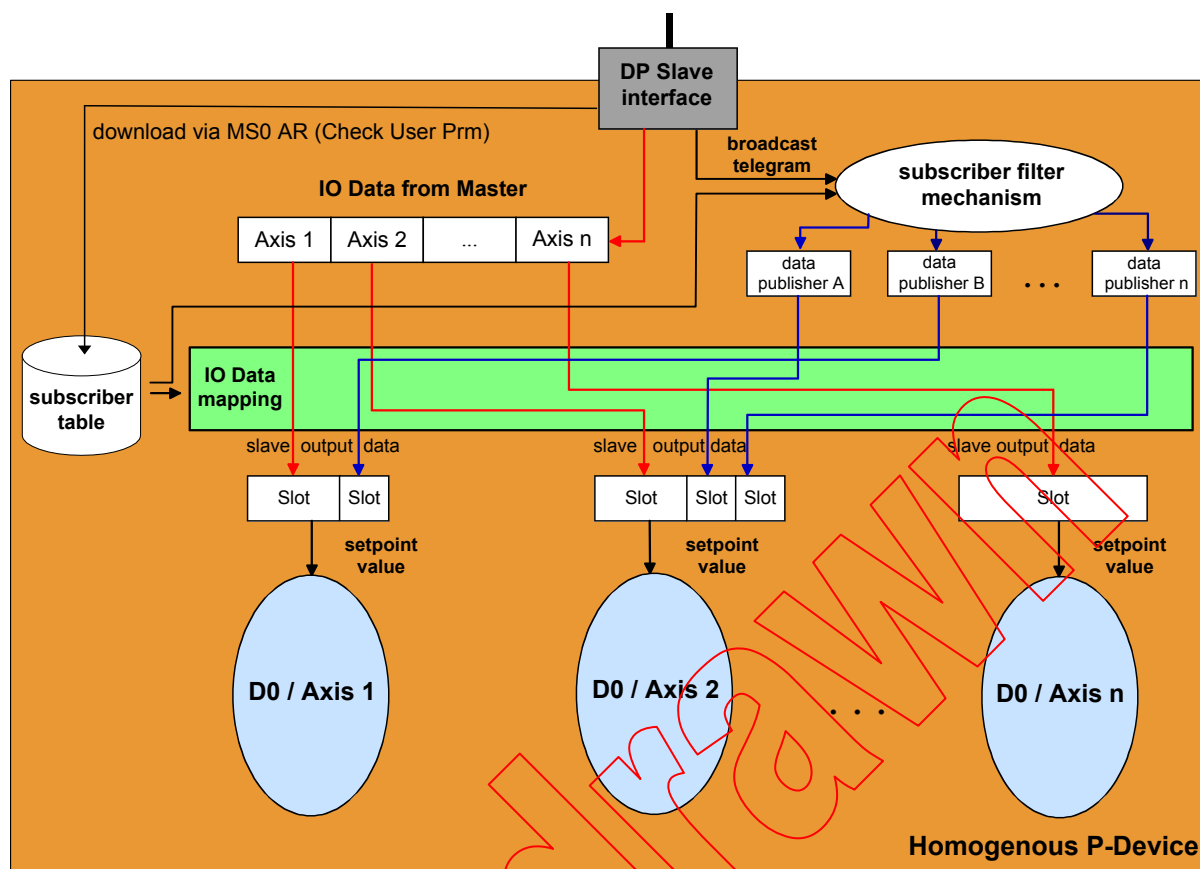


Figure 12 – Dataflow inside a Homogeneous P-Device with DXB relations

4.5.3.5 Subscriber table

4.5.3.5.1 General

In order that a DP-slave may operate as subscriber on the bus at run-up, the subscriber Table shall be loaded into the DP-slave via the Check User Prm or Check Ext User Prm service (if supported). Together with the configuration data, the DP-slave may undertake the required checks and settings and therefore map the data from the DP-master and from the publishers to its own output ranges (axis).

4.5.3.5.2 Structure of the DXB-Subscribertable

The DXB-SubscriberTable (see Figure 13) consists of one or more link blocks. The following information is saved in the link block of the subscriber table:

- Which publisher is to be accessed.
- How long the Publisher Input Data is (for test purposes).
- From which position in the Publisher Input Data the link data is to be accessed (byte offset).
- To which axis (DO) the filtered link data is to be merged.
- To which position of the axis Input IO Data stream the filtered link data is to be added.
- How many data (bytes) are to be accessed.

Element	Description	Value	Explanation
Block header	Block-Length	8 to 234	Including length byte
	Command	0x07	Identifier DXB-Subscribertable
	Slot	0	Device
	Specifier	0x00	reserved
Version	Version ID	0x01	Version 1
Link1	Publisher Address	0 to 125	Source DP-slave address
	Input Data Length Publisher	1 to 244	Length of publisher input telegram
	Source Offset Publisher	0 to 243	Offset for input data access
	Dest Slot Number	0 to 244	Slotnumber for link data mapping
	Offset Data Area	0 to 244	Offset for link data mapping
	Length Data Area	1 to 244	Length of accessed link data
Link2	Publisher Address	0 to 125	Source DP-slave address
	Input Data Length Publisher	1 to 244	Length of publisher input telegram
	Source Offset Publisher	0 to 243	Offset for input data access
	Dest Slot Number	0 to 244	Slotnumber for link data mapping
	Offset Data Area	0 to 244	Offset for link data mapping
	Length Data Area	1 to 244	Length of accessed link data
Link 3	...		
	...		

NOTE 1 In order to ensure that the system may be expanded, a version ID is provided in the subscriber table.

NOTE 2 The Table length may be determined via the length specification in the block header.

NOTE 3 If data from one publisher has to be distributed to several axis on one subscriber, this may be done by placing of multiple link entries in the subscriber table.

Figure 13 – Structure of a DXB Subscriber table (inside a Prm-Block)

4.5.3.5.3 Data transfer routes of the Subscriber table

The Subscriber Table may be transferred to the slave via two different transfer routes:

- Using the Check User Prm service (where the maximum length of the filter Table including header is limited to 234 bytes). This way is recommended because of general support by masters.
- or using the Check Ext User Prm service (where the maximum length of the filter Table including header is limited to 244 bytes).

The particular route that is used depends on the parameterisation master, the bus configuration tool and the supported services on the slave (see also 4.5.3.8).

4.5.3.6 Timing characteristics

4.5.3.6.1 Bus cycle

The DP cycle is extended by the delay times between the publisher broadcast telegrams and the next master telegram respectively (in comparison to a DP cycle without DXB communication).

Figure 14 shows telegram timing with DXB communication:

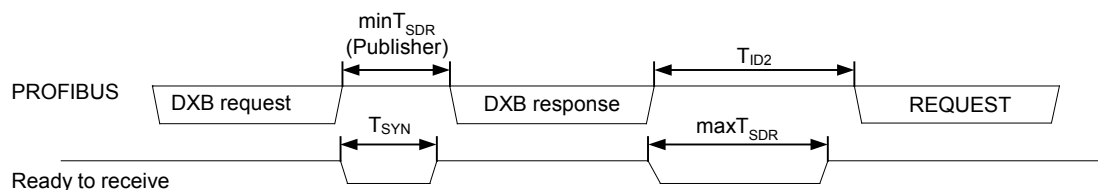


Figure 14 – Timing diagram of PROFIBUS with slave-to-slave communication

The timing may be optimised, using controllers which guarantee short response times. In this case the max. T_{SDR} shall be specified in the GSD of all of the devices. A bus configuration tool may then use this value when calculating T_{ID2} .

4.5.3.6.2 Delay time of the publisher data

At the instant that the master Output Data is received, the data of the publishers, which are in the cycle before the subscriber, are from the actual cycle; the data of the publishers, which are in the cycle after the subscriber, are from the last previous cycle. This concurrence may be optimised by using clock cycle synchronism.

4.5.3.7 Monitoring and diagnostics

4.5.3.7.1 General

The subscriber monitors a DXB communication link and may identify various errors in operation. The subscriber keeps a status report for each DXB communication link and signals every status change to its parameterisation DP-master. This means that this DP-master has essential information about the status of all of the DXB communication links.

The time and data are monitored by the subscriber for every publisher. The time monitoring interval corresponds to the response monitoring of the PROFIBUS-DP. Since the data is checked against the configured lengths, steady-state configuring errors and dynamic errors may be sensed during data transfer. When an error occurs, data cannot be re-sent as the publishers send their data as a broadcast. If the subscriber identifies a failure, it shall respond in an application-specific way and transfer a diagnostics message to the master.

The master may always interrogate the subscribers for the status of all DXB communication links. When interrogated by the master, the slave signals the statuses of the DXB communication links with the DXB link status object. In this object, the address of the publishers and the link status of every DXB communication link are transferred (see IEC 61158 Type 3 elements).

4.5.3.7.2 Monitoring the accessed data in the subscriber

In order to avoid dynamic as well as steady-state errors for the links, the subscriber shall recognise the publisher data length (this corresponds to the input data length).

- Dynamic errors may occur due to errors in the publisher (this sends data which are either too short or too long).
- Steady-state errors may occur if there are links outside the publisher data.

If a subscriber recognises a length error, the link for this publisher is not executed. The application in the subscriber may then respond appropriately.

4.5.3.7.3 Response in the subscriber for user data failure in the publisher

The response is manufacturer-specific. To recognise this failure, a sign-of-life may be used as by the DP-master/DP-slave relationship for clock cycle synchronism. The publisher generates and the subscriber monitors the sign-of-life.

4.5.3.8 Configuring, GSD extensions

The **GSD file (device data file)** is the basis and input for the configuring tool. This GSD file shall be supplied by the device manufacturer of a DP-slave which is to operate as a Subscriber/Publisher on PROFIBUS DP.

The parameters given in Table 12 are required in order to implement DXB communication:

Table 12 – Parameters (Set_Prm, GSD) for slave-to-slave communication (Data-eXchange Broadcast)

Parameter	Designation	Set_Prm	GSD	Data type	Units (in- ternal)	min. required values		Typical value	
						Publisher	Sub- scriber	(internal)	(absolute)
DPV1_ Slave	Support of the DPV1 functionality		x	Boolean (1: True)	-	--	True --	1	True
Publisher_ supp	Support of the Publisher functionality		x	Boolean (1: True)	-	True	True	1	True
Subscriber_ supp	Support of the Subscriber functionality		x	Boolean (1: True)	-	False	True	1	True
DXB_Max_ Link_Count	Number of max. possible links to different publishers		x	Unsigned8	-	--	1	8	8
DXB_Max_ Data_ Length	Maximum possible data length of a link to one publisher		x	Unsigned8	Byte	--	2	32	32
MaxTsdr_ xx	Maximum slave processing time at xx Mbaud		x	Unsigned16	tB17	≤ 800	≤ 800	400	33,2 µs ^a
DXB_Subscrib- table _Block_ _Location	Supported SAPs for DXB Subscribtable		x	Unsigned8	-	--	0	1	1
Publisher_ Addr	Publisher address of the link	x		Unsigned8	-				
Publisher_ Length	Total input data length of the Publisher	x		Unsigned8	Byte				
Sample_ Offset	Start of the link	x		Unsigned8	Byte				
Sample_ Length	Length of the link	x		Unsigned8	Byte				

^a Value at 12 Mbit/s.

If the extended parameterisation is used, then additional GSD parameters are necessary (refer to PNO/3.502).

4.6 Parameter Access

4.6.1 PAP for Parameter Access

For PROFIdrive at PROFIBUS, the Process data ASE index 47 (DS47) is defined as the PAP to provide the PROFIdrive Base Mode Parameter Access. For PROFIBUS only, the Base Mode Parameter Access – Global service is defined. The access for the Base Mode Parameter Access is done by a Process data ASE read/write on Index 47 (DS47) of the specific CO (Slot).

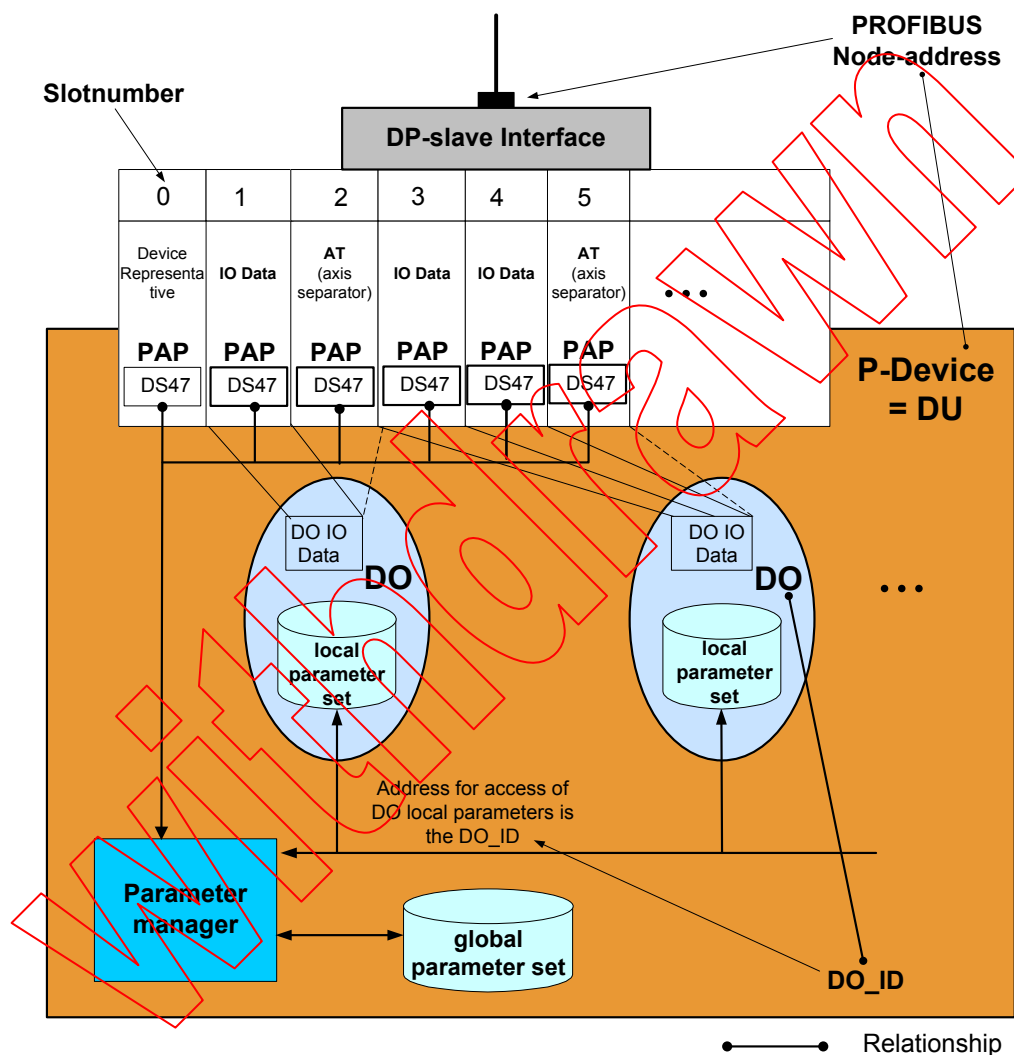


Figure 15 – PAP and Parameter Access mechanism for a PROFIBUS homogeneous P-Device

Every PROFIdrive P-Device on PROFIBUS shall support the Base Mode Parameter Access – Global via all Slots related to PROFIdrive DOs (within a DU). Homogeneous P-Devices shall support also the Base Mode Parameter Access – Global via slot 0, DS47. All PROFIdrive parameters of the complete Drive Unit (all DOs, global and local parameter) are accessible via all PAPs of a DU. Figure 15 and Figure 16 show the Parameter Access mechanism for Drive Units in different P-Devices.

The addressing of the DO local parameter is only done by the DO-ID sent to the device in the parameter request data structure (see IEC 61800-7-203, 6.2.3).

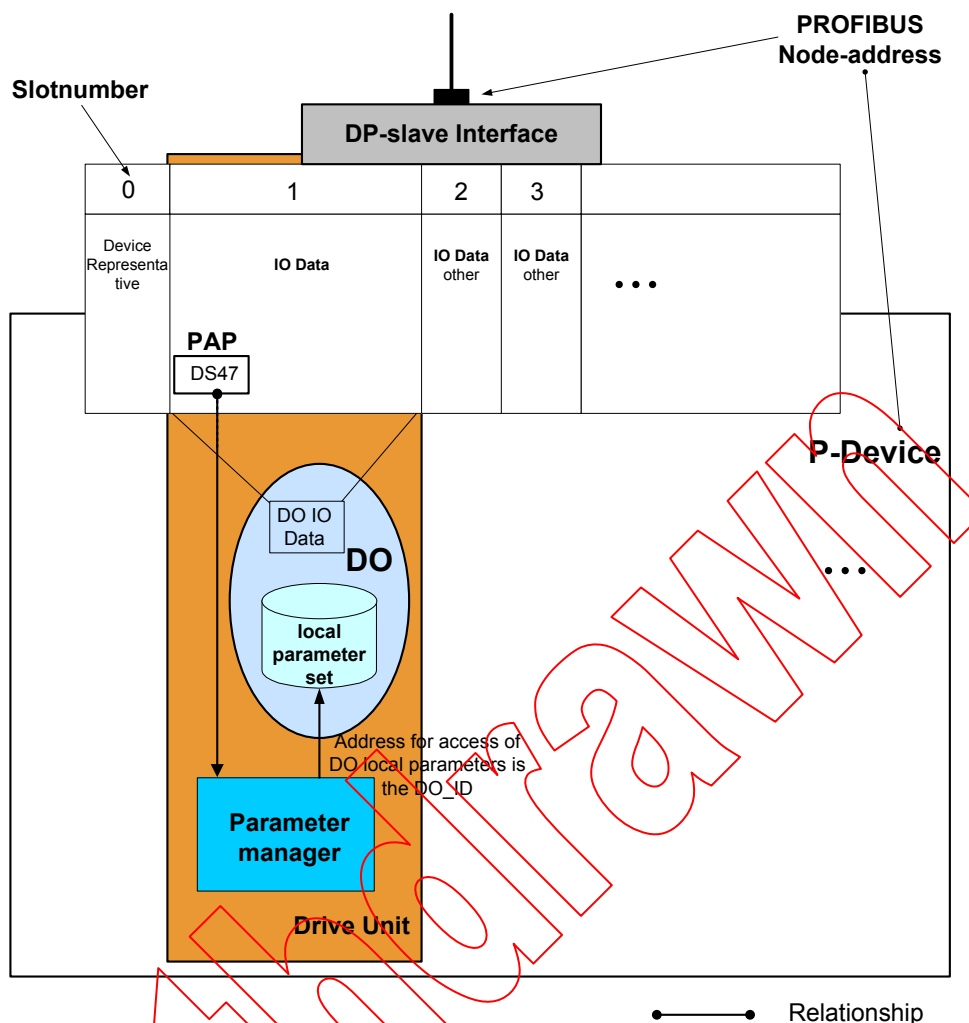


Figure 16 – PAP and Parameter Access mechanism for a PROFIBUS heterogeneous P-Device

Please note the following conventions:

- The Parameter Access to all DO of a Homogeneous P-Device shall be possible also via the Slot 0-PAP. Addressing of the DO is done by the DO-ID passed inside the request header data structure (Base Mode Parameter Access – Global).
- The P-Device of heterogeneous type shall not support a PAP at slot 0. Testing if the P-Device is of Homogeneous type can be done by read access to global parameter PNU964. If the access is successful, the P-Device is of Homogeneous type.
- Within a Drive Unit, access to the local parameters of every DO inside the DU shall be possible via every PAP related to the DU.
- The Parameter Access to a specific DO shall be possible via the PAPs of all COs (Slots) related to that DO.
- It is recommended to perform the Parameter Access to a specific DO via the PAP of the first (lowest Slotnumber) of the related Slots of the DO.

4.6.2 Definition of the Base Mode Parameter Access mechanism

4.6.2.1 General

In this subclause, the mechanism for transportation of the Base Mode Parameter Access request/response data structure by use of the MS1/MS2 AR Process data ASE read write

services is specified. Table 13 gives an overview about the PROFIBUS DP services used for the parameter channel.

Table 13 – Services used for Parameter Access on PROFIBUS DP

Service	DP	DPV1	
Master type	Class 1 (PLC)	Class 2 (PG, B&B)	
Connection type	MS0 AR	MS1 AR	MS2 AR
Service	Data Exchange	Process data ASE Read/Write	Data Transport
PROFIdrive application	DO IO Data	Parameter requests	-
NOTE The entries in bold indicate the services used for Parameter Access.			

Addressing of the PAP is done by CO/Slot and index/DS (data block). The definitions refer to the Read and Write services via the MS1 AR and MS2 AR. The Data Transport service is not used since it is only accessible for a DP-master (class 2).

The PROFIdrive Profile for drives defines the following PAPs for the Parameter Access on PROFIBUS DP (see Table 14):

Table 14 – Defined PAPs for Parameter Access

PAP	Contents	Index (Process data ASE)
Base Mode PAP	Access Point for Base Mode Parameter Access – Global	47

4.6.2.2 MS1/MS2 AR Read/Write sequences for Parameter Access

The data in the write request corresponds to the parameter request. The data in the read response corresponds to the parameter response.

A write request is first sent with the parameter request. The master shall send a read request so that the slave answers with a read response containing the parameter response (see Figure 17 and Table 15).

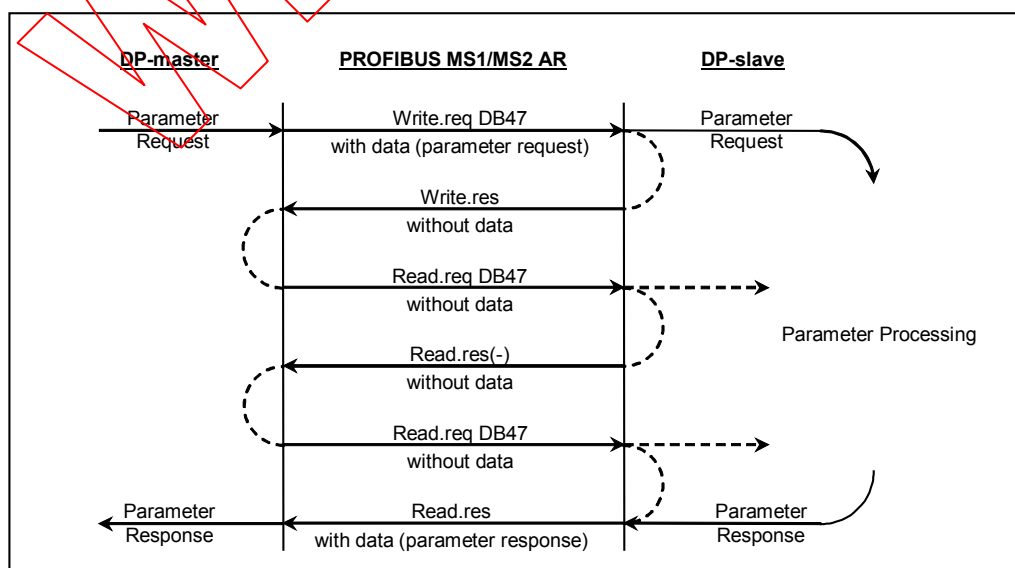


Figure 17 – Telegram sequence via MS1 AR or MS2 AR

Table 15 – State machine for DP-slave processing

Event		State			
		Connection disconnected	Idle	Request being processed	Response available
Connection being established	Action		Reset processing		
	Subsequent state	Idle	Idle		
Connection being disconnected	Action	(ignore)	Reset processing		
	Subsequent state	-	Connection disconnected		
Write.req	Action	(protocol error) Write.res(-)	Start processing Write.res(+)	Write.res(-) "state conflict"	Reject response Start processing Write.res(+)
	Subsequent state	-	Request being processed	-	Request being processed
Read.req	Action	(protocol error) Read.res(-)	Read.res(-) "state conflict"		Read.res(+)
	Subsequent state	-	-		Idle
Processing completed	Action	Reject	Reject		(internal error) reject
	Subsequent state	-	-	Response available	-
NOTE 1 Significance: the columns specify the state. The rows explain an event. Every row is subdivided into two fields. One describes the action and the other the subsequent state. NOTE 2 This state machine is valid for a MS1 AR or MS2 AR. If several connections have been set-up, then the appropriate number of state machines shall be available. The order of a MS1 AR or MS2 AR telegram sequence is always: first write request, then read request.					

4.6.2.3 MS1 AR, MS2 AR telegram frame

4.6.2.3.1 Standard case

The following four MS1/MS2 AR telegrams (see Table 16, Table 17, Table 18 and Table 19) are used for transmitting a parameter request/parameter response pair via the PAP (Slot X, Index 47):

- Transmission of the parameter request in a Write request:

Table 16 – MS1/MS2 AR telegram frame, Write request

Block	Byte n+1	Byte n
Write Header	Function_Num = 0x5F (Write)	Slot_Number =...
	Index = 47	Length = (Data)
Data (Length)	Parameter request...	
	...	

- Short acknowledgement of the parameter request with Write response (without data):

Table 17 – MS1/MS2 AR telegram frame, Write response

Block	Byte n+1	Byte n
Write Header	Function_Num = 0x5F (Write)	Slot_Number = (mirrored)
	Index = (mirrored)	Length = (mirrored)

- Request of the parameter response in a Read request (without data):

Table 18 – MS1/MS2 AR telegram frame, Read request

Block	Byte n+1	Byte n
Read Header	Function_Num = 0x5E (Read)	Slot_Number = ...
	Index = 47	Length = MAX

- Transmission of the parameter response in the Read Response:

Table 19 – MS1/MS2 AR telegram frame, Read response

Block	Byte n+1	Byte n
Read Header	Function_Num = 0x5E (Read)	Slot_Number = (mirrored)
	Index = (mirrored)	Length = (Data)
Data (Length)	Parameter response...	
	...	

Meaning and utilisation of the elements in the MS1/MS2 AR telegram Header:

- Function_Num:
ID for service (Read, Write, Error)
- Slot_Number:
MS1/MS2 AR: In the request: addressing of a real or virtual module of the DP-slave, in the response: mirrored.
PROFIdrive: no evaluation.
- Index (Process data ASE):
MS1/MS2 AR: In the request: addressing of a data block at the DP-slave, in the response: mirrored.
PROFIdrive: Index number 47 defined for parameter requests and for parameter response (DS47).
- Length:
MS1/MS2 AR: In the Write request and Read response, the length of the transmitted data in bytes.
PROFIdrive: Length of parameter request/parameter response.
MS1/MS2 AR: In the Read request, the requested length of a data block.
PROFIdrive: Maximum length possible.
MS1/MS2 AR: In the Write response, the data length accepted by the DP-slave.
PROFIdrive: Mirroring of the length from the Write request.

4.6.2.3.2 Error case

If there is an error, the reply to a Read or Write request is an error response (see Table 20).

- Process data ASE Error Response:

Table 20 – Process data ASE telegram frame, Error response

Block	Byte n+1	Byte n
Error	Function_Num = 0xDF (Error Write) = 0xDE (Error Read)	Error_Decode = 128
	Error_Code_1	Error_Code_2 = (don't care ⇒ always = 0)

- Error_Decode:
Process data ASE: ID as to how Error_Code_1/2 are to be interpreted.
PROFIdrive: always 128
- Error_Code_1:
Process data ASE: Breakdown into error class (4 bits) and error code (4 bits); refer to Table 21.
PROFIdrive: Utilising certain numbers
- Error_Code_2:
Process data ASE: Application-specific
PROFIdrive: not used (always = 0)

Table 21 – Allocation of Error class and code for PROFIdrive

Error_Class (from IEC 61158)	Error_Code (from IEC 61158)	Application PROFIdrive
0x0..0x9 = reserved		
0xA = application	0x0 = read error 0x1 = write error 0x2 = module failure 0x3 to 7 = reserved 0x8 = version conflict 0x9 = feature not supported 0xA to 0xF = user specific	
0xB = access	0x0 = invalid index	0xB0 = No PAP (DS47): parameter requests are not supported
	0x1 = write length error 0x2 = invalid slot 0x3 = type conflict 0x4 = invalid area	
	0x5 = state conflict	0xB5 = Access to PAP (DS47) temporarily not possible due to internal processing status
	0x6 = access denied	
	0x7 = invalid range	
	0x8 = invalid parameter 0x9 = invalid type 0xA to 0xF = user specific	
0xC = resource	0x0 = read constraint conflict 0x1 = write constraint conflict	
	0x2 = resource busy	
	0x3 = resource unavailable	
	0x4..0x7 = reserved	

Error_Class (from IEC 61158)	Error_Code (from IEC 61158)	Application PROFIdrive
	0x8..0xF = user specific	
0xD...0xF = user specific		

4.6.2.4 Data block lengths

If the data block length limitation of the MS1/MS2 AR Process data ASE (see IEC 61158 Type 3 elements) is used, then the following settings of the transferred data quantity, which help to optimise the DP cycle (see Table 22 and Table 23), are recommended.

Data quantities which may be transferred as a function of the maximum data block length.

Numerical data used as basis:

Table 22 – Data block lengths

(Length in bytes)	Complete	Half	Quarter
Max. Profibus length	255	127	63
FDL user data	244	116	52
MS1/MS2 AR user data	240	112	48
Parameter address and value	236	108	44
FDL header	1		
Process data ASE header	4		
Parameter header	4		
Parameter address	6		
Parameter value header	2		

Formulas:

- MS1/MS2 AR user data length required as a function of the number of parameters and number of values

MS1/MS2 AR user data length =

Parameter header (=4) +

Number of parameters × (Parameter address (=6) + Parameter value header (=2) + Format(=1,2,4) × number of values)

- Max. number of parameters for a specified MS1/MS2 AR user data length (number of values = 1)

Number of parameters =

(MS1/MS2 AR user data length – Parameter header (=4))

/ (Parameter address(=6) + Parameter value header(=2) + Format(=1,2,4))

- Maximum number of values for a specified MS1/MS2 AR user data length (number of parameters = 1)

Number of elements =

(MS1/MS2 AR user data length – Parameter header(=4)

– Parameter address(=6) – Parameter value header(=2))

/ Format(=1,2,4)

Table 23 – Limits due to the Process data ASE data block length

Object	Task	Limited by	Data block length 240 byte		Data block length 112 byte		Data block length 48 byte	
			Word	D Word	Word	D Word	Word	D Word
One parameter, several elements	Request	Number of elements	117	58	53	26	21	10
	Change		114	57	50	25	18	9
Multi-parameters, each one element	Request	Number of parameters	39	39	18	18	7	7
	Change		23	19	10	9	4	3
Description complete or string	Request	Lengths in bytes	234		106		42	
	Change		228		100		36	
Text (length=16)	Request	Number of requests	14		6		2	
	Change		14		6		2	

4.6.2.5 Scalability of the functionality

- Multi-Parameter Accesses: yes/no
- Parameter description available: yes/no
If no parameter description is available, the parameter description shall be added as a file to the drive.
- Process data ASE data block length: limitation of the data block length for the purpose of shorter bus cycles in the Isochronous Mode.

4.6.2.6 GSD parameters for MS1/MS2 AR services

The following GSD parameters in Table 24 are relevant for the MS1/MS2 AR services:

Table 24 – GSD parameters for the MS1/MS2 AR services

Parameter	Designation
DPV1_Slave	MS1/MS2 AR support
C1_Max_Data_Len	Maximum MS1/MS2 AR data block length for the communication channel with the DP-Master (class 1)
C2_Max_Data_Len	Maximum MS1/MS2 AR data block length for the communication channel with the DP-Master (class 2)
C1_Read_Write_supp	Supports the read and write services of the DP-master (class 1)
C2_Read_Write_supp	Supports the read and write services of the DP-master (class 2)
C2_Max_Count_Channels	Maximum account of active MS2 ARs of the DP-slave
NOTE The GSD entries for Isochronous Mode, Data eXchange Broadcast and MS1/MS2 AR services are given in PNO/3.502.	

4.7 P-Device Configuration

4.7.1 P-Device Configuration on PROFIBUS DP

According to the PROFIdrive Base Model, the P-Device may be of Homogeneous or Heterogeneous type. For evaluation of the P-Device type on PROFIBUS, an attempt to read the global parameter PNU964 via Slot 0, DS47 may be helpful. If the read access is

successful, the P-Device is of Homogeneous type and the parameter access shall also be possible via every Slot of this P-Device. This Homogeneous P-Device then consists exactly of one Drive Unit which comprises the whole P-Device (all Slots).

If the parameter read attempt on Slot 0 fails, the P-Device is of Heterogeneous type. In this case, the P-Device may contain one of several Drive Units. For further evaluation of the P-Device configuration, it is necessary to find out all Slots of the P-Device which are related to a PROFIdrive DO. This can be done by a Parameter read access via DS47 on the global parameter PNU964.5 (number of DOs). When the PROFIdrive Slots are found and the content of PNU964.5 of all PROFIdrive Slots is evaluated, the allocation of Slots to DOs and of Slots and DOs to Drive Units can be determined.

4.7.2 Drive Unit Configuration on PROFIBUS DP

The general Drive Unit (DU) configuration on PROFIBUS is shown in Figure 18. This Figure also shows the related data objects for IO Data, local and global parameter data and device or DO related configuration data. For the general classification of DU types see IEC 61800-7-203, 6.1.3.7.

A DU consists logically out of one or several Drive Objects (DO). The Drive Unit is represented by DO-ID=0.

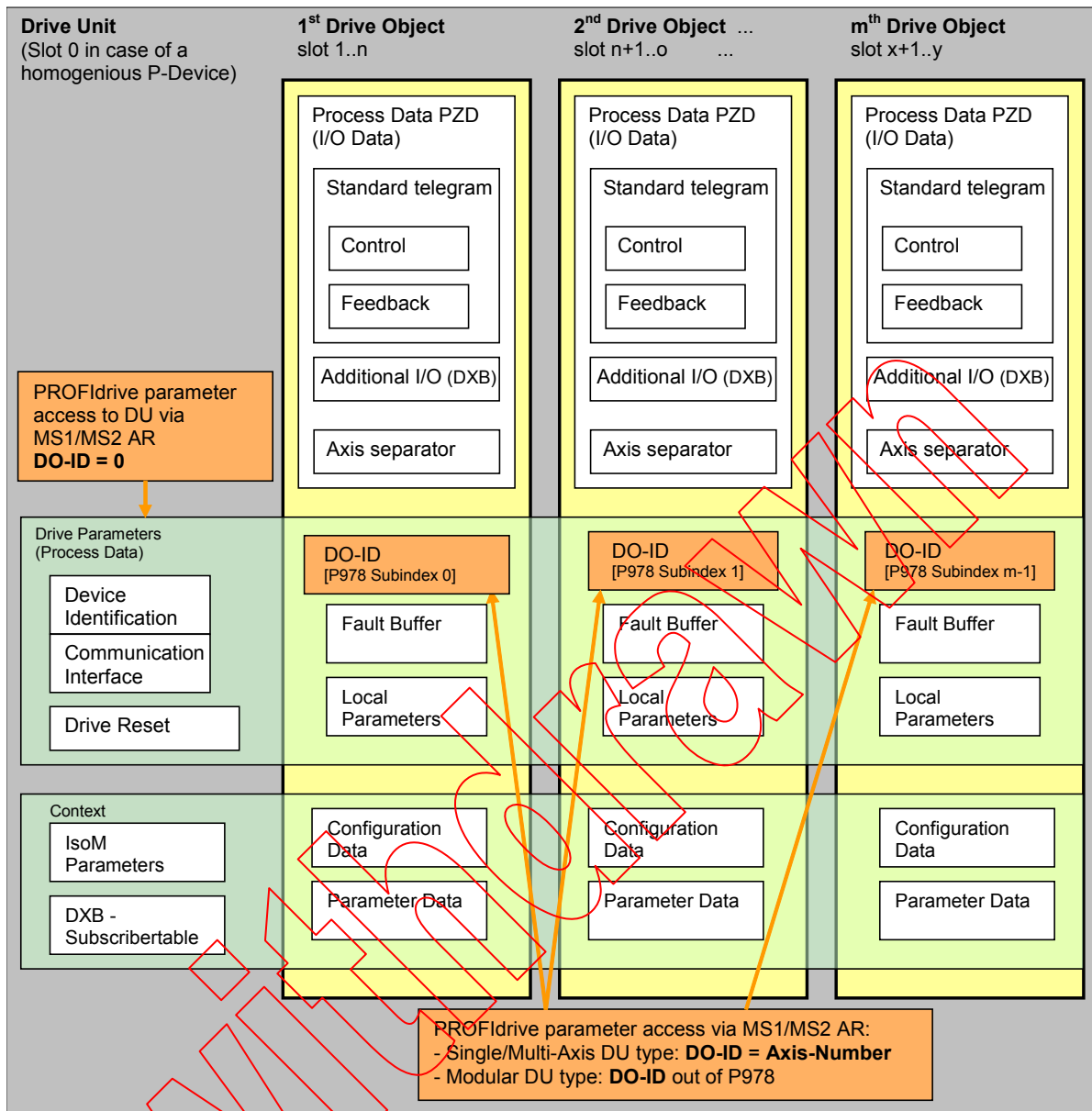
The DO consists of at least its specific parameters.

A DO of type Axis consists also of its IO Data (setpoint values, actual values), the axis specific parameters, and its axis-specific configuration data.

The DO IO Data is composed of several slots containing the IO Data of the telegrams used for this DO and the axis separator. There may be more slots for additional IO Data or DXB communication.

The context includes the configuration data of the DO. The configuration data itself consists of the configuration identifiers for each slot and the parameter data. All configuration identifiers are combined into one configuration string for this device, which is transferred to the device by the configuration telegram.

The parameter data is put together by the IsoM Parameter, the DXB-Subscribertable, and the DO specific parameters.



NOTE The expressions in parentheses are used in the PROFIBUS specification (see IEC 61158 Type 3 elements).

Figure 18 – Drive Unit Structure

Explanations:

- 1) The device itself has no IO Data, they are assigned to a DO.
- 2) The Axis Separator at the end of the last DO is optional.
- 3) If a Drive Unit consists only of one DO, the Axis Separator of this DO is optional.
- 4) Shorter configurations are allowed: if only a part of the DOs exchanges IO Data, and this part is set in the "list of DO-IDs" (refer to Drive Object – ID) in front of the DOs which do not exchange IO Data, then it is allowed to configure no axis separators for the non-used DOs.
- 5) Longer configurations are not allowed.

If the standard configuration is used, the ID required in the configuration telegram contains information on the direction (I/O), the format (word), the data length, and the data consistency (consistency over the complete length).