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Ersatzvermerk
siehe unten

Elektrische Leistungsantriebssysteme mit einstellbarer Drehzahl – Teil 7-304: Generisches Interface und Nutzung von Profilen für Leistungsantriebssysteme (PDS) – Abbildung von Profil-Typ 4 auf Netzwerktechnologien (IEC 61800-7-304:2007); Englische Fassung EN 61800-7-304:2008

Adjustable speed electrical power drive systems –
Part 7-304: Generic interface and use of profiles for power drive systems –
Mapping of profile type 4 to network technologies (IEC 61800-7-304:2007);
English version EN 61800-7-304:2008

Entraînements électriques de puissance à vitesse variable –
Partie 7-304: Interface et utilisation génériques de profils pour les entraînements électriques de puissance –
Mapping des profils de type 4 pour technologies réseaux (CEI 61800-7-304:2007);
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Mit DIN EN 61158-2:2008-09, DIN EN 61158-3-16:2008-09, DIN EN 61158-4-16:2008-09, DIN EN 61158-5-16:2008-09, DIN EN 61158-6-16:2008-09, DIN EN 61784-1:2008-10, DIN EN 61800-7-1:2008-11 und DIN EN 61800-7-204:2008-11 Ersatz für DIN EN 61491:1999-11
Siehe jedoch Beginn der Gültigkeit

Gesamtumfang 84 Seiten

DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik im DIN und VDE

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Beginn der Gültigkeit

Die von CENELEC am 2008-02-01 angenommene EN 61800-7-304 gilt als DIN-Norm ab 2008-11-01.

Daneben darf DIN 61491:1999-11 noch bis 2011-02-01 angewendet werden.

Nationales Vorwort

Vorausgegangener Norm-Entwurf: E DIN IEC 61800-7-3:2006-06.

Für diese Norm ist das nationale Arbeitsgremium K 226 „Ausrüstung von Starkstromgeräten und -anlagen mit elektronischen Betriebsmitteln“ der DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik im DIN und VDE (www.dke.de) zuständig.

Die enthaltene IEC-Publikation wurde vom SC 22G „Semiconductor power converters for adjustable speed electric drive systems“ erarbeitet.

Diese Norm erscheint ausschließlich in der englischsprachigen Originalfassung.

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Für den Fall einer undatierten Verweisung im normativen Text (Verweisung auf eine Norm ohne Angabe des Ausgabedatums und ohne Hinweis auf eine Abschnittsnummer, eine Tabelle, ein Bild usw.) bezieht sich die Verweisung auf die jeweils neueste gültige Ausgabe der in Bezug genommenen Norm.

Für den Fall einer datierten Verweisung im normativen Text bezieht sich die Verweisung immer auf die in Bezug genommene Ausgabe der Norm.

Der Zusammenhang der zitierten Normen mit den entsprechenden Deutschen Normen ergibt sich, soweit ein Zusammenhang besteht, grundsätzlich über die Nummer der entsprechenden IEC-Publikation. Beispiel: IEC 60068 ist als EN 60068 als Europäische Norm durch CENELEC übernommen und als DIN EN 60068 ins Deutsche Normenwerk aufgenommen.

Änderungen

Gegenüber DIN 61491:1999-11 wurden folgende Änderungen vorgenommen:

a) Aufnahme neuer Betriebsarten und Betriebsartenparameter;
b) Erweiterung des Zustandsgraphen;
c) Erweiterung der Funktionen zum Referenzieren;
d) Erweiterung der Diagnosefunktionen;
e) Anpassung der Koordinatensysteme;
f) Hinzufügung weiterer Grenzwerte;
g) Streichung der Funktionen zum elektronischen Getriebe.

Frühere Ausgaben

DIN 61491: 1999-11

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 61800-7-304

April 2008

ICS 29.200; 35.100.05

Partially supersedes EN 61491:1998

English version

Adjustable speed electrical power drive systems – Part 7-304: Generic interface and use of profiles for power drive systems – Mapping of profile type 4 to network technologies

(IEC 61800-7-304:2007)

Entraînements électriques de puissance à vitesse variable – Partie 7-304: Interface et utilisation génériques de profils pour les entraînements électriques de puissance – Mapping des profils de type 4 pour technologies réseaux (CEI 61800-7-304:2007)

Elektrische Leistungsantriebssysteme mit einstellbarer Drehzahl – Teil 7-304: Generisches Interface und Nutzung von Profilen für Leistungsantriebssysteme (PDS) – Abbildung von Profil-Typ 4 auf Netzwerktechnologien (IEC 61800-7-304:2007)

This European Standard was approved by CENELEC on 2008-02-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

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Foreword

The text of document 22G/185/FDIS, future edition 1 of IEC 61800-7-304, prepared by SC 22G, Adjustable speed electric drive systems incorporating semiconductor power converters, of IEC TC 22, Power electronic systems and equipment, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61800-7-304 on 2008-02-01.

This European Standard, together with its companion parts for Profile type 4 (SERCOS), partially replaces EN 61491:1998 which is at present being revised (to be issued as a Technical Report).

The following dates were fixed:

– latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2008-11-01
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2011-02-01

Annex ZA has been added by CENELEC.

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Endorsement notice

The text of the International Standard IEC 61800-7-304:2007 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 61158	NOTE	Harmonized in EN 61158 series (not modified).
IEC 61499-1	NOTE	Harmonized as EN 61499-1:2005 (not modified).
IEC 61800	NOTE	Harmonized in EN 61800 series (not modified).
IEC 61800-7-1	NOTE	Harmonized as EN 61800-7-1:2008 (not modified).
IEC 61800-7-201	NOTE	Harmonized as EN 61800-7-201:2008 (not modified).
IEC 61800-7-202	NOTE	Harmonized as EN 61800-7-202:2008 (not modified).
IEC 61800-7-203	NOTE	Harmonized as EN 61800-7-203:2008 (not modified).
IEC 61800-7-301	NOTE	Harmonized as EN 61800-7-301:2008 (not modified).
IEC 61800-7-302	NOTE	Harmonized as EN 61800-7-302:2008 (not modified).
IEC 61800-7-303	NOTE	Harmonized as EN 61800-7-303:2008 (not modified).

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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.

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IEC 61800-7-1 is divided into a generic part and several annexes as shown in Figure 1. The drive profile types for CiA 402[1], CIP Motion™[2], PROFIdrive[3] and SERCOS interface™[4] 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 4 (SERCOS™) is mapped to the network technologies SERCOS I, II, III and EtherCAT™[5].

IEC 61800-7-301, IEC 61800-7-302 and IEC 61800-7-303 specify how the profile types 1, 2 and 3 are mapped to different network technologies (such as CANopen[6], EtherCAT™, Ethernet Powerlink™[7], DeviceNet™[8], ControlNet™[9], EtherNet/IP™[10], PROFIBUS[11] and PROFINET[12]).

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1 CiA 402 is a trade name of CAN in Automation, e.V. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by IEC of the trade name holder or any of its products. Compliance to this profile does not require use of the trade name CiA 402.

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5 EtherCAT™ is a trade name of Beckhoff, Verl. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by IEC of the trademark holder or any of its products. Compliance to this profile does not require use of the trade name EtherCAT™. Use of the trade name EtherCAT™ requires permission of the trade name holder.

6 CANopen is an acronym for *C*ontroller *A*rea *N*etwork *open* and is used to refer to EN 50325-4.

7 Ethernet Powerlink™ is a trade name of B&R, control of trade name use is given to the non profit organization EPSG. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by IEC of the trademark holder or any of its products. Compliance to this profile does not require use of the trade name Ethernet Powerlink™. Use of the trade name Ethernet Powerlink™ requires permission of the trade name holder.

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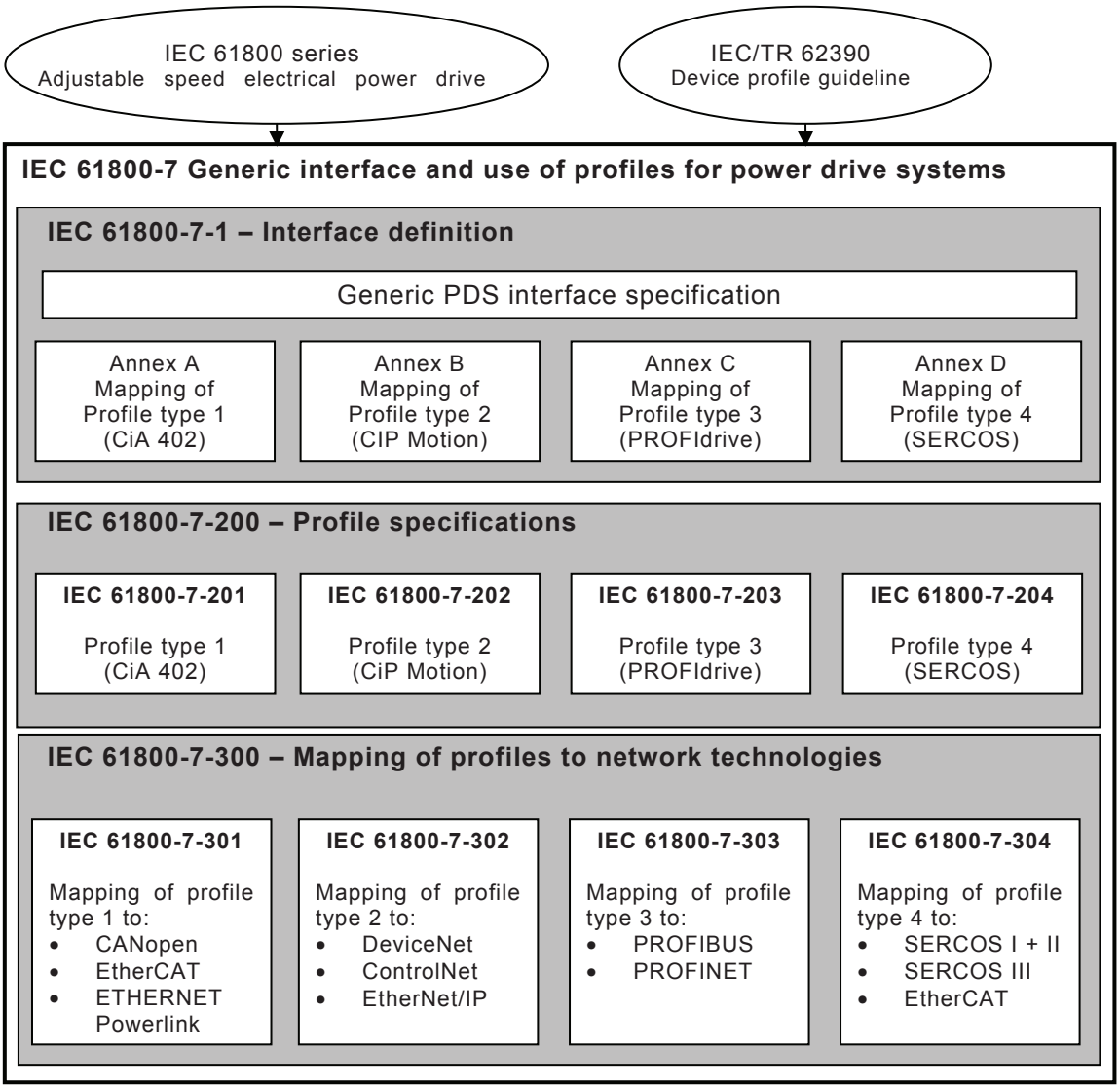

Figure 1 – Structure of IEC 61800-7

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ADJUSTABLE SPEED ELECTRICAL POWER DRIVE SYSTEMS –

Part 7-304: Generic interface and use of profiles for power drive systems – Mapping of profile type 4 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 the mapping of the profile type 4 (SERCOS) specified in IEC 61800-7-204 onto different network technologies.

- SERCOS I / II, see Clause 5,
- SERCOS III, see Clause 6,
- EtherCAT, see Clause 7.

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 61158-2, *Industrial communication networks – Fieldbus specifications – Part 2: Physical layer specification and service definition*

IEC 61158-4-16, *Industrial communication networks – Fieldbus specifications – Part 4-16: Data-link layer protocol specification – Type 16 elements*

IEC 61158-5-16, *Industrial communication networks – Fieldbus specifications – Part 5-16: Application layer service definition – Type 16 elements*

IEC 61158-6-16, *Industrial communication networks – Fieldbus specifications – Part 6-16: Application layer protocol specification – Type 16 elements*

IEC 61491:2002, *Electrical equipment of industrial machines – Serial data link for real-time communication between controls and drives*

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*

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IEC 61800-7-204, *Adjustable speed electrical power drive systems – Part 7-204: Generic interface and use of profiles for power drive systems – Profile type 4 specification*

ISO/IEC 8802-3:2000, *Information technology -Telecommunications and information exchange between systems - Local and metropolitan area networks – Specific requirements – Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications*

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
Acknowledge Telegram
AT
telegram, in which each slave inserts its data

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
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.

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3.1.7
communication cycle
accumulation of all telegrams between two master synchronisation telegrams

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
control unit
control device

3.1.11
control word
two adjacent bytes inside the master data telegram containing commands for the addressed PDS

3.1.12
cycle time
time span between two consecutive cyclically recurring events

3.1.13
cyclic communication
the periodic exchange of telegrams

3.1.14
cyclic data
the part of the telegram which does not change its meaning during cyclic operation of the interface

3.1.15
cyclic operation
devices in the communication network are addressed and queried one after the other at fixed, constant time intervals

3.1.16
data exchange
demand dependent, non cyclic transmission of information after a request was sent by the master (service channel)

3.1.17
data type
set of values together with a set of permitted operations

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

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3.1.18
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, modified]

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

[ISO 15745-1:2003]

3.1.19
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, 3.1.9, modified]

3.1.20
fibre optic cable
transmission medium for serial data transmission of optical signals

3.1.21
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]

3.1.22
identification number
IDN
designation of operating data under which a data block is preserved with its attribute, name, unit, minimum and maximum input values, and the data

3.1.23
input data
data transferred from an external source into a device, resource or functional element

[IEC/TR 62390:2005, 3.1.14]

3.1.24
interface
shared boundary between two entities defined by functional characteristics, signal characteristics, or other characteristics as appropriate

[IEV 351-21-35, modified]

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3.1.25
line
network topology in which the transmission medium is routed from station to station in the form of a line. The information is transmitted in one direction from the master down to the last slave in the line, and then flows back to the master via all the slaves in the reverse order (CP16/3, CP12)

3.1.26
master
node, which assigns the other nodes the right to transmit

3.1.27
Master Data Telegram
MDT
telegram, in which the master inserts its data

3.1.28
Master Synchronisation Telegram
MST
telegram transmitted by the master, which sends a time synchronisation signal to the slave(s) in a single network

3.1.29
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]

3.1.30
non-cyclic transmission
non-periodic exchange of data at the request of the master

3.1.31
operating cycle
period of the control loop within the PDS or the control unit

3.1.32
operating mode
characterisation of the way and the extent to which the human operator intervenes in the control equipment

[IEV 351-31-01]

3.1.33
output data
data originating in a device, resource or functional element and transferred from them to external systems

[IEC/TR 62390:2005, 3.1.21]

3.1.34
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.

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

3.1.35
PDS enable
command to close the feedback loop(s)

3.1.36
PDS on
command that the power stage can be activated

3.1.37
profile
representation of a PDS interface in terms of its parameters, parameter assemblies and behaviour according to a communication profile and a device profile

3.1.38
protocol
convention about the data formats, time sequences, and error correction in the data exchange of communication systems

3.1.39
ring, ring structure
network topology in which the transmission medium is routed from station to station in the form of a ring. The information is transmitted only in one direction (CP16/1, CP16/2) or in both directions (CP16/3)

3.1.40
slave
node, which is assigned the right to transmit by the master

3.1.41
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.

3.1.42
status word
two adjacent bytes inside the PDS telegram containing status information

3.1.43
telegram
dataset

3.1.44
topology
physical network architecture with respect to the connection between the stations of the communication system

3.1.45
transmission medium
collective term for the real form of the physical connection between the stations of a communication network

NOTE For instance, fibre optic cable.

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3.1.46
type
hardware or software element which specifies the common attributes shared by all instances of the type

[IEC/TR 62390:2005, 3.1.25]

3.2 Abbreviated terms

ADR	Address of a telegram. PDS address is XX [1 ≤ XX≤ 254]
AT	Acknowledge Telegram
C1D	Class 1 Diagnostic
C2D	Class 2 Diagnostic
C3D	Class 3 Diagnostic
IDN	Identification Number
I/O	Input/Output
K	Number of data records in the MDT (see also M)
k	Time sequence of data records in the MDT, labelled as k= 1 to K
M	Number of PDSs in one network (see also K)
m	Time sequence of the ATs, labelled as m = 1 to M
MDT	Master data telegram
MST	Master sync telegram
NC	Numerical control (also control unit or controller)
PDS	Power Drive System
PLC	Programmable logic controller without a motion control command set
RT	Real-time
SERCOS	SErial Real time COmmunication System
t3	Command value valid time
t4	Feedback acquisition capture point
t5	Minimum feedback processing time
tMTSG	Command value processing time
tNcyc	Control unit cycle time
tRcyc	PDS control loop cycle time
tScyc	Communication cycle time
XX	Address of a PDS

4 General

This mapping defines among others the mapping to CP16/1 (SERCOS I), which has been previously specified in IEC 61491:2002. The IEC maintenance group has decided to incorporate it in this standard as well as in the IEC 61158 and IEC 61784 communication standard families, while specifying the mapping of the SERCOS drive profile to the communication profiles CP16/2 (SERCOS II), CP16/3(SERCOS III) and CP12 (EtherCAT).

In this part of IEC 61800-7, the mapping of the SERCOS drive profile (IEC 61800-7-204) to the CPF16 (SERCOS I, II and III) and CP12 (EtherCAT) communication profiles is described.

The SERCOS CP16/1 and CP16/2 interface use fibre optic transmission between control units and PDSs. As a result, interference is eliminated.

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The SERCOS CP16/3 and EtherCAT CP12 use Ethernet data transmission instead. It may be realised either using 100BASE-TX (wire) or 100BASE-FX (fibre optic) depending upon the immunity performance needs.

5 Mapping to CP16/1 (SERCOS I) and CP16/2 (SERCOS II)

5.1 Reference to communication standards

CP16/1 and CP16/2 are specified in the IEC 61158 standard family. The detailed references are listed in the corresponding part of IEC 61784-1, which shows also the differences between these two communication profiles.

5.2 Overview

Table 1 summarises the major features of CP16/1 and CP16/2.

Table 1 – CP16/1 and CP16/2 feature summary

Feature	CP16/1	CP16/2
Topology	Ring	Same as CP16/1
Data flow	From the master to the 1st slave, then to the next one, and so on until the last slave, then to the master (simplex communication between each participant)	Same as CP16/1
Communication medium	Fibre optic	Same as CP16/1
Transmission rate	2 or 4 Mbit/s	Same as CP16/1 In addition: 8 or 16 Mbit/s
Transmission rate setting	Manual setting (e.g., using a switch)	Same as CP16/1 In addition: Automatic baud rate recognition
Cycle time t_{Scyc}	62,5 µs, 125 µs, 250 µs, 500 µs, and up to 65 ms by steps of 250 µs.	Same as CP16/1
Number of slaves	Up to 254	Same as CP16/1
Device address ADR	$1 \leq ADR \leq 254$	Same as CP16/1
Synchronisation telegram	MST	Same as CP16/1
Slave telegrams	1 AT per PDS	Same as CP16/1
Master telegram	1 MDT	Same as CP16/1
Telegram order within a cycle	Compulsory: MST – ATs – MDT	Same as CP16/1
Non cyclic communication	Service channel (SVC): 2 bytes are reserved for each slave within AT and MDT	Same as CP16/1 In addition: It shall be possible to configure each slave for 4, 6, or 8 bytes within SVC
Initialisation	Automatic at power-up ($t_{Scyc} \geq 1$ ms) 4 intermediate communication phases (CP0 to CP3) before reaching normal operation (CP4)	Same as CP16/1
File transfer	Using the service channel	Same as CP16/1 In addition: Communication phases (CP5 and CP6) for file transfer

The exact number of PDSs which can be serviced per communication network depends on the cycle time, the selected data volume, and the transmission rate. The number of PDSs per control unit can

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also be expanded by using several networks. Table 2 shows some examples that are valid under normal operating conditions. The spare time is available for transmitting other data (e.g., communication with PLC-like I/Os) or as a safety margin to be used for later application developments.

Table 2 – Number of PDSs per network (examples)

Communication profile	Transmission rate	Cycle time	Data record to each PDS	Data record from each PDS	Number of PDSs	Data rate (service channel) per PDS	Spare time
CP16/1 and 16/2	2 Mbit/s	2 ms	32 byte	32 byte	8	8 kbit/s (2 bytes)	390 µs
CP16/1 and 16/2	4 Mbit/s	1 ms	32 byte	32 byte	8	16 kbit/s (2 bytes)	125 µs
CP 16/2	8 Mbit/s	1 ms	36 byte	36 byte	15	32 kbit/s (4 bytes)	208 µs
CP 16/2	16 Mbit/s	500 µs	36 byte	36 byte	14	128 kbit/s (8 bytes)	113 µs
CP 16/2	16 Mbit/s	2 ms	16 byte	16 byte	112	8 kbit/s (2 bytes)	330 µs

IEC 61800-7-204 standardises the formats and scaling factors for operation data exchange between control units and PDSs. During initialisation, the operation of the interface is configured according to the performance characteristics of the control unit and the PDSs. Therefore, the velocity and/or position control is implemented by either the PDS or the control unit.

The control unit is capable of synchronising all connected PDSs by way of cyclic data exchange for command and feedback values, including exact equidistant timing and synchronisation of gated measurements and command values. Communication cycle times may be selected between 62,5 µs, 125 µs, 250 µs or any integer multiple of 250 µs.

In addition, the control panel of the control unit can be used to display and input PDS-specific data, parameters and diagnostic information which are available via an asynchronous service channel and standardised data records.

Command and feedback values in short or long words can be transmitted between the control unit and each PDS in both directions. Optional data (e.g., parameters, diagnostic texts) are transmitted in segments during every cycle. This data can be requested individually by the control unit. Errors in command and feedback values are corrected automatically through cyclic communication. The last valid command and feedback values are used until the next cycle. Two consecutive erroneous transmissions will cause the PDSs to halt.

With the SERCOS interface, a control unit may serve one or several networks, depending on the requirements. One example is shown in Figure 2.

The connection of the control unit on a network is called a master. This master shall direct and control any communication within one network.

A slave is the connection between one or more PDSs and the network, or between an I/O station and the network. As shown in Figure 2, a group of PDSs such as several PDSs and I/Os may be clustered and tied into the network through a single connection depending on application. Individual participants shall be connected to each other via transmission segments that shall meet the requirements of CP16/1 (SERCOS I) or CP16/2 (SERCOS II).

The information exchanged in such a network depends greatly on the distribution of tasks between the control unit, the PDSs and I/O stations. Direct exchange of information takes place between the control unit on one side, the PDSs and I/O stations on the other side.

Interoperability between the Communication Profiles shall be as shown in Table 3.

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Table 3 – Communication Profile Interoperability within a network

Master	Slave complying to CP16/1	Slave complying to CP16/2
CP16/1	yes	yes
CP16/2	yes [NOTE]	yes
NOTE With a CP16/2 master, CP16/1 slaves should be interoperable only at 2 or 4 Mbit/s.		

The CP16/1 and CP16/2 interfaces shall allow for synchronisation during cyclic data transmission as required by the SERCOS profile (see IEC 61800-7-204). It means that the operating cycle of the control unit can be synchronised with the communication cycle and operating cycle of the PDS so that beats between individual cycles can be prevented and the dead times in the control loops can be reduced to a minimum. It also implies that new command signals become active concurrently in all PDSs and that all PDSs take measurements at the same time, so that they can be sent back to the control unit as feedback values. This requires that the transmission cycles be strictly equidistant.

The data in the control loops need to be precise and punctual. Untimely data are of no value. When a transmission error is discovered, the communication cycle continues and the old data or an estimated value may be used for one communication cycle. To repeat the transmission with old data (for the purpose of correcting the error) is meaningless, since during the next communication cycle (e.g., 1 ms later), new command data will be transmitted. In the event of repeated transmission errors, a predetermined reaction, such as halting the system, shall ensue.

The non-cyclic transmission mode does not fulfil strict real-time requirements. The correctness of the data is acknowledged or is secured by repeating the transmission.

5.3 Physical layer and topology

The SERCOS CP16/1 (SERCOS I) and CP16/2 (SERCOS II) interface shall use fibre optic transmission between control units and PDSs, as specified in the corresponding part of IEC 61158-2.

Communication topology shall be a ring, as shown in Figure 2.

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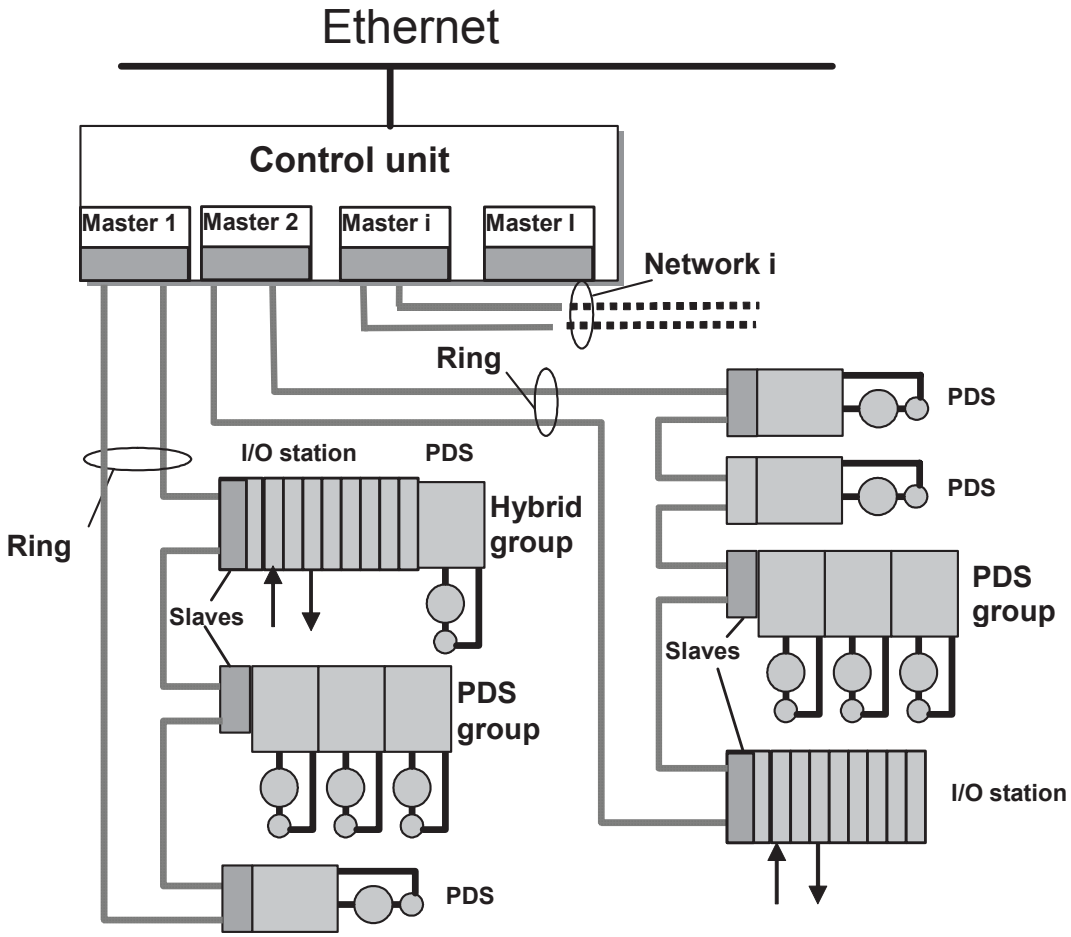

Figure 2 – Topology

5.4 Synchronisation mechanism

5.4.1 General

If, on a machine, several PDSs are moving in co-ordination with one control (contouring control), certain technical requirements shall be fulfilled in order to achieve a deviation-less trajectory:

- process the command values;
- capture the feedback values;
- synchronise different cycle times and fine interpolators in the PDSs.

CP16/1 and CP16/2 shall provide for the cyclic transmission of following telegrams, in that order, as can been shown in Figure 3:

1) The master shall send a synchronisation telegram that is called MST to all slaves.
2) Each slave shall send its data telegram that is called AT back to the master.
3) The master shall send its master data telegram that is called MDT to all slaves.

During network initialisation, the master shall transmit to each slave all parameters that determine the time slot and the data content of these telegrams. In that way each slave shall be able to transmit its AT and to read its part of the MDT without interfering with the others slaves.

The communication cycle time shall be selected among the following values:

62,5 µs, 125 µs, and then 250 µs to 65 ms in 250 µs increments.

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5.11.5 defines 3 granularities.

5.4.2 Handling of command and feedback values

The MST shall not only control the access to the network, but also assist in orienting the processing within the PDSs. Designs shall be possible in which the PDSs provide feedback values for the control unit. These values shall be captured in all affected PDSs simultaneously. The capture point indicated by t_4 referenced to the end of the MST shall be stored in the PDSs as an IDN. The PDSs shall already have a default time interval t_5 stored as an IDN. This time interval shall indicate the minimum amount of time needed between the capture point t_4 and the end of the next MST, to allow the PDS to process the captured feedback value for the following AT.

t_3 shall be defined as another parameter. This parameter shall indicate after which time interval, counting from the end of the MST, the PDS is allowed to access the new command values transmitted in the MDT. The master stores t_3 as an IDN in the PDSs. In order to determine t_3, the parameter t_{MTSG} (command value proceeding time) shall be stored in the PDSs as an IDN. This parameter shall describe the minimum time required by the slave to process the new command value(s) for the PDS(s) after the MDT.

Figure 3 illustrates these time intervals.

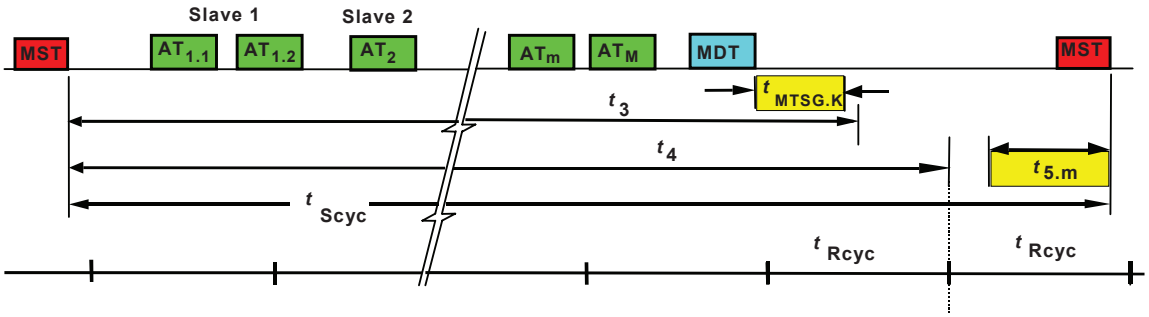

Figure 3 – Validity of command values and feedback acquisition time in the PDSs

Synchronisation of the control loops in the PDSs

The feedback values shall be captured in time t_4 in the PDS, and the control loops (cycle time t_{Rcyc}) shall be synchronised in the PDS at that time (see Figure 3 and Figure 4).

The PDSs need a certain time to activate a newly received command value in the control loop. The command values available at time t_3 shall be activated in the control loop to the next time t_4. If the time between t_3 and t_4 is too small, then the command values shall only be activated in the next cycle at time t_4.

If a PDS is programmed to detect that times t_3 and t_4 are in a critical range, it is recommended that the PDS generates a diagnostic message. The PDSs manufacturers shall document the dependencies of time t_3 and t_4 and the diagnostic message in the PDS's manual.

The cycle time within the control unit and the PDSs shall be as specified below:

a) The cycle time during which the control unit shall provide new command values for the PDSs shall be called t_{Ncyc}. The operating cycle inside of the control unit shall be an integer multiple of the communication cycle time. If the operating cycle time is n times longer than the communication cycle time, the same calculated values shall be transmitted n times in consecutive telegrams:

   $t_{Ncyc} = n \times t_{Scyc}$, n = 1,2... (n is an integer that is not related to the abbreviations)

b) Micro-processor controlled PDS shall have operating algorithms that are oriented to the data transmission. The cycle time during which the PDS shall perform its control algorithm shall be

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called t_{Rcyc}. It shall be an integer divider of the communication cycle time, and shall be in phase with the synchronisation telegram. If the PDS cycle time is z times shorter than the communication cycle time, intermediate values for command values shall be interpolated inside the PDS:

$z \times t_{Rcyc} = t_{Scyc}$, z = 1, 2... (z is an integer that is not related to the abbreviations)

Figure 4 shows graphically how tNcyc and tRcyc relate to tScyc.

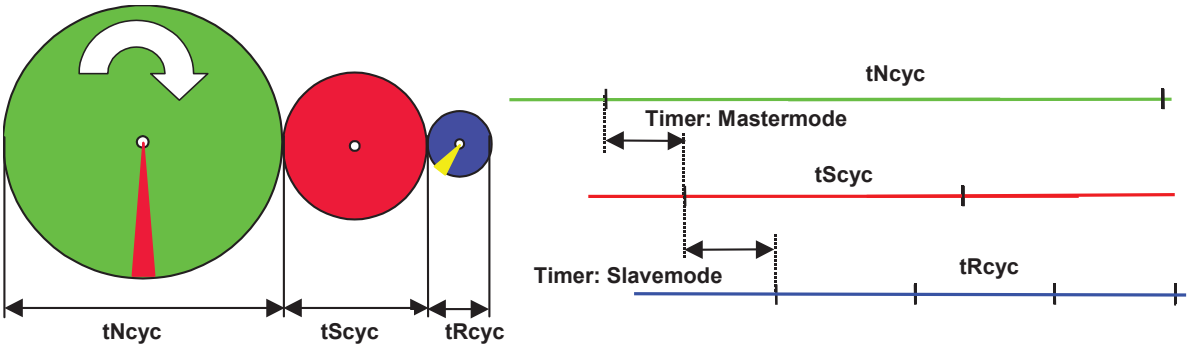

Figure 4 – Synchronisation of cycle times

5.4.3 Position loop with fine interpolator

At time t_4, the fine interpolator shall provide the corresponding received position command value to the position control. At the same time, the last received position command value shall be provided to the fine interpolator (see Figure 5). The fine interpolator shall calculate the differences in the position command values (Δ_{Pos}) for all steps (position control cycles). The differences in the position command values shall be calculated with:

- the ratio of the NC-cycle time and the PDS cycle time,
- the position command values,
- (optionally) the velocity and acceleration,
- type and order of fine interpolation.

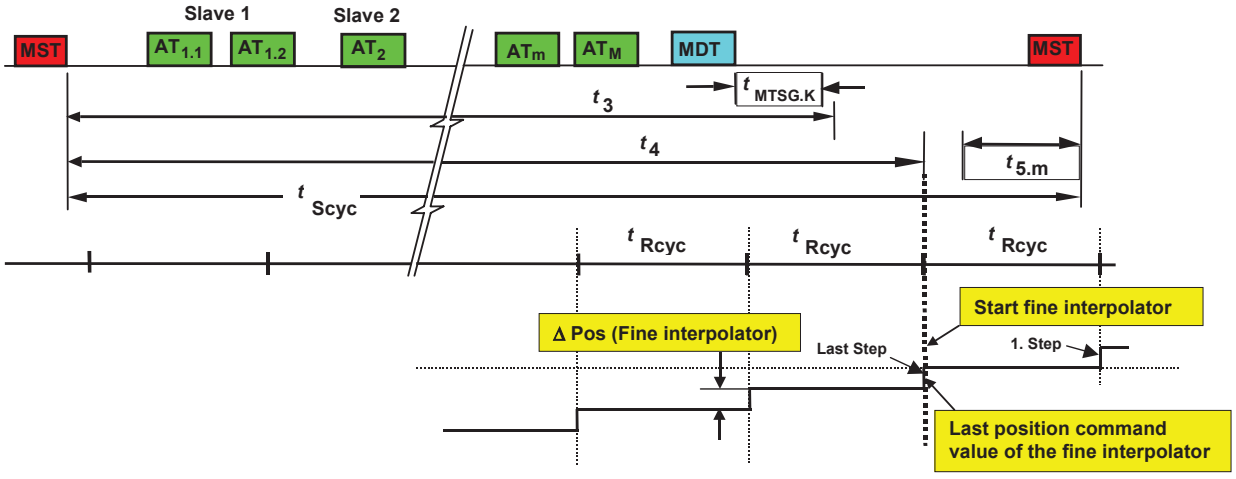

Figure 5 – Synchronisation of the control loops and the fine interpolator

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5.5 Telegram contents

5.5.1 General

IEC 61800-7-204, Clause 7 specifies a comprehensive list of transmittable data (as well as procedure commands) which are predetermined in the SERCOS profile. The Communication Profile specific part of IEC 61158-5-16 specifies additional, communication-specific transmittable data. The reader will find there also a description of individual data. In this subclause, an overview is presented, organised according to the mode of transmission (cyclic/non-cyclic) and the mode of operation. Table 4 gives an example of typical data that is transmitted cyclically.

During a communication cycle, one control word shall be sent from the control unit to each PDS and a status word shall be sent back from each PDS to the control unit. Configurable operation data shall be transmitted bidirectionally between the control unit and each PDS cyclically. Table 4 gives some typical representations. The three operating modes are shown with command and feedback values.

Table 4 – Typical operation data for cyclic transmission

	Position data	Velocity data	Torque data
Control unit to PDS	**Control word**		
	Position command value Additive position command value	Velocity command value Additive velocity command value	Torque command value Additive torque command value
PDS to control unit	**Status word**		
	Position feedback value 1 Position feedback value 2	Velocity feedback value	Torque feedback value

Both the control word and the status word are organised into a PDS-related and a transmit-related part. Non-cyclic transmissions are controlled by means of the transmit-related part (control/acknowledge steps). Each control and status word reserves two additional real-time bits for cyclic transmission.

The PDS-related part of the control word contains the desired modes of operation. This part is also used to transmit the commands for “PDS on” and “PDS enable”. The PDS-related part of the status word transmits grouped messages of errors and warnings which are divided into three classes. This part also issues messages indicating whether the PDS is ready to operate or ready for power-up.

Table 5 demonstrates that, typically, a much broader spectrum of data is exchanged by the non-cyclic transmission mode. However, this exchange is much slower than the cyclic mode.

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Table 5 – Typical data for non-cyclic transmission

Data related to the operating mode of the SERCOS interface		
Position data	**Velocity data**	**Torque data**
Positive limit value	Positive limit value	Positive limit value
Negative limit value	Negative limit value	Negative limit value
	Bipolar limit value	Bipolar limit value
Polarities	Polarities	Polarities
Reference distance 1	Homing velocity	
Reference distance 2		
Reversal clearance		
Position switch points 1 to 16		
Probe value 1 or 2 positive edge		
Probe value 1 or 2 negative edge		

As mentioned earlier, a component (PDS or control unit) which is equipped with the SERCOS interface does not need to support all possible data and procedure commands included in this specification. The system provides lists of data and procedure commands which are applicable for the appropriate component. These lists can be read from a PDS by means of the control unit, thus providing all necessary information concerning that particular PDS.

The data to be transmitted and the sequence shall be determined during initialisation.

Finally, during initialisation, it is useful to transmit scaling data as a group. In this way, the data formats used by the internal operating algorithms of the PDS will be recalculated and changed in accordance with the specifications of SERCOS interface.

5.5.2 Data block

The SERCOS interface is not just a data transmission system. It provides a large number of data and procedure commands which can be used for the operation of machines and their control units and PDSs.

All data, procedure commands and all supplementary information are summarised in a data block which contains a name, attribute, units, minimum and maximum input values as well as the data itself. See IEC 61800-7-204, Clause 8.

Access to the data or to the supplementary information is only possible via an identification number (IDN). There are 2^{16} IDNs available. The range from 0 to 32 767 is reserved for standard data which are defined by the SERCOS interface.

There will always be special applications for which none of the generally defined parameters apply. IDNs 32 768 to 65 535 are reserved for product specific data which can be defined by the manufacturers of control units and PDSs. No general compatibility can exist for these data and procedure commands.

5.5.3 Communication function group telegrams

The telegram contents of the configurable data records shall be determined either by the standard or application telegrams. This determination takes place in the telegram type parameter. For the structure of telegrams, refer to 5.5.4 and 5.5.5.

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