

**Kommunikationssystem mit hoher Effizienz
für kleine Datenpakete**

Deutsche Fassung EN 50254 : 1998, Text Englisch

DIN
EN 50254

ICS 35.160

High efficiency communication subsystem for small data packages;

German version of EN 50254 : 1998, text in English

Sous-système de communication à rendement élevé pour petits groupes de bits;

Version allemande de l'EN 50254 : 1998, texte en anglais

Die Europäische Norm EN 50254 : 1998 hat den Status einer Deutschen Norm.**Beginn der Gültigkeit**

Die EN 50254 wurde am 1998-10-01 angenommen.

Nationales Vorwort

Die Europäische Norm EN 50254 besteht nur in einer englischen Sprachfassung, weil sie nicht unmittelbar im Zusammenhang mit Rechtsvorschriften steht und nicht als Sicherheitsnorm anzusehen ist. Es kann davon ausgegangen werden, daß die Anwender dieser Norm über hinreichende englische Sprachkenntnisse verfügen. Für die meisten der verwendeten Begriffe existieren keine gebräuchlichen deutschen Benennungen, da sich die deutschen Anwender in der Regel ebenfalls der englischen Benennungen bedienen.

Das nationale Arbeitsgremium UK 951.3 „Feldbus“ der Deutschen Elektrotechnischen Kommission im DIN und VDE (DKE) ist für diese Deutsche Norm zuständig.

Der Norm-Inhalt war veröffentlicht als E DIN EN 50254 : 1997-10.

Fortsetzung Seite 2 und 3
und 254 Seiten EN

Deutsche Elektrotechnische Kommission im DIN und VDE (DKE)

**Documents**

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

Der Zusammenhang der zitierten Normen und anderen Unterlagen mit den entsprechenden Deutschen Normen und anderen Unterlagen ist nachstehend wiedergegeben. Zum Zeitpunkt der Veröffentlichung dieser Norm waren die angegebenen Ausgaben gültig.

IEC hat 1997 die Benummerung der IEC-Publikationen geändert. Zu den bisher verwendeten Normnummern wird jeweils 60 000 addiert. So ist zum Beispiel aus IEC 68 nun IEC 60068 geworden.

Europäische Norm	Internationale Norm	Deutsche Norm
EN ISO/IEC 7498-1 : 1995	ISO/IEC 7498-1 : 1994	DIN EN ISO/IEC 7498-1 : 1995-12
EN 50170 Volume 1/3 P-NET : 1996	-	DIN EN 50170/1 : 1997-07
EN 50170 Volume 2/3 PROFIBUS : 1996	-	DIN EN 50170/2 : 1997-07
EN 50170 Volume 3/3 WorldFIP : 1996	-	DIN EN 50170/3 : 1997-07
EN 50170/A2 : 1999	-	E DIN EN 50170/A2 : 1998-06
EN 61158-2 : 1994	IEC 61158-2 : 1993	DIN EN 61158-2 : 1994-10

Erläuterungen

Die vorliegende Europäische Norm enthält ein Netzwerkkonzept, bekannt als Interbus, und zwei Möglichkeiten der Anwendung von Konzepten, die bereits in der EN 50170 festgelegt und als PROFIBUS DP und World-FIP-Profil 1 bekannt sind und weitverbreitete Anwendung gefunden haben. INTERBUS war in Deutschland als Entwürfe zu den Normen der Reihe DIN 19258 "Leittechnik – InterbusS, Sensor-/Aktornetzwerke für industrielle Steuerungssysteme" und Profibus DP als Entwurf zur DIN 19245-3 "Messen, Steuern, Regeln – Profibus - Process Fieldbus – Dezentrale Peripherie (DP)" veröffentlicht. CENELEC/TC 65CX hat beschlossen, die obengenannten Spezifikationen in einer europäischen Norm zusammenzufassen und als "High efficiency communication subsystem for small data packages (HECS)" zu benennen.

Um dem Leser eine klare Anleitung zu geben, ist diese Europäische Norm in vier Bände unterteilt: Band 1 enthält allgemeine Informationen und die folgenden Bände betreffen das jeweilige Konzept. Die Bände sind in Teile unterteilt. Die Teilbenummerung dieses Dokumentes ist die gleiche, wie die der EN 50170: Die erste Ziffer nach der EN-Nummer zeigt den Teil des Bandes an, die zweite Ziffer den des Bandes, der den Teil enthält.

Beispiel:

Unter Teil 3-2 findet der Leser Teil 3 in Band 2, welcher die Festlegung des Data Link Layers für den Band 2 (Interbus) enthält.

Nationaler Anhang NA (informativ)

Literaturhinweise

DIN EN ISO/IEC 7498-1	Informationstechnik – Kommunikation Offener Systeme – Teil 1: Basis-Referenzmodell: Basismodell (ISO/IEC 7498-1:1994); Englische Fassung EN ISO/IEC 7498-1:1995
DIN EN 50170/1	Universelles Feldkommunikationssystem; Englische Fassung EN 50170:1996 Band 1/3 P-NET
DIN EN 50170/2	Universelles Feldkommunikationssystem; Englische Fassung EN 50170:1996 Band 2/3 PROFIBUS
DIN EN 50170/3	Universelles Feldkommunikationssystem; Englische Fassung EN 50170:1996 Band 3/3 WorldFIP
DIN EN 50170/A2	Universelles Feldkommunikationssystem, Englische Fassung EN 50170/A2:199X
DIN EN 61158-2	Feldbus für industrielle Leitsysteme – Teil 2: Spezifikation der Bitübertragungsschicht (Physical layer) und Definition deren Dienste (IEC 61158-2:1993); Deutsche Fassung EN 61158-2:1994
EIA-485	Standard for electrical characteristics of generators and receivers for use in balanced digital multipoint systems

Bezugsquelle für diese Norm der EIA (Electronic Industries Association/USA) ist:

Beuth Verlag Berlin, Abt: Auslandsnormenverkauf, 10772 Berlin, Tel.: 0 30/26 01-0

Nationaler Anhang NB (informativ)

Anwendungshinweise

Anwender und Hersteller von INTERBUS Produkten nach Band 2 der vorliegenden Norm haben sich im INTERBUS Club Deutschland e. V. zusammengeschlossen.

Weitere Festlegung auf Basis dieser Norm werden in Arbeitskreisen des INTERBUS Clubs erarbeitet. Die Erfahrungen bei der Geräteentwicklung und Anwendung werden in Implementierungsempfehlungen zusammengefaßt und stehen allen Interessenten zur Verfügung. Der INTERBUS Club beabsichtigt, diese Arbeitsergebnisse in die Normung einzubringen.

Um diese Informationen der Öffentlichkeit schnellstmöglich zugänglich zu machen, werden diese vorab durch den INTERBUS Club oder als VDI/VDE-Richtlinien veröffentlicht. Beispiele hierfür sind:

- anwendungsbezogene Festlegungen (Profile)
- Implementierungshinweise zu Band 2 der vorliegenden Norm
- Richtlinien für die Konformitätsprüfung und Zertifizierung

Die vollständige aktuelle Dokumentenliste mit allen verfügbaren Arbeitsergebnissen ist über die Geschäftsstelle des INTERBUS Clubs erhältlich.

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– Leerseite –

ICS 35.160

Descriptors: General purpose field communication system, small data packages

English version

**High efficiency communication subsystem
for small data packages**

This European Standard was approved by CENELEC on 1998-10-01. 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.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

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

Foreword

This European Standard was prepared by the Technical Committee CENELEC TC 65CX, Fieldbus.
The text of the draft was submitted to the Unique Acceptance Procedure and was approved by CENELEC as EN 50254 on 1998-10-01.

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) 1999-08-01
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 1999-08-01

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High Efficiency Communication Subsystem for Small Data Packages

Volume 1 (Introduction)

Structure of the Document

This European Standard contains one network concept, known as INTERBUS and two ways of using concepts already defined in EN 50170 known as PROFIBUS DP and WorldFIP Profile 1, which are in widespread use and which are already pre-standard at national level in Germany and in France. CENELEC TC 65CX decided to collate these specifications in one European Standard and to name it "High Efficiency Communication Subsystem for Small Data Packages" (HECS).

In order to give the reader a clear orientation, this European Standard is divided into four volumes, Volume one contains general information and the following volumes are specific for each concept. The volumes are divided into parts. The part numbering of this document is the same as in EN 50170 and reads as follows: The first digit after the EN number indicates the part of the volume, the second digit indicates the volume, which contains the part.

Example: Under Part 3-2 the reader will find part 3 in volume 2, which is the Data Link Layer specification of volume 2 (INTERBUS).

Common Background to all Volumes of EN 50254

This European Standard has been prepared by CENELEC Technical Committee 65CX.

For industrial communication several well recognised solutions are used, which meet the user needs. Many of these needs are covered by EN 50170, but there are additional needs such as a highly efficient protocol and a deterministic and predictable constant scan time for inputs and outputs.

Users and manufacturers in European industry have done research and development efforts to highly efficient communication networks a reality in the industrial automation market. CENELEC TC 65CX has selected three specifications for this European Standard which are market proven, open and validated.

According to the decision of TC 65CX to specify this standard according to Publicly Available Specification (ITSTC 1653) which implies neither to develop any new compromise nor to re-write the actual concepts on the market, the reader should pay his dedicated attention to the following notes:

Note 1:

This European Standard contains the following three different specifications without attempting to develop any compromise or to mix them.

EN 50254 Volume 2, based on and identical to E DIN 19258 series

EN 50254 Volume 3, specifies a distinct usage of EN 50170 volume 2

EN 50254 Volume 4, specifies a distinct usage of EN 50170 volume 3

Note 2:

The concepts of these specifications are different from each other and therefore they cannot communicate together unless there are adaptations. For each implementation you have to select the one which suits the user's application needs.

Provisions exist in each concept to detect any attempt to mix products pertaining to other concepts and to avoid that such a mistake will not lead to corrupt the working network ; several levels of protection exist, that cover connectors, physical layer coding, different speeds and effective network management.

High Efficiency Communication Subsystem for Small Data Packages

Part 1-1

General Description

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1 Scope

This European Standard is specifying a set of solutions named « High Efficiency Communication for Small Data Package » (HECS). The scope covers the communication of simple devices such as I/Os or sensors / actuators. It is not specified for a certain industry sector such as manufacturing automation, but is targeted to any application requesting fast access to small data packages with deterministic and predictable access.

High Efficiency Communication Systems for Small Data Packages have proven their utility besides the GPFCS (General Purpose Field Communication Systems) as complementary solution or to answer specific needs links with process efficiency. Having recognised this fact this standard is proposing concepts which have proven the effectiveness in industry for years.

2 General Aspects of High Efficiency Communication

2.1 High Efficiency Communication on the Control Architecture

The control architecture is logically divided into multiple networks, Actuator/Sensor bus, Device bus, Fieldbus, Cell bus, corresponding to different types of data exchange. This decomposition is guided by the aim of keeping the communication flow to a manageable level between all interconnected equipment. But each application system is different and developed with the process.

In order to meet the needs of a scaleable and flexible control architecture, this logical decomposition of networks should be realised by a limited number of physical networks, typically one for small size application or two for classical manufacturing cell.

2.2 Specific Requirements

The HECS constitutes an addition of the GPFCS (general purpose fieldbus communication system) requirements with specific ones to take into account that it connects rather simple devices with limited number of information (typically 16 bits) together with fast access to it by the controlling device (typically 10ms cycle time).

Also the deterministic aspect of the communication exchanges is mandatory to predict the control behaviour of the control scheme.

All the data which are to be processed by the controller are to come from the same cycle in order to be consistent (same sample time). Conversely the outputs should be activated at the same time. The target is to have with remote I/Os the same features as with local I/Os for a controlling device.

2.3 Selection Criteria

This European Standard has selected solutions according to the following criteria :

- 1 Candidates shall be national standard or pre-standard.
- 2 Candidates shall fit into the scope and the policy statement of TC65CX (CLC/TC65CX(SEC)4 and CLC/TC65CX(BXL/SEC)1).
- 3 Candidates should be documented in English language according to classical OSI/IEC decomposition in layers.
- 4 Candidates shall be already in use in commercial products and running in industrial plants (demo is not considered as industrial use).
- 5 Products should be available in quantities and at low price. Users shall be in the position to make experiences with simple I/O communications and be given advice how to use existing conceptions.

- 6 Products of the candidates shall be available from several sources and commercialised openly.
- 7 The physical layer of candidates shall be able to satisfy the IEC 801-2,801-3,801-4,801-5 and 801-6, class 3, for industrial use.
- 8 Candidates shall have appropriate mechanisms for transmission error detection.
- 9 The specification shall be open, widely accepted, well documented, stable and support interoperability.
- 10 The documentation of the candidates should - in line with the procedures and conditions of CENELEC - be free of intellectual Property Rights and Copyright aspects.
- 11 The specification shall be complete and describe the necessary interfaces in such a detail that no problems may arise for implementation purposes.
- 12 There must be no restriction related to testing the implementation.
- 13 Candidates shall support time critical requirements such as:
 - 13.1 Time-critical messages shall be short enough to be sent without segmentation.
 - 13.2 Non-time-critical PDUs shall not prejudice the delivery of time-critical PDUs.
 - 13.3 Candidates shall cope with dynamic sequencing.
 - 13.4 Predictability of message transfer times and transaction time is necessary.
 - 13.5 Agreed probability of interaction/transaction completion time is necessary.
 - 13.6 Temporal coherence is required.
- 14 Candidates shall have an application interface which supports the direct access to the I/O image through a local data base.
- 15 For the scenarios A and B candidates should have a complete cycle time (reading all inputs and writing all outputs) of not greater than 10 ms, at industrial speed over a minimum distance of 100 m.

Benchmark scenario A :

- Number of stations 31
- Number of inputs data per station 16 bits
- Number of outputs data per station 8 bits

Benchmark scenario B :

- Number of stations : 24
- Station 1 to 8 16 bits input
- Station 9 to 16 16 bits output
- Station 17 to 24 16 bits and 16 bit output

- 16 Candidates should provide a specification for the calculation of the cycle time.

3 Main Features of EN 50254 Volume 2 (INTERBUS)

This network is a digital, serial communication system for communication between control systems (e.g. programmable logic controllers, PLCs) and devices for the entire field of industrial sensors and actuators. These devices include simple limit switches and valves, as well as measuring sensors, measuring transducers, actuators but also complex high-tech control systems, such as controlled drives, wrenching and

process controllers, etc. This concept combines the requirements of Actuator/Sensor busses and Device busses, it is optimised, but not limited to factory automation applications.

The networks main characteristics are:

- master-slave concept
- ring structure with a one-total-frame protocol
- tree topology for the arrangement of devices
- little protocol overhead for cyclic input/output data
- input/output data oriented and message oriented services
- input/output data and messages are transferred concurrently
- message transfer does influence input/output data transfer only by a small fixed amount of time
- enhanced error detection facilities, such as CRC, stop bit, time-out check and loop back word (total frame transmission control word).
- 2 wire ring with a transmission speed of 500 kbits/sec

User benefits of the network are:

- fixed and predictable cycle time for a given network configuration
- scan of input/output data in a time constant and consistent way
- easy installation and maintenance; no device addresses are needed
- enhanced network diagnostic features; errors can be traced down to the ring segment and the device
- combination of simple and complex devices in one network

EN 50254 volume 2 has been published as a German Prestandard E DIN 19258 series (known as INTERBUS).

4 Main Features of EN 50254 Volume 3 (PROFIBUS-DP Profile)

EN 50170 Volume 2 specifies a communication system consisting of two variations. Both variations use the same Physical and Data Link Layer. Therefore both variations can operate in a network simultaneously on the same medium.

EN 50170 volume 2 parts 5 and 6, known as PROFIBUS-FMS, is optimized for the communication between intelligent devices. It offers powerful application services and is suitable for the transmission of large data packages. PROFIBUS-FMS specifies a complete Application Layer Protocol. It offers an enormous flexibility but on the other hand it causes a notable protocol overhead.

EN 50170 volume 2 part 8, known as PROFIBUS-DP, is optimized for simple I/O communication of small data packages, e. g. connecting binary I/Os with their related automation systems (PLC). This variation offers reduced functionality along with enormous increased protocol efficiency. This enables the transmission of one Kbyte input and output data in less than one millisecond.

PROFIBUS - DP offers the following features:

- reliable transmission protocol, Hamming Distance, HD=4
- optimised services for fast and efficient communication
- one message cycle transfers input and output data
- due to the reduced functionality and the lean protocol stack, single chip ASICs are available, implementing the complete protocol at a favourable price
- transmission speeds as defined in EN 50170, volume 2
- flexible and powerful diagnosis capabilities
- simple configuration, complete specification of the device characteristics included in EN 50170 volume 2
- computable and reliable message transfer and transaction time
- mixed operation with PROFIBUS-FMS

For a communication architecture based on EN 50170 volume 2, it is possible according to conformance classes to define different levels of communication interface while guaranteeing communication interoperability. The purpose of the volume 3 of this European Standard is to define a profile based on EN 50170 volume 2 part 8 (PROFIBUS-DP) for simple devices requiring fast communication.

The profile will not change the performances level of the communication network as defined in the EN 50170 volume 2.

5 Main Features of EN 50254 Volume 4 (WorldFIP Profile 1)

Simple and sophisticated devices should co-work on the same network, but without oversizing the communication interface of the simple device.

For a communication architecture based on EN 50170 volume 3, it is possible according to conformance classes to define different levels of communication interface while guaranteeing communication interoperability. The purpose of the volume 4 of this European Standard is to define a profile for simple device requiring fast communication.

The characteristics of this profile will provide the device with :

- easy interconnection with ready made user interface
- transmission speeds as defined in EN 50170 volume 3
- high EMC resistance level 3 and higher
- high integrity, the request for fast communication does not allow for time reasons to retransmit or verify transmission quality. Thus the residual error rate is below 10^{-18} for a raw error rate of 10^{-3} . Such an integrity makes retransmission not necessary
- media redundancy for application requiring high availability

The definition of the profile will specify :

- a reduced set of communication services based on the time critical services MPS. The time qualifiers **refreshment** and **promptness** are mandatory in order to ensure the data user of the quality of the information received,
- a limited address space for efficient decoding and reduced level of configuration,
- a limited volume of data to be transmitted both in term of quantity and individual length. Again the objective is to size the communication to the real need of the devices.

The profile will not change the performances level of the communication network as defined in the EN 50170 volume 3. Then high quality control with fast response time can be developed irrespective of whether the device is simple or sophisticated.

This profile has been registered as NF C 46 638, High efficiency communication for small data packages-WorldFIP profile 1.

High Efficiency Communication Subsystem for Small Data Packages

Volume 2 (INTERBUS)

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FOREWORD

All parts of the volume 2 describe together a complete sensor/actuator network.

The parts of volume 2 being:

- Part 1-2: General Description and System Architecture
- Part 2-2: Physical Layer
- Part 3-2: Data Link Layer

The sensor/actuator network is a digital, serial communication system for communication between control systems (e.g. programmable logic controllers, PLC) and devices for the entire field of industrial sensors and actuators. These devices include simple limit switches and valves, as well as measuring sensors, measuring transducers, actuators but also complex high-tech control systems, such as controlled drives, wrenching controllers, process controllers, etc.

The use of the Data Link Layer services for the transmission of parameter data blocks via the parameter channel will be described in a technical report which is being prepared by the CENELEC Technical Committee 65CX.

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High Efficiency Communication Subsystem for Small Data Packages

Part 1-2

General Description and System Architecture

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FOREWORD

Volume 2 of this European Standard has been prepared by CENELEC technical committee 65CX. All parts of volume 2 describe together a complete sensor/actuator network.

This part of this European Standard contains common definitions and conventions for volume 2 and defines the system architecture.

The other parts of volume 2 describe the following:

Part 2-2: Physical Layer

Part 3-2: Data Link Layer

INTRODUCTION

The sensor/actuator network is a digital, serial communication system for communication between control systems (e.g. programmable logic controllers, PLC) and devices for the entire field of industrial sensors and actuators. These devices include simple limit switches and valves, as well as measuring sensors, measuring transducers, actuators but also complex high-tech control systems, such as controlled drives, wrenching and process controllers, etc.

Unlike general purpose field communication systems, this network uses a one-total-frame (summation) protocol in the Data Link Layer. As far as the sensor/actuator level is concerned, this special protocol meets two demands which are very important in this application area. The first demand is the capability of the network to scan the input/output data in a time-constant and consistent way, and the second is a high protocol efficiency which is much higher at the same transmission rate than those of general purpose communication systems. This efficiency is due to drastic reductions when this protocol is used in a ring topology compared with the traditional transmission methods that are common in a line topology.

1 Scope

This part describes the system architecture of the sensor/actuator network defined in volume 2 of this European Standard. Furthermore it defines how the different parts of volume 2 are interrelated. .

2 Normative References

This European Standard contains by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of these publications apply to this European Standard only when incorporated in it by amendment or revisions. For undated references the latest edition of the publication referred to applies.

ISO 7498: 1984	Information processing - Open Systems Interconnection - Basic Reference Model (Status as of 1988)
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3 Definitions

For the purpose of volume 2 of this European Standard, the following definitions apply.

3.1 Bus coupler

A bus coupler divides the ring into segments. This is done by opening the ring and integrating another ring at this point.

3.2 Bus cycle time t_{BC} (cycle time)

The bus cycle time is the time between the sending of the first bit and the receiving of the last bit of a data sequence. The bus cycle time depends on the bus configuration, i. e. on the number of devices and the individual size of the 'process data channel' and the 'parameter channel' of every device. This arrangement is of physical nature and does, for a given network, never change. This time can be calculated as follows (cable run times are not allowed for) :

$$t_{BC} = (13 \times (6 + n) + 2 \times m) \times t_{Bit} \text{ with}$$

n Quantity of user data of all slaves in octets

m Quantity of bus devices

t_{Bit} Bit time (2 μ sec for 500 kbit/sec)

Where 'n' is the sum of data widths of all stations in the network, the data width specifies how many octets are occupied by a device. The network has full duplex communication the data width of a station is the max. length of either input-data or output-data and not the sum of input-data and output-data! (See appendix A for example calculations.)

3.3 Data transfer cycle

In this cycle the process data and message segments are transmitted from and to all slaves.

3.4 Incoming interface

Data from the previous device is received via the incoming interface. Data which is received by next device via an outgoing interface is sent back to the bus master via this incoming interface.

3.5 Local bus

The local bus is a ring segment of the sensor/actuator network, which is coupled to a remote bus via the bus coupler. Up to eight slaves may be connected to a local bus.

3.6 Local bus device

A local bus device operates as a slave on a local bus.

3.7 Local bus link

A local bus link connects two local bus devices.

3.8 Master

The master controls the data transfer on the network and initiates the media access of the slaves by sending messages. The master constitutes the interface to the control system.

3.9 Outgoing interface

Data is sent to the next slave via the outgoing interface. Data which is received through this outgoing interface is sent via another outgoing interface to the next slave or via an incoming interface to the previous slave and back to the master.

3.10 Peripherals Data Link Service Data Unit (PDLSDU)

A PDLSDU of the master contains all process data to be transmitted in a data cycle and PDL message segments. The PDLSDU of a slave is a subset of the PDLSDU of the master and contains only the process data to be transmitted in one data cycle and the PDL message segment of this slave (see Figure 1-1).

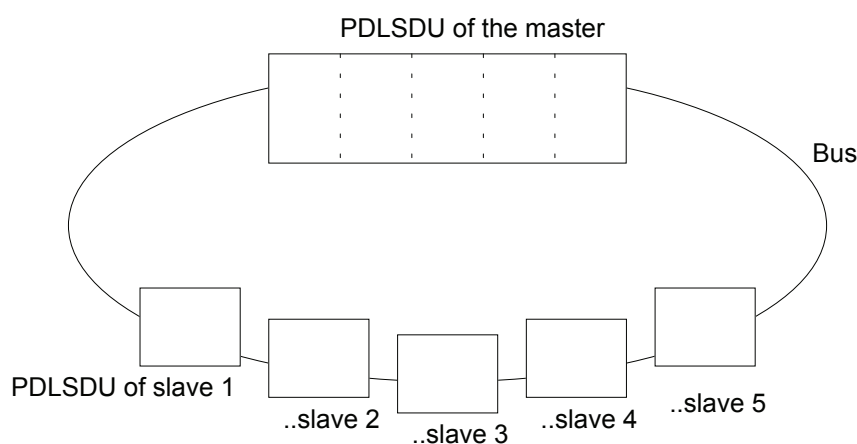


Figure 1-1: PDLSDU

3.11 Receive update memory

This memory area contains all process data and message segments which are received by all slaves in the order in which they lie in the ring.

3.12 Remote bus

The remote bus is a ring segment of the sensor/actuator network and starts at the master. Further ring segments can be coupled to the network via bus couplers.

3.13 Remote bus device

A remote bus device operates as a slave on a remote bus.

3.14 Remote bus link

A remote bus link connects two remote bus devices.

3.15 Ring position

The ring position of a slave is the position which is occupies in the ring. The first slave in the ring is the slave whose receive side is connected to the send side of the outgoing interface of the master.

3.16 Ring segment

A ring segment of the sensor/actuator network is one section of the data ring. This segment may be linked to the master or, via a bus coupler, to another ring segment.

3.17 Slave

All devices which are connected via the network to the master are slaves. Slaves are characterized by the fact that they access the medium only after they have been initiated by the preceding slave or master.

3.18 Transmit update memory

This memory area contains all process data and message segments which are sent to all slaves in the order in which they lie in the ring.

4 Abbreviations

The following abbreviations are used in this part of this European Standard:

BLL	Basic Link Layer
.con	.conformation (service primitive)
CRC	Cyclic Redundancy Check
DL	Data Link (as a prefix)
DL-Ph	Data Link Physical
DLL	Data Link Layer
DLPDU	Data Link Protocol Data Unit
.ind	.indication (service primitive)
LB	Local Bus
LLI	Lower Layer Interface
MAC	Medium Access Control
MAU	Medium Attachment Unit
MDS	Medium Dependent Sublayer
MIS	Medium Independent Sublayer
PDL	Peripherals Data Link
PDLSDU	Peripherals Data Link Service Data Unit
PDU	Protocol Data Unit
PhL	Physical Layer
PMS	Peripherals Message Specification
PNM	Peripherals Network Management
RB	Remote Bus
.req	.request (service primitive)
.res	.response (service primitive)
SM	System Management

5 Conventions

For the purpose of volume 2 of this European Standard, the following conventions apply.

5.1 Definition of Service Parameters

Service parameters are defined in a formal, logical description in the form of a table. The name of the parameter is given in the first column. The other column list the respective service primitives. The fact that a parameter belongs to a service primitive is noted with an entry in the line of the parameter and in the column of the service primitive.

The following types of relations are possible:

- M Mandatory: The parameter shall be specified
- S Selection: The parameter can be selected from a set of several parameters.
- C Conditional The existence of a parameter depends on another parameter.

The parameters may be structured. The name of a subparameter of a structured parameter is shown indented. The information whether an optional parameter is used or not and which parameter has been chosen from a selection the concrete case is not shown explicitly in this representation. However, this information is to be passed to a concrete interface.

With a service request and a service indication the parameter is called argument. The service confirmations (res and con) contain either the result(+) parameter for a positive confirmation or the result(-) parameter for a negative. Usually, these parameters are structured further (see Table).

Table 1-1: Representation of the parameters of the service primitives

Parameter name	.req .ind	.con .res
Argument	M	
invoke_parameter1	M	
parameter_A	S	
parameter_B	S	
invoke_parameter2	M	
Result(+)		S
confirmation_parameter2		M
confirmation_parameter1		C
Result(-)		S
error		M

- .con: Confirmation service primitive
- .ind: Indication service primitive
- .req Request service primitive
- .res Response service primitive

In the example in Table 1-1 the argument is further structured as an invoke parameter. It consists of the invoke_parameter1 and the invoke_parameter2. The invoke_parameter1 can either be parameter_A or parameter_B.

The result(+) parameter is used for a positive confirmation. It consists either of the confirmation_parameter1 or the confirmation_parameter1 and the confirmation_parameter2. In the event of a negative confirmation the result(-) parameter is used which consists of the error parameter.

6 System Architecture

The network is set up as a data ring with a central master-slave access method. Up to 256 so-called slaves may be connected to the bus cable (remote bus) starting at the central master. Apart from these slaves, 256 bus couplers which allow to integrate further ring segments into the data ring may be connected to this remote bus. Figure 1-2 shows the network topology.

To simplify system installation and system diagnostics, the ring system can be implemented into one single cable, so that the topology resembles a bus system (remote bus) with branching lines. The ring is closed automatically in the last slave of a ring segment. This allows to add devices to and remove them from the ring. Together with the possibility of connecting the outgoing interfaces in the bus couplers to, for example, a ring segment which is connected via a bus coupler, or to the next slave or to a bus coupler, the implementation of the ring structure into one cable also makes possible easy system diagnostics. The arrangement of the bus couplers in a branching ring segment allow to form a tree structure. Other network structures can be implemented independently of the protocol.

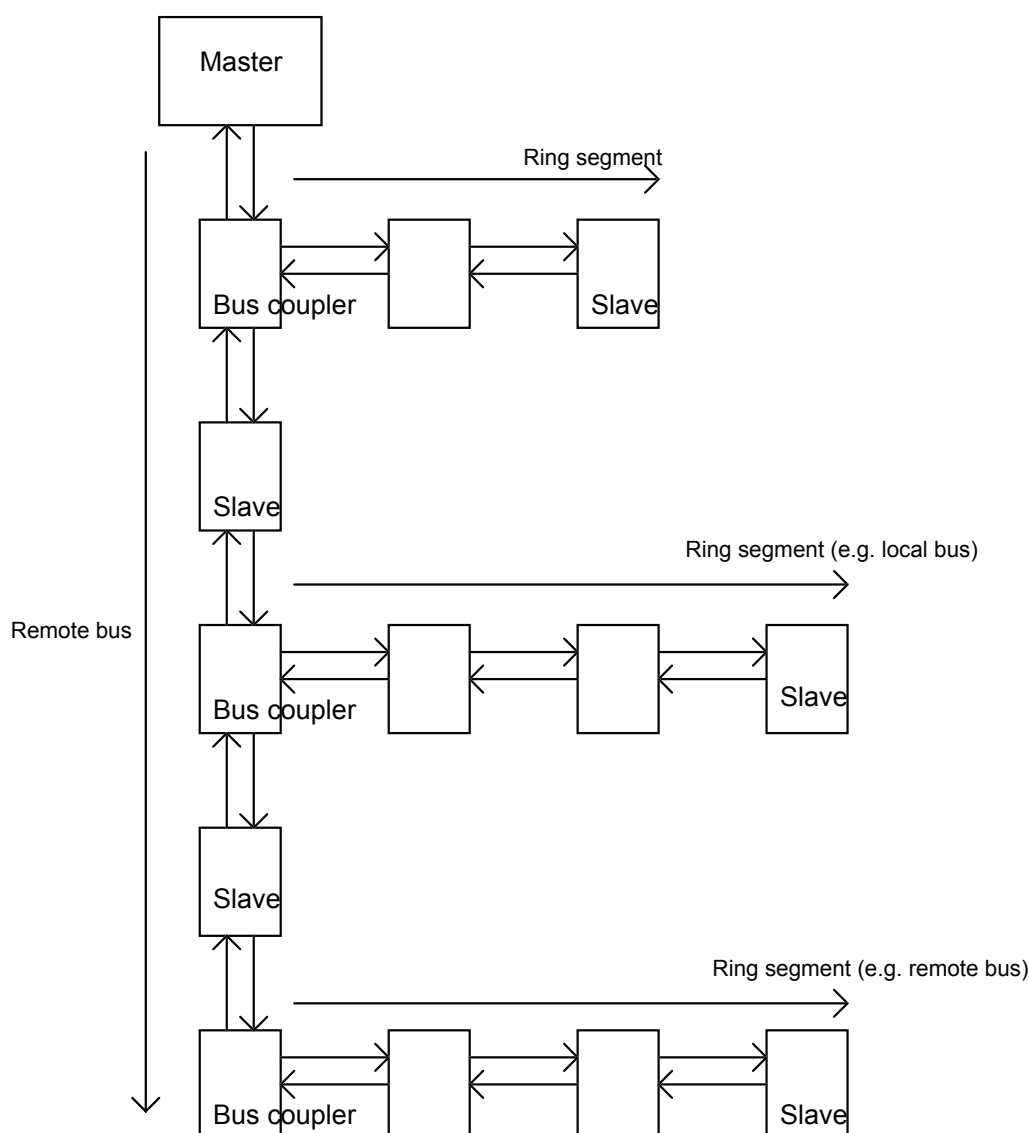


Figure 1-2: Topology of the network

7 Bus Devices

7.1 General

Up to four types of bus devices may be connected to this network: a master, bus couplers, local bus devices, and remote bus devices. They all differ in the way they access the bus and in the number and type of interfaces to the transmission medium.

A slave receives the data from the master via an incoming interface. A slave sends data to the next slave and from the last slave back to the master via an outgoing interface. At the outgoing interface, the sender can be connected with the receiver for diagnostic purposes.

7.2 Master

The master centrally controls the data traffic. It transmits data to all other slaves and, at the same time, receives data from the latter. The master causes the slaves, such as bus couplers or local bus and remote bus devices, to access the bus, i.e. to send or receive data. The master has an outgoing interface which allows to connect a remote bus link. Figure 1-3 shows a bus master.

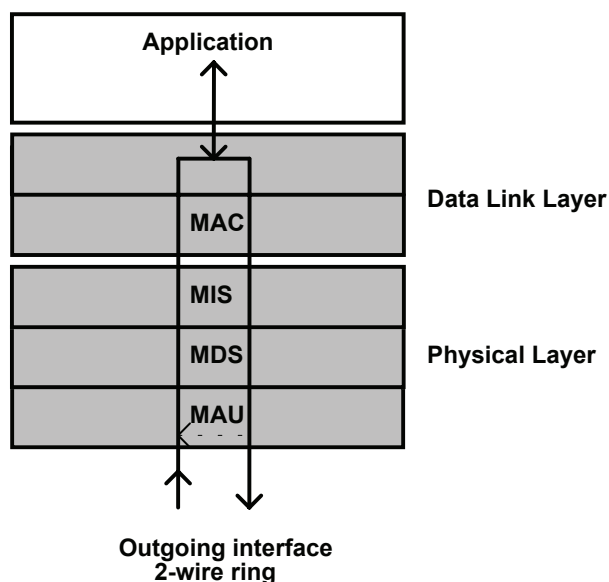


Figure 1-3: Bus master

7.3 Slave (Remote Bus Device or Local Bus Device)

A slave has an outgoing and incoming interface to connect another slave as shown in Figure 1-4.

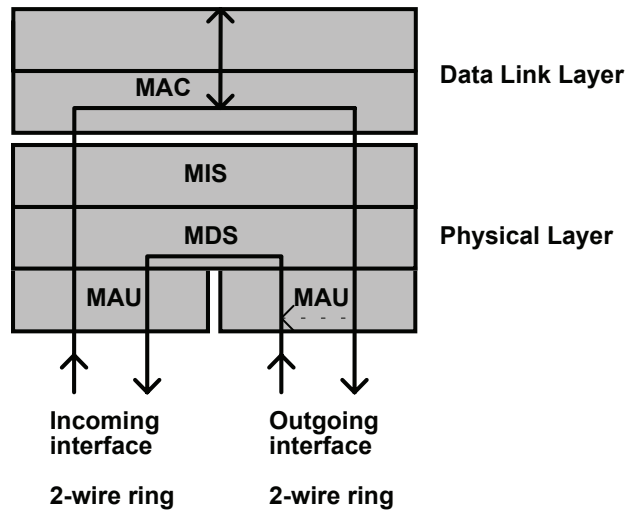


Figure 1-4: Slave

7.4 Bus Coupler

A bus coupler has an incoming and an outgoing interface to connect a remote bus link and an additional outgoing interface to connect another ring segment or a local bus link. Figure 1-5 shows a bus coupler which allows to couple a ring segment.

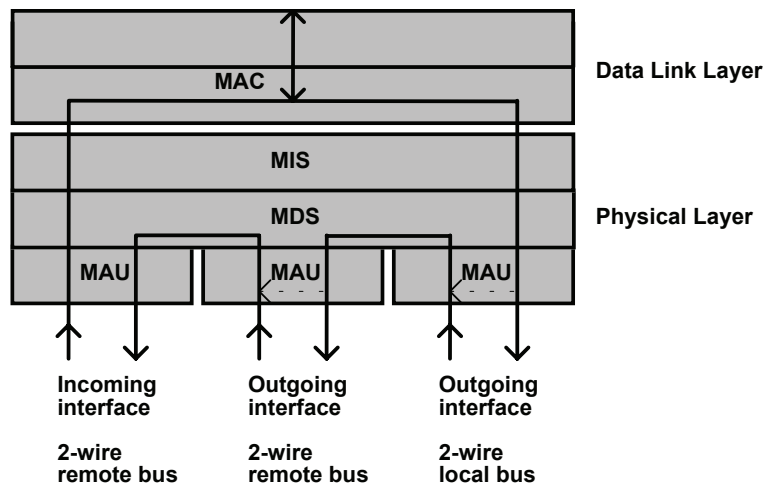


Figure 1-5: Bus coupler for the connection of a ring segment

8 Protocol Components

8.1 General

The protocol allows to exchange data between the application program of the control system with connected master and the applications or application programs of the slaves (bus couplers, local bus and remote bus devices). The protocol makes two transmission channels available to the user: the process data channel and the parameter channel. Together, both channels form the hybrid communication structure of the network. In addition, the protocol comprises the components shown in Figure 1-6.

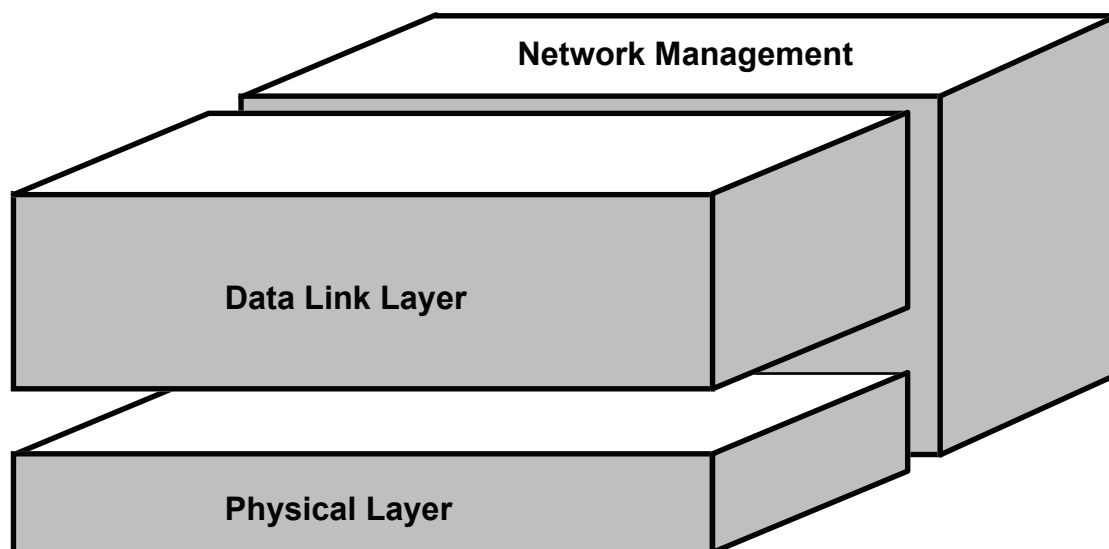


Figure 1-6: Protocol architecture

The architecture of the protocol is modelled according to the OSI basic reference model for open systems communications (see ISO 7498).

8.2 Physical Layer

The Physical Layer defines the interface of a bus device to the transmission medium, i.e. it defines the access to the 2-wire transmission protocol. Figure 1-7 shows the structure of the Physical Layer.

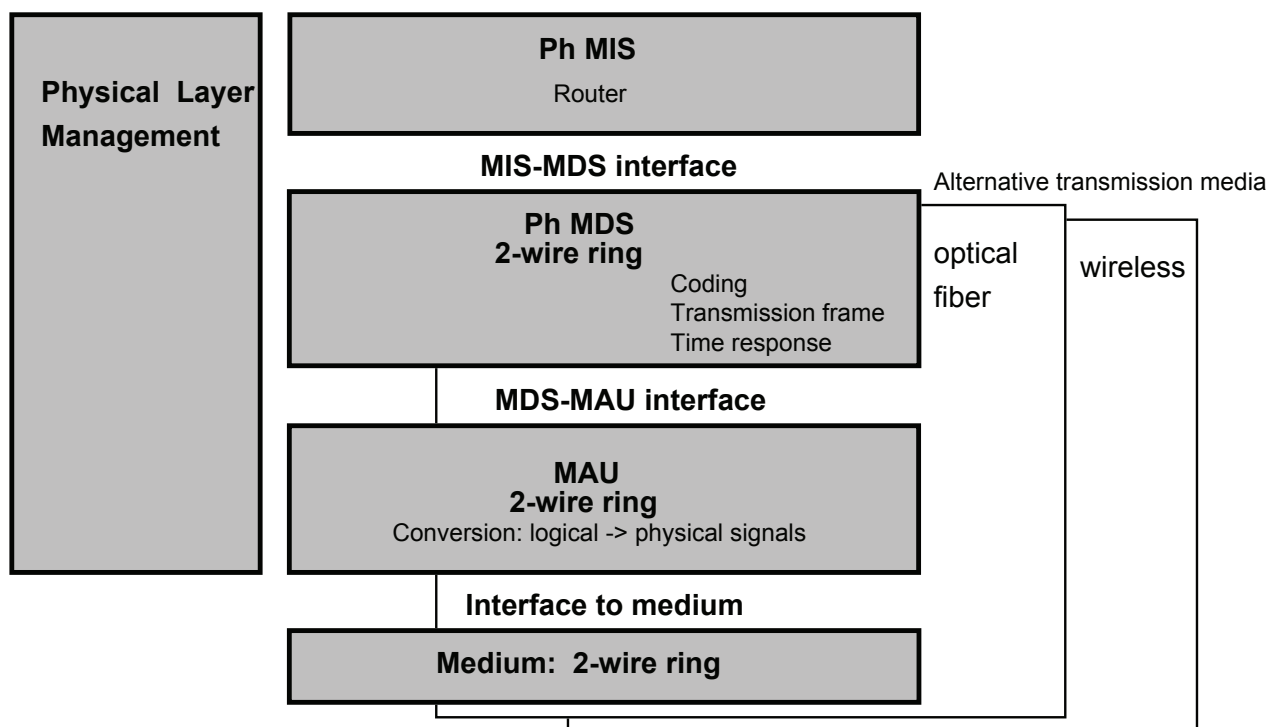


Figure 1-7: Structure of the Physical Layer

Depending on the topology, the Physical Layer of a bus device includes one or several MAUs. Slaves have at least two MAUs to implement the ring structure within a cable.

8.3 Data Link Layer

8.3.1 General

The Data Link Layer (DLL) comprises the sublayers Medium Access Control (MAC), the Basic Link Layer (BLL) and the Peripherals Data Link (PDL).

8.3.2 Medium Access Control (MAC)

The Medium Access Control sublayer is part of the DLL and controls the secured data transmission between the bus devices over the transmission medium. To secure the data transmission, the MAC sublayer calculates a checksum of the DLPDU to be transmitted in the form of a CRC polynomial and transfers it via the DL-Ph interface to the Physical Layer. Conversely, the MAC sublayer calculates the checksum of a received DLPDU in the form of a CRC polynomial and compares it with the received checksum. The functionality of the MAC sublayer is different for a master and a slave. In a slave only the data received by the lower layers and destined to this slave is passed on to the MAC user. All other data is returned to the sublayers and passed to the next slave. In a bus master, the MAC user transmits all data to the subordinate layers and vice versa.

8.3.3 Basic Link Layer (BLL)

The Basic Link Layer (BLL) is the component of the DLL that is responsible for a controlled bus access. In the cyclic mode, the master BLL has to receive output data from the higher-level components, pass it to the sublayer (MAC, layer 2a) as well as to pass input data received from the MAC in a secured way to the BLL user(s). In the OSI model the BLL is part of the Data Link Layer 2b.

8.3.4 Peripherals Data Link (PDL)

The Peripherals Data Link (PDL) is part of the Data Link Layer 2b of the OSI Reference Model and provides the user services for the transmission of process data (process data channel) and services for the transmission of data blocks (parameter channel). The services for the transmission of process data allow a very efficient and quick transmission of process relevant data such as setpoint and actual values between one bus master and the slaves. As a rule, process data has a simple structure, but is highly dynamic and up to date. The services for the transmission of data blocks allow the transmission of parameters.

Annex A

(informative)

Cycle Time Calculation for Benchmark Scenarios

Benchmark scenario A :

- Number of stations 31
- Number of inputs data per station 16 bits
- Number of outputs data per station 8 bits

$$t_{BC} = (13 \times (6 + n) + 2 \times m) \times t_{Bit}$$

$$\text{Cycle Time} = \{13 * (6 + 31 * 2) + 2 * 31\} * 2 \mu s = \underline{\underline{1,892 ms}}$$

Benchmark scenario B :

- Number of stations : 24
- Station 1 to 8 16 bits input
- Station 9 to 16 16 bits output
- Station 17 to 24 16 bits and 16 bit output

$$t_{BC} = (13 \times (6 + n) + 2 \times m) \times t_{Bit}$$

$$\text{Cycle Time} = \{13 * (6 + 24 * 2) + 2 * 24\} * 2 \mu s = \underline{\underline{1,5 ms}}$$

High Efficiency Communication Subsystem for Small Data Packages

Part 2-2

Physical Layer

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FOREWORD

Volume 2 of this European Standard has been prepared by CENELEC technical committee 65CX. All parts of volume 2 describe together a complete sensor/actuator network.

This part of volume 2 of this European Standard describes the Physical Layer (PhL, Layer 1) of the sensor/actuator network.

The other parts of volume 2 describe the following:

Part 1-2: General Description and System Architecture
also common definitions and conventions for volume 2

Part 3-2: Data Link Layer

INTRODUCTION

The Physical Layer (PhL), which is described in this part of volume 2 of this European Standard, allows the transparent transmission of data units between the facilities of the Data Link Layer (DLL) via physical connections.

The Physical Layer receives data units from the Data Link Layer, encodes them, if necessary by adding a communication frame, and transmits the resulting physical signals through a medium access to the transmission medium. Then these signals are received by the Physical Layer of another device through its medium access, decoded, if necessary by removing the communication frame, and the data units obtained in such a way are passed to the Data Link Layer.

The Physical Layer also allows to transmit data units which have been received through a medium access by the transmission medium directly through another medium access and its transmission protocol to another device.

This part of the standard only specifies the transmission media that use wires. The general characteristics of these transmission media are as follows:

1. digital data transmission
2. asynchronous transmission
3. full-duplex transmission
4. Non Return to Zero (NRZ) coding

This standard describes the 2-wire ring type with a transmission speed of 500 Kbit/s. However, transmission media (e.g. optical fibres, wireless transmission) and signal transmission rates are also allowed in the network.

The Physical Layer provides the following options:

- No power supply via the bus cable, not intrinsically safe
- Power supply via the bus cable and on additional conductors, not intrinsically safe

The structure of the Physical Layer is shown in Figure 2-1.

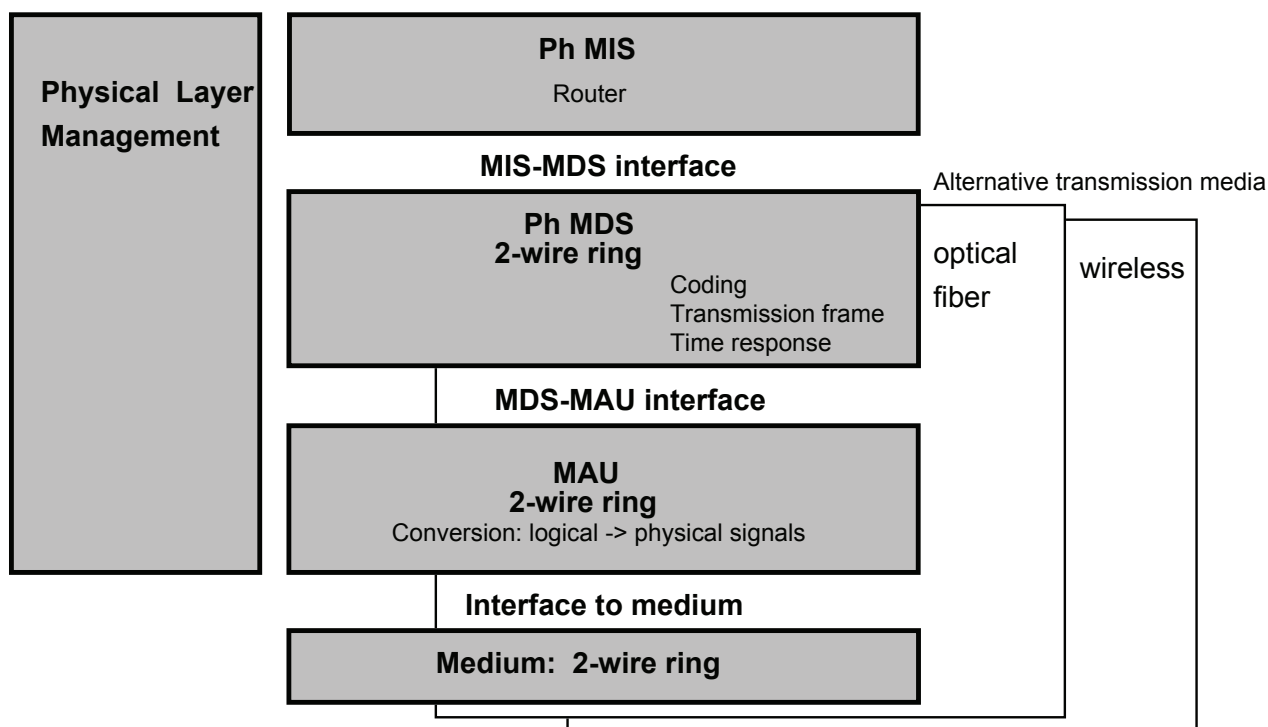


Figure 2-1: Structure of the Physical Layer

The Physical Layer is subdivided into a part that is independent of the medium and a part that is dependent on the medium. The part which is independent of the medium consists only of the MIS (Medium Independent Sublayer). The part which is dependent on the medium consists of the MDS (Medium Dependent Sublayer) and the MAU (Medium Attachment Unit).

The MIS transmits interface data units as a sequence of binary data units (bits) from the Data Link Layer through DLL-PhL interface to the MDS via the MIS-MDS interface and vice versa. The MIS also allows to directly transmit binary data units between MDS of the same or a different type.

The MDS codes the data received from the MIS, if necessary by adding a communication frame, and it decodes the signals received by the transmission medium through the MDS-MAU interface, if necessary by removing the communication frame. Then it transfers the received binary data to the MIS. The MDS also allows the direct coupling of signals of MAUs of the same type.

The transmission medium is accessed through the MAU. It converts the coded logical signals into physical signals and physical signals received from the transmission medium into logical signals. These signals are transmitted via the MDS-MAU interface to the MDS.

1 Scope

This part of volume 2 of this European Standard defines the requirements on a sensor/actuator network device, the transmission media, and the network configuration.

The Physical Layer of the sensor/actuator network corresponds to the definition of Layer 1 of the seven-layer OSI model in accordance with ISO 7498.

This part of the series should be read in connection with part 1-2 "General Description and System Architecture", and part 3-2 "Data Link Layer".

2 Normative References

This European Standard contains by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of these publications apply to this European Standard only when incorporated in it by amendment or revisions. For undated references the latest edition of the publication referred to applies.

ISO 7498: 1984	Information processing - Open Systems Interconnection - Basic Reference Model (Status as of 1988)
EIA-RS-485: 1991	Standard for electrical Characteristics of Generators and Receivers for use in balanced digital Multipoint Systems
IEC 189-1:1986	Low-frequency cables and wires with PVC insulation and PVC sheath Part 1: General test and measuring methods
IEC 1156-1:1994-07	Multicore and symmetrical pair/quad cables for digital communications Part 1: Generic specification
IEC 96-1	Radiofrequency cables Part 1: General requirements and measuring methods

3 Abbreviations

The following abbreviations are used in this part of this European Standard:

BC	Bus Connector
BCI	Bus Connector IN
BLL	Basic Link Layer
BSY	Busy
.con	.conformation
CRC	Cyclic Redundancy Check
CTS	Clear to Send
DI	Data In
DL	Data Link (as a prefix)
DLL	Data Link Layer
DLPDU	Data Link Process Data Unit
DO	Data Out
DS	Data Select
GND	Ground
ICI	Interface Control Information
ID	Identifier
.ind	.indication
LbE	Loopback Enable
LSB	Least Significant Byte
MA	Medium Activity
MAC	Medium Access Control
MAU	Medium Attachment Unit
MDS	Medium Dependent Sublayer
MIS	Medium Independent Sublayer
MSB	Most Significant Bit
PhICI	Physical Interface Control Information
PhIDU	Physical Interface Data Unit
PhPDU	Physical Protocol Data Unit
PhSDU	Physical Service Data Unit
PNM1/2	Peripherals Network Management of Layers 1 and 2
.req	.request
RI	Reset In
RO	Reset Out
RqDly1	Request Delay 1
RqDly2	Request Delay 2
RTS	Request to Send
RxA	Receive Activity
RxC	Receive Clock
RxCR	Receive Control Line
RxD	Receive Data
RxS	Receive Sequence
RxSL	Receive Select Line
SL	Select Line
T _{Rst}	See 8.4.2: Coding and Decoding (of the Reset PhPDU)
TxC	Transmit Clock
TxCR	Transmit Control Line
TxD	Transmit Data
TxS	Transmit Sequence
TxSL	Transmit Select Line

4 Physical Layer Interface

4.1 Required Services

PhIDUs shall be transmitted between DLL and PhL in accordance with the requirements of ISO 7498. Figure 2-2 shows the interface of the Physical Layer.

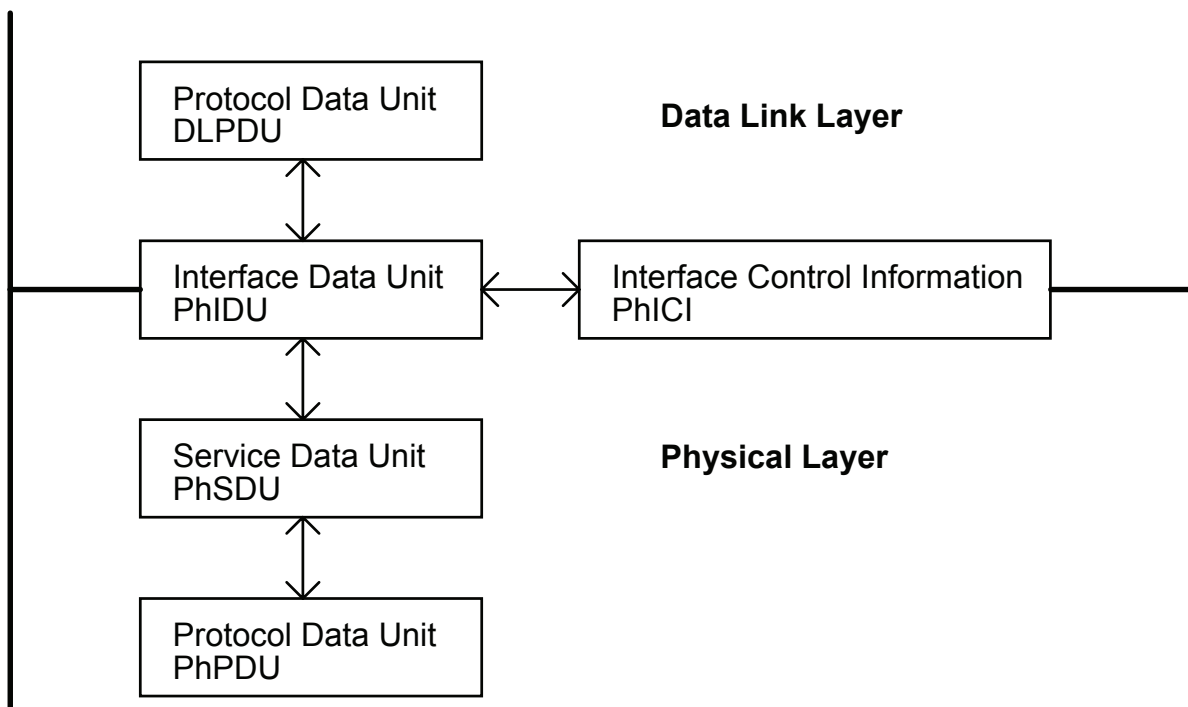


Figure 2-2: Physical Layer interface

PhIDUs are exchanged between the Data Link Layer (DLL) and the Physical Layer (PhL). For the data transfer, the DL-Ph interface (MAC-MIS interface) shall make the following service primitives available:

- Ph_Data.request
- Ph_Data.confirmation
- Ph_Data.indication

4.2 Description of the Service Primitives

4.2.1 Ph_Data.request (PhICI, PhIDU)

This service primitive is used to transfer a data unit from the MAC sublayer to the MIS. The **PhICI** parameter determines the interface components of the interface data unit (PhIDU) to be transmitted and can contain the following values:

ID_transfer

The beginning of a data sequence for the transmission of identification/control data is requested.

data_transfer

The beginning of a data sequence for the transmission of user data is requested.

start_ID_cycle

The beginning of an identification cycle for the transmission of identification/control data is requested by the master.

start_data_cycle

The beginning of a data cycle for the transmission of user data is requested by the master.

user_data

The transmission of the data unit of user data defined by the PhIDU parameter (identification/control data or user data) is requested.

CRC_data

The transmission of the data unit of checksum data defined by the PhIDU parameter is requested.

CRC_status

The transmission of the data unit for the checksum status defined by the PhIDU parameter is requested.

user_data_idle

The transmission of user_data_idle messages is requested.

CRC_data_idle

The transmission of CRC_data_idle messages is requested.

CRC_status_idle

The transmission of CRC_status_idle messages is requested.

NOTE:

The start_data_cycle and start_ID_cycle parameters are supported by the MAC sublayer of a master only.

The **PhIDU** parameter defines the data component of the interface data unit to be transmitted. It consists of one bit.

Only if PhICI = user_data, CRC_data or CRC_status

4.2.2 Ph_Data.confirmation (status)

This service primitive is the acknowledgement to a Ph_Data.request primitive and is used for synchronisation. The **status** parameter indicates whether the associated Ph_Data.request primitive was executed successfully or not.

4.2.3 Ph_Data.indication (PhICI, PhIDU)

This service primitive is used to transfer a data unit from the MIS to the MAC sublayer. The **PhICI** parameter defines the interface component of the interface data unit (PhIDU) to be transmitted and can assume the following values:

ID_transfer

Indicates the beginning of a data sequence for the transmission of identification/control data.

data_transfer

Indicates the beginning of a data sequence for the transmission of user data.

user_data

The correct receipt of the data unit for the transmission of user data (identification/control data or user data) defined by the PhIDU parameter is indicated.

CRC_data

The correct receipt of the data unit for transmission of the checksum defined by the PhIDU parameter is indicated.

CRC_status

The correct receipt of the data unit for the transmission of the checksum status defined by the PhIDU parameter is indicated.

user_data_idle

The receipt of user_data_idle messages is indicated.

CRC_data_idle

The receipt of CRC_data_idle messages is indicated.

CRC_status_idle

The receipt of CRC_status_idle messages is indicated.

The **PhIDU** parameter defines the data components of the received interface data unit. It consists of one bit.

4.3 Overview of the Interactions

NOTE:

For the data transfer via the DL-Ph interface, a difference is made between the data sequence (transmission of user or identification data) and the check sequence (transmission of checksum data).

The following applies to Figure 2-3, Figure 2-4,

Figure 2-5 and Figure 2-6 :

- If a data sequence of a data cycle is followed by a data sequence of an identification cycle, the interactions marked with (+) are omitted for an identification cycle.
- If a data sequence of an identification cycle is followed by a data sequence of a data cycle, the interactions marked with (+) are omitted for a data cycle.

4.3.1 Data Sequence

4.3.1.1 Master

Figure 2-3 and Figure 2-4 show the interactions for a data sequence (identification cycle and data cycle) at the DL-Ph interface of a master (controller board).

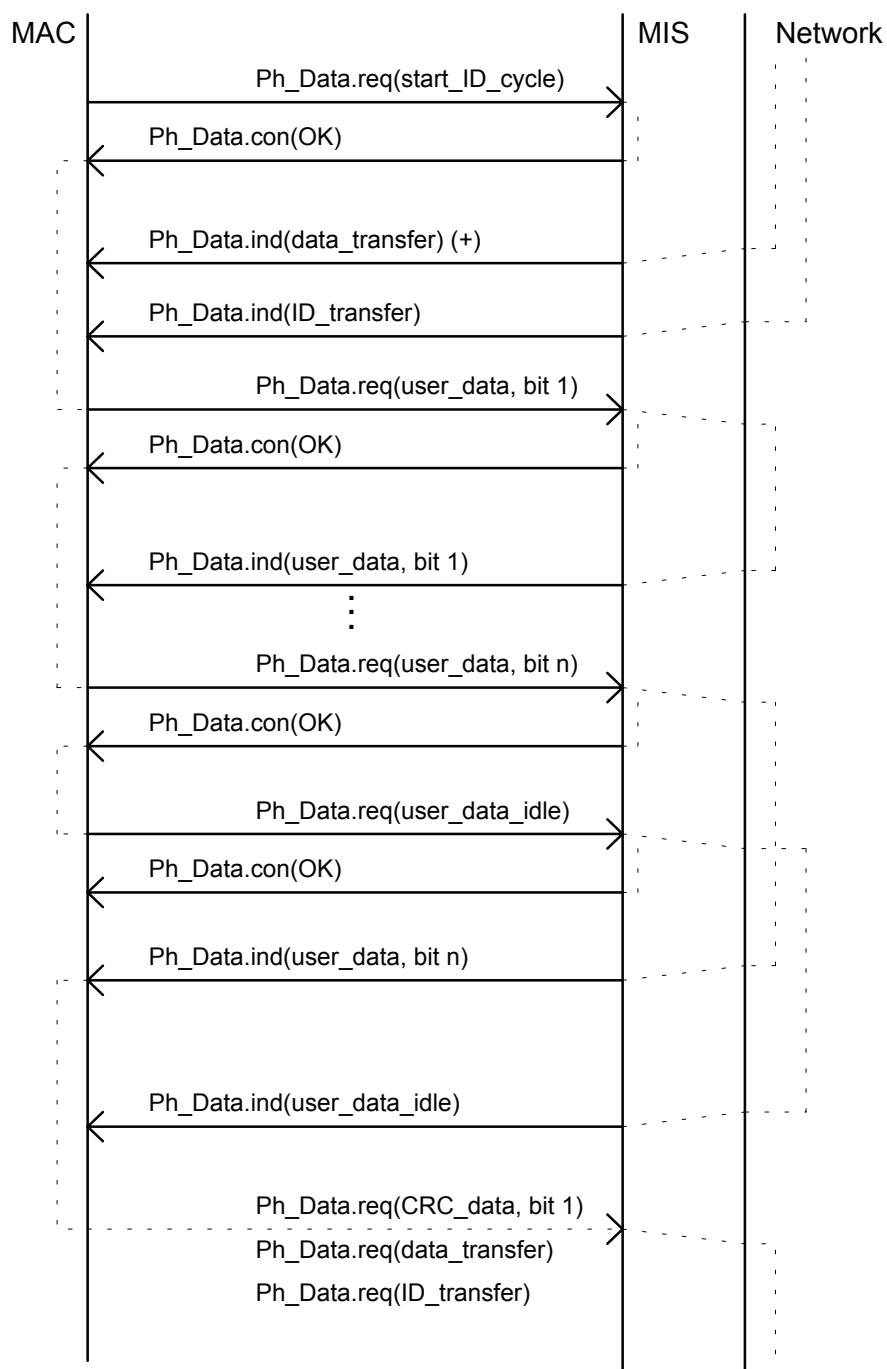


Figure 2-3: Interactions for a data sequence of a master: identification cycle

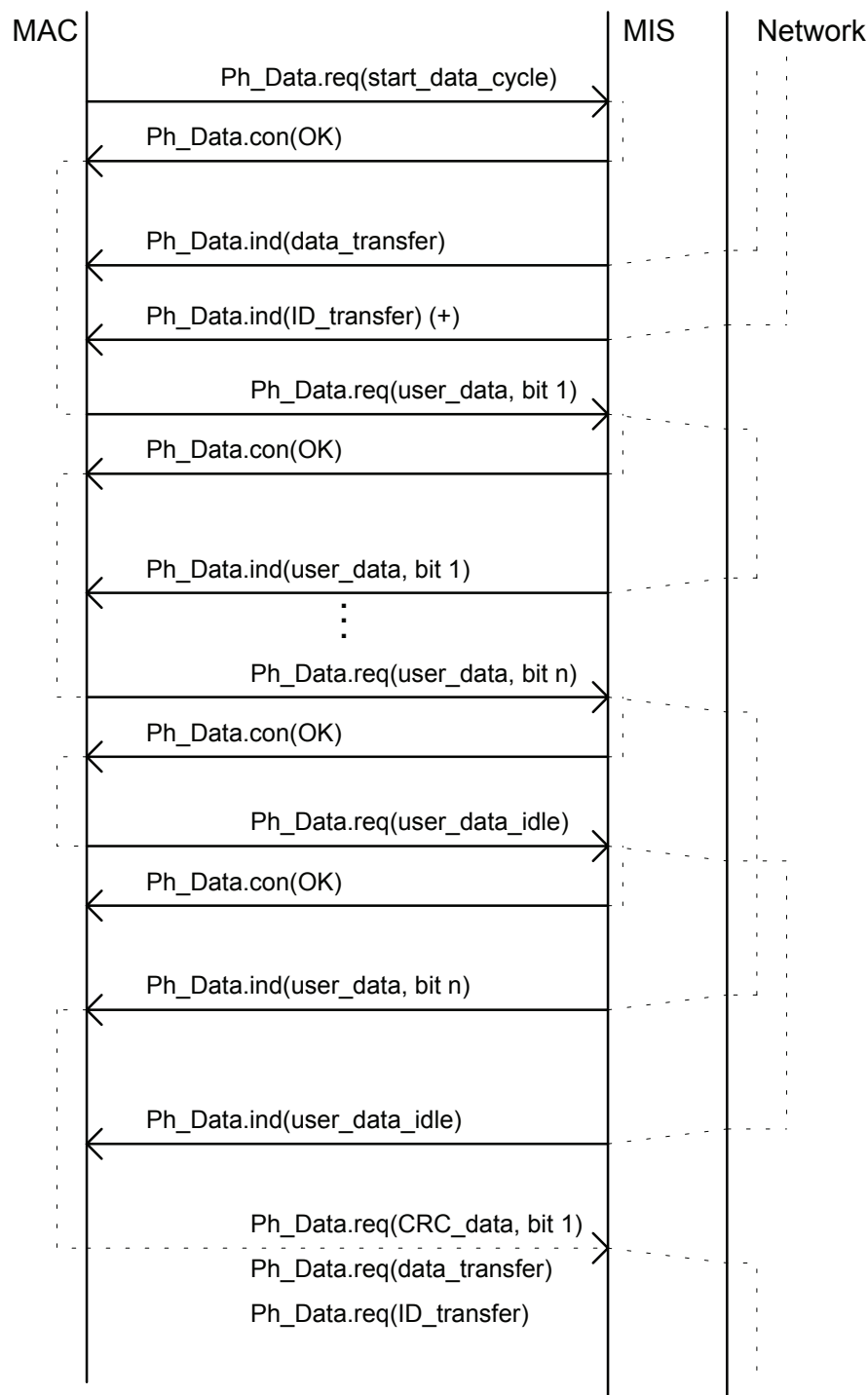


Figure 2-4: Interactions for a data sequence of a master: data cycle

4.3.1.2 Slave

Figure 2-5 and Figure 2-6 show the interactions for a data sequence (identification cycle and data cycle) at the DL-Ph interface of a slave (remote bus device, local bus device or bus coupler).

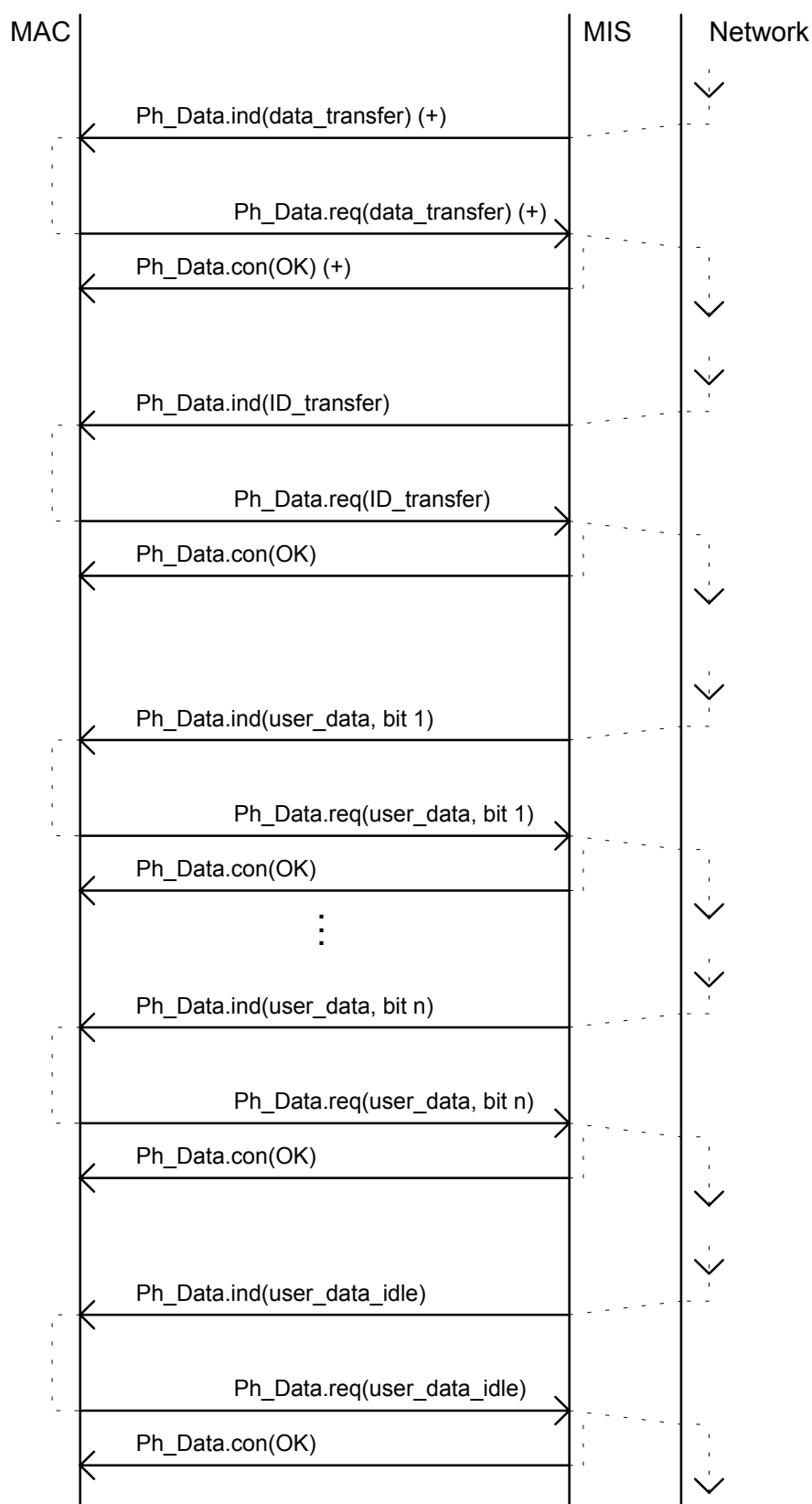


Figure 2-5: Interactions for a data sequence of a slave: identification cycle

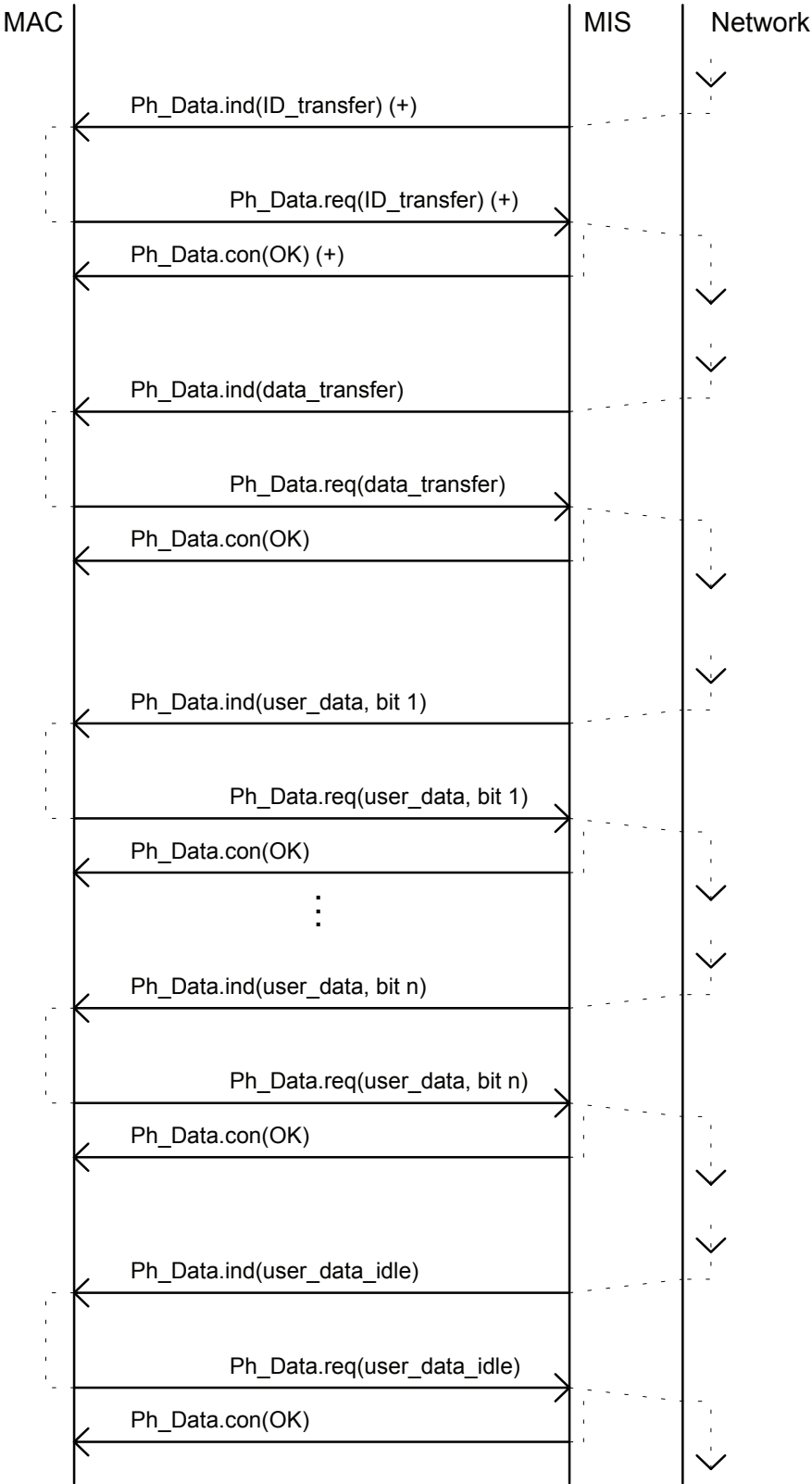


Figure 2-6: Interactions for a data sequence of a slave: data cycle

4.3.2 Check Sequence

4.3.2.1 Master

Figure 2-7 shows the interactions for a check sequence at the DL-Ph interface of a master.

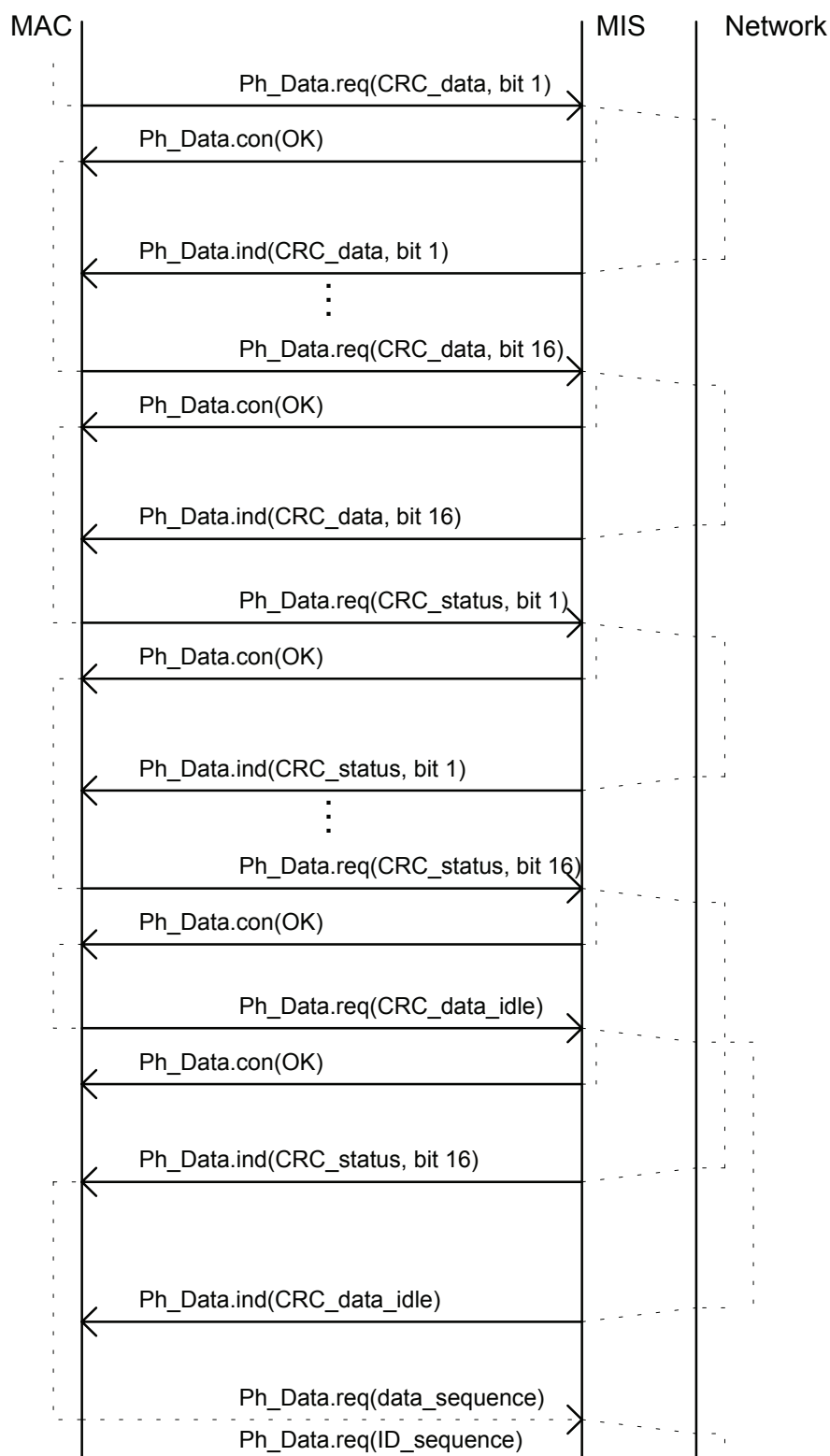


Figure 2-7: Interactions for a check sequence of a master

4.3.2.2 Slave

Figure 2-8 shows the interactions for a check sequence at the DL-Ph interface of a slave.

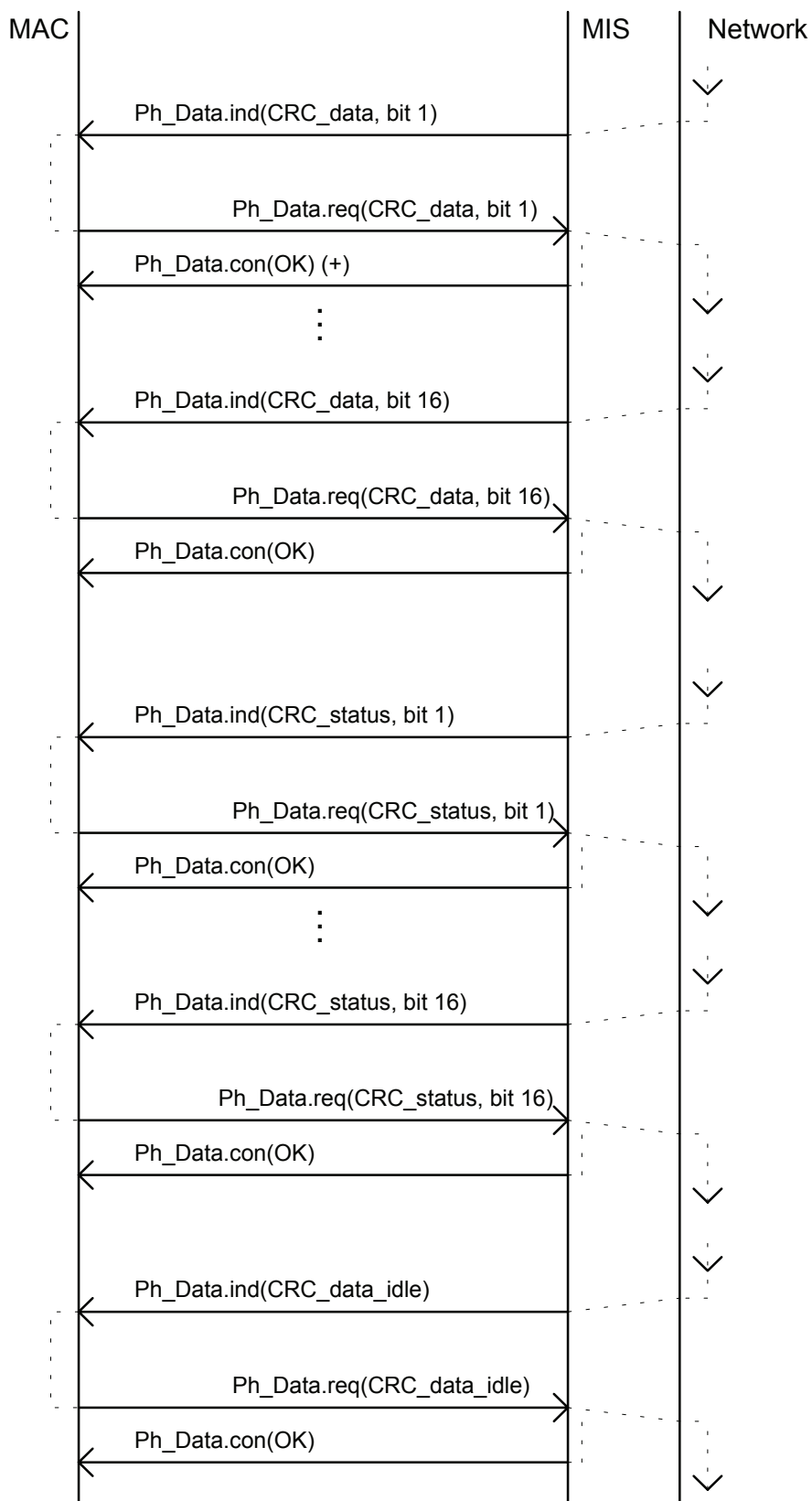


Figure 2-8: Interactions for a check sequence of a slave

5 Physical Layer Management

5.1 Functionality of the Physical Layer Management

The management of the PhL is the part of the PhL which produces the management functionality of the PhL that are demanded by the PNM1/2. The management of the PhL handles the initialisation, the monitoring, and the error recovery in the PhL.

5.2 PhL-PNM1/2 Interface

This subclause defines the administrative PhL management services which are available to the PNM1/2, together with their service primitives and associated parameters. Figure 2-9 shows the interface between PhL and PNM1/2 in the layer model.

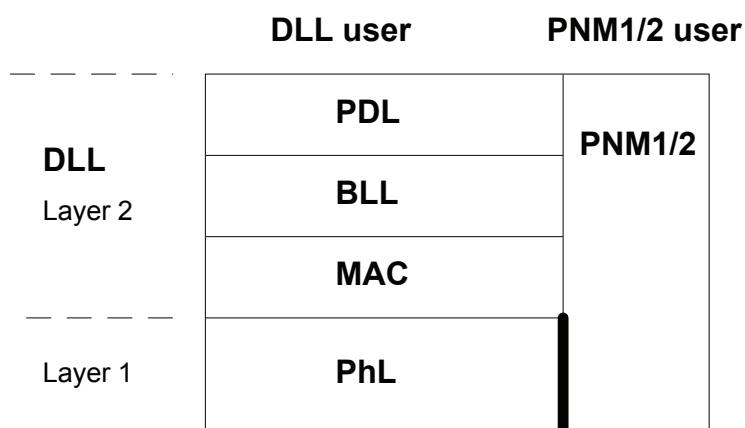


Figure 2-9: Interface between PhL and PNM1/2 in the layer model

The service interface between PhL and PNM1/2 provides the following functions:

- Reset of the PhL
- Request and change of the current operating parameters of the PhL
- Indication of unexpected events, errors and status changes, which occurred or were detected in the PhL

5.2.1 Overview of the Services

The PhL makes the following services available to the PNM1/2:

- Reset PhL
- Set Value PhL or Read Value PhL
- Event PhL

Reset PhL (mandatory)

The PNM1/2 uses this service to reset the PhL. The reset is equivalent to power on. Upon execution of the service, the PNM1/2 receives a confirmation.

Set Value PhL (optional)

The PNM1/2 uses this service to set new values to the PhL variables. Upon completion, the PNM1/2 of the PhL receives a confirmation whether the defined variables assumed the new values.

Read Value PhL (optional)

The PNM1/2 uses this service to read out variables of the PhL. The current value of the defined variable is returned in the response of the PhL.

Event PhL (mandatory)

The PhL uses this service to inform the PNM1/2 user about certain events or errors in the PhL.

5.2.2 Overview of the Interactions

The PhL services are described by the following primitives (beginning with Ph_...):

Reset PhL

Ph_Reset.request
Ph_Reset.confirmation

Set Value PhL

Ph_Set_Value.request
Ph_Set_Value.confirmation

Read Value PhL

Ph_Read_Value.request
Ph_Read_Value.confirmation

Event PhL

Ph_Event.indication

Figure 2-10 and **Figure 2-11** show the time relations of the service primitives.

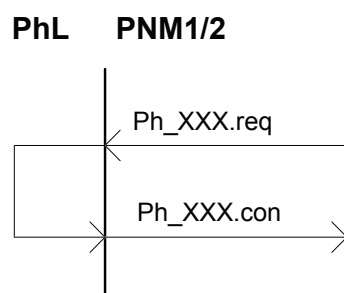


Figure 2-10: Reset, Set/Read Value PhL services

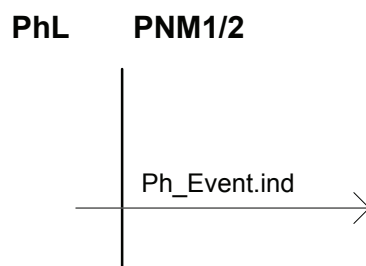


Figure 2-11: Event PhL service

5.2.3 Detailed Definitions of the Services and Interactions