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Industrial communication networks – Fieldbus specifications – Part 4-3: Data-link layer protocol specification – Type 3 elements

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INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

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FOREWORD

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NOTE Combinations of protocol types are specified in IEC 61784-1 and IEC 61784-2.

International Standard IEC 61158-4-3 has been prepared by subcommittee 65C: Industrial networks, of IEC technical committee 65: Industrial-process measurement, control and automation.

This fourth edition cancels and replaces the third edition published in 2014. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- corrections in Table 3;
- corrections in Table A.15;
- spelling and grammar.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
65C/946/FDIS	65C/955/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

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

A list of all parts of the IEC 61158 series, published under the general title *Industrial communication networks – Fieldbus specifications*, can be found on the IEC web site

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under <http://webstore.iec.ch> in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

This part of IEC 61158 is one of a series produced to facilitate the interconnection of automation system components. It is related to other standards in the set as defined by the "three-layer" fieldbus reference model described in IEC 61158-1.

The data-link protocol provides the data-link service by making use of the services available from the physical layer. The primary aim of this document is to provide a set of rules for communication expressed in terms of the procedures to be carried out by peer data-link entities (DLEs) at the time of communication. These rules for communication are intended to provide a sound basis for development in order to serve a variety of purposes:

a) as a guide for implementors and designers;

b) for use in the testing and procurement of equipment;

c) as part of an agreement for the admittance of systems into the open systems environment;

d) as a refinement to the understanding of time-critical communications within OSI.

This document is concerned, in particular, with the communication and interworking of sensors, effectors and other automation devices. By using this document together with other standards positioned within the OSI or fieldbus reference models, otherwise incompatible systems may work together in any combination.

NOTE Use of some of the associated protocol types is restricted by their intellectual-property-right holders. In all cases, the commitment to limited release of intellectual-property-rights made by the holders of those rights permits a particular data-link layer protocol type to be used with physical layer and application layer protocols in Type combinations as specified explicitly in its profile parts. Use of the various protocol types in other combinations may require permission from their respective intellectual-property-right holders.

INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 4-3: Data-link layer protocol specification – Type 3 elements

1 Scope

1.1 General

The data-link layer provides basic time-critical messaging communications between devices in an automation environment.

This protocol provides communication opportunities to a pre-selected “master” subset of data-link entities in a cyclic asynchronous manner, sequentially to each of those data-link entities. Other data-link entities communicate only as permitted and delegated by those master data-link entities.

For a given master, its communications with other data-link entities can be cyclic, or acyclic with prioritized access, or a combination of the two.

This protocol provides a means of sharing the available communication resources in a fair manner. There are provisions for time synchronization and for isochronous operation.

1.2 Specifications

This document specifies

a) procedures for the timely transfer of data and control information from one data-link user entity to a peer user entity, and among the data-link entities forming the distributed data-link service provider;

b) the structure of the fieldbus DLPDUs used for the transfer of data and control information by the protocol of this document, and their representation as physical interface data units.

1.3 Procedures

The procedures are defined in terms of

a) the interactions between peer DL-entities (DLEs) through the exchange of fieldbus DLPDUs;

b) the interactions between a DL-service (DLS) provider and a DLS-user in the same system through the exchange of DLS primitives;

c) the interactions between a DLS-provider and a Ph-service provider in the same system through the exchange of Ph-service primitives.

1.4 Applicability

These procedures are applicable to instances of communication between systems which support time-critical communications services within the data-link layer of the OSI or fieldbus reference models, and which require the ability to interconnect in an open systems interconnection environment.

Profiles provide a simple multi-attribute means of summarizing an implementation’s capabilities, and thus its applicability to various time-critical communications needs.

1.5 Conformance

This document also specifies conformance requirements for systems implementing these procedures. This document does not contain tests to demonstrate compliance with such requirements.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

NOTE All parts of the IEC 61158 series, as well as IEC 61784-1 and IEC 61784-2 are maintained simultaneously. Cross-references to these documents within the text therefore refer to the editions as dated in this list of normative references.

IEC 61131-3, *Programmable controllers – Part 3: Programming languages*

IEC 61158-2:2014, *Industrial communication networks – Fieldbus specifications – Part 2: Physical layer specification and service definition*

IEC 61158-3-3:2014, *Industrial communication networks – Fieldbus specifications – Part 3-3: Data link service definition – Type 3 elements*

ISO/IEC 646, *Information technology – ISO 7-bit coded character set for information interchange*

ISO/IEC 2022, *Information technology – Character code structure and extension techniques*

ISO/IEC 7498–1, *Information technology – Open Systems Interconnection – Basic Reference Model: The Basic Model*

ISO/IEC 7498–3, *Information technology – Open Systems Interconnection – Basic Reference Model: Naming and addressing*

ISO/IEC 10731, *Information technology – Open Systems Interconnection – Basic Reference Model – Conventions for the definition of OSI services*

ISO 1177, *Information processing – Character structure for start/stop and synchronous character oriented transmission*

3 Terms, definitions, symbols and abbreviations

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1 Reference model terms and definitions

This document is based in part on the concepts developed in ISO/IEC 7498-1 and ISO/IEC 7498-3, and makes use of the following terms defined therein.

3.1.1	**called-DL-address**	[ISO/IEC 7498-3]
3.1.2	**calling-DL-address**	[ISO/IEC 7498-3]
3.1.3	**centralized multi-end-point-connection**	[ISO/IEC 7498-3]
3.1.4	**correspondent (N)-entities** **correspondent DL-entities (N=2)** **correspondent Ph-entities (N=1)**	[ISO/IEC 7498-3]
3.1.5	**demultiplexing**	[ISO/IEC 7498-3]
3.1.6	**DL-address**	[ISO/IEC 7498-3]
3.1.7	**DL-address-mapping**	[ISO/IEC 7498-3]
3.1.8	**DL-connection**	[ISO/IEC 7498-3]
3.1.9	**DL-connection-end-point**	[ISO/IEC 7498-3]
3.1.10	**DL-connection-end-point-identifier**	[ISO/IEC 7498-3]
3.1.11	**DL-connection-mode transmission**	[ISO/IEC 7498-3]
3.1.12	**DL-connectionless-mode transmission**	[ISO/IEC 7498-3]
3.1.13	**DL-data-sink**	[ISO/IEC 7498-3]
3.1.14	**DL-data-source**	[ISO/IEC 7498-3]
3.1.15	**DL-duplex-transmission**	[ISO/IEC 7498-3]
3.1.16	**DL-facility**	[ISO/IEC 7498-3]
3.1.17	**DL-local-view**	[ISO/IEC 7498-3]
3.1.18	**DL-name**	[ISO/IEC 7498-3]
3.1.19	**DL-protocol**	[ISO/IEC 7498-3]
3.1.20	**DL-protocol-connection-identifier**	[ISO/IEC 7498-3]
3.1.21	**DL-protocol-control-information**	[ISO/IEC 7498-3]
3.1.22	**DL-protocol-data-unit**	[ISO/IEC 7498-3]
3.1.23	**DL-protocol-version-identifier**	[ISO/IEC 7498-3]
3.1.24	**DL-relay**	[ISO/IEC 7498-3]
3.1.25	**DL-service-connection-identifier**	[ISO/IEC 7498-3]
3.1.26	**DL-service-data-unit**	[ISO/IEC 7498-3]
3.1.27	**DL-simplex-transmission**	[ISO/IEC 7498-3]
3.1.28	**DL-subsystem**	[ISO/IEC 7498-3]
3.1.29	**DL-user-data**	[ISO/IEC 7498-3]
3.1.30	**flow control**	[ISO/IEC 7498-3]
3.1.31	**layer-management**	[ISO/IEC 7498-3]
3.1.32	**multiplexing**	[ISO/IEC 7498-3]

3.1.33 naming-(addressing)-authority [ISO/IEC 7498-3]

3.1.34 naming-(addressing)-domain [ISO/IEC 7498-3]

3.1.35 naming-(addressing)-subdomain [ISO/IEC 7498-3]

3.1.36 (N)-entity [ISO/IEC 7498-3]
DL-entity
Ph-entity

3.1.37 (N)-interface-data-unit [ISO/IEC 7498-3]
DL-service-data-unit (N=2)
Ph-interface-data-unit (N=1)

3.1.38 (N)-layer [ISO/IEC 7498-3]
DL-layer (N=2)
Ph-layer (N=1)

3.1.39 (N)-service [ISO/IEC 7498-3]
DL-service (N=2)
Ph-service (N=1)

3.1.40 (N)-service-access-point [ISO/IEC 7498-3]
DL-service-access-point (N=2)
Ph-service-access-point (N=1)

3.1.41 (N)-service-access-point-address [ISO/IEC 7498-3]
DL-service-access-point-address (N=2)
Ph-service-access-point-address (N=1)

3.1.42 peer-entities [ISO/IEC 7498-3]

3.1.43 Ph-interface-control-information [ISO/IEC 7498-3]

3.1.44 Ph-interface-data [ISO/IEC 7498-3]

3.1.45 primitive name [ISO/IEC 7498-3]

3.1.46 reassembling [ISO/IEC 7498-3]

3.1.47 recombining [ISO/IEC 7498-3]

3.1.48 reset [ISO/IEC 7498-3]

3.1.49 responding-DL-address [ISO/IEC 7498-3]

3.1.50 routing [ISO/IEC 7498-3]

3.1.51 segmenting [ISO/IEC 7498-3]

3.1.52 sequencing [ISO/IEC 7498-3]

3.1.53 splitting [ISO/IEC 7498-3]

3.1.54 synonymous name [ISO/IEC 7498-3]

3.1.55 systems-management [ISO/IEC 7498-3]

3.2 Service convention terms and definitions

This document also makes use of the following terms defined in ISO/IEC 10731 as they apply to the data-link layer:

3.2.1 acceptor

3.2.2 asymmetrical service

3.2.3 confirm (primitive);
requestor.deliver (primitive)

3.2.4 deliver (primitive)

3.2.5 DL-confirmed-facility

3.2.6 DL-facility

3.2.7 DL-local-view

3.2.8 DL-mandatory-facility

3.2.9 DL-non-confirmed-facility

3.2.10 DL-provider-initiated-facility

3.2.11 DL-provider-optional-facility

3.2.12 DL-service-primitive;
primitive

3.2.13 DL-service-provider

3.2.14 DL-service-user

3.2.15 DL-user-optional-facility

3.2.16 indication (primitive)
acceptor.deliver (primitive)

3.2.17 multi-peer

3.2.18 request (primitive);
requestor.submit (primitive)

3.2.19 requestor

3.2.20 response (primitive);
acceptor.submit (primitive)

3.2.21 submit (primitive)

3.2.22 symmetrical service

3.3 Common terms and definitions

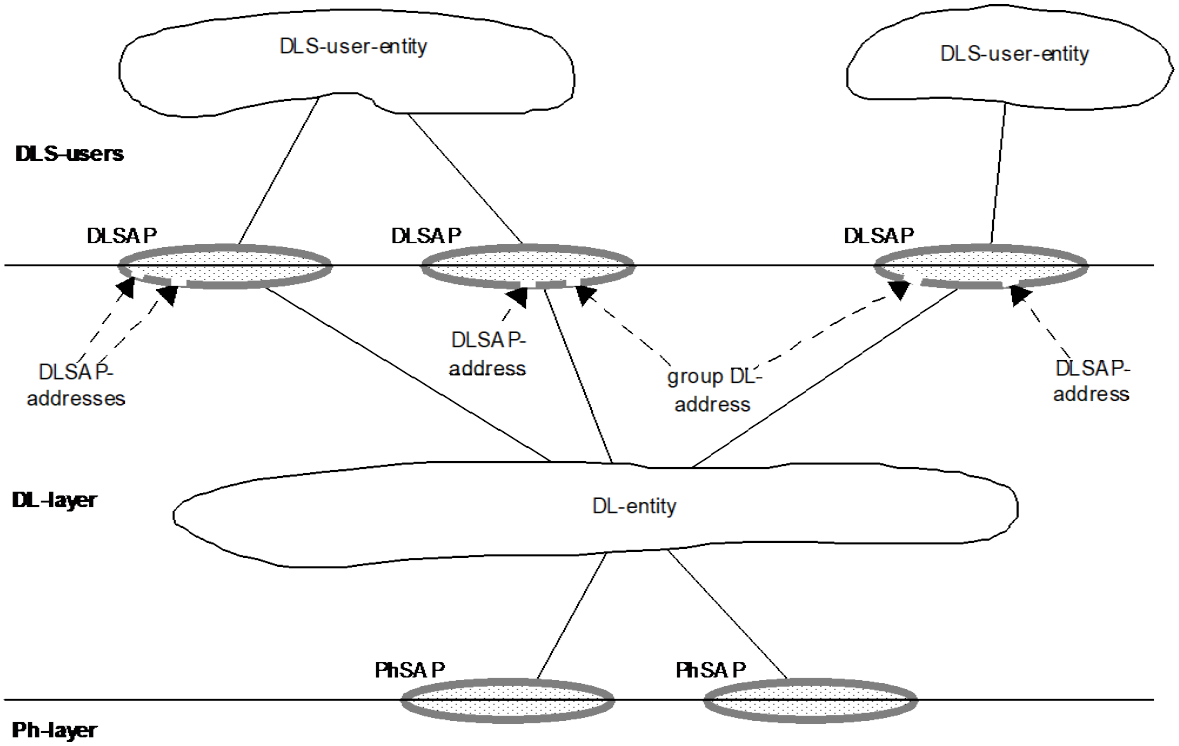
For the purposes of this document, the following terms and definitions apply.

NOTE Many definitions are common to more than one protocol Type; they are not necessarily used by all protocol Types.

3.3.1
DL-segment,
link,
local link
single DL-subnetwork in which any of the connected DLEs may communicate directly, without any intervening DL-relaying, whenever all of those DLEs that are participating in an instance of communication are simultaneously attentive to the DL-subnetwork during the period(s) of attempted communication

3.3.2
DLSAP
distinctive point at which DL-services are provided by a single DL-entity to a single higher-layer entity

Note 1 to entry: This definition, derived from ISO/IEC 7498-1, is repeated here to facilitate understanding of the critical distinction between DLSAPs and their DL-addresses. (See Figure 1.)



NOTE 1 DLSAPs and PhSAPs are depicted as ovals spanning the boundary between two adjacent layers.

NOTE 2 DL-addresses are depicted as designating small gaps (points of access) in the DLL portion of a DLSAP.

NOTE 3 A single DL-entity may have multiple DLSAP-addresses and group DL-addresses associated with a single DLSAP.

Figure 1 – Relationships of DLSAPs, DLSAP-addresses and group DL-addresses

3.3.3
DL(SAP)-address
either an individual DLSAP-address, designating a single DLSAP of a single DLS-user, or a group DL-address potentially designating multiple DLSAPs, each of a single DLS-user

Note 1 to entry: This terminology is chosen because ISO/IEC 7498-3 does not permit the use of the term DLSAP-address to designate more than a single DLSAP at a single DLS-user.

3.3.4
(individual) DLSAP-address
DL-address that designates only one DLSAP within the extended link

Note 1 to entry: A single DL-entity may have multiple DLSAP-addresses associated with a single DLSAP.

3.3.5
extended link
DL-subnetwork, consisting of the maximal set of links interconnected by DL-relays, sharing a single DL-name (DL-address) space, in which any of the connected DL-entities may communicate, one with another, either directly or with the assistance of one or more of those intervening DL-relay entities

Note 1 to entry: An extended link may be composed of just a single link.

3.3.6
frame
denigrated synonym for DLPDU

3.3.7
group DL-address
DL-address that potentially designates more than one DLSAP within the extended link

Note 1 to entry: A single DL-entity may have multiple group DL-addresses associated with a single DLSAP.

Note 2 to entry: A single DL-entity also may have a single group DL-address associated with more than one DLSAP

3.3.8
node
single DL-entity as it appears on one local link

3.3.9
receiving DLS-user
DL-service user that acts as a recipient of DL-user-data

Note 1 to entry: A DL-service user can be concurrently both a sending and receiving DLS-user.

3.3.10
sending DLS-user
DL-service user that acts as a source of DL-user-data

3.4 Additional Type 3 definitions

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

3.4.1
acknowledge DLPDU
reply DLPDU that contains no DLSDU

3.4.2
address extension
DLSAP address or region/segment address

3.4.3
bit time
time to transmit one bit

3.4.4
confirmed message exchange
complete data transfer with request and acknowledgement or response DLPDU

3.4.5
controller_type
hardware class of the communications entity

3.4.6
current master
token holder

3.4.7
data DLPDU
DLPDU that carries a DLSDU from a local DLS-user to a remote DLS-user

3.4.8
DL_status
status that specifies the result of the execution of the associated request

3.4.9
GAP
range of station (DLE) DL-addresses from this station (TS) to its successor (NS) in the logical token ring, excluding stations above HSA

3.4.10
GAP maintenance
registration of new Master and slave stations

3.4.11
isochronous mode
special operational mode that implies both a constant (isochronous) cycle with a fixed schedule of high and low priority messages, and the synchronization of the DLS-users with this constant (isochronous) cycle

3.4.12
local DLS-user
DLS-user that initiates the current service

3.4.13
message exchange
complete confirmed or unconfirmed data transfer

3.4.14
region/segment address
address extension that identifies a particular fieldbus subnetwork

Note 1 to entry: This supports DL-routing between fieldbuses.

3.4.15
request data
DLSDU provided by the remote DLS-user to the local DLS-user

3.4.16
remote DLE
addressed DLE of a service request (that is, the intended receiving DLE of any resulting send/request DLPDU)

3.4.17
remote DLS-user
addressed DLS-user of a service request (that is, the intended receiver of any resulting indication primitive)

3.4.18
reply DLPDU
DLPDU transmitted from a remote DLE to the initiating (local) DLE, and possibly other DLEs

Note 1 to entry: When the remote DLE is a Publisher, the reply DLPDU also can be sent to several remote DLEs.

3.4.19
response DLPDU
reply DLPDU that carries a DLSDU from a remote DLS-user to local DLS-user

3.4.20
send data
DLSDU provided by a local DLS-user to a remote DLS-user

3.4.21
send/request DLPDU
DLPDU that carries either a request for data or a DLSDU or both from a local DLS-user to a remote DLS-user

3.4.22
time master
device which is able to send clock synchronization DLPDUs

Note 1 to entry: Link devices have time master functionality.

3.4.23
time receiver
device which is able to be time synchronized by a time Master

3.4.24
token holder
Master station that controls bus access

3.4.25
token passing
medium access method, in which the right to transmit is passed from master station to master station in a logical ring

3.5 Common symbols and abbreviations

3.5.1 Data units

3.5.1.1	**DLPDU**	DL-protocol data unit
3.5.1.2	**DLSDU**	DL-service data unit
3.5.1.3	**PhIDU**	Ph-interface data unit
3.5.1.4	**PhPDU**	Ph-protocol data unit

3.5.2 Miscellaneous

3.5.2.1	**DL-**	data link layer (as a prefix)
3.5.2.2	**DLCEP**	DL-connection endpoint
3.5.2.3	**DLE**	DL-entity (the local active instance of the Data Link layer)
3.5.2.4	**DLL**	DL-layer
3.5.2.5	**DLM-**	DL-management (as a prefix)
3.5.2.6	**DLMS**	DL-management-service
3.5.2.7	**DLS**	DL-service
3.5.2.8	**DLSAP**	DL-service access point
3.5.2.9	**FIFO**	first-in first-out (queuing method)
3.5.2.10	**LLC**	logical link control
3.5.2.11	**MAC**	medium access control
3.5.2.12	**OSI**	open systems interconnection

3.5.2.13 Ph- physical layer (as a prefix)

3.5.2.14 PhE Ph-entity (the local active instance of the Physical layer)

3.5.2.15 PhL Ph-layer

3.5.2.16 PhS Ph-service

3.5.2.17 PhSAP Ph-service access point

3.5.2.18 QoS quality of service

3.6 Type 3 symbols and abbreviations

3.6.1 ACK acknowledge(ment) DLPDU

3.6.2 ASM active spare time message

3.6.3 ASP active spare time period

3.6.4 Bus ID bus identification, an address extension (region/DL-segment address) that identifies a particular bus as supporting routing between DL-segments

3.6.5 CRX character receive execution

3.6.6 CS clock synchronization

3.6.7 CTX character transmit execution

3.6.8 DA destination address of a DLPDU

3.6.9 DAE destination address extension(s) of a DLPDU, which convey D_SAP_index and/or destination bus ID

3.6.10 D_SAP destination service access point, the DLSAP associated with the remote DLS-user

3.6.11 D_SAP_index destination service access point index – that component of a DLSAP address which designates a DLSAP and remote DLS-user within the remote DLE

3.6.12 DXM data exchange multicast

3.6.13 ED end delimiter of a DLPDU

3.6.14 EOA End-of-Activity

3.6.15 EOD End-of-Data

3.6.16 EODA End-of-Data-and-Activity

3.6.17 EXT address extension bit of a DLPDU

3.6.18 FC frame control (frame type) field of a DLPDU

3.6.19 FCB frame count bit of a DLPDU (FC field) used to eliminate lost or duplicated DLPDUs

3.6.20 FCV frame count bit valid bit of a DLPDU, indicates whether the FCB is to be evaluated

3.6.21	**FCS**	frame check sequence (synchronous) or frame checksum (asynchronous)
3.6.22	**FLC**	fieldbus link control
3.6.23	**G**	GAP update factor, the number of token rotations between GAP maintenance (update) cycles
3.6.24	**GAPL**	GAP list containing the status of all stations in this station's GAP
3.6.25	**IsoM**	isochronous mode
3.6.26	**Hd**	Hamming distance, a measure of DLPDU integrity, the minimum number of bit errors that can cause acceptance of a spurious DLPDU
3.6.27	**HSA**	highest station address installed (configured) on this fieldbus
3.6.28	**L**	length of the information field, the part of a DLPDU that is checked by the FCS
3.6.29	**LE**	field giving the length of a DLPDU beyond the fixed part
3.6.30	**LEr**	field that repeats the length to increase DLPDU integrity
3.6.31	**LMS**	list of master stations
3.6.32	**LR**	local resource not available or not sufficient (DL/DLM_status of the service primitive)
3.6.33	**LS**	local service not activated at DL-service access point or local DLSAP not activated (DL/DLM_status of the service primitive)
3.6.34	**lsb**	least significant bit of a field or octet
3.6.35	**max**	the arithmetic maximum function
3.6.36	**MCT**	multicast
3.6.37	**MP**	message transfer message retry transfer periods
3.6.38	**mr**	number of retries
3.6.39	**msb**	most significant bit of a field or octet
3.6.40	**MSRD**	DLS: Send and Request Data with Multicast reply
3.6.41	**mt**	number of retries per token rotation
3.6.42	**n**	number of stations
3.6.43	**NA**	no acknowledgement/response (DL/DLM_status of the service primitive)
3.6.44	**na**	number of active stations
3.6.45	**NIL**	locally determined value
3.6.46	**NO**	not ok (DL/DLM_status of the service primitive)
3.6.47	**np**	number of passive stations
3.6.48	**NR**	no response DL-data acknowledgement negative and send data ok (DL_status of the service primitive)

3.6.49	**NRZ**	non-return-to-zero (PhL), an encoding technique where transitions occur only when successive data bits have different values
3.6.50	**NS**	next station, the station to which this master will pass the token
3.6.51	**OK**	service finished according to the rules (DL/DLM_status of the service primitive)
3.6.52	**PhICI**	PhL Interface Control Information [ISO/IEC 7498-1]
3.6.53	**PhPCI**	PhL Protocol Control Information [ISO/IEC 7498-1]
3.6.54	**PON**	power on transition occurs at a station
3.6.55	**PS**	previous station, the station which passes the token to this master station
3.6.56	**PSP**	passive spare time period
3.6.57	**RDH**	response DL-data high and no resource for send data (DL/DLM_status of the service primitive)
3.6.58	**RDL**	response DL/DLM-data low and no resource for send data (DL/DLM_status of the service primitive)
3.6.59	**Res**	reserved
3.6.60	**RET**	retry
3.6.61	**RR**	no resource for send data and no response DL-data available (negative acknowledgement) (DL/DLM_status of the service primitive)
3.6.62	**RS**	no service, or no service activated at remote DLSAP (negative acknowledgement) (DL/DLM_status of the service primitive)
3.6.63	**RSYS**	system message rate (in message transfer periods per second) at which confirmed DL-message exchanges are performed
3.6.64	**SA**	source address of a DLPDU
3.6.65	**SAE**	source address extension(s) of a DLPDU, which convey S_SAP_index and/or source bus ID
3.6.66	**SC**	single character acknowledge DLPDU
3.6.67	**SD1 to SD4**	start delimiters of asynchronous DLPDU transmission
3.6.68	**SDA**	Send Data with Acknowledge (DL-service)
3.6.69	**SDA_H/L**	Send Data with Acknowledge high/low (DLPDU Function)
3.6.70	**SDX**	start delimiter of asynchronous or synchronous DLPDU transmission
3.6.71	**SDL1 to SDL5**	start delimiters of synchronous DLPDU transmission
3.6.72	**SDN**	Send Data with No Acknowledge (DL-service)
3.6.73	**SDN_H/L**	Send Data with No Acknowledge high/low (DLPDU Function)
3.6.74	**SM**	state machine

3.6.75	**SOA**	Start-of-Activity
3.6.76	**SRC**	send receive control
3.6.77	**SRD**	Send and Request Data with Reply (DL-service)
3.6.78	**SRD_H/L**	Send and Request Data with Reply high/low (DLPDU Function)
3.6.79	**SRU**	send receive unit
3.6.80	**S_SAP**	source service access point, the DLSAP associated with the initiating local DLS-user
3.6.81	**S_SAP_index**	source service access point index – a component of a DLSAP-address which designates that DLSAP within the DLE at which the transaction is being initiated
3.6.82	**Stn**	station, a device implementing a DLE with a fieldbus DL-address
3.6.83	**SYN**	synchronizing bits of a DLPDU (period of idle), which guarantees the specified DLPDU integrity and allows for receiver synchronization
3.6.84	**TA/R**	time to transmit an acknowledgement/response DLPDU
3.6.85	**TASM**	ASM message time
3.6.86	**t_{BIT}**	bit time
3.6.87	**TCSI**	clock synchronization interval time
3.6.88	**T_{CT}**	isochronous cycle time
3.6.89	**TGUD**	GAP update time
3.6.90	**T_{ID}**	idle time
3.6.91	**TIM**	timer state machine
3.6.92	**T_{MP}**	message transfer period
3.6.93	**TP**	token transfer period
3.6.94	**TPSP**	passive spare time
3.6.95	**TPTG**	post transmission gap time
3.6.96	**TQUI**	quiet time
3.6.97	**TRCT**	real isochronous cycle time
3.6.98	**T_{RD}**	receive delay time
3.6.99	**TRDY**	ready time
3.6.100	**TRES**	spare time
3.6.101	**T_{RR}**	real rotation time
3.6.102	**TS**	this station
3.6.103	**TS/R**	send/request DLPDU time
3.6.104	**T_{SD}**	send delay time

3.6.105 TSDI station delay of initiator

3.6.106 TSDR station delay of responder

3.6.107 TSET setup time

3.6.108 T_{SH} time shift

3.6.109 T_{SL} slot time

3.6.110 T_{SM} safety margin time

3.6.111 T_{SR} system reaction time

3.6.112 TSYN synchronization time

3.6.113 TSYNI synchronization interval time

3.6.114 T_{TC} token cycle time

3.6.115 T_{TD} transmission delay time

3.6.116 T_{TF} token DLPDU time

3.6.117 T_{TH} token holding time

3.6.118 T_{TO} timeout time

3.6.119 T_{TP} token transfer period

3.6.120 T_{TR} target rotation time

3.6.121 UART universal asynchronous receiver/transmitter

3.6.122 UC UART character

3.6.123 UE negative acknowledgement, remote user interface error (DL/DLM_status of the service primitive)

4 Common DL-protocol elements

4.1 Frame check sequence

4.1.1 General

Any reference to bit *K* of an octet is a reference to the bit whose weight in a one-octet unsigned integer is 2^K.

NOTE 1 This is sometimes referred to as “little endian” bit numbering.

As in other International Standards (see Note 2), DLPDU-level error detection is provided by calculating and appending a multi-bit frame check sequence (FCS) to the other DLPDU fields during transmission to form a "systematic code word"[1)] of length *n* consisting of *k* DLPDU message bits followed by $n - k$ redundant bits, and by calculating during reception that the message and concatenated FCS form a legal (*n*,*k*) code word. The mechanism for this checking is as follows:

1) W. W. Peterson and E. J. Weldon, Jr., *Error Correcting Codes* (2nd edition), MIT Press, Cambridge, 1972.