

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Industrial communication networks – Fieldbus specifications –
Part 4-2: Data-link layer protocol specification – Type 2 elements**

**Réseaux de communication industriels – Spécifications de bus de terrain –
Partie 4-2: Spécification du protocole de la couche de liaison de données –
Éléments de Type 2**



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2010 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester.

If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de la CEI ou du Comité national de la CEI du pays du demandeur.

Si vous avez des questions sur le copyright de la CEI ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de la CEI de votre pays de résidence.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

Useful links:

IEC publications search - www.iec.ch/searchpub

The advanced search enables you to find IEC publications by a variety of criteria (reference number, text, technical committee,...).

It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available on-line and also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 30 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary (IEV) on-line.

Customer Service Centre - webstore.iec.ch/csc2/iec-

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

A propos de la CEI

La Commission Electrotechnique Internationale (CEI) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications CEI

Le contenu technique des publications de la CEI est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Liens utiles:

Recherche de publications CEI - www.iec.ch/searchpub

La recherche avancée vous permet de trouver des publications CEI en utilisant différents critères (numéro de référence, texte, comité d'études,...).

Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

Just Published CEI - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications de la CEI. Just Published détaille les nouvelles publications parues. Disponible en ligne et aussi une fois par mois par email.

Electropedia - www.electropedia.org

Le premier dictionnaire en ligne au monde de termes électroniques et électriques. Il contient plus de 30 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans les langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (VEI) en ligne.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: csc@iec.ch.

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Industrial communication networks – Fieldbus specifications –
Part 4-2: Application layer protocol specification – Type 2 elements**

**Réseaux de communication industriels – Spécifications des bus de terrain –
Partie 4-2: Spécification de protocole de la couche application – Eléments de
Type 2**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE **XH**
CODE PRIX

ICS 25.040.40; 35.100.20; 35.110

ISBN 978-2-83220-126-8

**Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

CONTENTS

FOREWORD.....	9
INTRODUCTION.....	11
1 Scope.....	13
1.1 General.....	13
1.2 Specifications.....	13
1.3 Procedures.....	13
1.4 Applicability.....	14
1.5 Conformance.....	14
2 Normative references.....	14
3 Terms, definitions, symbols and abbreviations.....	15
3.1 Reference model terms and definitions.....	15
3.2 Service convention terms and definitions.....	17
3.3 Common terms and definitions.....	18
3.4 Additional Type 2 definitions.....	20
3.5 Type 2 symbols and abbreviations.....	27
4 Overview of the data-link protocol.....	28
4.1 General.....	28
4.2 Services provided by the DL.....	30
4.3 Structure and definition of DL-addresses.....	31
4.4 Services assumed from the PhL.....	33
4.5 Functional classes.....	36
5 General structure and encoding of PhPDUs and DLPDUs and related elements of procedure.....	36
5.1 Overview.....	36
5.2 Media access procedure.....	36
5.3 DLPDU structure and encoding.....	40
5.4 Lpacket components.....	44
5.5 DLPDU procedures.....	46
5.6 Summary of DLL support services and objects.....	47
6 Specific DLPDU structure, encoding and procedures.....	49
6.1 Modeling language.....	49
6.2 DLS user services.....	51
6.3 Generic tag Lpacket.....	57
6.4 Moderator Lpacket.....	58
6.5 Time distribution Lpacket.....	59
6.6 UCMM Lpacket.....	61
6.7 Keeper UCMM Lpacket.....	62
6.8 TUI Lpacket.....	62
6.9 Link parameters Lpacket and tMinus Lpacket.....	63
6.10 I'm-alive Lpacket.....	65
6.11 Ping Lpackets.....	66
6.12 WAMI Lpacket.....	68
6.13 Debug Lpacket.....	68
6.14 IP Lpacket.....	69
6.15 Ethernet Lpacket.....	69
7 Objects for station management.....	69

7.1	General	69
7.2	ControlNet object	70
7.3	Keeper object	80
7.4	Scheduling object	102
7.5	TCP/IP Interface object	113
7.6	Ethernet link object	122
7.7	DeviceNet object	130
7.8	Connection configuration object (CCO)	139
7.9	DLR object	159
7.10	QoS object	168
8	Other DLE elements of procedure	170
8.1	Network attachment monitor (NAM)	170
8.2	Calculating link parameters	177
9	Detailed specification of DL components	185
9.1	General	185
9.2	Access control machine (ACM)	185
9.3	TxLLC	202
9.4	RxLLC	206
9.5	Transmit machine (TxM)	209
9.6	Receive machine (RxM)	212
9.7	Serializer	218
9.8	Deserializer	219
9.9	DLL management	220
10	Device Level Ring (DLR) protocol	222
10.1	General	222
10.2	Supported topologies	222
10.3	Overview of DLR operation	224
10.4	Classes of DLR implementation	226
10.5	DLR behavior	227
10.6	Implementation requirements	232
10.7	Using non-DLR nodes in the ring network	234
10.8	DLR messages	237
10.9	State diagrams and state-event-action matrices	241
10.10	Performance analysis	262
	Annex A (normative) Indicators and switches	267
	Bibliography	280
	Figure 1 – Relationships of DLSAPs, DLSAP-addresses and group DL-addresses	19
	Figure 2 – Data-link layer internal architecture	29
	Figure 3 – Basic structure of a MAC ID address	31
	Figure 4 – Basic structure of a generic tag address	32
	Figure 5 – Basic structure of a fixed tag address	32
	Figure 6 – M_symbols and Manchester encoding at 5 MHz	34
	Figure 7 – NUT structure	37
	Figure 8 – Media access during scheduled time	38
	Figure 9 – Media access during unscheduled time	39
	Figure 10 – DLPDU format	40

Figure 11 – Aborting a DLPDU during transmission	43
Figure 12 – Lpacket format	44
Figure 13 – Generic tag Lpacket format	45
Figure 14 – Fixed tag Lpacket format	45
Figure 15 – Goodness parameter of TimeDist_Lpacket	60
Figure 16 – Example I'm alive processing algorithm	66
Figure 17 – Keeper CRC algorithm	87
Figure 18 – Keeper object power-up state diagram	98
Figure 19 – Keeper object operating state diagram	99
Figure 20 – Synchronized network change processing	102
Figure 21 – State transition diagram for TCP/IP Interface object	122
Figure 22 – Connection configuration object edit flowchart	159
Figure 23 – NAM state machine	171
Figure 24 – DLR rings connected to switches	223
Figure 25 – Normal operation of a DLR network	224
Figure 26 – Beacon and Announce frames	224
Figure 27 – Link failure	225
Figure 28 – Network reconfiguration after link failure	226
Figure 29 – Neighbor Check process	232
Figure 30 – Unsupported topology – example 1	236
Figure 31 – Unsupported topology – example 2	236
Figure 32 – State transition diagram for Beacon frame based non-supervisor ring node	242
Figure 33 – State transition diagram for Announce frame based non-supervisor ring node	247
Figure 34 – State transition diagram for ring supervisor	250
Figure A.1 – Non redundant network status indicator labeling	271
Figure A.2 – Redundant network status indicator labeling	272
Table 1 – Data-link layer components	29
Table 2 – MAC ID addresses allocation	32
Table 3 – Fixed tag service definitions	33
Table 4 – Data encoding rules	34
Table 5 – M Data symbols	35
Table 6 – Truth table for ph_status_indication	35
Table 7 – FCS length, polynomials and constants	41
Table 8 – DLL support services and objects	48
Table 9 – Elementary data types	51
Table 10 – DLL events	55
Table 11 – Time distribution priority	60
Table 12 – Format of the TUI Lpacket	63
Table 13 – ControlNet object class attributes	71
Table 14 – ControlNet object instance attributes	71
Table 15 – TUI status flag bits	75

Table 16 – Channel state bits	76
Table 17 – ControlNet object common services.....	78
Table 18 – ControlNet object class specific services	79
Table 19 – Keeper object revision history	81
Table 20 – Keeper object class attributes	81
Table 21 – Keeper object instance attributes	82
Table 22 – Keeper operating state definitions	84
Table 23 – Port status flag bit definitions	85
Table 24 – TUI status flag bits	86
Table 25 – Keeper attributes.....	88
Table 26 – Memory requirements (in octets) for the Keeper attributes.....	89
Table 27 – Keeper object common services	89
Table 28 – Keeper object class specific services	90
Table 29 – Service error codes	91
Table 30 – Wire order format of the TUI Lpacket.....	95
Table 31 – Service error codes	96
Table 32 – Keeper object operating states	96
Table 33 – Keeper object state event matrix	100
Table 34 – Scheduling object class attributes	103
Table 35 – Scheduling object instance attributes	104
Table 36 – Scheduling object common services	104
Table 37 – Status error descriptions for Create.....	105
Table 38 – Status error descriptions for Delete and Kick_Timer	106
Table 39 – Scheduling object class specific services	106
Table 40 – Status error descriptions for Read	108
Table 41 – Status error descriptions for Conditional_Write	109
Table 42 – Status error descriptions for Forced_Write	109
Table 43 – Status error descriptions for Change_Start	110
Table 44 – Status error descriptions for Break_Connections	110
Table 45 – Status error descriptions for Change_Complete.....	111
Table 46 – Status error descriptions for Restart_Connections	112
Table 47 – TCP/IP Interface object class attributes.....	113
Table 48 – TCP/IP Interface object instance attributes.....	114
Table 49 – Status bits	116
Table 50 – Configuration capability bits	116
Table 51 – Configuration control bits.....	117
Table 52 – Example path	117
Table 53 – Interface configuration components	118
Table 54 – Alloc control values	119
Table 55 – TCP/IP Interface object common services	120
Table 56 – Get_Attribute_All reply format	120
Table 57 – Ethernet link object revision history	122
Table 58 – Ethernet link object class attributes	123

Table 59 – Ethernet link object instance attributes	124
Table 60 – Interface flags bits	127
Table 61 – Control bits	128
Table 62 – Interface type	128
Table 63 – Interface state	129
Table 64 – Admin state	129
Table 65 – Ethernet Link object common services	129
Table 66 – Ethernet Link object class specific services	130
Table 67 – DeviceNet object revision history	131
Table 68 – DeviceNet object class attributes	131
Table 69 – DeviceNet object instance attributes	132
Table 70 – Bit rate attribute values	134
Table 71 – BOI attribute values	135
Table 72 – Diagnostic counters bit description	136
Table 73 – DeviceNet object common services	137
Table 74 – Reset service parameter	138
Table 75 – Reset service parameter values	138
Table 76 – DeviceNet object class specific services	138
Table 77 – Connection configuration object revision history	139
Table 78 – Connection configuration object class attributes	140
Table 79 – Format number values	141
Table 80 – Connection configuration object instance attributes	142
Table 81 – Originator connection status values	144
Table 82 – Target connection status values	145
Table 83 – Connection flags	145
Table 84 – I/O mapping formats	147
Table 85 – Connection configuration object common services	148
Table 86 – Get_Attribute_All error codes	148
Table 87 – Get_Attribute_All response	149
Table 88 – Set_Attribute_All error codes	150
Table 89 – Set_Attribute_All request	151
Table 90 – Create request parameters	152
Table 91 – Create error codes	153
Table 92 – Delete error codes	153
Table 93 – Restore error codes	153
Table 94 – Connection configuration object class specific services	154
Table 95 – Kick_Timer error codes	154
Table 96 – Open_Connection error codes	155
Table 97 – Close_Connection error codes	155
Table 98 – Stop_Connection error codes	155
Table 99 – Change_Start error codes	156
Table 100 – Get_Status service parameter	156
Table 101 – Get_Status service response	156

Table 102 – Get_Status service error codes	157
Table 103 – Change_Complete service parameter	157
Table 104 – Change_Complete service error codes	157
Table 105 – Audit_Changes service parameter	158
Table 106 – Audit_Changes service error codes	158
Table 107 – Class attributes	160
Table 108 – Instance attributes	160
Table 109 – Network Status values	162
Table 110 – Ring Supervisor Status values	163
Table 111 – DLR object common services	166
Table 112 – Get_Attributes_All Response – non supervisor device	166
Table 113 – Get_Attributes_All Response – supervisor-capable device	166
Table 114 – DLR object class specific services	167
Table 115 – QoS object revision history	168
Table 116 – QoS object class attributes	168
Table 117 – QoS object instance attributes	169
Table 118 – Default DCSP values and usages	170
Table 119 – Common services	170
Table 120 – NAM states	171
Table 121 – Default link parameters	172
Table 122 – PhL timing characteristics	178
Table 123 – DLR variables	227
Table 124 – MAC addresses for DLR messages	238
Table 125 – IEEE 802.1Q frame format	238
Table 126 – Common fields in DLR messages	238
Table 127 – Format of the Beacon frame	239
Table 128 – Ring State values	239
Table 129 – Format of the Neighbor_Check request	239
Table 130 – Format of the Neighbor_Check response	240
Table 131 – Format of the Link_Status/Neighbor_Status frame	240
Table 132 – Link/Neighbor status values	240
Table 133 – Format of the Announce frame	241
Table 134 – Format of the Sign_On frame	241
Table 135 – Parameter values for Beacon frame based non-supervisor ring node	242
Table 136 – State-event-action matrix for Beacon frame based non-supervisor ring node	243
Table 137 – Parameter values for Announce frame based non-supervisor ring node	247
Table 138 – State-event-action matrix for Announce frame based non-supervisor ring node	248
Table 139 – Parameter values for ring supervisor node	251
Table 140 – State-event-action matrix for ring supervisor node	252
Table 141 – Parameters/assumptions for example performance calculations	263
Table 142 – Example ring configuration parameters and performance	266

Table A.1 – Module status indicator 268

Table A.2 – Network status indicators 269

Table A.3 – Network status indicator 273

Table A.4 – Network status indicator 275

Table A.5 – Combined module/network status indicator 276

Table A.6 – I/O status indicator 277

Table A.7 – Bit rate switch encoding 279

Withhold

iTeh STANDARD PREVIEW
(standards.iteh.ai)

IEC 61158-4-2:2010
<https://standards.iteh.ai/catalog/standards/sist/b1416-f2b2-4bad-a0fc-a459d7c53302/iec-61158-4-2-2010>

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**INDUSTRIAL COMMUNICATION NETWORKS –
FIELDBUS SPECIFICATIONS –****Part 4-2: Data-link layer protocol specification –
Type 2 elements**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.

International Standard IEC 61158-4-2 has been prepared by subcommittee 65C: Industrial networks, of IEC technical committee 65: Industrial process measurement, control and automation.

This second edition cancels and replaces the first edition published in 2007. This edition constitutes a technical revision.

The main changes with respect to the previous edition are listed below.

- Clause 2 and Bibliography: update of normative and bibliographic references;
- subclause 3.5: update of abbreviations;
- subclause 7.6: updates of the Ethernet Link object;
- subclause 7.7: minor update of the Devicenet object (additional attribute);
- new subclauses 7.9 and 7.10: new DLR and QoS objects;
- new Clause 10: new DLR protocol.

This bilingual version (2012-07) corresponds to the monolingual English version, published in 2010-08.

The text of this standard is based on the following documents:

FDIS	Report on voting
65C/605/FDIS	65C/619/RVD

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

The French version has not been voted upon.

This publication has been drafted in accordance with 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.

NOTE The revision of this standard will be synchronized with the other parts of the IEC 61158 series.

<https://standards.iteh.ai/catalog/standards/sist/416-f2b2-4bad-a0fc-a459d7c53302/iec-61158-4-2-2010>

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

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/TR 61158-1:2010.

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 standard 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 implementers 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 standard is concerned, in particular, with the communication and interworking of sensors, effectors and other automation devices. By using this standard 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 the IEC 61784 series. Use of the various protocol types in other combinations may require permission from their respective intellectual-property-right holders.

The International Electrotechnical Commission (IEC) draws attention to the fact that it is claimed that compliance with this document may involve the use of patents given in several subclauses as indicated in the table below. These patents are held by their respective inventors under license to ODVA, Inc.

US 5,400,331	[ODVA]	Communication network interface with screeners for incoming messages	Subclause 3.4, Clauses 4 to 9
US 5,471,461	[ODVA]	Digital communication network with a moderator station election process	
US 5,491,531	[ODVA]	Media access controller with a shared class message delivery capability	
US 5,493,571	[ODVA]	Apparatus and method for digital communications with improved delimiter detection	
US 5,537,549	[ODVA]	Communication network with time coordinated station activity by time slot and periodic interval number	
US 5,553,095	[ODVA]	Method and apparatus for exchanging different classes of data during different time intervals	
US 12/493,838	[ODVA]	Industrial controller employing the network ring topology	Clause 10

IEC takes no position concerning the evidence, validity and scope of these patent rights.

ODVA and the holders of these patent rights have assured the IEC that ODVA is willing to negotiate licences under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statement of ODVA and the holders of these patent rights is registered with IEC. Information may be obtained from:

[ODVA] ODVA, Inc.
2370 East Stadium Boulevard #1000
Ann Arbor, Michigan 48104
USA
Attention: Office of the Executive Director
e-mail: odva@odva.org

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights other than those identified above. IEC shall not be held responsible for identifying any or all such patent rights.

ISO (www.iso.org/patents) and IEC (http://www.iec.ch/tctools/patent_decl.htm) maintain on-line data bases of patents relevant to their standards. Users are encouraged to consult the data bases for the most up to date information concerning patents.

iTeh STANDARD PREVIEW
(standards.itih.ai)

IEC 61158-4-2:2010

<https://standards.itih.ai/catalog/standards/sstdb/416-f2b2-4bad-a0fc-a459d7c53302/iec-61158-4-2-2010>

Withdrawing

INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 4-2: Data-link layer protocol specification – Type 2 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 all participating data-link entities, sequentially and in a cyclic synchronous manner. Foreground scheduled access is available for time-critical activities together with background unscheduled access for less critical activities.

Deterministic and synchronized transfers can be provided at cyclic intervals up to 1 ms and device separations of 25 km. This performance is adjustable dynamically and on-line by re-configuring the parameters of the local link whilst normal operation continues. By similar means, DL connections and new devices may be added or removed during normal operation.

This protocol provides means to maintain clock synchronization across an extended link with a precision better than 10 μ s.

This protocol optimizes each access opportunity by concatenating multiple DLSDUs and associated DLPCI into a single DLPDU, thereby improving data transfer efficiency for data-link entities that actively source multiple streams of data.

The maximum system size is an unlimited number of links of 99 nodes, each with 255 DLSAP-addresses. Each link has a maximum of 2^{24} related peer and publisher DLCEPs.

1.2 Specifications

This standard 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 standard, 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.