



BSI Standards Publication

Industrial communication networks - Fieldbus specifications

Part 4-2: Data-link layer protocol specification - Type 2 elements

National foreword

This British Standard is the UK implementation of EN IEC 61158-4-2:2019. It is identical to IEC 61158-4-2:2019. It supersedes BS EN 61158-4-2:2014, which will be withdrawn on 23 May 2022.

The UK participation in its preparation was entrusted to Technical Committee GEL/65/3, Industrial communications: process measurement and control, including fieldbus.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© The British Standards Institution 2019
Published by BSI Standards Limited 2019

ISBN 978 0 539 04853 7

ICS 35.110; 35.100.20; 25.040.40

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 July 2019.

Amendments/corrigenda issued since publication

Date	Text affected
------	---------------

EUROPEAN STANDARD

EN IEC 61158-4-2

NORME EUROPÉENNE

EUROPÄISCHE NORM

June 2019

ICS 25.040.40; 35.100.20; 35.110

Supersedes EN 61158-4-2:2014

English Version

**Industrial communication networks - Fieldbus specifications -
Part 4-2: Data-link layer protocol specification - Type 2 elements
(IEC 61158-4-2:2019)**

Réseaux de communication industriels - Spécifications des
bus de terrain - Partie 4-2: Spécification du protocole de la
couche liaison de données - Éléments de Type 2
(IEC 61158-4-2:2019)

Industrielle Kommunikationsnetze - Feldbusse - Teil 4-2:
Protokollspezifikation des Data Link Layer
(Sicherheitsschicht) - Typ 2-Elemente
(IEC 61158-4-2:2019)

This European Standard was approved by CENELEC on 2019-05-23. 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 CEN-CENELEC Management Centre 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 CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.



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

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

European foreword

The text of document 65C/946/FDIS, future edition 4 of IEC 61158-4-2, prepared by SC 65C "Industrial networks" of IEC/TC 65 "Industrial-process measurement, control and automation" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 61158-4-2:2019.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2020-02-23
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2022-05-23

This document supersedes EN 61158-4-2:2014.

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

Endorsement notice

The text of the International Standard IEC 61158-4-2:2019 was approved by CENELEC as a European Standard without any modification.

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

- IEC 61158-1:2019 NOTE Harmonized as EN IEC 61158-1:2019 (not modified)
- IEC 61158-2:2014 NOTE Harmonized as EN 61158-2:2014 (not modified)
- IEC 61784-1:2019 NOTE Harmonized as EN IEC 61784-1:2019 (not modified)
- IEC 61784-2:2019 NOTE Harmonized as EN IEC 61784-2:2019 (not modified)

CONTENTS

FOREWORD.....	15
INTRODUCTION.....	17
1 Scope.....	19
1.1 General.....	19
1.2 Specifications	19
1.3 Procedures	19
1.4 Applicability	20
1.5 Conformance	20
2 Normative references	20
3 Terms, definitions, symbols, abbreviated terms and conventions	22
3.1 Reference model terms and definitions	22
3.2 Service convention terms and definitions	24
3.3 Common terms and definitions.....	24
3.4 Additional Type 2 definitions	25
3.5 Type 2 symbols and abbreviated terms	33
3.6 Conventions for station management objects	34
4 Overview of the data-link protocol.....	35
4.1 General.....	35
4.1.1 DLL architecture	35
4.1.2 Access control machine (ACM) and scheduling support functions	36
4.1.3 Connection-mode, connectionless-mode data transfer and DL service.....	37
4.2 Services provided by the DL	37
4.2.1 Overview	37
4.2.2 QoS.....	37
4.3 Structure and definition of DL-addresses	38
4.3.1 General	38
4.3.2 MAC ID address	38
4.3.3 Generic tag address	39
4.3.4 Fixed tag address	39
4.4 Services assumed from the PhL.....	40
4.4.1 General requirements	40
4.4.2 Data encoding rules.....	41
4.4.3 DLL to PhL interface.....	41
4.5 Functional classes	43
5 General structure and encoding of PhIDUs and DLPDUs and related elements of procedure.....	43
5.1 Overview	43
5.2 Media access procedure	43
5.3 DLPDU structure and encoding	47
5.3.1 General	47
5.3.2 DLPDU components	47
5.3.3 Preamble.....	47
5.3.4 Start and end delimiters.....	47
5.3.5 DLPDU octets and ordering	47
5.3.6 Source MAC ID.....	48
5.3.7 Lpackets field	48
5.3.8 Frame check sequence (FCS).....	48

5.3.9	Null DLPDU	51
5.3.10	Abort DLPDU	51
5.4	Lpacket components	51
5.4.1	General Lpacket structure	51
5.4.2	Size	51
5.4.3	Control	52
5.4.4	Generic tag Lpackets	52
5.4.5	Fixed tag Lpackets	53
5.5	DLPDU procedures	53
5.5.1	General	53
5.5.2	Sending scheduled DLPDUs	54
5.5.3	Sending unscheduled DLPDUs	54
5.5.4	Receiving DLPDUs	54
5.6	Summary of DLL support services and objects	54
6	Specific DLPDU structure, encoding and procedures	56
6.1	Modeling language	56
6.1.1	State machine description	56
6.1.2	Use of DLL- prefix	57
6.1.3	Data types	57
6.2	DLS user services	58
6.2.1	General	58
6.2.2	Connected mode and connectionless mode transfer service	58
6.2.3	Queue maintenance service	60
6.2.4	Tag filter service	60
6.2.5	Link synchronization service	61
6.2.6	Synchronized parameter change service	61
6.2.7	Event reports service	62
6.2.8	Bad FCS service	63
6.2.9	Current moderator service	63
6.2.10	Power up and online services	64
6.2.11	Enable moderator service	64
6.2.12	Listen only service	64
6.3	Generic tag Lpacket	64
6.3.1	General	64
6.3.2	Structure of the generic-tag Lpacket	65
6.3.3	Sending and receiving the generic-tag Lpacket	65
6.4	Moderator Lpacket	65
6.4.1	General	65
6.4.2	Structure of the moderator Lpacket	65
6.4.3	Sending and receiving the moderator Lpacket	66
6.5	Time distribution Lpacket	67
6.5.1	General	67
6.5.2	Structure of the time distribution Lpacket	67
6.5.3	Sending and receiving the time distribution Lpacket	69
6.6	UCMM Lpacket	69
6.6.1	General	69
6.6.2	Structure of the UCMM Lpacket	69
6.6.3	Sending and receiving the UCMM Lpacket	69

6.7	Keeper UCMM Lpacket	69
6.7.1	General	69
6.7.2	Structure of the Keeper UCMM Lpacket	70
6.7.3	Sending and receiving the Keeper UCMM Lpacket	70
6.8	TUI Lpacket	70
6.8.1	General	70
6.8.2	Structure of the TUI Lpacket	70
6.8.3	Sending and receiving the TUI Lpacket	71
6.9	Link parameters Lpacket and tMinus Lpacket	71
6.9.1	General	71
6.9.2	Structure of link parameters and tMinus Lpackets	72
6.9.3	Sending and receiving the tMinus and Link parameters Lpackets	72
6.10	I'm-alive Lpacket	73
6.10.1	General	73
6.10.2	Structure of the I'm-alive Lpacket	73
6.10.3	Sending and receiving I'm Alive	73
6.10.4	I'm alive state processing	73
6.11	Ping Lpackets	74
6.11.1	General	74
6.11.2	Structure of the ping Lpackets	75
6.11.3	Sending and receiving the ping Lpackets	75
6.12	WAMI Lpacket	76
6.12.1	General	76
6.12.2	Structure of the WAMI Lpacket	76
6.12.3	Sending and receiving the WAMI Lpacket	76
6.13	Debug Lpacket	76
6.14	IP Lpacket	77
6.15	Ethernet Lpacket	77
7	Objects for station management	77
7.1	General	77
7.2	ControlNet™ object	79
7.2.1	Overview	79
7.2.2	Class attributes	79
7.2.3	Instance attributes	79
7.2.4	Common services	87
7.2.5	Class specific services	88
7.2.6	Behavior	89
7.2.7	Module status indicator	89
7.3	Keeper object	90
7.3.1	Overview	90
7.3.2	Revision history	90
7.3.3	Class attributes	90
7.3.4	Instance attributes	90
7.3.5	Common services	98
7.3.6	Class specific services	99
7.3.7	Service error codes	105
7.3.8	Behavior	106
7.3.9	Miscellaneous notes	107
7.3.10	Keeper power up sequence	108

7.4	Scheduling object	113
7.4.1	Overview	113
7.4.2	Class attributes	114
7.4.3	Instance attributes	114
7.4.4	Common services	115
7.4.5	Class specific services	117
7.4.6	Typical scheduling session	123
7.5	TCP/IP Interface object.....	124
7.5.1	Overview	124
7.5.2	Revision history.....	124
7.5.3	Class attributes	125
7.5.4	Instance attributes	125
7.5.5	Common services	139
7.5.6	Class specific services	141
7.5.7	Behavior	142
7.5.8	Address Conflict Detection (ACD).....	144
7.6	Ethernet link object.....	150
7.6.1	Overview	150
7.6.2	Revision history.....	150
7.6.3	Class attributes	150
7.6.4	Instance attributes	151
7.6.5	Common services	161
7.6.6	Class specific services	163
7.6.7	Behavior.....	163
7.7	DeviceNet™ object.....	164
7.7.1	Overview	164
7.7.2	Revision history.....	164
7.7.3	Class attributes	165
7.7.4	Instance attributes	165
7.7.5	Common services	172
7.7.6	Class specific services	173
7.8	Connection configuration object (CCO).....	173
7.8.1	Overview	173
7.8.2	Revision history.....	174
7.8.3	Class attributes	174
7.8.4	Instance attributes	176
7.8.5	Connection Configuration Object change control	185
7.8.6	Common services	185
7.8.7	Class specific services	192
7.8.8	Behavior	195
7.9	DLR object.....	196
7.9.1	Overview	196
7.9.2	Revision history.....	196
7.9.3	Class attributes	197
7.9.4	Instance attributes	197
7.9.5	Common services	208
7.9.6	Class specific services	212
7.10	QoS object.....	213
7.10.1	Overview	213

7.10.2	Revision History	213
7.10.3	Class attributes	213
7.10.4	Instance Attributes.....	214
7.10.5	Common services	215
7.10.6	Get_Attributes_All response (class level).....	216
7.11	Port object	216
7.11.1	Overview	216
7.11.2	Revision History	216
7.11.3	Class attributes	217
7.11.4	Instance attributes	217
7.11.5	Common services	223
7.12	PRP/HSR Protocol object.....	224
7.12.1	Overview	224
7.12.2	Revision history.....	224
7.12.3	Class attributes	225
7.12.4	Instance attributes	225
7.12.5	Common Services	232
7.13	PRP/HSR Nodes Table object.....	234
7.13.1	Overview	234
7.13.2	Revision history.....	234
7.13.3	Class attributes	234
7.13.4	Instance attributes	234
7.13.5	Common services	237
8	Other DLE elements of procedure.....	237
8.1	Network attachment monitor (NAM).....	237
8.1.1	General	237
8.1.2	Default parameters	238
8.1.3	Auto-addressing	239
8.1.4	Valid MAC IDs	239
8.1.5	State machine description	239
8.2	Calculating link parameters.....	245
8.2.1	Link parameters.....	245
8.2.2	Conditions affecting link parameters	246
8.2.3	Moderator change.....	246
8.2.4	NUT timing	246
8.2.5	Slot timing	248
8.2.6	Blanking	248
8.2.7	Example implementation.....	249
9	Detailed specification of DL components	253
9.1	General.....	253
9.2	Access control machine (ACM)	253
9.3	TxLLC.....	273
9.4	RxLLC	277
9.5	Transmit machine (TxM)	281
9.6	Receive machine (RxM)	285
9.7	Serializer	291
9.8	Deserializer	293
9.8.1	Octet construction	293
9.8.2	FCS checking	293

9.8.3	End of DLPDU processing	294
9.9	DLL management.....	294
10	Device Level Ring (DLR) protocol.....	296
10.1	General.....	296
10.2	Support for Multiple DLR Ring Pairs.....	296
10.3	Supported topologies	297
10.4	Overview of DLR operation	298
10.4.1	Normal operation	298
10.4.2	Link failures.....	300
10.5	Classes of DLR implementation	301
10.6	DLR behavior.....	302
10.6.1	DLR variables.....	302
10.6.2	Ring supervisor	302
10.6.3	Ring node.....	305
10.6.4	Sign on process.....	306
10.6.5	Neighbor check process	307
10.7	Implementation requirements.....	307
10.7.1	Embedded switch requirements and recommendations	307
10.7.2	DLR implementation requirements	308
10.7.3	IEC 61588 and CP 2/2.1 considerations.....	309
10.7.4	IEEE 802.1D/IEEE 802.1Q STP/RSTP/MSTP considerations	309
10.8	Using non-DLR nodes in the ring network	309
10.8.1	General considerations	309
10.8.2	Non-DLR end devices.....	310
10.8.3	Non-DLR switches	310
10.9	Redundant gateway devices on DLR network.....	313
10.9.1	General	313
10.9.2	Supported topologies.....	313
10.9.3	Redundant gateway capable device.....	314
10.9.4	Redundant gateway device behavior	314
10.10	DLR messages	317
10.10.1	General	317
10.10.2	Common frame header	318
10.10.3	Beacon frame	319
10.10.4	Neighbor_Check request	319
10.10.5	Neighbor_Check_response.....	320
10.10.6	Link_Status/Neighbor_Status.....	320
10.10.7	Locate_Fault.....	321
10.10.8	Announce	321
10.10.9	Sign_On	321
10.10.10	Advertise	322
10.10.11	Flush_Tables.....	322
10.10.12	Learning_Update	323
10.11	State diagrams and state-event-action matrices.....	323
10.11.1	Beacon-based ring node.....	323
10.11.2	Announce-based ring node	330
10.11.3	Ring supervisor	334
10.11.4	Redundant gateway.....	349

10.12	Performance analysis	354
10.12.1	General	354
10.12.2	Redundant gateway switchover performance	358
11	PRP and HSR redundancy protocols	359
11.1	General.....	359
11.2	PRP overview	360
11.2.1	General	360
11.2.2	Address Conflict Detection (ACD).....	361
11.3	HSR overview	362
Annex A (normative)	Indicators and switches	364
A.1	Purpose	364
A.2	Indicators.....	364
A.2.1	General indicator requirements.....	364
A.2.2	Common indicator requirements	364
A.2.3	Fieldbus specific indicator requirements – option 1	366
A.2.4	Fieldbus specific indicator requirements – option 2	370
A.2.5	Fieldbus specific indicator requirements – option 3.....	374
A.3	Switches	378
A.3.1	Common switch requirements.....	378
A.3.2	Fieldbus specific switch requirements – option 1	378
A.3.3	Fieldbus specific switch requirements – option 2	378
A.3.4	Fieldbus specific switch requirements – option 3	379
Bibliography	380
Figure 1	– Data-link layer internal architecture.....	36
Figure 2	– Relationships of DLSAPs, DLSAP-addresses, and group DL-addresses.....	38
Figure 3	– Basic structure of a MAC ID address.....	39
Figure 4	– Basic structure of a generic tag address	39
Figure 5	– Basic structure of a fixed tag address	39
Figure 6	– M_symbols and Manchester encoding at 5 MHz	41
Figure 7	– NUT structure	44
Figure 8	– Media access during scheduled time	45
Figure 9	– Media access during unscheduled time	46
Figure 10	– DLPDU format.....	47
Figure 11	– Aborting a DLPDU during transmission	51
Figure 12	– Lpacket format	51
Figure 13	– Generic tag Lpacket format	52
Figure 14	– Fixed tag Lpacket format.....	53
Figure 15	– Goodness parameter of TimeDist_Lpacket.....	68
Figure 16	– Example I'm alive processing algorithm.....	74
Figure 17	– Keeper CRC algorithm	96
Figure 18	– Keeper object power-up state diagram	109
Figure 19	– Keeper object operating state diagram	110
Figure 20	– Synchronized network change processing	113
Figure 21	– State transition diagram for TCP/IP Interface object.....	143
Figure 22	– State transition diagram for TCP/IP Interface object.....	144

Figure 23 – ACD Behavior	146
Figure 24 – State transition diagram for Ethernet Link object	164
Figure 25 – Connection configuration object edit flowchart.....	196
Figure 26 – NAM state machine	238
Figure 27 – Devices with Multiple DLR Ring Pairs.....	297
Figure 28 – DLR rings connected to switches.....	298
Figure 29 – Normal operation of a DLR network.....	299
Figure 30 – Beacon and Announce frames.....	299
Figure 31 – Link failure	300
Figure 32 – Network reconfiguration after link failure	301
Figure 33 – Neighbor Check process	307
Figure 34 – Unsupported topology – example 1	311
Figure 35 – Unsupported topology – example 2	311
Figure 36 – DLR ring connected to switches through redundant gateways	313
Figure 37 – DLR redundant gateway capable device.....	314
Figure 38 – Advertise frame.....	316
Figure 39 – State transition diagram for Beacon frame based non-supervisor ring node.....	324
Figure 40 – State transition diagram for Announce frame based non-supervisor ring node	330
Figure 41 – State transition diagram for ring supervisor	335
Figure 42 – State transition diagram for redundant gateway.....	350
Figure 43 – PRP network	360
Figure 44 – Directly Attached SANs	361
Figure 45 – Virtual DANs	362
Figure 46 – HSR network.....	362
Figure A.1 – Non redundant network status indicator labeling	370
Figure A.2 – Redundant network status indicator labeling	370
Figure A.3 – Network status indicator state diagram	373
Figure A.4 – Examples of multiple network status indicators	373
Table 1 – Format of attribute tables	34
Table 2 – Data-link layer components	35
Table 3 – MAC ID addresses allocation	39
Table 4 – Fixed tag service definitions	40
Table 5 – Data encoding rules	41
Table 6 – M Data symbols	42
Table 7 – Truth table for ph_status_indication.....	42
Table 8 – FCS length, polynomials and constants	49
Table 9 – DLL support services and objects.....	55
Table 10 – Elementary data types.....	58
Table 11 – DLL events.....	63
Table 12 – Time distribution priority	68
Table 13 – Format of the TUI Lpacket.....	71

Table 14 – ControlNet object class attributes	79
Table 15 – ControlNet object instance attributes	80
Table 16 – TUI status flag bits	84
Table 17 – Mac_ver bits.....	85
Table 18 – Channel state bits	85
Table 19 – ControlNet object common services.....	87
Table 20 – ControlNet object class specific services	88
Table 21 – Keeper object revision history	90
Table 22 – Keeper object class attributes	90
Table 23 – Keeper object instance attributes	91
Table 24 – Keeper operating state definitions	94
Table 25 – Port status flag bit definitions	94
Table 26 – TUI status flag bits	95
Table 27 – Keeper attributes.....	97
Table 28 – Memory requirements (in octets) for the Keeper attributes.....	98
Table 29 – Keeper object common services	98
Table 30 – Keeper object class specific services	100
Table 31 – Service error codes	101
Table 32 – Wire order format of the TUI Lpacket.....	105
Table 33 – Service error codes	106
Table 34 – Keeper object operating states	107
Table 35 – Keeper object state event matrix	111
Table 36 – Scheduling object class attributes	114
Table 37 – Scheduling object instance attributes	115
Table 38 – Scheduling object common services	115
Table 39 – Status error descriptions for Create	116
Table 40 – Status error descriptions for Delete and Kick_Timer	117
Table 41 – Scheduling object class specific services	117
Table 42 – Status error descriptions for Read	119
Table 43 – Status error descriptions for Conditional_Write.....	120
Table 44 – Status error descriptions for Forced_Write	120
Table 45 – Status error descriptions for Change_Start.....	121
Table 46 – Status error descriptions for Break_Connections	122
Table 47 – Status error descriptions for Change_Complete.....	122
Table 48 – Status error descriptions for Restart_Connections	123
Table 49 – Revision history.....	124
Table 50 – TCP/IP Interface object class attributes.....	125
Table 51 – TCP/IP Interface object instance attributes.....	126
Table 52 – Status bits	129
Table 53 – Configuration capability bits	130
Table 54 – Configuration control bits.....	131
Table 55 – Example path	132
Table 56 – Interface configuration components	133

Table 57 – Alloc control values	135
Table 58 – AcdActivity values	136
Table 59 – ArpPdu – ARP Response PDU in binary format	136
Table 60 – Admin Capability member bit definitions	137
Table 61 – Admin Capability member bit definitions	138
Table 62 – TCP/IP Interface object common services	139
Table 63 – Get_Attributes_All reply format.....	140
Table 64 – TCP/IP Interface object class specific services.....	141
Table 65 – Set_Port_Admin_State service request parameters	141
Table 66 – Set_Protocol_Admin_State service request parameters.....	142
Table 67 – Class specific error codes	142
Table 68 – Ethernet link object revision history	150
Table 69 – Ethernet link object class attributes	151
Table 70 – Ethernet link object instance attributes	151
Table 71 – Interface flags bits.....	157
Table 72 – Control bits.....	158
Table 73 – Interface type	159
Table 74 – Interface state	159
Table 75 – Admin state	159
Table 76 – Capability Bits	160
Table 77 – Ethernet Link object common services.....	161
Table 78 – Get_Attributes_All reply format.....	162
Table 79 – Ethernet Link object class specific services	163
Table 80 – DeviceNet object revision history.....	165
Table 81 – DeviceNet object class attributes.....	165
Table 82 – DeviceNet object instance attributes.....	166
Table 83 – Bit rate attribute values	168
Table 84 – BOI attribute values.....	169
Table 85 – Diagnostic counters bit description	171
Table 86 – DeviceNet object common services	172
Table 87 – Reset service parameter	172
Table 88 – Reset service parameter values	172
Table 89 – DeviceNet object class specific services.....	173
Table 90 – Connection configuration object revision history	174
Table 91 – Connection configuration object class attributes	174
Table 92 – Format number values.....	176
Table 93 – Connection configuration object instance attributes	176
Table 94 – Originator connection status values.....	180
Table 95 – Target connection status values	181
Table 96 – Connection flags	181
Table 97 – I/O mapping formats.....	183
Table 98 – Services valid during a change operation	185
Table 99 – Connection configuration object common services.....	186

Table 100 – Get_Attributes_All Response – class level.....	186
Table 101 – Get_Attributes_All response – instance level.....	187
Table 102 – Set_Attributes_All error codes	188
Table 103 – Set_Attributes_All request	189
Table 104 – Create request parameters	190
Table 105 – Create error codes	191
Table 106 – Delete error codes.....	191
Table 107 – Restore error codes.....	192
Table 108 – Connection configuration object class specific services	192
Table 109 – Change_Start error codes	193
Table 110 – Get_Status service parameter	193
Table 111 – Get_Status service response.....	194
Table 112 – Get_Status service error codes	194
Table 113 – Change_Complete service parameter	194
Table 114 – Change_Complete service error codes	195
Table 115 – Audit_Changes service parameter	195
Table 116 – Audit_Changes service error codes	195
Table 117 – Revision history.....	197
Table 118 – DLR object class attributes	197
Table 119 – DLR object instance attributes.....	198
Table 120 – Network Status values	201
Table 121 – Ring Supervisor Status values.....	201
Table 122 – Capability flags.....	205
Table 123 – Redundant Gateway Status values	207
Table 124 – DLR object common services	208
Table 125 – Get_Attributes_All Response – Object Revision 1, non supervisor device.....	209
Table 126 – Get_Attributes_All Response – Object Revision 1, supervisor-capable device.....	210
Table 127 – Get_Attributes_All Response – Object Revision 2, non supervisor device.....	210
Table 128 – Get_Attributes_All Response – All other cases	211
Table 129 – DLR object class specific services	212
Table 130 – QoS object revision history.....	213
Table 131 – QoS object class attributes.....	214
Table 132 – QoS object instance attributes.....	214
Table 133 – Default DCSP values and usages	215
Table 134 – QoS object common services	216
Table 135 – Port object revision history	217
Table 136 – Port object class attributes	217
Table 137 – Port object instance attributes	218
Table 138 – Port Type and associated Link Object classes and Port Type Name values.....	220
Table 139 – Port Routing Capabilities attribute bit definitions.....	222
Table 140 – Port object common services	223
Table 141 – Get_Attributes_All response– class level.....	224

Table 142 – Get_Attributes_All response– instance level	224
Table 143 – Revision history	225
Table 144 – Class attributes	225
Table 145 – Instance attributes	226
Table 146 – Node Type	229
Table 147 – Switching Node	230
Table 148 – HSR Mode	230
Table 149 – RedBox ID	231
Table 150 – PRP/HSR Protocol object common services	232
Table 151 – Get_Attributes_All response	233
Table 152 – Revision history	234
Table 153 – Class attributes	234
Table 154 – Instance attributes	235
Table 155 – Remote Node Type	236
Table 156 – PRP/HSR Nodes Tables object common services	237
Table 157 – Get_Attributes_All response	237
Table 158 – NAM states	238
Table 159 – Default link parameters	239
Table 160 – PhL timing characteristics	246
Table 161 – DLR variables	302
Table 162 – DLR Link speed and duplex requirements	308
Table 163 – Redundant gateway variables	315
Table 164 – MAC addresses for DLR messages	318
Table 165 – IEEE 802.1Q common frame header format	318
Table 166 –DLR message payload fields	318
Table 167 – DLR frame types	319
Table 168 – Format of the Beacon frame	319
Table 169 – Ring State values	319
Table 170 – Format of the Neighbor_Check request	320
Table 171 – Format of the Neighbor_Check response	320
Table 172 – Format of the Link_Status/Neighbor_Status frame	320
Table 173 – Link/Neighbor status values	321
Table 174 – Format of the Locate_Fault frame	321
Table 175 – Format of the Announce frame	321
Table 176 – Format of the Sign_On frame	322
Table 177 – Format of the Advertise frame	322
Table 178 – Gateway state values	322
Table 179 – Format of the Flush_Tables frame	323
Table 180 – Format of the Learning_Update frame	323
Table 181 – Parameter values for Beacon frame based non-supervisor ring node	324
Table 182 – LastBcnRcvPort bit definitions	325
Table 183 – State-event-action matrix for Beacon frame based non-supervisor ring node	325

Table 184 – Parameter values for Announce frame based non-supervisor ring node	331
Table 185 – State-event-action matrix for Announce frame based non-supervisor ring node	332
Table 186 – Parameter values for ring supervisor node	336
Table 187 – LastBcnRcvPort bit definitions	337
Table 188 – State-event-action matrix for ring supervisor node	337
Table 189 – Parameter values for redundant gateway node	350
Table 190 – State-event-action matrix for redundant gateway node	352
Table 191 – Parameters/assumptions for example performance calculations	354
Table 192 – Example ring configuration parameters and performance	358
Table 193 – Variables for performance analysis	358
Table A.1 – Module status indicator	365
Table A.2 – Time Sync status indication	366
Table A.3 – Network status indicators	368
Table A.4 – Network status indicator	372
Table A.5 – Network status indicator	375
Table A.6 – Combined module/network status indicator	376
Table A.7 – I/O status indicator	377
Table A.8 – Bit rate switch encoding	379

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.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

Attention is drawn to the fact that the use of the associated protocol type is restricted by its 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 layer protocol type to be used with other layer protocols of the same type, or in other type combinations explicitly authorized by its intellectual-property-right holders.

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

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 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:

- clarifications of ControlNet object in 7.2;
- extensions and clarifications of TCP/IP interface object in 7.5;
- extensions and clarifications of Ethernet Link object in 7.6;
- clarifications of DeviceNet object in 7.7;
- extensions and clarifications of CCO object in 7.8;
- extensions and clarifications of DLR object in 7.9;
- extensions and clarifications of Port object in 7.11;
- addition of PRP/HSR Protocol and PRP/HSR Nodes Table objects in 7.12 and 7.13;
- extensions and clarifications of DLR protocol in Clause 10;
- addition of PRP/HSR protocol mapping in Clause 11;
- update of indicator behaviour in A.2.2 and A.2.4;
- miscellaneous editorial corrections.

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 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.

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 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 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 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.

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 8,244,838	[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 either free of charge or 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

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

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 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.