

© Copyright SEK Svensk Elstandard. Reproduction in any form without permission is prohibited.

Industriell processtyrning – Fältbuss – Del 6-10: Specifikation av protokoll i applikationsskiktet – Delar i fältbuss, Typ 10

*Industrial communication networks –
Fieldbus specifications –
Part 6-10: Application layer protocol specification –
Type 10 elements*

Som svensk standard gäller europastandarden EN IEC 61158-6-10:2019. Den svenska standarden innehåller den officiella engelska språkversionen av EN IEC 61158-6-10:2019.

Nationellt förord

Europastandarden EN IEC 61158-6-10:2019

består av:

- **europastandardens ikraftsättningsdokument**, utarbetat inom CENELEC
- **IEC 61158-6-10, Fourth edition, 2019 - Industrial communication networks - Fieldbus specifications - Part 6-10: Application layer protocol specification - Type 10 elements**

utarbetad inom International Electrotechnical Commission, IEC.

Tidigare fastställd svensk standard SS-EN 61158-6-10, utgåva 3, 2015, gäller ej fr o m 2022-07-25.

Standarder underlättar utvecklingen och höjer elsäkerheten

Det finns många fördelar med att ha gemensamma tekniska regler för bl a mätning, säkerhet och provning och för utförande, skötsel och dokumentation av elprodukter och elanläggningar.

Genom att utforma sådana standarder blir säkerhetsfordringar tydliga och utvecklingskostnaderna rimliga samtidigt som marknadens acceptans för produkten eller tjänsten ökar.

Många standarder inom elområdet beskriver tekniska lösningar och metoder som åstadkommer den elsäkerhet som föreskrivs av svenska myndigheter och av EU.

SEK är Sveriges röst i standardiseringsarbetet inom elområdet

SEK Svensk Elstandard svarar för standardiseringen inom elområdet i Sverige och samordnar svensk medverkan i internationell och europeisk standardisering. SEK är en ideell organisation med frivilligt deltagande från svenska myndigheter, företag och organisationer som vill medverka till och påverka utformningen av tekniska regler inom elektrotekniken.

SEK samordnar svenska intressenters medverkan i SEKs tekniska kommittéer och stödjer svenska experters medverkan i internationella och europeiska projekt.

Stora delar av arbetet sker internationellt

Utformningen av standarder sker i allt väsentligt i internationellt och europeiskt samarbete. SEK är svensk nationalkommitté av International Electrotechnical Commission (IEC) och Comité Européen de Normalisation Electrotechnique (CENELEC).

Standardiseringsarbetet inom SEK är organiserat i referensgrupper bestående av ett antal tekniska kommittéer som speglar hur arbetet inom IEC och CENELEC är organiserat.

Arbetet i de tekniska kommittéerna är öppet för alla svenska organisationer, företag, institutioner, myndigheter och statliga verk. Den årliga avgiften för deltagandet och intäkter från försäljning finansierar SEKs standardiseringsverksamhet och medlemsavgift till IEC och CENELEC.

Var med och påverka!

Den som deltar i SEKs tekniska kommittéarbete har möjlighet att påverka framtida standarder och får tidig tillgång till information och dokumentation om utvecklingen inom sitt teknikområde. Arbetet och kontakterna med kollegor, kunder och konkurrenter kan gynnsamt påverka enskilda företags affärsutveckling och bidrar till deltagarnas egen kompetensutveckling.

Du som vill dra nytta av dessa möjligheter är välkommen att kontakta SEKs kansli för mer information.

SEK Svensk Elstandard

Box 1284
164 29 Kista
Tel 08-444 14 00
www.elstandard.se

English Version

Industrial communication networks - Fieldbus specifications -
Part 6-10: Application layer protocol specification - Type 10
elements
(IEC 61158-6-10:2019)

Réseaux de communication industriels - Spécifications des
bus de terrain - Partie 6-10: Spécification du protocole de la
couche application - Eléments de type 10
(IEC 61158-6-10:2019)

Industrielle Kommunikationsnetze - Feldbusse - Teil 6-10:
Protokollspezifikation des Application Layer
(Anwendungsschicht) - Typ 10-Elemente
(IEC 61158-6-10:2019)

This European Standard was approved by CENELEC on 2019-07-25. 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/948/FDIS, future edition 4 of IEC 61158-6-10, 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 61158-6-10:2019.

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) 2020-04-25
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2022-07-25

This document supersedes EN 61158-6-10:2014 and all of its amendments and corrigenda (if any).

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 61158-6-10:2019 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 60793-2-30 NOTE Harmonized as EN 60793-2-30
IEC 60793-2-40 NOTE Harmonized as EN 60793-2-40
IEC 61784-3-3 NOTE Harmonized as EN 61784-3-3

Annex ZA

(normative)

Normative references to international publications with their corresponding European publications

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 1 Where an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 61131-9	-	Programmable controllers - Part 9: Single-drop digital communication interface for small sensors and actuators (SDCI)	EN 61131-9	-
IEC 61158-1	2019	Industrial communication networks Fieldbus specifications - Part 1: Overview and guidance for the IEC 61158 and IEC 61784 series	EN IEC 61158-1	2019
IEC 61158-2	-	Industrial communication networks Fieldbus specifications - Part 2: Physical layer specification and service definition	EN 61158-2	-
IEC 61158-5-10	2019	Industrial communication networks Fieldbus specifications - Part 5-10: Application layer service definition - Type 10 elements	EN IEC 61158-5-10	2019
IEC 61158-6-3	2019	Industrial communication networks Fieldbus specifications - Part 6-3: Application layer protocol specification - Type 3 elements	--	-
IEC 62439-2	-	Industrial communication networks – High availability automation networks – Part 2: Media Redundancy Protocol (MRP)	EN 62439-2	-
ISO 8601	-	Data elements and interchange formats -- Information interchange - Representation of dates and times	--	-
ISO/IEC 646	1991	Information technology - ISO 7-bit coded-character set for information interchange	--	-
ISO/IEC 7498-1	-	Information technology - Open Systems-Interconnection - Basic Reference Model: The Basic Model	--	-
ISO/IEC 8822	-	Information technology - Open Systems-Interconnection - Presentation service definition	--	-
ISO/IEC 8824-1	-	Information technology - Abstract Syntax-Notation One (ASN.1): Specification of basic notation	--	-
ISO/IEC 9545	-	Information technology - Open Systems-Interconnection - Application Layer structure	--	-

ISO/IEC 9834-8	-	Information technology - Procedures for the operation of object identifier registration authorities - Part 8: Generation of universally unique identifiers (UUIDs) and their use in object identifiers	-
ISO/IEC 10646	-	Information technology - Universal Coded-Character Set (UCS)	-
ISO/IEC 10731	-	Information technology - Open Systems-Interconnection - Basic Reference Model - Conventions for the definition of OSI services	-
IEEE Std 802	-	IEEE Standard for Local and metropolitan-area networks: Overview and Architecture	-
IEEE Std 802.15.1	-	IEEE Standard for Information technology -- Telecommunications and information exchange between systems - Local and metropolitan area networks - Specific requirements. - Part 15.1: Wireless medium access control (MAC) and physical layer (PHY) specifications for wireless personal area networks (WPANs)	-
IEEE Std 802.1AB	2016	IEEE Standard for Local and metropolitan-area networks: Station and Media Access Control Connectivity Discovery	-
IEEE Std 802.1AC	-	IEEE Standard for Local and metropolitan area networks: Media Access Control (MAC) Service definition	-
IEEE Std 802.1AS	-	IEEE Standard for Local and metropolitan-area networks - Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks	-
IEEE Std 802.1Q	2018	IEEE Standard for Local and metropolitan-area networks - Bridges and Bridged Networks	-
IEEE Std 802.3	-	IEEE Standard for Ethernet	-
IEEE Std 802.11	-	IEEE Standard for Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications	-
IETF RFC 1034	-	Domain names - concepts and facilities	-
IETF RFC 1213	-	Management Information Base for Network-Management of TCP/IP-based Internets: MIB-II	-
IETF RFC 2131	-	Dynamic Host Configuration Protocol	-
IETF RFC 2132	-	DHCP Options and BOOTP Vendor-Extensions	-
IETF RFC 2236	-	Internet Group Management Protocol,-Version 2	-
IETF RFC 2365	-	Administratively Scoped IP Multicast	-
IETF RFC 2474	-	Definition of the Differentiated Services-Field (DS Field) in the IPv4 and IPv6 Headers	-
IETF RFC 2674	-	Definitions of Managed Objects for Bridges-with Traffic Classes, Multicast Filtering and Virtual LAN Extensions	-
IETF RFC 2863	-	The Interfaces Group MIB	-

IETF RFC 3418	-	Management Information Base (MIB) for the Simple Network Management Protocol (SNMP)	-
IETF RFC 3621	-	Power Ethernet MIB	-
IETF RFC 4361	-	Node-specific Client Identifiers for Dynamic-Host Configuration Protocol Version Four (DHCPv4)	-
IETF RFC 4363	-	Definitions of Managed Objects for Bridges-with Traffic Classes, Multicast Filtering, and Virtual LAN Extensions	-
IETF RFC 4604	-	Using Internet Group Management-Protocol Version 3 (IGMPv3) and Multicast Listener Discovery Protocol Version 2 (MLDv2) for Source-Specific Multicast	-
IETF RFC 4632	-	Classless Inter-domain Routing (CIDR): The Internet Address Assignment and Aggregation Plan	-
IETF RFC 4836	-	Definitions of Managed Objects for IEEE-802.3 Medium Attachment Units (MAUs)	-
IETF RFC 5227	-	IPv4 Address Conflict Detection	-
IETF RFC 5890	-	Internationalized Domain Names for Applications (IDNA): Definitions and Document Framework	-
IETF RFC 5905	-	Network Time Protocol Version 4: Protocol and Algorithms Specification	-
IETF RFC 6151	-	Updated Security Considerations for the MD5 Message-Digest and the HMAC-MD5 Algorithms	-
IETF RFC 6890	-	Special-Purpose IP Address Registries	-
IETF RFC 768	-	User Datagram Protocol	-
IETF RFC 791	-	Internet protocol darpa internet program-protocol specification	-
IETF RFC 792	-	Internet Control Message Protocol	-
IETF RFC 826	-	Ethernet Address Resolution Protocol: Or-Converting Network Protocol Addresses to 48.bit Ethernet Address for Transmission on Ethernet Hardware	-
IETF RFC 950	-	Internet Standard Subnetting Procedure	-
ISO/IEC/IEEE 60559	2011	Information technology - Microprocessor-Systems - Floating-Point arithmetic	-
The Open Group,- Publication C706		Technical standard DCE1.1: Remote Procedure Call	-

CONTENTS

FOREWORD.....	37
INTRODUCTION.....	39
1 Scope.....	41
1.1 General.....	41
1.2 Specifications	41
1.3 Conformance	41
2 Normative references	42
3 Terms, definitions, abbreviated terms, symbols and conventions	45
3.1 Referenced terms and definitions.....	45
3.1.1 ISO/IEC 7498-1 terms.....	45
3.1.2 ISO/IEC 8822 terms.....	45
3.1.3 ISO/IEC 8824-1 terms.....	45
3.1.4 ISO/IEC 9545 terms.....	45
3.2 Terms and definitions for decentralized periphery	46
3.3 Abbreviated terms and symbols	54
3.3.1 Abbreviated terms and symbols for media redundancy	54
3.3.2 Abbreviated terms and symbols for decentralized periphery.....	54
3.3.3 Abbreviated terms and symbols for services	58
3.3.4 Abbreviated terms and symbols for IEEE 802.1Q.....	58
3.3.5 Abbreviated terms and symbols for IETF RFC 2474.....	58
3.3.6 Abbreviated terms and symbols for IETF RFC 4291.....	58
3.4 Conventions.....	58
3.4.1 General concept	58
3.4.2 Conventions for decentralized periphery	58
3.4.3 Conventions used in state machines.....	67
4 Application layer protocol specification for common protocols.....	72
4.1 FAL syntax description.....	72
4.1.1 DLPDU abstract syntax reference	72
4.1.2 Data types	74
4.2 Transfer syntax.....	75
4.2.1 Coding of basic data types	75
4.2.2 Coding section related to common basic fields	83
4.3 Discovery and basic configuration.....	94
4.3.1 DCP syntax description	94
4.3.2 DCP protocol state machines.....	122
4.3.3 DLL Mapping Protocol Machines.....	139
4.4 Precision working time control	140
4.4.1 FAL syntax description	140
4.4.2 AP-Context state machine	151
4.4.3 FAL Service Protocol Machines	151
4.4.4 Application Relationship Protocol Machines.....	152
4.4.5 DLL Mapping Protocol Machines.....	215
4.5 Time synchronization	215
4.5.1 General	215
4.5.2 GlobalTime	216
4.5.3 WorkingClock	216
4.6 Media redundancy	217

4.6.1	Media redundancy and loop prevention.....	217
4.6.2	Seamless media redundancy	220
4.7	Real time cyclic.....	220
4.7.1	FAL syntax description	220
4.7.2	FAL transfer syntax	221
4.7.3	FAL Service Protocol Machines	231
4.7.4	Application Relationship Protocol Machines	231
4.7.5	DLL Mapping Protocol Machines.....	249
4.8	Real time acyclic.....	249
4.8.1	RTA syntax description	249
4.8.2	RTA transfer syntax	250
4.8.3	FAL Service Protocol Machines	254
4.8.4	Application Relationship Protocol Machines	254
4.8.5	DLL Mapping Protocol Machines.....	269
4.9	Fragmentation.....	269
4.9.1	General	269
4.9.2	FRAG syntax description	272
4.9.3	FRAG transfer syntax	273
4.9.4	FAL Service Protocol Machines	275
4.9.5	Application Relationship Protocol Machines	275
4.9.6	DLL Mapping Protocol Machines.....	275
4.10	Remote procedure call	286
4.10.1	General	286
4.10.2	RPC syntax description	286
4.10.3	RPC Transfer syntax	288
4.10.4	FAL Service Protocol Machines	304
4.10.5	Application Relationship Protocol Machines	304
4.10.6	DLL Mapping Protocol Machines.....	305
4.11	Link layer discovery	305
4.11.1	General	305
4.11.2	FAL common syntax description	305
4.11.3	LLDP transfer syntax	307
4.11.4	FAL Service Protocol Machines	317
4.11.5	Application Relation Protocol Machines	317
4.11.6	DLL Mapping Protocol Machines.....	317
4.12	Bridges and End Stations.....	317
4.12.1	General	317
4.12.2	Model	318
4.12.3	Traffic Shaping	333
4.12.4	Bridge extensions	334
4.12.5	QueueHandler	335
4.12.6	FAL Service Protocol Machines	335
4.12.7	Application Relation Protocol Machines	335
4.12.8	DLL Mapping Protocol Machines.....	335
4.13	IP suite	374
4.13.1	Overview	374
4.13.2	IP/UDP syntax description	374
4.13.3	IP/UDP transfer syntax	375
4.13.4	ARP.....	378

4.14	Domain name system.....	380
4.14.1	General	380
4.14.2	Primitive definitions	380
4.14.3	DNS state transition diagram	381
4.14.4	State machine description	381
4.14.5	DNS state table	381
4.14.6	Functions, Macros, Timers and Variables	381
4.15	Dynamic host configuration	381
4.15.1	General	381
4.15.2	Primitive definitions	382
4.15.3	DHCP state transition diagram.....	382
4.15.4	State machine description	382
4.15.5	DHCP state table	382
4.15.6	Functions, Macros, Timers and Variables	382
4.16	Simple network management	383
4.16.1	Overview	383
4.16.2	IETF RFC 1213-MIB	383
4.16.3	Enterprise number for PNIO MIB	383
4.16.4	MIB cross reference	384
4.16.5	Behavior in case of modular built bridges	384
4.16.6	LLDP EXT MIB	384
4.17	Common DLL Mapping Protocol Machines	384
4.17.1	Overview	384
4.17.2	Data Link Layer Mapping Protocol Machine	385
4.18	Additional definitions.....	390
5	Application layer protocol specification for decentralized periphery.....	390
5.1	FAL syntax description.....	390
5.1.1	DLPDU abstract syntax reference	390
5.1.2	APDU abstract syntax.....	390
5.2	Transfer syntax.....	409
5.2.1	Coding section related to BlockHeader specific fields	409
5.2.2	Coding section related to RTA-SDU specific fields.....	424
5.2.3	Coding section related to common address fields	429
5.2.4	Coding section related to AL services	445
5.2.5	Coding section related to ARVendorBlock.....	479
5.2.6	Coding section related to PNIOStatus.....	481
5.2.7	Coding section related to I&M Records	498
5.2.8	Coding section related to Alarm and Diagnosis PDUs	505
5.2.9	Coding section related to upload and retrieval	527
5.2.10	Coding section related to iParameter	527
5.2.11	Coding section related to Physical Device Interface Data	528
5.2.12	Coding section related to Physical Device Port Data.....	528
5.2.13	Coding section related to Physical Device IR Data.....	531
5.2.14	Coding section related to Physical Sync Data	554
5.2.15	Coding section related to Isochrone Mode Data.....	559
5.2.16	Coding section related to Physical Time Data	561
5.2.17	Coding section related to Media Redundancy	564
5.2.18	Coding section related to fiber optics	575
5.2.19	Coding section related to network components	577

5.2.20	Coding section related port statistic	578
5.2.21	Coding section related to fast startup.....	581
5.2.22	Coding section related to DFP	583
5.2.23	Coding section related to MRPD	587
5.2.24	Coding section related to auto configuration	588
5.2.25	Coding section related to controller to controller communication.....	591
5.2.26	Coding section related to system redundancy	592
5.2.27	Coding section related to energy saving	595
5.2.28	Coding section related to asset management.....	595
5.2.29	Coding section related to reporting system	600
5.2.30	Coding section related to Logbook.....	606
5.2.31	Coding section related to Time	607
5.2.32	Coding section related to Channel Related Process Alarm Reason.....	607
5.2.33	PDU checking rules	610
5.3	FAL protocol state machines.....	643
5.3.1	Overall structure	643
5.4	AP-Context state machine.....	645
5.5	FAL Service Protocol Machines	645
5.5.1	Overview	645
5.5.2	FAL Service Protocol Machine Device	645
5.5.3	FAL Service Protocol Machine Controller.....	654
5.6	Application Relationship Protocol Machines	665
5.6.1	Alarm Protocol Machine Initiator	665
5.6.2	Alarm Protocol Machine Responder	669
5.6.3	Device	673
5.6.4	Controller	756
5.7	DLL Mapping Protocol Machines.....	818
Annex A	(normative) Unified establishing of an AR for all RT classes	819
A.1	General.....	819
A.2	AR establishing.....	820
A.3	Startup of Alarm transmitter and receiver	825
Annex B	(normative) Compatible establishing of an AR.....	828
Annex C	(informative) Establishing of a device access AR.....	831
Annex D	(informative) Establishing of an AR (accelerated procedure).....	832
Annex E	(informative) Establishing of an AR (fast startup procedure).....	835
Annex F	(informative) Example of the upload, storage and retrieval procedure	837
Annex G	(informative) OSI reference model layers.....	839
Annex H	(informative) Overview of the IO controller and the IO device state machines	840
Annex I	(informative) Priority regeneration	842
Annex J	(informative) Overview of the PTCP synchronization master hierarchy	843
Annex K	(informative) Optimization of bandwidth usage.....	845
Annex L	(informative) Time constraints for bandwidth allocation	847
Annex M	(informative) Time constraints for the forwarding of a frame	849
M.1	Principle	849
M.2	Forwarding.....	849
Annex N	(informative) Principle of dynamic frame packing	851
Annex O	(informative) Principle of Fragmentation	855

Annex P (informative) MRPD – Principle of seamless media redundancy	858
Annex Q (normative) Principle of a RED_RELAY without forwarding information in PDIRFrameData	860
Annex R (informative) Optimization for fast startup without autonegotiation	863
Annex S (informative) Example of a PrmBegin, PrmEnd and ApplRdy sequence	866
Annex T (informative) List of supported MIBs	867
Annex U (informative) Structure and content of BLOB	868
Annex V (normative) LLDP EXT MIB	869
Annex W (normative) Cross reference to the IEC 62439-2	887
W.1 Cross reference to the IEC 62439-2	887
W.1.1 General	887
W.1.2 Ring	887
W.1.3 Interconnection	888
Annex X (normative) Maintaining statistic counters for Ethernet	890
X.1 General	890
X.2 Counting model	890
X.3 Explanation of the IETF RFC defined statistic counters	892
X.4 Value range of the IETF RFC defined statistic counters	893
Bibliography	894
Figure 1 – Common structure of specific fields for octet 1 (high)	60
Figure 2 – Common structure of specific fields for octet 2	60
Figure 3 – Common structure of specific fields for octet 3	60
Figure 4 – Common structure of specific fields for octet 4	61
Figure 5 – Common structure of specific fields for octet 5	61
Figure 6 – Common structure of specific fields for octet 6	61
Figure 7 – Common structure of specific fields for octet 7	62
Figure 8 – Common structure of specific fields for octet 8	62
Figure 9 – Common structure of specific fields for octet 9	62
Figure 10 – Common structure of specific fields for octet 10	63
Figure 11 – Common structure of specific fields for octet 11	63
Figure 12 – Common structure of specific fields for octet 12	63
Figure 13 – Common structure of specific fields for octet 13	64
Figure 14 – Common structure of specific fields for octet 14	64
Figure 15 – Common structure of specific fields for octet 15	64
Figure 16 – Common structure of specific fields for octet 16 (low)	65
Figure 17 – Coding of the data type BinaryDate	77
Figure 18 – Encoding of TimeOfDay with date indication value	77
Figure 19 – Encoding of TimeOfDay without date indication value	78
Figure 20 – Encoding of TimeDifference with date indication value	78
Figure 21 – Encoding of TimeDifference without date indication value	78
Figure 22 – Encoding of a NetworkTime value	79
Figure 23 – Encoding of NetworkTimeDifference value	79
Figure 24 – Encoding of TimeStamp value	80

Figure 25 – Encoding of TimeStampDifference value	81
Figure 26 – Encoding of TimeStampDifferenceShort value.....	82
Figure 27 – FastForwardingMulticastMACAdd.....	88
Figure 28 – State transition diagram of DCPUCS	123
Figure 29 – State transition diagram of DCPUCR.....	127
Figure 30 – State transition diagram of DCPMCS.....	131
Figure 31 – State transition diagram of DCPMCR	134
Figure 32 – State transition diagram of DCPHMCS	137
Figure 33 – State transition diagram of DCPHMCR	139
Figure 34 – PTCP_SequenceID value range	144
Figure 35 – Timescale correspondence between PTCP_Time and CycleCounter	147
Figure 36 – Message timestamp point.....	152
Figure 37 – Timer model	152
Figure 38 – Four message timestamps	153
Figure 39 – Line delay protocol with follow up.....	154
Figure 40 – Line delay protocol without follow up	154
Figure 41 – Line delay measurement	156
Figure 42 – Model parameter for GSDML usage	158
Figure 43 – Bridge delay measurement.....	159
Figure 44 – Delay accumulation.....	160
Figure 45 – Worst case accumulated time deviation of synchronization	161
Figure 46 – Signal generation for measurement of deviation	161
Figure 47 – Measurement of deviation	162
Figure 48 – PTCP master sending Sync-Frame without Follow Up-Frame	163
Figure 49 – PTCP master sending Sync-Frame with FollowUp-Frame.....	163
Figure 50 – !FU Sync Slave Forwarding Sync-Frame	164
Figure 51 – FU Sync Slave Forwarding Sync- and FollowUp-Frame.....	165
Figure 52 – FU Sync Slave Forwarding Sync- and Generating FollowUp-Frame.....	166
Figure 53 – Principle of the monitoring of the line delay measurement.....	167
Figure 54 – State transition diagram of DELAY_REQ.....	169
Figure 55 – State transition diagram of DELAY_RSP	177
Figure 56 – Overview of PTCP.....	181
Figure 57 – State transition diagram of SYN_BMA.....	184
Figure 58 – State transition diagram of SYN_MPSM	193
Figure 59 – State transition diagram of SYN_SPSM.....	199
Figure 60 – State transition diagram of SYNC_RELAY.....	206
Figure 61 – State transition diagram of SCHEDULER	212
Figure 62 – GlobalTime timer model	216
Figure 63 – WorkingClock timer model.....	217
Figure 64 – Media redundancy – Ring.....	217
Figure 65 – Media redundancy – Interconnection.....	219
Figure 66 – CycleCounter value range	222
Figure 67 – Structure of the CycleCounter	223

Figure 68 – Optimized CycleCounter setting	224
Figure 69 – SFCRC16 generation rule	228
Figure 70 – SFCycleCounter value range.....	229
Figure 71 – Basic structure of a PPM with frame structure	232
Figure 72 – Basic structure of a PPM with subframe structure.....	233
Figure 73 – State transition diagram of PPM.....	235
Figure 74 – Basic structure of a CPM.....	239
Figure 75 – State transition diagram of CPM.....	241
Figure 76 – Addressing scheme of RTA	251
Figure 77 – Structure of the APM	255
Figure 78 – Structure of the APMS.....	256
Figure 79 – State transition diagram of APMS.....	258
Figure 80 – Structure of the APMR	263
Figure 81 – State transition diagram of APMR	265
Figure 82 – State transition diagram of FRAG_D	276
Figure 83 – State transition diagram of FRAG_S.....	280
Figure 84 – State transition diagram of DEFRAG	283
Figure 85 – DLL Maping Protocol Machines (DMPM)	317
Figure 86 – Principle traffic flow model of a bridge.....	322
Figure 87 – Principle resource model of a bridge	323
Figure 88 – End station – on port bridge – transmit.....	328
Figure 89 – End station – on port bridge – receive	329
Figure 90 – Bridge with End Station.....	330
Figure 91 – Transmit – one port of a bridge	330
Figure 92 – Forwarding process – bridge	331
Figure 93 – Receive – on port of a bridge	331
Figure 94 – Transmit – Management port.....	332
Figure 95 – Receive – Management port.....	333
Figure 96 – State transition diagram of RTC3PSM	339
Figure 97 – State transition diagram for generating events	343
Figure 98 – State transition diagram of RED_RELAY	345
Figure 99 – Scheme of the DFP_RELAY	349
Figure 100 – Scheme of the DFP_RELAY_INBOUND and DFP_RELAY_IN_STORAGE	349
Figure 101 – Scheme of the DFP_RELAY_OUTBOUND.....	350
Figure 102 – State transition diagram of DFP_RELAY	351
Figure 103 – State transition diagram of DFP_RELAY_INBOUND	354
Figure 104 – State transition diagram of DFP_RELAY_IN_STORAGE.....	358
Figure 105 – State transition diagram of DFP_RELAY_OUTBOUND	362
Figure 106 – State transition diagram of MUX.....	366
Figure 107 – State transition diagram of DEMUX	371
Figure 108 – State transition diagram of ACCM	379
Figure 109 – Structuring of the protocol machines within the DMPM (bridge)	385
Figure 110 – State transition diagram of LMPM.....	388

Figure 111 – AlarmSpecifier.SequenceNumber value range	427
Figure 112 – FrameSendOffset vs. duration of a cycle	472
Figure 113 – Severity classification of fault, maintenance and normal	526
Figure 114 – Calculation principle for a cycle	548
Figure 115 – Calculation principle for the minimum YellowTime	549
Figure 116 – Definition of the reserved interval	556
Figure 117 – Toplevel view to the PLL window	559
Figure 118 – Definition of PLL window	559
Figure 119 – Toplevel view to the time PLL window	562
Figure 120 – Definition of time PLL window	563
Figure 121 – Detection of dropped frames – appear	578
Figure 122 – Detection of dropped frames – disappear	578
Figure 123 – Detection of DFP late error – appear and disappear	586
Figure 124 – MediaRedundancyWatchDog expired – appear and disappear	588
Figure 125 – EndPoint1 and Endpoint2 scheme – above and below	593
Figure 126 – EndPoint1 and Endpoint2 scheme – left and right	593
Figure 127 – Relationship among Protocol Machines	643
Figure 128 – State transition diagram of ALPMI	666
Figure 129 – State transition diagram of ALPMR	670
Figure 130 – Scheme of the IO device CM	674
Figure 131 – State transition diagram of the IO device CM	676
Figure 132 – State transition diagram of CMDEV	680
Figure 133 – Scheme of the IO device CM – device access	685
Figure 134 – State transition diagram of CMDEV_DA	687
Figure 135 – State transition diagram of CMSU	691
Figure 136 – State transition diagram of CMIO	696
Figure 137 – State transition diagram of CMRS	699
Figure 138 – State transition diagram of CMWRR	702
Figure 139 – State transition diagram of CMRDR	707
Figure 140 – State transition diagram of CMSM	709
Figure 141 – State transition diagram of CMPBE	713
Figure 142 – State transition diagram of CMDMC	718
Figure 143 – State transition diagram of CMINA	723
Figure 144 – State transition diagram of CMRPC	734
Figure 145 – Intersection and residual amount using different ARUUID.ConfigIDs	740
Figure 146 – Intersection and removed amount using different ARUUID.ConfigIDs	741
Figure 147 – State transition diagram of CMSRL	742
Figure 148 – Single Input and single Output buffer of CMSRL	748
Figure 149 – Dynamic reconfiguration with CMSRL	749
Figure 150 – Alarm queue management of CMSRL	750
Figure 151 – Reporting System management of CMSRL	751
Figure 152 – Primary: Switchover time between two ARs of an ARset	751
Figure 153 – Backup: Switchover time between two ARs of an ARset	752

Figure 154 – State transition diagram of CMSRL_AL	754
Figure 155 – Scheme of the IO controller CM	757
Figure 156 – State transition diagram of the IO controller CM	758
Figure 157 – State transition diagram of CMCTL.....	762
Figure 158 – State transition diagram of CTLSM.....	769
Figure 159 – State transition diagram of CTLIO	771
Figure 160 – State transition diagram of CTLRDI	775
Figure 161 – State transition diagram of CTLRDR.....	778
Figure 162 – State transition diagram of CTLRPC.....	782
Figure 163 – State transition diagram of CTLSU	787
Figure 164 – State transition diagram of CTLWRI	792
Figure 165 – State transition diagram of CTLWRR.....	796
Figure 166 – State transition diagram of CTLPBE	799
Figure 167 – State transition diagram of CTLDINA.....	805
Figure 168 – Automatic NameOfStation assignment.....	810
Figure 169 – State transition diagram of CTLSRL	812
Figure 170 – Input and Output buffer of CTLSRL	816
Figure 171 – Input and Output buffer with dynamic reconfiguration	816
Figure 172 – Alarm queue management of CTLSRL.....	817
Figure 173 – Alarm queue management with dynamic reconfiguration	818
Figure A.1 – Establishing of an AR using RT_CLASS_1, RT_CLASS_2 or RT_CLASS_3 (Initial connection monitoring w/o RT).....	820
Figure A.2 – Establishing of an AR using RT_CLASS_1, RT_CLASS_2 or RT_CLASS_3 (Connection monitoring with RT)	821
Figure A.3 – Principle of the data evaluation during startup (delayed RED channel establishment)	822
Figure A.4 – Principle of the data evaluation during startup (immediate RED channel establishment)	823
Figure A.5 – Principle of the data evaluation during startup (Special case: Isochronous mode application)	824
Figure A.6 – Startup of Alarm transmitter and receiver without System Redundancy.....	825
Figure A.7 – Startup of Alarm transmitter and receiver with System Redundancy.....	826
Figure A.8 – Startup of Alarm transmitter and receiver during a PrmBegin / PrmEnd / ApplRdy sequence	827
Figure B.1 – Establishing of an AR using RT_CLASS_3 AR with startup mode “Legacy”	829
Figure B.2 – Establishing of an AR using RT_CLASS_1, 2 or UDP AR with startup mode “Legacy”	830
Figure C.1 – Establishing of a device access AR	831
Figure D.1 – Accelerated establishing of an IOAR without error	833
Figure D.2 – Accelerated establishing of an IOAR with “late” error	834
Figure E.1 – Establishing of an IOAR using fast startup	836
Figure F.1 – Example of upload with storage	837
Figure F.2 – Example of retrieval with storage	838
Figure G.1 – Assignment of the OSI reference model layers	839
Figure H.1 – Overview of the IO controller state machines.....	840

Figure H.2 – Overview of the IO device state machines	840
Figure J.1 – Level model for synchronization master hierarchy	843
Figure J.2 – Two level variant of the synchronization master hierarchy	844
Figure K.1 – Devices build up in a linear structure	845
Figure K.2 – Propagation of frames in linear transmit direction	845
Figure K.3 – Propagation of a frames in receive direction	846
Figure L.1 – Overview of time constraints for bandwidth allocation.....	847
Figure L.2 – Calculation of the length of a RED period.....	847
Figure L.3 – Calculation of the length of a GREEN period	848
Figure M.1 – IEEE 802.3 definition.....	849
Figure M.2 – Minimization of bridge delay.....	849
Figure N.1 – Dynamic frame packing	851
Figure N.2 – Dynamic frame packing – truncation of outputs.....	852
Figure N.3 – Dynamic frame packing – concatenation of inputs.....	852
Figure N.4 – End node mode	853
Figure N.5 – DFPFeed definition.....	853
Figure O.1 – Principle of fragmentation.....	855
Figure O.2 – Protocol elements of fragments	855
Figure O.3 – Bandwidth allocation using fragmentation.....	856
Figure O.4 – Guardian for a fragmentation domain.....	856
Figure P.1 – Principle of seamless media redundancy – I/OCR.....	858
Figure P.2 – Principle of seamless media redundancy – MCR.....	859
Figure P.3 – Principle of seamless media redundancy – Line.....	859
Figure Q.1 – Generating the FrameSendOffset for a RED_RELAY without forwarding information in PDIRFrameData	860
Figure R.1 – Scheme of a 2-port switch	863
Figure R.2 – Scheme of 2-ports	863
Figure S.1 – PrmBegin, PrmEnd and ApplRdy procedure	866
Figure X.1 – IEEE 802 structure used for statistic counters.....	891
Figure X.2 – IEEE 802 summary for statistic counters.....	892
Table 1 – One octet	65
Table 2 – Two subsequent octets.....	66
Table 3 – Four subsequent octets	66
Table 4 – Eight subsequent octets	67
Table 5 – Sixteen subsequent octets	67
Table 6 – State machine description elements	68
Table 7 – Description of state machine elements	68
Table 8 – Conventions used in state machines	69
Table 9 – Conventions for services used in state machines	70
Table 10 – IEEE 802.3 DLPDU syntax	72
Table 11 – IEEE 802.11 DLPDU syntax	73
Table 12 – IEEE 802.15.1 DLPDU syntax	74

Table 13 – Status	79
Table 14 – Time source	81
Table 15 – SourceAddress.....	83
Table 16 – Single port device.....	83
Table 17 – DCP_MulticastMACAdd for Identify	84
Table 18 – DCP_MulticastMACAdd for Hello.....	84
Table 19 – DCP_MulticastMACAdd	84
Table 20 – MulticastMACAdd range 1	84
Table 21 – MulticastMACAdd range 2	84
Table 22 – MulticastMACAdd range 3	85
Table 23 – PTCP_MulticastMACAdd range 2	85
Table 24 – PTCP_MulticastMACAdd range 3	85
Table 25 – PTCP_MulticastMACAdd range 4	85
Table 26 – PTCP_MulticastMACAdd range 5	86
Table 27 – PTCP_MulticastMACAdd range 6	86
Table 28 – PTCP_MulticastMACAdd range 7	86
Table 29 – MulticastMACAdd range 8	86
Table 30 – MulticastMACAdd range 9	86
Table 31 – MulticastMACAdd range 10	87
Table 32 – MulticastMACAdd range 11	87
Table 33 – RT_CLASS_3 destination multicast address.....	88
Table 34 – RT_CLASS_3 invalid frame multicast address	89
Table 35 – LT (Length/Type).....	89
Table 36 – TagControllInformation.VID	89
Table 37 – TagControllInformation.DEI	90
Table 38 – TagControllInformation.PCP	90
Table 39 – FrameID range 1	90
Table 40 – FrameID range 2	91
Table 41 – FrameID range 3	91
Table 42 – FrameID range 4	91
Table 43 – FrameID range 5	91
Table 44 – FrameID range 6	92
Table 45 – FrameID range 7	92
Table 46 – FrameID range 8	92
Table 47 – FrameID range 9	93
Table 48 – FrameID range 10	93
Table 49 – FrameID range 11	93
Table 50 – FrameID range 12	93
Table 51 – FrameID range 13	93
Table 52 – FragmentationFrameID.FragSequence	94
Table 53 – FragmentationFrameID.Constant.....	94
Table 54 – DCP APDU syntax.....	94
Table 55 – DCP substitutions.....	95

Table 56 – ServiceID	98
Table 57 – ServiceType.Selection	98
Table 58 – ServiceType.Reserved	98
Table 59 – ServiceType.Selection	99
Table 60 – ServiceType.Reserved_1	99
Table 61 – ServiceType.Response	99
Table 62 – ServiceType.Reserved_2	99
Table 63 – ResponseDelayFactor	100
Table 64 – List of options	101
Table 65 – List of suboptions for option IPOption	102
Table 66 – List of suboptions for option DevicePropertiesOption	102
Table 67 – List of suboptions for option DHCPOption	102
Table 68 – List of suboptions for option ControlOption	103
Table 69 – List of suboptions for option DeviceInitiativeOption	103
Table 70 – List of suboptions for option AllSelectorOption	103
Table 71 – List of suboptions for option ManufacturerSpecificOption	103
Table 72 – SuboptionDHCP	105
Table 73 – Coding of DCPBlockLength in conjunction with SuboptionStart	106
Table 74 – Coding of DCPBlockLength in conjunction with SuboptionStop	106
Table 75 – Coding of DCPBlockLength in conjunction with SuboptionSignal	106
Table 76 – Coding of DCPBlockLength in conjunction with SuboptionFactoryReset	107
Table 77 – Alignment between FactoryReset and ResetToFactory	107
Table 78 – Coding of DCPBlockLength in conjunction with SuboptionResetToFactory	107
Table 79 – Meaning of the different ResetToFactory modes	108
Table 80 – Coding of DCPBlockLength in conjunction with SuboptionDeviceInitiative	108
Table 81 – Coding of DCPBlockLength	109
Table 82 – BlockQualifier with options IPOption, DevicePropertiesOption, DHCPOption and ManufacturerSpecificOption	109
Table 83 – BlockQualifier with option ControlOption and suboption SuboptionResetToFactory	110
Table 84 – BlockQualifier with option ControlOption and NOT suboption SuboptionResetToFactory	111
Table 85 – BlockError	111
Table 86 – BlockInfo for SuboptionIPParameter	111
Table 87 – Bit 1 and Bit 0 of BlockInfo for SuboptionIPParameter	112
Table 88 – Bit 7 of BlockInfo for SuboptionIPParameter	112
Table 89 – BlockInfo for all other suboptions	112
Table 90 – DeviceInitiativeValue	112
Table 91 – SignalValue	113
Table 92 – DeviceRoleDetails	115
Table 93 – IPAddress	115
Table 94 – Subnetmask	117
Table 95 – StandardGateway	118
Table 96 – Correlation between the subfields of IPSuite	119

Table 97 – MACAddress as client identifier.....	120
Table 98 – NameOfStation as client identifier	120
Table 99 – Arbitrary client identifier	120
Table 100 – DHCPParameterValue using DHCP Option 255.....	121
Table 101 – StandardGatewayValue.StandardGateway	122
Table 102 – Remote primitives issued or received by DCPUCS	122
Table 103 – Local primitives issued or received by DCPUCS	123
Table 104 – DCPUCS state table	124
Table 105 – Functions, Macros, Timers and Variables used by the DCPUCS	126
Table 106 – Remote primitives issued or received by DCPUCR	127
Table 107 – Local primitives issued or received by DCPUCR.....	127
Table 108 – DCPUCR state table.....	128
Table 109 – Functions, Macros, Timers and Variables used by the DCPUCR.....	130
Table 110 – Remote primitives issued or received by DCPMCS	130
Table 111 – Local primitives issued or received by DCPMCS.....	131
Table 112 – DCPMCS state table.....	132
Table 113 – Functions used by the DCPMCS.....	133
Table 114 – Remote primitives issued or received by DCPMCR	134
Table 115 – Local primitives issued or received by DCPMCR	134
Table 116 – DCPMCR state table	135
Table 117 – Functions, Macros, Timers and Variables used by the DCPMCR	136
Table 118 – Remote primitives issued or received by DCPHMCS	136
Table 119 – Local primitives issued or received by DCPHMCS	137
Table 120 – DCPHMCS state table	137
Table 121 – Functions, Macros, Timers and Variables used by the DCPHMCS	138
Table 122 – Remote primitives issued or received by DCPHMCR	138
Table 123 – Local primitives issued or received by DCPHMCR	138
Table 124 – DCPHMCR state table	139
Table 125 – Functions, Macros, Timers and Variables used by the DCPHMCR	139
Table 126 – PTCP APDU syntax	140
Table 127 – PTCP substitutions	140
Table 128 – PTCP_TLVHeader.Type	141
Table 129 – PTCP_Delay10ns	142
Table 130 – PTCP_Delay1ns_Byte.Value	142
Table 131 – PTCP_Delay1ns	143
Table 132 – PTCP_Delay1ns_FUP	143
Table 133 – PTCP_SequenceID.....	143
Table 134 – PTCP_SubType for OUI (=00-0E-CF)	144
Table 135 – PTCP_Seconds	145
Table 136 – PTCP_NanoSeconds	145
Table 137 – PTCP_Flags.LeapSecond.....	145
Table 138 – Timescale correspondence between PTCP_EpochNumber, PTCP_Second, PTCP_Nanosecond, CycleCounter and SendClockFactor	146

Table 139 – PTCP_CurrentUTCOffset.....	148
Table 140 – PTCP_MasterPriority1.Priority for SyncID == 0 and SyncProperties.Role == 2	148
Table 141 – PTCP_MasterPriority1.Priority for SyncID == 0 and SyncProperties.Role == 1	148
Table 142 – PTCP_MasterPriority1.Level.....	149
Table 143 – PTCP_MasterPriority2	149
Table 144 – PTCP_ClockClass for SyncID == 0 (working clock synchronization)	149
Table 145 – PTCP_ClockAccuracy.....	150
Table 146 – PTCP_ClockVariance	151
Table 147 – PTCP_T2PortRxDelay	151
Table 148 – PTCP_T3PortTxDelay	151
Table 149 – PTCP_T2TimeStamp	151
Table 150 – Remote primitives issued or received by DELAY_REQ	168
Table 151 – Local primitives issued or received by DELAY_REQ	168
Table 152 – DELAY_REQ state table	170
Table 153 – Functions, macros, timers and variables used by the DELAY_REQ	174
Table 154 – Remote primitives issued or received by DELAY_RSP.....	176
Table 155 – Local primitives issued or received by DELAY_RSP	176
Table 156 – DELAY_RSP state table	178
Table 157 – Functions, Macros, Timers and Variables used by the DELAY_RSP	180
Table 158 – Remote primitives issued or received by SYN_BMA	182
Table 159 – Local primitives issued or received by SYN_BMA	182
Table 160 – SYN_BMA state table	185
Table 161 – Functions, Macros, Timers and Variables used by the SYN_BMA	189
Table 162 – Remote primitives issued or received by SYN_MPSM.....	192
Table 163 – Local primitives issued or received by SYN_MPSM	192
Table 164 – SYN_MPSM state table	194
Table 165 – Functions, Macros, Timers and Variables used by the SYN_MPSM	197
Table 166 – Remote primitives issued or received by SYN_SPSM	198
Table 167 – Local primitives issued or received by SYN_SPSM.....	198
Table 168 – SYN_SPSM state table	200
Table 169 – Functions, Macros, Timers and Variables used by the SYN_SPSM.....	203
Table 170 – Truth table for one SyncID for receiving sync and follow up frames	204
Table 171 – Remote primitives issued or received by SYNC_RELAY	205
Table 172 – Local primitives issued or received by SYNC_RELAY	205
Table 173 – SYNC_RELAY state table.....	207
Table 174 – Functions, Macros, Timers and Variables used by the SYNC_RELAY	208
Table 175 – Truth table for one SyncID for receiving.....	210
Table 176 – Truth table for one SyncID for transmitting	211
Table 177 – Remote primitives issued or received by SCHEDULER.....	211
Table 178 – Local primitives issued or received by SCHEDULER	212
Table 179 – SCHEDULER state table	213
Table 180 – Functions, Macros, Timers and Variables used by the SCHEDULER	214
Table 181 – Truth table for RxPeriodChecker of one port.....	215

Table 182 – Truth table for TxPeriodChecker of one port	215
Table 183 – Timescales	215
Table 184 – Timescale correspondence between GlobalTime, TAI and UTC	216
Table 185 – Conjunction between supported MRP_Role and default MRP_Prio	218
Table 186 – Extended forwarding rule.....	218
Table 187 – Managed Multicast MAC address.....	219
Table 188 – RTC APDU syntax	220
Table 189 – RTC substitutions	221
Table 190 – CycleCounter Difference.....	222
Table 191 – DataStatus.State	224
Table 192 – DataStatus.Redundancy in conjunction with DataStatus.State==Backup.....	225
Table 193 – DataStatus.Redundancy in conjunction with DataStatus.State==Primary	225
Table 194 – DataStatus.DataValid	225
Table 195 – DataStatus.ProviderState	225
Table 196 – DataStatus.StationProblemIndicator	226
Table 197 – DataStatus.Ignore of a frame.....	226
Table 198 – DataStatus.Ignore of a sub frame	226
Table 199 – TransferStatus for RT_CLASS_3.....	227
Table 200 – SFPosition.Position	228
Table 201 – SFPosition.Reserved	228
Table 202 – SFDataLength	228
Table 203 – SFCycleCounter Difference	230
Table 204 – IOxS.Extension.....	230
Table 205 – IOxS.Instance.....	230
Table 206 – IOxS.DataState	231
Table 207 – APDU_Status of a PPM with subframe structure.....	233
Table 208 – Remote primitives issued or received by PPM	234
Table 209 – Local primitives issued or received by PPM	234
Table 210 – PPM state table	236
Table 211 – Functions, Macros, Timers and Variables used by the PPM.....	237
Table 212 – Truth table used by the PPM for TxOption	238
Table 213 – Remote primitives issued or received by CPM	240
Table 214 – Local primitives issued or received by CPM.....	240
Table 215 – CPM state table.....	242
Table 216 – Functions, Macros, Timers and Variables used by the CPM.....	245
Table 217 – Truth table used by the CPM for RxOption.....	246
Table 218 – Truth table for one frame using RT_CLASS_x	247
Table 219 – Truth table for one frame using RT_CLASS_UDP	247
Table 220 – Truth table for the C_SDU	247
Table 221 – Truth table for arranging DHt and data	248
Table 222 – Truth table for the subframe – frame check.....	248
Table 223 – Truth table for the subframe – sub frame check	248
Table 224 – Truth table for the subframe – sub frame data check	249

Table 225 – Truth table for the subframe – DHt and data	249
Table 226 – RTA APDU syntax	249
Table 227 – RTA substitutions	250
Table 228 – PDUType.Type	252
Table 229 – PDUType.Version	252
Table 230 – AddFlags.WindowSize	252
Table 231 – AddFlags.TACK	252
Table 232 – SendSeqNum	253
Table 233 – SendSeqNum and AckSeqNum start sequence	253
Table 234 – AckSeqNum	254
Table 235 – VarPartLen	254
Table 236 – Remote primitives issued or received by APMS	256
Table 237 – Local primitives issued or received by APMS	257
Table 238 – APMS state table	259
Table 239 – Functions, Macros, Timers and Variables used by the APMS	261
Table 240 – Remote primitives issued or received by APMR	264
Table 241 – Local primitives issued or received by APMR	265
Table 242 – APMR state table	266
Table 243 – Functions, Macros, Timers and Variables used by the APMR	268
Table 244 – TagControllInformation.PCP vs. streams	269
Table 245 – Lower limit of fragments	272
Table 246 – FRAG APDU syntax	272
Table 247 – FRAG substitutions	273
Table 248 – FragDataLength	274
Table 249 – FragStatus.FragmentNumber	274
Table 250 – FragStatus.Reserved	274
Table 251 – FragStatus.MoreFollows	275
Table 252 – Remote primitives issued or received by FRAG_D	275
Table 253 – Local primitives issued or received by FRAG_D	275
Table 254 – FRAG_D state table (dynamic)	277
Table 255 – Functions, Macros, Timers and Variables used by the FRAG_D (dynamic)	278
Table 256 – Remote primitives issued or received by FRAG_S	279
Table 257 – Local primitives issued or received by FRAG_S	279
Table 258 – FRAG_S state table (static)	281
Table 259 – Functions, Macros, Timers and Variables used by the FRAG_S (static)	282
Table 260 – Remote primitives issued or received by DEFRAG	283
Table 261 – Local primitives issued or received by DEFRAG	283
Table 262 – DEFRAG state table	284
Table 263 – Functions, Macros, Timers and Variables used by the DEFRAG	285
Table 264 – Truth table for the DefragGuard – first fragment	285
Table 265 – Truth table for the DefragGuard – next fragment	285
Table 266 – Truth table for the DefragGuard – last fragment	286
Table 267 – RPC APDU syntax	286

Table 268 – RPC substitutions	287
Table 269 – RPCVersion	288
Table 270 – RPCPacketType	288
Table 271 – RPCFlags	289
Table 272 – RPCFlags2	289
Table 273 – RPCDRep.Character- and IntegerEncoding	290
Table 274 – RPCDRep Octet 2 – Floating Point Representation	290
Table 275 – RPCObjectUUID.Data4	291
Table 276 – RPCObjectUUID for devices	291
Table 277 – Instance or node number	291
Table 278 – RPCInterfaceUUID for PNIO	292
Table 279 – RPCInterfaceUUID for the RPC end point mapper	292
Table 280 – RPCInterfaceVersion.Major	293
Table 281 – RPCInterfaceVersion.Minor	293
Table 282 – RPCOperationNmb (IO device, controller and supervisor)	294
Table 283 – RPCOperationNmb for endpoint mapper	294
Table 284 – RPCVersionFack	295
Table 285 – RPCDataRepresentationUUID – defined values	296
Table 286 – RPCInquiryType	298
Table 287 – RPCEPMapStatus	300
Table 288 – Values of NCAFaultStatus	302
Table 289 – Values of NCAREjectStatus	303
Table 290 – Remote primitives issued or received by RPC	304
Table 291 – Local primitives issued or received by RPC	304
Table 292 – LLDP APDU syntax	306
Table 293 – LLDP substitutions	306
Table 294 – LLDP_ChassisID in conjunction with MultipleInterfaceMode.NameOfDevice == 0 and NameOfStation	307
Table 295 – LLDP_ChassisID in conjunction with MultipleInterfaceMode.NameOfDevice == 1	307
Table 296 – LLDP_PortID in conjunction with MultipleInterfaceMode.NameOfDevice	308
Table 297 – LLDP_PNIO_SubType	308
Table 298 – PTCP_PortRxDelayLocal	309
Table 299 – PTCP_PortRxDelayRemote	309
Table 300 – PTCP_PortTxDelayLocal	309
Table 301 – PTCP_PortTxDelayRemote	309
Table 302 – CableDelayLocal	310
Table 303 – RTClass2_PortStatus.State with ARProperties.StartupMode == Legacy	310
Table 304 – RTClass2_PortStatus.State with ARProperties.StartupMode == Advanced	310
Table 305 – RTClass3_PortStatus.State	311
Table 306 – RTClass3_PortStatus.Fragmentation	311
Table 307 – RTClass3_PortStatus.PreambleLength	311
Table 308 – Truth table for shortening of the preamble	312
Table 309 – RTClass3_PortStatus.Optimized	312

Table 310 – MRRT_PortStatus.State	313
Table 311 – IRDataUUID	313
Table 312 – LLDP_RedOrangePeriodBegin.Offset	313
Table 313 – LLDP_RedOrangePeriodBegin.Valid.....	313
Table 314 – LLDP_OrangePeriodBegin.Offset	314
Table 315 – LLDP_OrangePeriodBegin.Valid with ARProperties.StartupMode == Legacy	314
Table 316 – LLDP_OrangePeriodBegin.Valid with ARProperties.StartupMode == Advanced	314
Table 317 – LLDP_GreenPeriodBegin.Offset	315
Table 318 – LLDP_GreenPeriodBegin.Valid.....	315
Table 319 – LLDP_LengthOfPeriod.Length	315
Table 320 – LLDP_LengthOfPeriod.Valid	315
Table 321 – Priority remapping at an ingress boundary port.....	319
Table 322 – Trees and FDBs	320
Table 323 – Available queue.....	322
Table 324 – Queue related memory management	323
Table 325 – Queue usage.....	324
Table 326 – Queue usage.....	324
Table 327 – QB TSA usage.....	325
Table 328 – QB TSA usage.....	326
Table 329 – Traffic Classes[0..7] for eight queues	334
Table 330 – Traffic Classes[0..3] for four queues	334
Table 331 – Unicast FDB entries	335
Table 332 – Multicast FDB entries	336
Table 333 – Broadcast FDB entry	337
Table 334 – Remote primitives issued or received by MAC_RELAY	337
Table 335 – Local primitives issued or received by MAC_RELAY.....	338
Table 336 – Functions, Macros, Timers and Variables used by the MAC_RELAY.....	338
Table 337 – Remote primitives issued or received by RTC3PSM	339
Table 338 – Local primitives issued or received by RTC3PSM	339
Table 339 – RTC3PSM state table	340
Table 340 – Functions, Macros, Timers and Variables used by the RTC3PSM	341
Table 341 – Truth table for the RTC3PSM	342
Table 342 – RXBeginEndAssignment and TXBeginEndAssignment.....	342
Table 343 – Event function table.....	343
Table 344 – Remote primitives issued or received by RED_RELAY	344
Table 345 – Local primitives issued or received by RED_RELAY	344
Table 346 – RED_RELAY state table	346
Table 347 – Functions, Macros, Timers and Variables used by the RED_RELAY	347
Table 348 – Truth table for the RedGuard with full check	347
Table 349 – Truth table for the RedGuard with reduced check	348
Table 350 – Truth table for the RedGuard with minimal check.....	348
Table 351 – Remote primitives issued or received by DFP_RELAY.....	350

Table 352 – Local primitives issued or received by DFP_RELAY	351
Table 353 – DFP_RELAY state table	352
Table 354 – Functions, Macros, Timers and Variables used by the DFP_RELAY	352
Table 355 – Truth table for the DFPGuard	353
Table 356 – Remote primitives issued or received by DFP_RELAY_INBOUND	353
Table 357 – Local primitives issued or received by DFP_RELAY_INBOUND	354
Table 358 – DFP_RELAY_INBOUND state table	355
Table 359 – Functions, Macros, Timers and Variables used by the DFP_RELAY_INBOUND	355
Table 360 – Truth table for the InboundGuard – frame check	356
Table 361 – Truth table for the InboundGuard – sub frame check	356
Table 362 – Truth table for the InboundGuard – sub frame data check	356
Table 363 – Truth table for the InboundGuard – full check	357
Table 364 – Remote primitives issued or received by DFP_RELAY_IN_STORAGE	357
Table 365 – Local primitives issued or received by DFP_RELAY_IN_STORAGE	358
Table 366 – DFP_RELAY_IN_STORAGE state table	359
Table 367 – Functions, Macros, Timers and Variables used by the DFP_RELAY_IN_STORAGE	360
Table 368 – Remote primitives issued or received by DFP_RELAY_OUTBOUND	361
Table 369 – Local primitives issued or received by DFP_RELAY_OUTBOUND	361
Table 370 – APDU_Status used if frame is shortened	362
Table 371 – DFP_RELAY_OUTBOUND state table	363
Table 372 – Functions, Macros, Timers and Variables used by the DFP_RELAY_OUTBOUND	364
Table 373 – Truth table for the OutboundGuard – frame check	364
Table 374 – Truth table for the OutboundGuard – sub frame check	365
Table 375 – Remote primitives issued or received by MUX	365
Table 376 – Local primitives issued or received by MUX	365
Table 377 – MUX state table	367
Table 378 – Functions, Macros, Timers and Variables used by MUX	368
Table 379 – Truth table for FrameSizeFits	369
Table 380 – Truth table for StateChecker	369
Table 381 – Remote primitives issued or received by DEMUX	370
Table 382 – Local primitives issued or received by DEMUX	370
Table 383 – DEMUX state table	372
Table 384 – Functions, Macros, Timers and Variables used by the DEMUX	373
Table 385 – IP/UDP APDU syntax	374
Table 386 – IP/UDP substitutions	375
Table 387 – UDP_SrcPort	376
Table 388 – UDP_DstPort	376
Table 389 – IP_DstIPAddress	376
Table 390 – IP Multicast DstIPAddress according to IETF RFC 2365	376
Table 391 – IP_DifferentiatedServices.DSCP	377
Table 392 – IP_DifferentiatedServices.ECN	377

Table 393 – Remote primitives issued or received by ACCM	378
Table 394 – Local primitives issued or received by ACCM	379
Table 395 – ACCM state table	380
Table 396 – Functions, Macros, Timers and Variables used by the ACCM	380
Table 397 – Remote primitives issued or received by DNS	381
Table 398 – Local primitives issued or received by DNS	381
Table 399 – Functions, Macros, Timers and Variables used by the DNS	381
Table 400 – Remote primitives issued or received by DHCP	382
Table 401 – Local primitives issued or received by machines	382
Table 402 – Functions, Macros, Timers and Variables used by the DHCP	383
Table 403 – List of supported IETF RFC 1213-MIB objects	383
Table 404 – Enterprise number	384
Table 405 – Cross reference – MIBs	384
Table 406 – Cross reference – PDPortDataAdjust	384
Table 407 – Remote primitives issued or received by LMPM	386
Table 408 – Local primitives issued or received by LMPM	387
Table 409 – LMPM state table	388
Table 410 – Functions, Macros, Timers and Variables used by the LMPM	389
Table 411 – IO APDU substitutions	391
Table 412 – BlockType	409
Table 413 – BlockLength	422
Table 414 – BlockVersionHigh	423
Table 415 – BlockVersionLow	423
Table 416 – AlarmType	424
Table 417 – AlarmSpecifier.SequenceNumber	427
Table 418 – AlarmSpecifier.SequenceNumber Difference	428
Table 419 – AlarmSpecifier.ChannelDiagnosis	428
Table 420 – AlarmSpecifier.ManufacturerSpecificDiagnosis	428
Table 421 – AlarmSpecifier.SubmoduleDiagnosisState	429
Table 422 – AlarmSpecifier.ARDiagnosisState	429
Table 423 – API	430
Table 424 – SlotNumber	430
Table 425 – SubslotNumber	430
Table 426 – Index range	431
Table 427 – Expression 1 (subslot specific)	432
Table 428 – Expression 2 (slot specific)	432
Table 429 – Expression 3 (AR specific)	432
Table 430 – Expression 4 (API specific)	432
Table 431 – Expression 5 (device specific)	432
Table 432 – Grouping of DiagnosisData	433
Table 433 – Index (user specific)	434
Table 434 – Index (subslot specific)	434
Table 435 – Index (slot specific)	438

Table 436 – Index (AR specific)	439
Table 437 – Index (API specific)	441
Table 438 – Index (device specific)	442
Table 439 – RecordDataLength	445
Table 440 – ARType	445
Table 441 – IOCRMulticastMACAdd using RT_CLASS_UDP	446
Table 442 – IOCRMulticastMACAdd using RT_CLASS_x	446
Table 443 – Type 10 OUI	447
Table 444 – ARProperties.State	447
Table 445 – ARProperties.SupervisorTakeoverAllowed	447
Table 446 – ARProperties.ParameterizationServer	448
Table 447 – ARProperties.DeviceAccess	448
Table 448 – ARProperties.CompanionAR	448
Table 449 – ARProperties.AcknowledgeCompanionAR	448
Table 450 – ARProperties.CombinedObjectContainer with ARProperties.StartupMode == Legacy	449
Table 451 – ARProperties.CombinedObjectContainer with ARProperties.StartupMode == Advanced	449
Table 452 – ARProperties.StartupMode	449
Table 453 – ARProperties.PullModuleAlarmAllowed	449
Table 454 – IOCRProperties.RTClass	450
Table 455 – IOCRTagHeader.IOCRVLANID	451
Table 456 – IOCRTagHeader.IOUserPriority	451
Table 457 – IOCRTType	451
Table 458 – CMInitiatorActivityTimeoutFactor with ARProperties.DeviceAccess==0	451
Table 459 – CMInitiatorActivityTimeoutFactor with ARProperties.DeviceAccess==1 or ARProperties.StartupMode==1	452
Table 460 – CMInitiatorTriggerTimeoutFactor	452
Table 461 – IODataObjectFrameOffset	453
Table 462 – IOCSFrameOffset	453
Table 463 – LengthIOCS	454
Table 464 – LengthIOPS	454
Table 465 – LengthData	454
Table 466 – AlarmCRProperties.Priority	455
Table 467 – AlarmCRProperties.Transport	455
Table 468 – AlarmCRTagHeaderHigh.AlarmCRVLANID	455
Table 469 – AlarmCRTagHeaderHigh.AlarmUserPriority	456
Table 470 – AlarmCRTagHeaderLow.AlarmCRVLANID	456
Table 471 – AlarmCRTagHeaderLow.AlarmUserPriority	456
Table 472 – AlarmSequenceNumber	456
Table 473 – AlarmCRType	457
Table 474 – RTATimeoutFactor	457
Table 475 – RTARetries	457
Table 476 – AddressResolutionProperties.Protocol	458

Table 477 – AddressResolutionProperties.Factor	458
Table 478 – MCTimeoutFactor	459
Table 479 – DeviceIDLow and DeviceIDHigh	459
Table 480 – VendorIDLow	460
Table 481 – VendorIDHigh	460
Table 482 – ModuleIdentNumber	460
Table 483 – SubmoduleIdentNumber	461
Table 484 – ARUUID	462
Table 485 – ARUUID in conjunction with ARTYPE==IOCARSR	462
Table 486 – Conjunction between ARUUID.ARnumber and Endpoint1 or Endpoint2	462
Table 487 – ARUUID.ConfigID generation rule	463
Table 488 – TargetARUUID	463
Table 489 – AdditionalValue1 and AdditionalValue2	463
Table 490 – ControlBlockProperties in conjunction with ControlCommand.ApplicationReady with ARProperties.StartupMode==1	463
Table 491 – ControlBlockProperties in conjunction with ControlCommand.ApplicationReady with ARProperties.StartupMode==0	464
Table 492 – ControlBlockProperties in conjunction with the other values of the field ControlCommand	464
Table 493 – ControlCommand.PrmEnd	464
Table 494 – ControlCommand.ApplicationReady	464
Table 495 – ControlCommand.Release	465
Table 496 – ControlCommand.Done	465
Table 497 – ControlCommand.ReadyForCompanion	465
Table 498 – ControlCommand.ReadyForRT_CLASS_3	465
Table 499 – ControlCommand.PrmBegin	465
Table 500 – DataDescription.Type	466
Table 501 – Values of DataLength	466
Table 502 – Values of SendClockFactor	467
Table 503 – Values of ReductionRatio for RT_CLASS_1 and RT_CLASS_2	468
Table 504 – Values of ReductionRatio for RT_CLASS_3 and SendClockFactor ≥ 8	468
Table 505 – Values of ReductionRatio for RT_CLASS_3 and SendClockFactor < 8	468
Table 506 – Values of ReductionRatio in conjunction with a non power of 2 SendClockFactor	468
Table 507 – Values of ReductionRatio for RT_CLASS_UDP	469
Table 508 – Values of Phase	469
Table 509 – Values of Sequence	469
Table 510 – DataHoldFactor of a frame	470
Table 511 – DataHoldFactor of a Subframe	470
Table 512 – Values of FrameSendOffset	471
Table 513 – ModuleState	472
Table 514 – SubmoduleState.AddInfo	473
Table 515 – SubmoduleState.Advice	473
Table 516 – SubmoduleState.MaintenanceRequired	473

Table 517 – SubmoduleState.MaintenanceDemanded	473
Table 518 – SubmoduleState.Fault	474
Table 519 – SubmoduleState.ARInfo	474
Table 520 – SubmoduleState.IdentInfo	474
Table 521 – SubmoduleState.FormatIndicator.....	475
Table 522 – SubmoduleProperties.Type.....	475
Table 523 – SubmoduleProperties.SharedInput	475
Table 524 – SubmoduleProperties.ReduceInputSubmoduleDataLength	476
Table 525 – SubmoduleProperties.ReduceOutputSubmoduleDataLength.....	476
Table 526 – SubmoduleProperties.DiscardIOXS	476
Table 527 – SubstitutionMode.....	477
Table 528 – SubstituteActiveFlag.....	477
Table 529 – InitiatorUDPRTPort.....	478
Table 530 – ResponderUDPRTPort.....	478
Table 531 – InitiatorRPCServerPort	478
Table 532 – ResponderRPCServerPort.....	479
Table 533 – MaxAlarmDataLength	479
Table 534 – APStructureIdentifier with API==0	480
Table 535 – APStructureIdentifier with API ≠ 0.....	480
Table 536 – ExtendedIdentificationVersionHigh	480
Table 537 – ExtendedIdentificationVersionLow	480
Table 538 – Values of ErrorCode for negative responses.....	481
Table 539 – Values of ErrorDecode	482
Table 540 – Coding of ErrorCode1 with ErrorDecode PNORW	482
Table 541 – Coding of ErrorCode2 with ErrorDecode PNORW	483
Table 542 – Coding of ErrorCode1 with ErrorDecode:= PNIO	484
Table 543 – Values of ErrorCode2 for ErrorDecode:= PNIO and ErrorCode1 (part 1)	487
Table 544 – Values of ErrorCode2 for ErrorDecode:= PNIO and ErrorCode1 (part 2 – alarm acknowledge).....	490
Table 545 – Values of ErrorCode2 for ErrorDecode:= PNIO and ErrorCode1 (part 3 – machines).....	491
Table 546 – Values of ErrorCode2 for ErrorDecode:= PNIO and ErrorCode1 (part 4 – IO controller)	492
Table 547 – Values of ErrorCode2 for ErrorDecode:= PNIO and ErrorCode1 (part 5 – IO device).....	494
Table 548 – Values of ErrorCode2 for ErrorDecode:= PNIO and ErrorCode1 (part 6 – abort reasons)	495
Table 549 – Values of ErrorCode2 for ErrorDecode:= PNIO and ErrorCode1 (part 7 – Reserved).....	498
Table 550 – Coding of ErrorCode1 for ErrorDecode with the value ManufacturerSpecific	498
Table 551 – Coding of ErrorCode2 for ErrorDecode with the value ManufacturerSpecific	498
Table 552 – Visible characters.....	498
Table 553 – FactoryReset / ResetToFactory behavior (legacy from IEC 61158-x-3)	499

Table 554 – FactoryReset / ResetToFactory behavior (default without IEC 61158-x-3 history)	499
Table 555 – FactoryReset / ResetToFactory behavior if used in conjunction with functional safety submodules	499
Table 556 – IM_Hardware_Revision	499
Table 557 – IM_SWRevision_Functional_Enhancement	500
Table 558 – IM_SWRevision_Bug_Fix	500
Table 559 – IM_SWRevision_Internal_Change	500
Table 560 – IM_Revision_Counter	500
Table 561 – IM_Profile_ID	501
Table 562 – IM_Profile_Specific_Type in conjunction with IM_Profile_ID == 0x0000	501
Table 563 – IM_Profile_Specific_Type in conjunction with IM_Profile_ID range 0x0001 – 0xF6FF	501
Table 564 – IM_Version_Major	502
Table 565 – IM_Version_Minor	502
Table 566 – IM_Supported.I&M1	502
Table 567 – IM_Date with time	504
Table 568 – IM_Date without time	504
Table 569 – IM_Annotation	504
Table 570 – IM_OrderID	505
Table 571 – IM_UniquelIdentifier	505
Table 572 – UserStructureIdentifier	506
Table 573 – ChannelErrorType – range 1	508
Table 574 – ChannelErrorType – range 2	509
Table 575 – ChannelErrorType – range 3	509
Table 576 – ChannelErrorType – range 4	510
Table 577 – ChannelNumber	510
Table 578 – ChannelProperties.Type	511
Table 579 – ChannelProperties.Accumulative	511
Table 580 – ChannelProperties.Maintenance	512
Table 581 – Valid combinations within ChannelProperties	512
Table 582 – Valid combinations for Alarmnotification and RecordDataRead(DiagnosisData)	513
Table 583 – ChannelProperties.Specifier	514
Table 584 – ChannelProperties.Direction	514
Table 585 – ExtChannelErrorType	514
Table 586 – Allowed combinations of ChannelErrorType, ExtChannelErrorType, and ExtChannelAddValue	515
Table 587 – ExtChannelErrorType for ChannelErrorType 0 – 0xFF	515
Table 588 – Additional ExtChannelErrorType for ChannelErrorType 0x0F and 0x10	515
Table 589 – ExtChannelErrorType for ChannelErrorType 0x0100 – 0x7FFF	515
Table 590 – ExtChannelErrorType for ChannelErrorType “Data transmission impossible”	516
Table 591 – ExtChannelErrorType for ChannelErrorType “Remote mismatch”	516

Table 592 – ExtChannelErrorType for ChannelErrorType “Media redundancy mismatch – Ring”	517
Table 593 – ExtChannelErrorType for ChannelErrorType “Media redundancy mismatch – Interconnection”	517
Table 594 – ExtChannelErrorType for ChannelErrorType “Sync mismatch” and for ChannelErrorType “Time mismatch”	518
Table 595 – ExtChannelErrorType for ChannelErrorType “Isochronous mode mismatch”	518
Table 596 – ExtChannelErrorType for ChannelErrorType “Multicast CR mismatch”	518
Table 597 – ExtChannelErrorType for ChannelErrorType “Fiber optic mismatch”	519
Table 598 – ExtChannelErrorType for ChannelErrorType “Network component function mismatch”	519
Table 599 – ExtChannelErrorType for ChannelErrorType “Dynamic Frame Packing function mismatch”	519
Table 600 – ExtChannelErrorType for ChannelErrorType “Media redundancy with planned duplication mismatch”	520
Table 601 – ExtChannelErrorType for ChannelErrorType “Multiple interface mismatch”	520
Table 602 – Values for ExtChannelAddValue	521
Table 603 – Values for “Accumulative Info”	521
Table 604 – Values for ExtChannelErrorType “Parameter fault detail”	522
Table 605 – Values for ExtChannelAddValue.Index	522
Table 606 – Values for ExtChannelAddValue.Offset	522
Table 607 – Values for ExtChannelErrorType “Consistency fault detail”	522
Table 608 – Values for ExtChannelAddValue.Index	523
Table 609 – Values for “Fiber optic mismatch” – “Power Budget”	523
Table 610 – Values for “Network component function mismatch” – “Frame dropped”	523
Table 611 – Values for “Remote mismatch” – “Peer CableDelay mismatch”	524
Table 612 – Values for “Multiple interface mismatch” – “Conflicting MultipleInterfaceMode.NameOfDevice mode”	524
Table 613 – Values for “Multiple interface mismatch” – “Inactive StandardGateway”	524
Table 614 – Values for QualifiedChannelQualifier	525
Table 615 – Values for MaintenanceStatus	525
Table 616 – URRecordIndex	527
Table 617 – URRecordLength	527
Table 618 – iPar_Req_Header	527
Table 619 – Max_Segm_Size	527
Table 620 – Transfer_Index	528
Table 621 – Total_iPar_Size	528
Table 622 – MultipleInterfaceMode.NameOfDevice	528
Table 623 – NumberOfPeers in conjunction with PDPortDataCheck	529
Table 624 – NumberOfPeers in conjunction with PDPortDataReal or PDPortDataRealExtended	529
Table 625 – LineDelay.Value with LineDelay.FormatIndicator == 0	530
Table 626 – LineDelay.Value with LineDelay.FormatIndicator == 1	530
Table 627 – LineDelay.FormatIndicator	531
Table 628 – RxPort	531
Table 629 – NumberOfTxPortGroups	531

Table 630 – TxPortEntry	532
Table 631 – FrameDetails.SyncFrame in conjunction with FrameDataProperties.ForwardingMode=="Absolute mode"	533
Table 632 – FrameDetails.SyncFrame in conjunction with FrameDataProperties.ForwardingMode=="Relative mode"	533
Table 633 – FrameDetails.MeaningFrameSendOffset	534
Table 634 – FrameDetails.MediaRedundancyWatchDog	534
Table 635 – FrameDataProperties.ForwardingMode	534
Table 636 – FrameDataProperties.FastForwardingMulticastMACAdd	534
Table 637 – FrameDataProperties.FragmentationMode	535
Table 638 – MAUType	535
Table 639 – MAUType with MAUTypeExtension.....	539
Table 640 – Valid combinations between MAUType and LinkState.....	539
Table 641 – MAUTypeExtensions and its corresponding MAUTypes	540
Table 642 – CheckSyncMode.CableDelay.....	540
Table 643 – CheckSyncMode.SyncMaster	540
Table 644 – MAUTypeMode.Check	541
Table 645 – DomainBoundaryIngress	541
Table 646 – DomainBoundaryEgress	541
Table 647 – DomainBoundaryAnnounce	542
Table 648 – MulticastBoundary.....	542
Table 649 – PeerToPeerBoundary	543
Table 650 – DCPBoundary.....	543
Table 651 – PreambleLength.Length.....	544
Table 652 – LinkState.Link	544
Table 653 – LinkState.Port	545
Table 654 – MediaType	545
Table 655 – MaxBridgeDelay	545
Table 656 – NumberOfPorts	546
Table 657 – MaxPortTxDelay	546
Table 658 – MaxPortRxDelay.....	546
Table 659 – MaxLineRxDelay	546
Table 660 – YellowTime.....	547
Table 661 – StartOfRedFrameID in conjunction with ARProperties.StartupMode:= Legacy	549
Table 662 – StartOfRedFrameID in conjunction with ARProperties.StartupMode:= Advanced	550
Table 663 – EndOfRedFrameID	550
Table 664 – Dependencies of StartOfRedFrameID and EndOfRedFrameID.....	550
Table 665 – NumberOfAssignments	550
Table 666 – NumberOfPhases	551
Table 667 – AssignedValueForReservedBegin.....	551
Table 668 – AssignedValueForOrangeBegin.....	552
Table 669 – AssignedValueForReservedEnd	552

Table 670 – Values of RedOrangePeriodBegin	552
Table 671 – Dependencies of RedOrangePeriodBegin, OrangePeriodBegin and GreenPeriodBegin	553
Table 672 – Values of OrangePeriodBegin with ARProperties.StartupMode == Legacy	553
Table 673 – Values of OrangePeriodBegin with ARProperties.StartupMode == Advanced	553
Table 674 – Values of GreenPeriodBegin	553
Table 675 – EtherType	554
Table 676 – SyncProperties.Role	554
Table 677 – SyncProperties.SyncID	554
Table 678 – ReservedIntervalBegin with ARProperties.StartupMode == Legacy	555
Table 679 – ReservedIntervalBegin with ARProperties.StartupMode == Advanced	555
Table 680 – ReservedIntervalEnd with ARProperties.StartupMode == Legacy	555
Table 681 – ReservedIntervalEnd with ARProperties.StartupMode == Advanced	555
Table 682 – Dependencies of ReservedIntervalBegin and ReservedIntervalEnd	555
Table 683 – SyncSendFactor	556
Table 684 – PTCPTimeoutFactor	557
Table 685 – PTCPTakeoverTimeoutFactor	557
Table 686 – PTCPMasterStartupTime	558
Table 687 – PLLWindow	558
Table 688 – TimeIObase	560
Table 689 – TimeDataCycle	560
Table 690 – TimeIOInput	560
Table 691 – TimeIOOutput	561
Table 692 – TimeIOInputValid	561
Table 693 – TimeIOOutputValid	561
Table 694 – ControllerApplicationCycleFactor	561
Table 695 – TimePLLWindow	562
Table 696 – TimeMasterPriority1	563
Table 697 – TimeMasterPriority2	563
Table 698 – MRP_Version	564
Table 699 – MRP_RingState	564
Table 700 – MRP_DomainUUID	564
Table 701 – MRP_LengthDomainName	565
Table 702 – MRP_DomainName	565
Table 703 – MRP_Role	565
Table 704 – MRP_Version	565
Table 705 – MRP_Prio	566
Table 706 – MRP_TOPchgT	566
Table 707 – MRP_TOPNRmax	567
Table 708 – MRP_TSTshortT	567
Table 709 – MRP_TSTdefaultT	567
Table 710 – MRP_TSTNRmax	568
Table 711 – MRP_LNKdownT	568

Table 712 – MRP_LNKupT	568
Table 713 – MRP_LNKNRmax	569
Table 714 – MRP_Check.MediaRedundancyManager	569
Table 715 – MRP_Check.MRP_DomainUUID	569
Table 716 – MRP_NumberOfEntries	570
Table 717 – MRP_Instance	570
Table 718 – MRPIC_LengthDomainName	570
Table 719 – MRPIC_DomainName	570
Table 720 – MRPIC_State	571
Table 721 – MRPIC_Role	571
Table 722 – MRPIC_DomainID	571
Table 723 – MRPIC_TOPchgT	572
Table 724 – MRPIC_TOPNRmax	572
Table 725 – MRPIC_LinkStatusChangeT	573
Table 726 – MRPIC_LinkStatusNRmax	573
Table 727 – MRPIC_LNKdownT	573
Table 728 – MRPIC_LNKupT	574
Table 729 – MRPIC_LNKNRmax	574
Table 730 – MRPIC_StartDelay	575
Table 731 – MRPIC_Check.MIM	575
Table 732 – MRPIC_Check.MRPIC_DomainID	575
Table 733 – VendorBlockType	576
Table 734 – FiberOpticType	576
Table 735 – FiberOpticCableType	576
Table 736 – FiberOpticPowerBudgetType.Value	577
Table 737 – FiberOpticPowerBudgetType.CheckEnable	577
Table 738 – NCDropBudgetType.Value	577
Table 739 – NCDropBudgetType.CheckEnable	578
Table 740 – CounterStatus.ifInOctets	579
Table 741 – CounterStatus.ifOutOctets	579
Table 742 – CounterStatus.ifInDiscards	579
Table 743 – CounterStatus.ifOutDiscards	579
Table 744 – CounterStatus.ifInErrors	579
Table 745 – CounterStatus.ifOutErrors	580
Table 746 – CounterStatus.Reserved	580
Table 747 – FSHelloMode.Mode	581
Table 748 – FSHelloInterval	581
Table 749 – FSHelloRetry	582
Table 750 – FSHelloDelay	582
Table 751 – FSPParameterMode.Mode	582
Table 752 – FSPParameterUUID	583
Table 753 – NumberOfSubframeBlocks	583
Table 754 – SFIOCRProperties.DistributedWatchDogFactor	583

Table 755 – SFIOCRProperties.RestartFactorForDistributedWD	584
Table 756 – SFIOCRProperties.DFPMODE	584
Table 757 – SFIOCRProperties.DFPDirection	585
Table 758 – SFIOCRProperties.DFPRedundantPathLayout.....	585
Table 759 – SFIOCRProperties.SFCRC16	585
Table 760 – SubframeData.Position	586
Table 761 – SubframeData.DataLength	586
Table 762 – Event function table	587
Table 763 – SubframeOffset	587
Table 764 – Event function table	588
Table 765 – SCFEntry.....	589
Table 766 – ACCommunicationProperties.DFP	590
Table 767 – ACCommunicationProperties.RTC3	590
Table 768 – ACCommunicationProperties.RTCUDP	590
Table 769 – ACMinDeviceInterval	591
Table 770 – FromOffsetData.....	591
Table 771 – NextOffsetData.....	591
Table 772 – TotalSize	591
Table 773 – RedundancyInfo.EndPoint1	592
Table 774 – RedundancyInfo.EndPoint2	592
Table 775 – Valid combination of RedundancyInfo.EndPoint1 and RedundancyInfo.EndPoint2.....	592
Table 776 – SRProperties.InputValidOnBackupAR with SRProperties.Mode == 0	593
Table 777 – SRProperties.InputValidOnBackupAR with SRProperties.Mode == 1	594
Table 778 – SRProperties.Reserved_1	594
Table 779 – SRProperties.Mode	594
Table 780 – RedundancyDataHoldFactor	594
Table 781 – NumberOfEntries.....	595
Table 782 – PE_OperationalMode	595
Table 783 – AM_Location.Structure	596
Table 784 – AM_Location.Levelx	596
Table 785 – AM_Location.Reserved1.....	597
Table 786 – AM_Location.BeginSubslotNumber.....	597
Table 787 – AM_Location.EndSubslotNumber	597
Table 788 – AM_Location.Reserved2.....	597
Table 789 – AM_Location.Reserved3.....	598
Table 790 – AM_Location.Reserved4.....	598
Table 791 – AM_DeviceIdentification.DeviceSubID	598
Table 792 – AM_DeviceIdentification.DeviceSubID for AM_DeviceIdentification.Organization:= 0x0000	599
Table 793 – AM_DeviceIdentification.DeviceID	599
Table 794 – AM_DeviceIdentification.VendorID.....	599
Table 795 – AM_DeviceIdentification.Organization	599
Table 796 – RS_Properties.AlarmTransport	600

Table 797 – RS_BlockType used for events	600
Table 798 – RS_BlockType used for adjust	601
Table 799 – RS_BlockLength in conjunction with RS_EventBlock	601
Table 800 – RS_BlockLength in conjunction with other blocks	602
Table 801 – RS_Specifier.SequenceNumber	602
Table 802 – RS_Specifier.Specifier	602
Table 803 – RS_MinusError	603
Table 804 – RS_PlusError	603
Table 805 – RS_ExtensionBlockType	603
Table 806 – RS_ExtensionBlockLength	603
Table 807 – RS_MaxScanDelay	604
Table 808 – RS_AdjustSpecifier.Incident	604
Table 809 – RS_ReasonCode.Reason	604
Table 810 – RS_ReasonCode.Detail	605
Table 811 – RS_DigitalInputCurrentValue.Value	605
Table 812 – RS_DomainIdentification	605
Table 813 – RS_MasterIdentification	605
Table 814 – ActualLocalTimeStamp	606
Table 815 – LocalTimeStamp	606
Table 816 – NumberOfLogEntries	606
Table 817 – EntryDetail	606
Table 818 – Time_TimeStamp	607
Table 819 – Allowed combinations of PRAL_Reason, PRAL_ExtReason, and PRAL_ReasonAddValue	607
Table 820 – PRAL_ChannelProperties.Reserved_1	607
Table 821 – PRAL_ChannelProperties.Accumulative	608
Table 822 – PRAL_ChannelProperties.Reserved_2	608
Table 823 – PRAL_ChannelProperties.Direction	608
Table 824 – Values for PRAL_Reason	608
Table 825 – Values for PRAL_ExtReason	610
Table 826 – Usage of PRAL_ReasonAddValue	610
Table 827 – Values for PRAL_ReasonAddValue[0..3]	610
Table 828 – Values for PRAL_ReasonAddValue[0] to [127]	610
Table 829 – ArgsLength check	611
Table 830 – ARBlockReq – request check	612
Table 831 – IOCRBlockReq – request check	613
Table 832 – AlarmCRBlockReq – request check	617
Table 833 – ExpectedSubmoduleBlockReq – request check	617
Table 834 – PrmServerBlock – request check	619
Table 835 – MCRBlockReq – request check	619
Table 836 – ARRPCBlockReq – request check	620
Table 837 – IRInfoBlock – request check	620
Table 838 – SRInfoBlock – request check	621

Table 839 – RSInfoBlock – request check.....	621
Table 840 – ArgsLength check.....	622
Table 841 – ARBlockRes – response check.....	622
Table 842 – IOCRBlockRes – response check.....	623
Table 843 – AlarmCRBlockRes – response check.....	624
Table 844 – ModuleDiffBlock – response check.....	624
Table 845 – ARServerBlockRes – response check.....	625
Table 846 – ArgsLength check.....	626
Table 847 – ControlBlockConnect(PrmEnd) – request check.....	626
Table 848 – ControlBlockPlug(PrmEnd) – request check.....	627
Table 849 – ControlBlockConnect(PrmBegin) – request check.....	627
Table 850 – SubmoduleListBlock – request check.....	628
Table 851 – ArgsLength check.....	628
Table 852 – ControlBlockConnect – response check.....	629
Table 853 – ControlBlockPlug – response check.....	629
Table 854 – ControlBlockConnect(PrmBegin) – response check.....	630
Table 855 – ArgsLength check.....	631
Table 856 – ControlBlockConnect(ApplRdy) – request check.....	631
Table 857 – ControlBlockPlug(ApplRdy) – request check.....	632
Table 858 – ArgsLength check.....	632
Table 859 – ControlBlockConnect – response check.....	633
Table 860 – ControlBlockPlug – response check.....	633
Table 861 – ArgsLength check.....	634
Table 862 – ReleaseBlock – request check.....	635
Table 863 – ArgsLength check.....	635
Table 864 – ReleaseBlock – response check.....	636
Table 865 – ArgsLength check.....	636
Table 866 – IODWriteReqHeader – request check.....	637
Table 867 – ArgsLength check.....	637
Table 868 – IODWriteResHeader – response check.....	638
Table 869 – ArgsLength check.....	639
Table 870 – ArgsLength check.....	640
Table 871 – ArgsLength check.....	640
Table 872 – IODReadReqHeader – request check.....	641
Table 873 – RecordDataReadQuery – request check.....	642
Table 874 – ArgsLength check.....	642
Table 875 – IODReadResHeader – response check.....	642
Table 876 – Primitives issued by AP-Context (FAL user) to FSPMDEV.....	645
Table 877 – Primitives issued by FSPMDEV to AP-Context (FAL user).....	648
Table 878 – Functions, Macros, Timers and Variables used by the AP-Context (FAL user) to FSPMDEV.....	651
Table 879 – Functions, Macros, Timers and Variables used by the FSPMDEV to AP-Context (FAL user).....	652
Table 880 – Primitives issued by AP-Context (FAL user) to FSPMCTL.....	655

Table 881 – Primitives issued by FSPMCTL to AP-Context (FAL user).....	657
Table 882 – Functions, Macros, Timers and Variables used by AP-Context (FAL user) to FSPMCTL	661
Table 883 – Functions, Macros, Timers and Variables used by FSPMCTL to AP- Context (FAL user)	662
Table 884 – Remote primitives issued or received by ALPMI	665
Table 885 – Local primitives issued or received by ALPMI	666
Table 886 – ALPMI state table	667
Table 887 – Functions, Macros, Timers and Variables used by ALPMI	668
Table 888 – Remote primitives issued or received by ALPMR	669
Table 889 – Local primitives issued or received by ALPMR	670
Table 890 – ALPMR state table	671
Table 891 – Functions, Macros, Timers and Variables used by ALPMR	673
Table 892 – Remote primitives issued or received by CMDEV	677
Table 893 – Local primitives issued or received by CMDEV	679
Table 894 – CMDEV state table	682
Table 895 – Functions, Macros, Timers and Variables used by CMDEV	684
Table 896 – Remote primitives issued or received by CMDEV_DA	686
Table 897 – Local primitives issued or received by CMDEV_DA	686
Table 898 – CMDEV_DA state table	688
Table 899 – Functions, Macros, Timers and Variables used by CMDEV(DA)	688
Table 900 – Remote primitives issued or received by CMSU	689
Table 901 – Local primitives issued or received by CMSU	689
Table 902 – CMSU state table	692
Table 903 – Functions, Macros, Timers and Variables used by the CMSU	695
Table 904 – Remote primitives issued or received by CMIO	695
Table 905 – Local primitives issued or received by CMIO	695
Table 906 – CMIO state table	697
Table 907 – Functions used by the CMIO	698
Table 908 – Remote primitives issued or received by CMRS	698
Table 909 – Local primitives issued or received by CMRS	699
Table 910 – CMRS state table	700
Table 911 – Functions, Macros, Timers and Variables used by the CMRS	700
Table 912 – Remote primitives issued or received by CMWRR	701
Table 913 – Local primitives issued or received by CMWRR	701
Table 914 – CMWRR state table	703
Table 915 – Functions, Macros, Timers and Variables used by CMWRR	705
Table 916 – Remote primitives issued or received by CMRDR	706
Table 917 – Local primitives issued or received by CMRDR	706
Table 918 – CMRDR state table	707
Table 919 – Functions, Macros, Timers and Variables used by CMRDR	708
Table 920 – Remote primitives issued or received by CMSM	708
Table 921 – Local primitives issued or received by CMSM	709
Table 922 – CMSM state table	710

Table 923 – Functions, Macros, Timers and Variables used by the CMSM	711
Table 924 – Remote primitives received by CMPBE.....	712
Table 925 – Local primitives issued or received by CMPBE	712
Table 926 – CMPBE state table	714
Table 927 – Functions, Macros, Timers and Variables used by the CMPBE	716
Table 928 – Remote primitives issued or received by CMDMC.....	716
Table 929 – Local primitives issued or received by CMDMC	717
Table 930 – CMDMC state table	719
Table 931 – Functions, Macros, Timers and Variables used by the CMDMC	721
Table 932 – Remote primitives issued or received by CMINA.....	722
Table 933 – Local primitives issued or received by CMINA	722
Table 934 – CMINA state table	724
Table 935 – Functions, Macros, Timers and Variables used by the CMINA	730
Table 936 – Return values of CheckAPDU	731
Table 937 – Remote primitives issued or received by CMRPC	732
Table 938 – Local primitives issued or received by CMRPC	734
Table 939 – CMRPC state table.....	735
Table 940 – Functions, Macros, Timers and Variables used by the CMRPC	738
Table 941 – Return values of CheckRPC	740
Table 942 – Remote primitives issued or received by CMSRL.....	741
Table 943 – Local primitives issued or received by CMSRL	742
Table 944 – CMSRL state table	743
Table 945 – Functions, Macros, Timers and Variables used by the CMSRL	746
Table 946 – Combinations of DataStatus for Output buffers	747
Table 947 – Combinations of DataStatus for Input buffers.....	747
Table 948 – Remote primitives issued or received by CMSRL_AL.....	753
Table 949 – Local primitives issued or received by CMSRL_AL	753
Table 950 – CMSRL_AL state table	755
Table 951 – Functions, Macros, Timers and Variables used by the CMSRL_AL	756
Table 952 – Remote primitives issued or received by CMCTL	759
Table 953 – Local primitives issued or received by CMCTL.....	760
Table 954 – CMCTL state table.....	764
Table 955 – Functions, Macros, Timers and Variables used by the CMCTL	767
Table 956 – Remote primitives issued or received by CTLSM	767
Table 957 – Local primitives issued or received by CTLSM.....	768
Table 958 – CTLSM state table.....	769
Table 959 – Functions, Macros, Timers and Variables used by the CTLSM.....	770
Table 960 – Remote primitives issued or received by CTLIO.....	770
Table 961 – Local primitives issued or received by CTLIO	771
Table 962 – CTLIO state table	772
Table 963 – Functions, Macros, Timers and Variables used by the CTLIO	773
Table 964 – Remote primitives received by CTLRDI	774
Table 965 – Local primitives issued or received by CTLRDI	774

Table 966 – CTLRDI state table	776
Table 967 – Functions, Macros, Timers and Variables used by CTLRDI	776
Table 968 – Remote Primitives received by CTLRDR	777
Table 969 – Local primitives issued or received by CTLRDR	778
Table 970 – CTLRDR state table	778
Table 971 – Functions, Macros, Timers and Variables used by CTLRDR	779
Table 972 – Remote primitives received by CTLRPC	779
Table 973 – Local primitives issued or received by CTLRPC	782
Table 974 – CTLRPC state table	783
Table 975 – Functions, Macros, Timers and Variables used by the CTLRPC	785
Table 976 – Remote primitives issued or received by CTLSU	785
Table 977 – Local Primitives issued or received by CTLSU	786
Table 978 – CTLSU state table	788
Table 979 – Functions, Macros, Timers and Variables used by the CTLSU	790
Table 980 – Remote primitives issued or received by CTLWRI	791
Table 981 – Local primitives issued or received by CTLWRI	791
Table 982 – CTLWRI state table	793
Table 983 – Functions, Macros, Timers and Variables used by CTLWRI	794
Table 984 – Remote primitives issued or received by CTLWRR	795
Table 985 – Local primitives issued or received by CTLWRR	795
Table 986 – CTLWRR state table	797
Table 987 – Functions, Macros, Timers and Variables used by CTLWRR	797
Table 988 – Remote primitives issued or received by CTLPBE	798
Table 989 – Local primitives issued or received by CTLPBE	799
Table 990 – CTLPBE state table	800
Table 991 – Functions, Macros, Timers and Variables used by CTLPBE	802
Table 992 – Remote primitives issued or received by CTLDINA	803
Table 993 – Local primitives issued or received by CTLDINA	804
Table 994 – CTLDINA state table	806
Table 995 – Functions, Macros, Timers and Variables used by the CTLDINA	809
Table 996 – Remote primitives issued or received by CTLSRL	811
Table 997 – Local primitives issued or received by CTLSRL	811
Table 998 – CTLSRL state table	813
Table 999 – Functions, Macros, Timers and Variables used by the CTLSRL	815
Table A.1 – Examples for the AR establishing	819
Table A.2 – Startup of Alarm transmitter and receiver	819
Table B.1 – Examples for compatible AR establishing	828
Table I.1 – Priority regeneration and queue usage	842
Table M.1 – IEEE 802.3 cross reference	849
Table R.1 – Truth table	864
Table R.2 – “MAC/PHY configuration/status” with AutoNegotiation disabled	864
Table R.3 – “MAC/PHY configuration/status” with AutoNegotiation enabled	864
Table R.4 – Auto-negotiation support within “MAC/PHY configuration/status”	864

Table R.5 – Auto-negotiation settings	865
Table T.1 – List of supported MIBs	867
Table U.1 – Content of archive	868
Table W.1 – Cross reference IEC 62439-2 “MRP MIB objects”	887
Table W.2 – Cross reference IEC 62439-2 “Events, created by state machines”	887
Table W.3 – Cross reference IEC 62439-2 “MRM parameter”	888
Table W.4 – Cross reference IEC 62439-2 “MRC parameter”	888
Table W.5 – Cross reference IEC 62439-2 “MRP MIB objects”	888
Table W.6 – Cross reference IEC 62439-2 “Events, created by state machines”	889
Table W.7 – Cross reference IEC 62439-2 “MIM parameter”	889
Table W.8 – Cross reference IEC 62439-2 “MIC parameter”	889
Table X.1 – Meaning of numbers	891
Table X.2 – Statistic counters – octets	892
Table X.3 – Statistic counters – packets or frames.....	893
Table X.4 – Statistic counters – errors	893

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**INDUSTRIAL COMMUNICATION NETWORKS –
FIELDBUS SPECIFICATIONS –****Part 6-10: Application layer protocol specification –
Type 10 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 61158-6-10 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:

- a) integration of system redundancy basic functionality;
- b) integration of dynamic reconfiguration basic functionality;
- c) integration of reporting system basic functionality;
- d) integration of asset management basic functionality; e) integration of media redundancy ring interconnection basic functionality.

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

FDIS	Report on voting
65C/948/FDIS	65C/956/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 'color inside' logo on the cover page of this publication indicates that it contains colors which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a color printer.

INTRODUCTION

This document 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 application protocol provides the application service by making use of the services available from the data-link or other immediately lower 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 application entities (AEs) 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:

- as a guide for implementers and designers;
- for use in the testing and procurement of equipment;
- as part of an agreement for the admittance of systems into the open systems environment;
- 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 Attention is drawn to the fact that use of the associated protocol type(s) is restricted by its (their) intellectual-property-right holder(s). In all cases, the commitment to limited release of intellectual-property-rights made by the holder(s) 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 protocol type(s) in other combinations may require permission of their respective intellectual-property-right holder(s).

The International Electrotechnical Commission (IEC) draws attention to the fact that it is claimed that compliance with this document may involve the use of a patent concerning Type 10 elements and possibly other types given in this document as follows:

The following patent rights for Type 10 have been announced by [SI]:

Publication	Title
WO 02/043336	System and method for parallel transfer of real-time critical and non-real-time critical data via switchable data networks, particularly Ethernet
WO 02/076033	Synchronous clocked communication system with decentralized input/output modules and methods for integrating decentralized input/output modules in such a system
WO 03/028258	Method for synchronizing nodes of a communication system
WO 03/028259	Communications system and method for synchronizing a communications cycle
WO 04/030284	Method for permanent redundant transmission of data telegrams in communication systems
EP 1558002	Method for assigning an IP address to a device
EP 1318630	Matrices for controlling the device specific data transfer rates on a field bus

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

The holder of these patent rights has assured the IEC that he/she 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 the holder of these patent rights is registered with IEC. Information may be obtained from:

[SI]: Siemens AG
LC TE IP&IT

Otto-Hahn-Ring 6
D-81739 Munich
Germany

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.

INDUSTRIAL COMMUNICATION NETWORKS – FIELDBUS SPECIFICATIONS –

Part 6-10: Application layer protocol specification – Type 10 elements

1 Scope

1.1 General

The Fieldbus Application Layer (FAL) provides user programs with a means to access the fieldbus communication environment. In this respect, the FAL can be viewed as a “window between corresponding application programs.”

This part of IEC 61158 provides common elements for basic time-critical and non-time-critical messaging communications between application programs in an automation environment and material specific to Type 10 fieldbus. The term “time-critical” is used to represent the presence of a time-window, within which one or more specified actions are required to be completed with some defined level of certainty. Failure to complete specified actions within the time window risks failure of the applications requesting the actions, with attendant risk to equipment, plant and possibly human life.

This International Standard defines in an abstract way the externally visible behavior provided by the Type 10 fieldbus application layer in terms of:

- a) the abstract syntax defining the application layer protocol data units conveyed between communicating application entities,
- b) the transfer syntax defining the application layer protocol data units conveyed between communicating application entities,
- c) the application context state machine defining the application service behavior visible between communicating application entities, and
- d) the application relationship state machines defining the communication behavior visible between communicating application entities.

The purpose of this document is to define the protocol provided to:

- a) define the wire-representation of the service primitives defined in IEC 61158-5-10 and
- b) define the externally visible behavior associated with their transfer.

This document specifies the protocol of the Type 10 fieldbus application layer, in conformance with the OSI Basic Reference Model (ISO/IEC 7498-1) and the OSI Application Layer Structure (ISO/IEC 9545).

1.2 Specifications

The principal objective of this document is to specify the syntax and behavior of the application layer protocol that conveys the application layer services defined in IEC 61158-5-10.

A secondary objective is to provide migration paths from previously-existing industrial communications protocols. It is this latter objective which gives rise to the diversity of protocols standardized in IEC 61158-6.

1.3 Conformance

This document does not specify individual implementations or products, nor does it constrain the implementations of application layer entities within industrial automation systems.

Conformance is achieved through implementation of this application layer protocol specification.

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.

IEC 61131-9, *Programmable controllers – Part 9: Single-drop digital communication interface for small sensors and actuators (SDCI)*

IEC 61158-1:2019, *Industrial communication networks – Fieldbus specifications – Part 1: Overview and guidance for the IEC 61158 and IEC 61784 series*

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

IEC 61158-5-10:2019, *Industrial communication networks – Fieldbus specifications – Application layer service definition – Type 10 elements*

IEC 61158-6-3:2019, *Industrial communication networks – Fieldbus specifications – Part 6-3: Application layer protocol specification – Type 3 elements*

IEC 62439-2, *Industrial communication networks – High availability automation networks – Part 2: Media Redundancy Protocol (MRP)*

ISO/IEC 646:1991, *Information technology – ISO 7-bit coded character set for information interchange*

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

ISO/IEC 8822, *Information technology – Open Systems Interconnection – Presentation service definition*

ISO/IEC 8824-1, *Information technology – Abstract Syntax Notation One (ASN.1): Specification of basic notation*

ISO/IEC 9545, *Information technology – Open Systems Interconnection – Application Layer structure*

ISO/IEC 9834-8, *Information technology – Procedures for the operation of object identifier registration authorities – Part 8: Generation of universally unique identifiers (UUIDs) and their use in object identifiers*

ISO/IEC 10646, *Information technology – Universal Coded Character Set (UCS)*

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

ISO/IEC/IEEE 60559:2011, *Information technology – Microprocessor Systems – Floating-Point arithmetic*

ISO 8601, *Data elements and interchange formats – Information interchange – Representation of dates and times*

IEEE Std 802, *IEEE Standard for Local and metropolitan area networks: Overview and Architecture*, available at <http://www.ieee.org> [viewed 2018-09-27]

IEEE Std 802.1AB:2016, *IEEE Standard for Local and metropolitan area networks: Station and Media Access Control Connectivity Discovery*, available at <http://www.ieee.org> [viewed 2018-09-27]

IEEE Std 802.1AC, *IEEE Standard for Local and metropolitan area networks – Media Access Control (MAC) Service definition*, available at <http://www.ieee.org> [viewed 2018-09-27]

IEEE Std 802.1AS, *IEEE standard for Local and metropolitan area networks – Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks*, available at <http://www.ieee.org> [viewed 2018-09-27]

IEEE Std 802.1Q-2018, *IEEE Standard for Local and metropolitan area networks – Bridges and Bridged Networks*, available at <http://www.ieee.org> [viewed 2018-09-27]

IEEE Std 802.3, *IEEE Standard for Ethernet*, available at <http://www.ieee.org> [viewed 2018-09-27]

IEEE Std 802.11, *IEEE Standard for Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications*, available at <http://www.ieee.org> [viewed 2018-09-27]

IEEE Std 802.15.1, *IEEE Standard for Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 15.1: Wireless medium access control (MAC) and physical layer (PHY) specifications for wireless personal area networks (WPANs)*, available at <http://www.ieee.org> [viewed 2018-09-27]

IETF RFC 768, *User Datagram Protocol*; available at <http://www.ietf.org> [viewed 2018-09-27]

IETF RFC 791, *Internet Protocol*; available at <http://www.ietf.org> [viewed 2018-09-27]

IETF RFC 792, *Internet Control Message Protocol*; available at <http://www.ietf.org> [viewed 2018-09-27]

IETF RFC 826, *An Ethernet Address Resolution Protocol or Converting Network Protocol Addresses to 48.bit Ethernet Address for Transmission on Ethernet Hardware*; available at <http://www.ietf.org> [viewed 2018-09-27]

IETF RFC 950, *Internet Standard Subnetting Procedure*; available at <http://www.ietf.org> [viewed 2018-09-27]

IETF RFC 1034, *Domain names – Concepts and Facilities*; available at <http://www.ietf.org> [viewed 2018-09-27]

IETF RFC 1213, *Management Information Base for Network Management of TCP/IP-based internets: MIB-II*; available at <http://www.ietf.org> [viewed 2018-09-27]

IETF RFC 2131, *Dynamic Host Configuration Protocol*; available at <http://www.ietf.org> [viewed 2018-09-27]

IETF RFC 2132, *DHCP Options and BOOTP Vendor Extensions*; available at <http://www.ietf.org> [viewed 2018-09-27]

IETF RFC 2236, *Internet Group Management Protocol, Version 2*; available at <http://www.ietf.org> [viewed 2018-09-27]

IETF RFC 2365, *Administratively Scoped IP Multicast*; available at <http://www.ietf.org> [viewed 2018-09-27]

IETF RFC 2474, *Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers*; available at <http://www.ietf.org> [viewed 2018-09-27]

IETF RFC 2674, *Definitions of Managed Objects for Bridges with Traffic Classes, Multicast Filtering and Virtual LAN Extensions*; available at <http://www.ietf.org> [viewed 2018-09-27]

IETF RFC 2863, *The Interfaces Group MIB*; available at <http://www.ietf.org> [viewed 2018-09-27]

IETF RFC 3418, *Management Information Base (MIB) for the Simple Network Management Protocol (SNMP)*; available at <http://www.ietf.org> [viewed 2018-09-27]

IETF RFC 3621, *Power Ethernet MIB*; available at <http://www.ietf.org> [viewed 2018-09-27]

IETF RFC 4361, *Node-specific Client Identifiers for Dynamic Host Configuration Protocol Version Four (DHCPv4)*; available at <http://www.ietf.org> [viewed 2018-09-27]

IETF RFC 4363, *Definitions of Managed Objects for Bridges with Traffic Classes, Multicast Filtering, and Virtual LAN Extensions*; available at <http://www.ietf.org> [viewed 2018-09-27]

IETF RFC 4604, *Using Internet Group Management Protocol Version 3 (IGMPv3) and Multicast Listener Discovery Protocol Version 2 (MLDv2) for Source-Specific Multicast*, available at <http://www.ietf.org> [viewed 2018-09-27]

IETF RFC 4632, *Classless Inter-domain Routing (CIDR): The Internet Address Assignment and Aggregation Plan*, available at <http://www.ietf.org> [viewed 2018-09-27]

IETF RFC 4836, *Definitions of Managed Objects for IEEE Std 802.3 Medium Attachment Units (MAUs)*, available at <http://www.ietf.org> [viewed 2018-09-27]

IETF RFC 5227, *IPv4 Address Conflict Detection*; available at <http://www.ietf.org> [viewed 2018-09-27]

IETF RFC 5890, *Internationalized Domain Names for Applications (IDNA): Definitions and Document Framework*; available at <http://www.ietf.org> [viewed 2018-09-27]

IETF RFC 5905, *Network Time Protocol Version 4: Protocol and Algorithms Specification*; available at <http://www.ietf.org> [viewed 2018-09-27]

IETF RFC 6151, *Updated Security Considerations for the MD5 Message-Digest and the HMAC-MD5 Algorithms*; available at <http://www.ietf.org> [viewed 2018-09-27]

IETF RFC 6890, *Special-Purpose IP Address Registries*; available at <http://www.ietf.org> [viewed 2018-09-27]

The Open Group, *Publication C706, Technical standard DCE1.1: Remote Procedure Call*, available at <<http://www.opengroup.org/onlinepubs/9629399/toc.htm>> [viewed 2018-09-27]