

© Copyright SEK. 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 61158-6-10:2014. Den svenska standarden innehåller den officiella engelska språkversionen av EN 61158-6-10:2014.

Nationellt förord

Europastandarden EN 61158-6-10:2014

består av:

- **europastandardens ikraftsättningsdokument**, utarbetat inom CENELEC
- **IEC 61158-6-10, Third edition, 2014 - 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 2, 2012, gäller ej fr o m 2017-09-23.

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 61158-6-10:2014)**

Réseaux de communication industriels - Spécifications des
bus de terrain - Partie 6-10: Spécification du protocole de la
couche application - Eléments de type 10
(CEI 61158-6-10:2014)

Industrielle Kommunikationsnetze - Feldbusse - Teil 6-10:
Protokollspezifikation des Application Layer
(Anwendungsschicht) - Typ 10-Elemente
(IEC 61158-6-10:2014)

This European Standard was approved by CENELEC on 2014-09-23. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, 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: Avenue Marnix 17, B-1000 Brussels

Foreword

The text of document 65C/764/FDIS, future edition 3 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 61158-6-10:2014.

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) 2015-06-23
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2017-09-23

This document supersedes EN 61158-6-10:2012.

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

This document has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association.

Endorsement notice

The text of the International Standard IEC 61158-6-10:2014 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 61784-1	NOTE	Harmonized as EN 61784-1.
IEC 61784-2	NOTE	Harmonized as EN 61784-2.
IEC 61784-3-3	NOTE	Harmonized as EN 61784-3-3.
IEC 60793-2-30	NOTE	Harmonized as EN 60793-2-30.
IEC 60793-2-40	NOTE	Harmonized as EN 60793-2-40.

Annex ZA

(normative)

Normative references to international publications with their corresponding European publications

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE 1 When 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 61158-1	2014	Industrial communication networks - Fieldbus specifications - Part 1: Overview and guidance for the IEC 61158 and IEC 61784 series	EN 61158-1	2014
IEC 61158-2	2014	Industrial communication networks - Fieldbus specifications - Part 2: Physical layer specification and service definition	EN 61158-2	2014
IEC 61158-5-10	2014	Industrial communication networks - Fieldbus specifications - Part 5-10: Application layer service definition - Type 10 elements	EN 61158-5-10	2014
IEC 61158-6-3	2014	Industrial communication networks - Fieldbus specifications - Part 6-3: Application layer protocol specification - Type 3 elements	EN 61158-6-3	2014
IEC 61588	-	Precision clock synchronization protocol for networked measurement and control systems	-	-
IEC 62439-2	-	Industrial communication networks - High availability automation networks - Part 2: Media Redundancy Protocol (MRP)	EN 62439-2	-
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	-	-

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
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 10731	-	Information technology - Open Systems Interconnection - Basic Reference Model - Conventions for the definition of OSI services	-	-
ISO 8601	-	Data elements and interchange formats - Information interchange - Representation of dates and times	-	-
IEEE 754	-	IEEE Standard for Floating-Point Arithmetic	-	-
IEEE 802	-	IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture	-	-
IEEE 802.1AB	2005	IEEE Standard for Local and metropolitan area networks - Station and Media Access Control Connectivity Discovery	-	-
IEEE 802.1AS	-	IEEE Standard for Local and Metropolitan Area Networks - Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks	-	-
IEEE 802.1D	-	IEEE Standard for local and metropolitan area networks - Media Access Control (MAC) Bridges	-	-
IEEE 802.1Q	-	IEEE Standard for Local and metropolitan area networks - Media Access Control (MAC) Bridges and Virtual Bridged Local Area Networks	-	-
IEEE 802.3	-	IEEE Standard for Information technology - Telecommunications and information exchange between systems - Local and metropolitan area networks - Specific requirements - Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications	-	-
IEEE 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	-	-

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEEE 802.15.1	2005	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)	-	-
IETF RFC 768	-	User Datagram Protocol	-	-
IETF RFC 791	-	Internet Protocol	-	-
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 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 4836	-	Definitions of Managed Objects for IEEE 802.3 Medium Attachment Units (MAUs)	-	-
IETF RFC 5735	-	Special Use IPv4 Addresses	-	-

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IETF RFC 5890	-	Internationalized Domain Names for Applications (IDNA): Definitions and Document Framework	-	-
The Open Group - Publication C706	-	Technical Standard DCE1.1: Remote Procedure Call	-	-

CONTENTS

FOREWORD.....	28
INTRODUCTION.....	31
1 Scope.....	33
1.1 General.....	33
1.2 Specifications.....	33
1.3 Conformance.....	34
2 Normative references	34
3 Terms, definitions, abbreviations, symbols and conventions	36
3.1 Referenced terms and definitions	36
3.2 Additional terms and definitions for decentralized periphery	37
3.3 Abbreviations and symbols	45
3.4 Conventions	48
4 Application layer protocol specification for common protocols.....	56
4.1 FAL syntax description	56
4.2 Transfer syntax	59
4.3 Discovery and basic configuration	71
4.4 Precision working time control	110
4.5 Time synchronization	185
4.6 Media redundancy	185
4.7 Real time cyclic	185
4.8 Real time acyclic	213
4.9 Fragmentation	231
4.10 Remote procedure call	247
4.11 Link layer discovery.....	265
4.12 MAC Bridges	276
4.13 Virtual bridges	305
4.14 IP suite.....	314
4.15 Domain name system	317
4.16 Dynamic host configuration	318
4.17 Simple network management.....	319
4.18 Common DLL Mapping Protocol Machines.....	320
5 Application layer protocol specification for decentralized periphery.....	325
5.1 FAL syntax description	325
5.2 Transfer syntax	343
5.3 FAL protocol state machines	522
5.4 AP-Context state machine	524
5.5 FAL Service Protocol Machines	524
5.6 Application Relationship Protocol Machines	544
5.7 DLL Mapping Protocol Machines	663
Annex A (normative) Unified establishing of an AR for all RT classes	664
Annex B (normative) Compatible establishing of an AR.....	670
Annex C (informative) Establishing of a device access AR.....	673
Annex D (informative) Establishing of an AR (accelerated procedure).....	674
Annex E (informative) Establishing of an AR (fast startup procedure).....	677
Annex F (informative) Example of the upload, storage and retrieval procedure	679

Annex G (informative) OSI reference model layers.....	682
Annex H (informative) Overview of the IO controller and the IO device state machines	683
Annex I (informative) Priority regeneration	685
Annex J (informative) Overview of the PTCP synchronization master hierarchy	687
Annex K (informative) Optimization of bandwidth usage.....	689
Annex L (informative) Time constraints for bandwidth allocation	691
Annex M (informative) Time constraints for the forwarding of a frame	693
Annex N (informative) Principle of dynamic frame packing	694
Annex O (informative) Principle of Fragmentation	697
Annex P (informative) MRPD – Principle of seamless media redundancy.....	700
Annex Q (normative) Principle of a RED_RELAY without forwarding information in PDIRFrameData	702
Annex R (informative) Optimization for fast startup without autonegotiation	704
Annex S (informative) TX-error handling	706
Annex T (informative) Example of a PrmBegin, PrmEnd and ApplRdy sequence	707
Annex U (informative) List of supported MIBs	708
Annex V (informative) Structure and content of BLOB	709
Annex W (normative) LLDP EXT MIB	710
Bibliography.....	727
Figure 1 – Common structure of specific fields.....	49
Figure 2 – Common structure of specific fields for octet 1 (high)	50
Figure 3 – Common structure of specific fields for octet 2 (low)	50
Figure 4 – Common structure of specific fields for octet 1 (high)	51
Figure 5 – Common structure of specific fields for octet 2	51
Figure 6 – Common structure of specific fields for octet 3	52
Figure 7 – Common structure of specific fields for octet 4 (low)	52
Figure 8 – Coding of the data type BinaryDate.....	61
Figure 9 – Encoding of TimeOfDay with date indication value	61
Figure 10 – Encoding of TimeOfDay without date indication value	62
Figure 11 – Encoding of TimeDifference with date indication value	62
Figure 12 – Encoding of TimeDifference without date indication value	62
Figure 13 – FastForwardingMulticastMACAdd.....	66
Figure 14 – State transition diagram of DCPUCS	95
Figure 15 – State transition diagram of DCPUCR.....	99
Figure 16 – State transition diagram of DCPMCS.....	102
Figure 17 – State transition diagram of DCPMCR	105
Figure 18 – State transition diagram of DCPHMCS	108
Figure 19 – State transition diagram of DCPHMCR	109
Figure 20 – PTCP_SequenceID value range	115
Figure 21 – Timescale correspondence between PTCP_Time and CycleCounter	118
Figure 22 – Message timestamp point.....	123

Figure 23 – Timer model	123
Figure 24 – Four message timestamps	124
Figure 25 – Line delay protocol with follow up.....	125
Figure 26 – Line delay protocol without follow up	125
Figure 27 – Line delay measurement	127
Figure 28 – Model parameter for GSDML usage	129
Figure 29 – Bridge delay measurement.....	130
Figure 30 – Delay accumulation	131
Figure 31 – Worst case accumulated time deviation of synchronization	132
Figure 32 – Scheme for measurement of deviation	132
Figure 33 – Measurement of deviation	132
Figure 34 – PTCP master sending Sync-Frame without Follow Up-Frame	133
Figure 35 – PTCP master sending Sync-Frame with FollowUp-Frame.....	134
Figure 36 – !FU Sync Slave Forwarding Sync-Frame	135
Figure 37 – FU Sync Slave Forwarding Sync- and FollowUp-Frame.....	136
Figure 38 – FU Sync Slave Forwarding Sync- and Generating FollowUp-Frame.....	137
Figure 39 – Principle of the monitoring of the line delay measurement.....	138
Figure 40 – State transition diagram of DELAY_REQ	140
Figure 41 – State transition diagram of DELAY_RSP	147
Figure 42 – Overview of PTCP.....	151
Figure 43 – State transition diagram of SYN_BMA	153
Figure 44 – State transition diagram of SYN_MPSM	163
Figure 45 – State transition diagram of SYN_SPSM.....	169
Figure 46 – State transition diagram of SYNC_RELAY	175
Figure 47 – State transition diagram of SCHEDULER	182
Figure 48 – CycleCounter value range	187
Figure 49 – Structure of the CycleCounter	188
Figure 50 – Optimized CycleCounter setting	189
Figure 51 – SFCRC16 generation rule	192
Figure 52 – SFCycleCounter value range.....	194
Figure 53 – Basic structure of a PPM with frame structure	196
Figure 54 – Basic structure of a PPM with subframe structure.....	197
Figure 55 – State transition diagram of PPM.....	199
Figure 56 – Basic structure of a CPM.....	203
Figure 57 – State transition diagram of CPM.....	205
Figure 58 – Addressing scheme of RTA	215
Figure 59 – Structure of the APM	218
Figure 60 – Structure of the APMS.....	219
Figure 61 – State transition diagram of APMS.....	221
Figure 62 – Structure of the APMR	226
Figure 63 – State transition diagram of APMR	228
Figure 64 – State transition diagram of FRAG_D	238
Figure 65 – State transition diagram of FRAG_S.....	241

Figure 66 – State transition diagram of DEFrag	244
Figure 67 – State transition diagram of RTC3PSM	280
Figure 68 – State transition diagram for generating events	284
Figure 69 – State transition diagram of RED_RELAY	285
Figure 70 – Scheme of the DFP_RELAY	289
Figure 71 – Scheme of the DFP_INBOUND and DFP_STORAGE	290
Figure 72 – Scheme of the DFP_OUTBOUND	290
Figure 73 – State transition diagram of DFP_RELAY	291
Figure 74 – State transition diagram of DFP_RELAY_INBOUND	294
Figure 75 – State transition diagram of DFP_RELAY_IN_STORAGE	298
Figure 76 – State transition diagram of DFP_RELAY_OUTBOUND	302
Figure 77 – State transition diagram of MUX	306
Figure 78 – State transition diagram of DEMUX	311
Figure 79 – Structuring of the protocol machines within the DMPM (bridge)	321
Figure 80 – State transition diagram of LMPM	323
Figure 81 – AlarmSpecifier.SequenceNumber value range	357
Figure 82 – FrameSendOffset vs. duration of a cycle	393
Figure 83 – Severity classification of diagnosis, maintenance and qualified	436
Figure 84 – Calculation principle for a cycle	455
Figure 85 – Calculation principle for the minimum YellowTime	456
Figure 86 – Definition of the reserved interval	462
Figure 87 – Toplevel view to the PLL window	466
Figure 88 – Definition of PLL window	466
Figure 89 – Toplevel view to the time PLL window	469
Figure 90 – Definition of time PLL window	470
Figure 91 – Detection of dropped frames — appear	478
Figure 92 – Detection of dropped frames — disappear	478
Figure 93 – Detection of DFP late error — appear and disappear	485
Figure 94 – MediaRedundancyWatchDog expired — appear and disappear	486
Figure 95 – Relationship among Protocol Machines	523
Figure 96 – State transition diagram of ALPMI	546
Figure 97 – State transition diagram of ALPMR	550
Figure 98 – Scheme of the IO device CM	553
Figure 99 – State transition diagram of the IO device CM	555
Figure 100 – State transition diagram of CMDEV	559
Figure 101 – Scheme of the IO device CM – device access	563
Figure 102 – State transition diagram of CMDEV_DA	565
Figure 103 – State transition diagram of CMSU	569
Figure 104 – State transition diagram of CMIO	574
Figure 105 – State transition diagram of CMWRR	578
Figure 106 – State transition diagram of CMRDR	582
Figure 107 – State transition diagram of CMSM	584
Figure 108 – State transition diagram of CMPBE	588

Figure 109 – State transition diagram of CMDMC	593
Figure 110 – State transition diagram of CMINA	597
Figure 111 – State transition diagram of CMRPC	606
Figure 112 – Scheme of the IO controller CM	612
Figure 113 – State transition diagram of the IO controller CM	613
Figure 114 – State transition diagram of CMCTL	617
Figure 115 – State transition diagram of CTLSM	623
Figure 116 – State transition diagram of CTLIO	626
Figure 117 – State transition diagram of CTRLDI	629
Figure 118 – State transition diagram of CTRLDR	632
Figure 119 – State transition diagram of CTRLRPC	636
Figure 120 – State transition diagram of CTLSU	641
Figure 121 – State transition diagram of CTLWRI	646
Figure 122 – State transition diagram of CTLWRR	650
Figure 123 – State transition diagram of CTLPBE	653
Figure 124 – State transition diagram of CTLDINA	658
Figure 125 – Automatic NameOfStation assignment	663
Figure A.1 – Establishing of an AR using RT_CLASS_1, RT_CLASS_2 or RT_CLASS_3 (Initial connection monitoring w/o RT)	665
Figure A.2 – Establishing of an AR using RT_CLASS_1, RT_CLASS_2 or RT_CLASS_3 (Connection monitoring with RT)	666
Figure A.3 – Principle of the data evaluation during startup (RED channel establishment delayed)	667
Figure A.4 – Principle of the data evaluation during startup (RED channel establishment early)	668
Figure A.5 – Principle of the data evaluation during startup (Special case: Isochronous mode application)	669
Figure B.1 – Establishing of an AR using RT_CLASS_3 AR with startup mode “Legacy”	671
Figure B.2 – Establishing of an AR using RT_CLASS_1, 2 or UDP AR with startup mode “Legacy”	672
Figure C.1 – Establishing of a device access AR	673
Figure D.1 – Accelerated establishing of an IOAR without error	675
Figure D.2 – Accelerated establishing of an IOAR with “late” error	676
Figure E.1 – Establishing of an IOAR using fast startup	678
Figure F.1 – Example of upload with storage	680
Figure F.2 – Example of retrieval with storage	681
Figure G.1 – Assignment of the OSI reference model layers	682
Figure H.1 – Overview of the IO controller state machines	683
Figure H.2 – Overview of the IO device state machines	683
Figure H.3 – Overview of the common state machines	684
Figure J.1 – Level model for synchronization master hierarchy	687
Figure J.2 – Two level variant of the synchronization master hierarchy	688
Figure K.1 – Devices build up in a linear structure	689
Figure K.2 – Propagation of frames in linear transmit direction	689
Figure K.3 – Propagation of a frames in receive direction	690

Figure L.1 – Overview of time constraints for bandwidth allocation.....	691
Figure L.2 – Calculation of the length of a RED period.....	691
Figure L.3 – Calculation of the length of a GREEN period.....	692
Figure M.1 – Minimization of bridge delay.....	693
Figure N.1 – Dynamic frame packing.....	694
Figure N.2 – Dynamic frame packing – truncation of outputs.....	695
Figure N.3 – Dynamic frame packing – concatenation of inputs.....	695
Figure N.4 – End node mode.....	696
Figure N.5 – DFPFeed definition.....	696
Figure O.1 – Principle of fragmentation.....	697
Figure O.2 – Protocol elements of fragments.....	697
Figure O.3 – Bandwidth allocation using fragmentation.....	698
Figure O.4 – Guardian for a fragmentation domain.....	698
Figure P.1 – Principle of seamless media redundancy – I/OCR.....	700
Figure P.2 – Principle of seamless media redundancy – MCR.....	701
Figure P.3 – Principle of seamless media redundancy – Line.....	701
Figure Q.1 – Generating the FrameSendOffset for a RED_RELAY without forwarding information in PDIRFrameData.....	702
Figure R.1 – Scheme of a 2-port switch.....	704
Figure R.2 – Scheme of 2-ports.....	704
Figure T.1 – PrmBegin, PrmEnd and ApplRdy procedure.....	707
Table 1 – State machine description elements.....	53
Table 2 – Description of state machine elements.....	53
Table 3 – Conventions used in state machines.....	53
Table 4 – Conventions for services used in state machines.....	54
Table 5 – IEEE 802.3 DLPDU syntax.....	56
Table 6 – IEEE 802.11 DLPDU syntax.....	57
Table 7 – IEEE 802.15.1 DLPDU syntax.....	58
Table 8 – SourceAddress.....	63
Table 9 – DCP_MulticastMACAdd for Identify.....	64
Table 10 – DCP_MulticastMACAdd for Hello.....	64
Table 11 – DCP_MulticastMACAdd.....	64
Table 12 – PTCP_MulticastMACAdd range 1.....	64
Table 13 – PTCP_MulticastMACAdd range 2.....	64
Table 14 – PTCP_MulticastMACAdd range 3.....	65
Table 15 – PTCP_MulticastMACAdd range 4.....	65
Table 16 – PTCP_MulticastMACAdd range 5.....	65
Table 17 – PTCP_MulticastMACAdd range 6.....	65
Table 18 – PTCP_MulticastMACAdd range 7.....	65
Table 19 – PTCP_MulticastMACAdd range 8.....	66
Table 20 – RT_CLASS_3 destination multicast address.....	67
Table 21 – RT_CLASS_3 invalid frame multicast address.....	67

Table 22 – LT (Length/Type).....	67
Table 23 – TagControlInformation.Priority.....	68
Table 24 – FrameID range 1	68
Table 25 – FrameID range 2	68
Table 26 – FrameID range 3	69
Table 27 – FrameID range 4	69
Table 28 – FrameID range 5	69
Table 29 – FrameID range 6	69
Table 30 – FrameID range 7	69
Table 31 – FrameID range 8	70
Table 32 – FrameID range 9	70
Table 33 – FrameID range 10	70
Table 34 – FrameID range 11	71
Table 35 – FrameID range 12	71
Table 36 – FrameID range 13	71
Table 37 – FragmentationFrameID.FragSequence	71
Table 38 – FragmentationFrameID.Constant.....	71
Table 39 – DCP APDU syntax.....	72
Table 40 – DCP substitutions.....	72
Table 41 – ServiceID	75
Table 42 – ServiceType.Selection.....	75
Table 43 – ServiceType.Reserved	76
Table 44 – ServiceType.Selection.....	76
Table 45 – ServiceType.Reserved_1.....	76
Table 46 – ServiceType.Response.....	76
Table 47 – ServiceType.Reserved_2.....	77
Table 48 – ResponseDelayFactor	77
Table 49 – List of options.....	78
Table 50 – List of suboptions for option IPOption	79
Table 51 – List of suboptions for option DevicePropertiesOption.....	79
Table 52 – List of suboptions for option DHCPOption.....	79
Table 53 – List of suboptions for option ControlOption	79
Table 54 – List of suboptions for option DeviceInitiativeOption.....	80
Table 55 – List of suboptions for option AllSelectorOption	80
Table 56 – List of suboptions for option ManufacturerSpecificOption.....	80
Table 57 – SuboptionDHCP	81
Table 58 – Coding of DCPBlockLength in conjunction with SuboptionStart.....	82
Table 59 – Coding of DCPBlockLength in conjunction with SuboptionStop	82
Table 60 – Coding of DCPBlockLength in conjunction with SuboptionSignal	83
Table 61 – Coding of DCPBlockLength in conjunction with SuboptionFactoryReset	83
Table 62 – Coding of DCPBlockLength in conjunction with SuboptionResetToFactory	84
Table 63 – Coding of DCPBlockLength in conjunction with SuboptionDeviceInitiative	84

Table 64 – BlockQualifier with options IOption, DevicePropertiesOption, DHCPOption and ManufacturerSpecificOption	85
Table 65 – BlockQualifier with option ControlOption and suboption SuboptionResetToFactory	85
Table 66 – BlockQualifier with all other options and suboptions	86
Table 67 – BlockError	86
Table 68 – BlockInfo for SuboptionIPParameter	87
Table 69 – Bit 1 and Bit 0 of BlockInfo for SuboptionIPParameter	87
Table 70 – Bit 7 of BlockInfo for SuboptionIPParameter	87
Table 71 – BlockInfo for all other suboptions	87
Table 72 – DeviceInitiativeValue	87
Table 73 – SignalValue	88
Table 74 – DeviceRoleDetails	90
Table 75 – IPAddress	90
Table 76 – Subnetmask	90
Table 77 – StandardGateway	92
Table 78 – Remote primitives issued or received by DCPUCS	94
Table 79 – Local primitives issued or received by DCPUCS	95
Table 80 – DCPUCS state table	96
Table 81 – Functions, Macros, Timers and Variables used by the DCPUCS	98
Table 82 – Remote primitives issued or received by DCPUCR	98
Table 83 – Local primitives issued or received by DCPUCR	99
Table 84 – DCPUCR state table	100
Table 85 – Functions, Macros, Timers and Variables used by the DCPUCR	101
Table 86 – Remote primitives issued or received by DCPMCS	102
Table 87 – Local primitives issued or received by DCPMCS	102
Table 88 – DCPMCS state table	103
Table 89 – Functions used by the DCPMCS	104
Table 90 – Remote primitives issued or received by DCPMCR	105
Table 91 – Local primitives issued or received by DCPMCR	105
Table 92 – DCPMCR state table	106
Table 93 – Functions, Macros, Timers and Variables used by the DCPMCR	106
Table 94 – Remote primitives issued or received by DCPHMCS	107
Table 95 – Local primitives issued or received by DCPHMCS	107
Table 96 – DCPHMCS state table	108
Table 97 – Functions, Macros, Timers and Variables used by the DCPHMCS	109
Table 98 – Remote primitives issued or received by DCPHMCR	109
Table 99 – Local primitives issued or received by DCPHMCR	109
Table 100 – DCPHMCR state table	110
Table 101 – Functions, Macros, Timers and Variables used by the DCPHMCR	110
Table 102 – PTCP APDU syntax	111
Table 103 – PTCP substitutions	111
Table 104 – PTCP_TLVHeader.Type	112
Table 105 – PTCP_Delay10ns	113

Table 106 – PTCP_Delay1ns_Byte.Value	113
Table 107 – PTCP_Delay1ns	113
Table 108 – PTCP_Delay1ns_FUP	114
Table 109 – PTCP_SequenceID.....	114
Table 110 – PTCP_SubType for OUI (=00-0E-CF)	115
Table 111 – PTCP_Seconds	116
Table 112 – PTCP_NanoSeconds	116
Table 113 – PTCP_Flags.LeapSecond.....	116
Table 114 – Timescale correspondence between MJD, UTC and PTCP_EPOCHNumber	117
Table 115 – Timescale correspondence between PTCP_EPOCHNumber, PTCP_Second, PTCP_Nanosecond, CycleCounter and SendClockFactor.....	117
Table 116 – PTCP_MasterPriority1.Priority for SyncID == 0 and SyncProperties.Role == 2.....	119
Table 117 – PTCP_MasterPriority1.Priority for SyncID == 0 and SyncProperties.Role == 1.....	119
Table 118 – PTCP_MasterPriority1.Level.....	119
Table 119 – PTCP_MasterPriority2	120
Table 120 – PTCP_ClockClass for SyncID == 0 (working clock synchronization)	120
Table 121 – PTCP_ClockAccuracy.....	121
Table 122 – PTCP_ClockVariance	121
Table 123 – PTCP_T2PortRxDelay	121
Table 124 – PTCP_T3PortTxDelay	122
Table 125 – PTCP_T2TimeStamp	122
Table 126 – Remote primitives issued or received by DELAY_REQ	139
Table 127 – Local primitives issued or received by DELAY_REQ	139
Table 128 – DELAY_REQ state table	141
Table 129 – Functions, macros, timers and variables used by the DELAY_REQ	144
Table 130 – Remote primitives issued or received by DELAY_RSP.....	146
Table 131 – Local primitives issued or received by DELAY_RSP	147
Table 132 – DELAY_RSP state table	148
Table 133 – Functions, Macros, Timers and Variables used by the DELAY_RSP	150
Table 134 – Remote primitives issued or received by SYN_BMA	151
Table 135 – Local primitives issued or received by SYN_BMA	152
Table 136 – SYN_BMA state table	154
Table 137 – Functions, Macros, Timers and Variables used by the SYN_BMA.....	159
Table 138 – Remote primitives issued or received by SYN_MPSM.....	161
Table 139 – Local primitives issued or received by SYN_MPSM	162
Table 140 – SYN_MPSM state table	164
Table 141 – Functions, Macros, Timers and Variables used by the SYN_MPSM	167
Table 142 – Remote primitives issued or received by SYN_SPSM	168
Table 143 – Local primitives issued or received by SYN_SPSM.....	168
Table 144 – SYN_SPSM state table.....	170
Table 145 – Functions, Macros, Timers and Variables used by the SYN_SPSM.....	173
Table 146 – Truth table for one SyncID for receiving sync and follow up frames	174

Table 147 – Remote primitives issued or received by SYNC_RELAY	175
Table 148 – Local primitives issued or received by SYNC_RELAY	175
Table 149 – SYNC_RELAY state table	176
Table 150 – Functions, Macros, Timers and Variables used by the SYNC_RELAY	178
Table 151 – Truth table for one SyncID for receiving	180
Table 152 – Truth table for one SyncID for transmitting	180
Table 153 – Remote primitives issued or received by SCHEDULER	181
Table 154 – Local primitives issued or received by SCHEDULER	181
Table 155 – SCHEDULER state table	182
Table 156 – Functions, Macros, Timers and Variables used by the SCHEDULER	184
Table 157 – Truth table for RxPeriodChecker of one port	184
Table 158 – Truth table for TxPeriodChecker of one port	184
Table 159 – RTC APDU syntax	185
Table 160 – RTC substitutions	185
Table 161 – CycleCounter Difference	187
Table 162 – DataStatus.State	189
Table 163 – DataStatus.Redundancy	190
Table 164 – DataStatus.DataValid	190
Table 165 – DataStatus.ProviderState	190
Table 166 – DataStatus.StationProblemIndicator	190
Table 167 – DataStatus.Ignore of a frame	191
Table 168 – DataStatus.Ignore of a sub frame	191
Table 169 – TransferStatus for RT_CLASS_3	191
Table 170 – SFPosition.Position	192
Table 171 – SFPosition.Reserved	193
Table 172 – SFDataLength	193
Table 173 – SFCycleCounter Difference	194
Table 174 – IOxS.Extension	195
Table 175 – IOxS.Instance	195
Table 176 – IOxS.DataState	195
Table 177 – Remote primitives issued or received by PPM	197
Table 178 – Local primitives issued or received by PPM	198
Table 179 – PPM state table	200
Table 180 – Functions, Macros, Timers and Variables used by the PPM	201
Table 181 – Truth table used by the PPM for TxOption	202
Table 182 – Remote primitives issued or received by CPM	203
Table 183 – Local primitives issued or received by CPM	204
Table 184 – CPM state table	206
Table 185 – Functions, Macros, Timers and Variables used by the CPM	209
Table 186 – Truth table used by the CPM for RxOption	210
Table 187 – Truth table for one frame using RT_CLASS_x	210
Table 188 – Truth table for one frame using RT_CLASS_UDP	211
Table 189 – Truth table for the C_SDU	211

Table 190 – Truth table for arranging Dht and data	212
Table 191 – Truth table for the subframe – frame check.....	212
Table 192 – Truth table for the subframe – sub frame check	212
Table 193 – Truth table for the subframe – sub frame data check	213
Table 194 – Truth table for the subframe – Dht and data	213
Table 195 – RTA APDU syntax	213
Table 196 – RTA substitutions	214
Table 197 – PDUType.Type	215
Table 198 – PDUType.Version	216
Table 199 – AddFlags.WindowSize	216
Table 200 – AddFlags.TACK	216
Table 201 – SendSeqNum	217
Table 202 – AckSeqNum	217
Table 203 – VarPartLen	217
Table 204 – Remote primitives issued or received by APMS	219
Table 205 – Local primitives issued or received by APMS.....	220
Table 206 – APMS state table.....	222
Table 207 – Functions, Macros, Timers and Variables used by the APMS.....	224
Table 208 – Remote primitives issued or received by APMR	226
Table 209 – Local primitives issued or received by APMR	227
Table 210 – APMR state table	229
Table 211 – Functions, Macros, Timers and Variables used by the APMR	231
Table 212 – TagControllInformation.Priority vs. streams	231
Table 213 – Lower limit of fragments	234
Table 214 – FRAG APDU syntax.....	235
Table 215 – FRAG substitutions.....	235
Table 216 – FragDataLength	236
Table 217 – FragStatus.FragmentNumber.....	236
Table 218 – FragStatus.Reserved.....	236
Table 219 – FragStatus.MoreFollows	237
Table 220 – Remote primitives issued or received by FRAG_D	237
Table 221 – Local primitives issued or received by FRAG_D	237
Table 222 – FRAG_D state table (dynamic)	238
Table 223 – Functions, Macros, Timers and Variables used by the FRAG_D (dynamic)	240
Table 224 – Remote primitives issued or received by FRAG_S	241
Table 225 – Local primitives issued or received by FRAG_S.....	241
Table 226 – FRAG_S state table (static)	242
Table 227 – Functions, Macros, Timers and Variables used by the FRAG_S (static)	243
Table 228 – Remote primitives issued or received by DEFRAG	244
Table 229 – Local primitives issued or received by DEFRAG	244
Table 230 – DEFRAG state table	245
Table 231 – Functions, Macros, Timers and Variables used by the DEFRAG	246
Table 232 – Truth table for the DefragGuard – first fragment	246

Table 233 – Truth table for the DefragGuard – next fragment.....	246
Table 234 – Truth table for the DefragGuard – last fragment.....	247
Table 235 – RPC APDU syntax.....	247
Table 236 – RPC substitutions.....	247
Table 237 – RPCVersion.....	248
Table 238 – RPCPacketType	249
Table 239 – RPCFlags.....	249
Table 240 – RPCFlags2.....	249
Table 241 – RPCDRep.Character- and IntegerEncoding	250
Table 242 – RPCDRep Octet 2 – Floating Point Representation	250
Table 243 – RPCObjectUUID.Data4.....	251
Table 244 – RPCObjectUUID for PNIO	251
Table 245 – RPCObjectUUID for PNIO with multiple interfaces	252
Table 246 – RPCInterfaceUUID for PNIO	252
Table 247 – RPCInterfaceUUID for the RPC end point mapper	253
Table 248 – RPCInterfaceVersion.Major	253
Table 249 – RPCInterfaceVersion.Minor	254
Table 250 – RPCOperationNmb (IO device, controller and supervisor)	254
Table 251 – RPCOperationNmb for endpoint mapper.....	254
Table 252 – RPCDataRepresentationUUID – defined values.....	257
Table 253 – RPCInquiryType	258
Table 254 – RPCEPMapStatus	260
Table 255 – Values of NCAFaultStatus	262
Table 256 – Values of NCAResjectStatus	263
Table 257 – Remote primitives issued or received by RPC	264
Table 258 – Local primitives issued or received by RPC	264
Table 259 – LLDP APDU syntax	265
Table 260 – LLDP substitutions	266
Table 261 – LLDP_ChassisID in conjunction with MultipleInterfaceMode.NameOfDevice and NameOfStation	267
Table 262 – LLDP_PortID in conjunction with MultipleInterfaceMode.NameOfDevice	267
Table 263 – LLDP_PNIO_SubType	268
Table 264 – PTCP_PortRxDelayLocal.....	268
Table 265 – PTCP_PortRxDelayRemote	268
Table 266 – PTCP_PortTxDelayLocal	268
Table 267 – PTCP_PortTxDelayRemote	269
Table 268 – CableDelayLocal	269
Table 269 – RTClass2_PortStatus.State with ARProperties.StartupMode == Legacy	269
Table 270 – RTClass2_PortStatus.State with ARProperties.StartupMode == Advanced	269
Table 271 – RTClass3_PortStatus.State	270
Table 272 – RTClass3_PortStatus.Fragmentation.....	270
Table 273 – RTClass3_PortStatus.PreambleLength.....	270
Table 274 – Truth table for shortening of the preamble	271

Table 275 – RTClass3_PortStatus.Optimized.....	271
Table 276 – MRRT_PortStatus.State	272
Table 277 – IRDataUUID	272
Table 278 – LLDP_RedOrangePeriodBegin.Offset	272
Table 279 – LLDP_RedOrangePeriodBegin.Valid.....	273
Table 280 – LLDP_OrangePeriodBegin.Offset	273
Table 281 – LLDP_OrangePeriodBegin.Valid with ARProperties.StartupMode == Legacy	273
Table 282 – LLDP_OrangePeriodBegin.Valid with ARProperties.StartupMode == Advanced	273
Table 283 – LLDP_GreenPeriodBegin.Offset	274
Table 284 – LLDP_GreenPeriodBegin.Valid	274
Table 285 – LLDP_LengthOfPeriod.Length	274
Table 286 – LLDP_LengthOfPeriod.Valid	274
Table 287 – Unicast FDB entries	277
Table 288 – Multicast FDB entries	277
Table 289 – Broadcast FDB entry	278
Table 290 – Remote primitives issued or received by MAC_RELAY	279
Table 291 – Local primitives issued or received by MAC_RELAY	279
Table 292 – Functions, Macros, Timers and Variables used by the MAC_RELAY	279
Table 293 – Remote primitives issued or received by RTC3PSM	280
Table 294 – Local primitives issued or received by RTC3PSM	280
Table 295 – RTC3PSM state table	281
Table 296 – Functions, Macros, Timers and Variables used by the RTC3PSM	281
Table 297 – Truth table for the RTC3PSM	283
Table 298 – RXBeginEndAssignment and TXBeginEndAssignment.....	283
Table 299 – Event function table.....	284
Table 300 – Remote primitives issued or received by RED_RELAY	285
Table 301 – Local primitives issued or received by RED_RELAY	285
Table 302 – RED_RELAY state table	286
Table 303 – Functions, Macros, Timers and Variables used by the RED_RELAY	287
Table 304 – Truth table for the RedGuard with full check	288
Table 305 – Truth table for the RedGuard with reduced check	288
Table 306 – Truth table for the RedGuard with minimal check.....	288
Table 307 – Remote primitives issued or received by DFP_RELAY	291
Table 308 – Local primitives issued or received by DFP_RELAY	291
Table 309 – DFP_RELAY state table	292
Table 310 – Functions, Macros, Timers and Variables used by the DFP_RELAY	293
Table 311 – Truth table for the DFPGuard	293
Table 312 – Remote primitives issued or received by DFP_RELAY_INBOUND	293
Table 313 – Local primitives issued or received by DFP_RELAY_INBOUND	294
Table 314 – DFP_RELAY_INBOUND state table.....	295
Table 315 – Functions, Macros, Timers and Variables used by the DFP_RELAY_INBOUND	295

Table 316 – Truth table for the InboundGuard – frame check	296
Table 317 – Truth table for the InboundGuard – sub frame check	296
Table 318 – Truth table for the InboundGuard – sub frame data check.....	296
Table 319 – Truth table for the InboundGuard – full check	296
Table 320 – Remote primitives issued or received by DFP_RELAY_IN_STORAGE	297
Table 321 – Local primitives issued or received by DFP_RELAY_IN_STORAGE.....	297
Table 322 – DFP_RELAY_IN_STORAGE state table	298
Table 323 – Functions, Macros, Timers and Variables used by the DFP_RELAY_IN_STORAGE	300
Table 324 – Remote primitives issued or received by DFP_RELAY_OUTBOUND	301
Table 325 – Local primitives issued or received by DFP_RELAY_OUTBOUND	301
Table 326 – DFP_RELAY_OUTBOUND state table	303
Table 327 – Functions, Macros, Timers and Variables used by the DFP_RELAY_OUTBOUND.....	304
Table 328 – Truth table for the OutboundGuard – frame check	304
Table 329 – Truth table for the OutboundGuard – sub frame check.....	304
Table 330 – Remote primitives issued or received by MUX	305
Table 331 – Local primitives issued or received by MUX.....	306
Table 332 – MUX state table.....	307
Table 333 – Functions, Macros, Timers and Variables used by MUX.....	308
Table 334 – Truth table for FrameSizeFits	309
Table 335 – Truth table for StateChecker.....	309
Table 336 – Remote primitives issued or received by DEMUX	310
Table 337 – Local primitives issued or received by DEMUX	310
Table 338 – DEMUX state table	312
Table 339 – Functions, Macros, Timers and Variables used by the DEMUX	313
Table 340 – IP/UDP APDU syntax	314
Table 341 – IP/UDP substitutions	314
Table 342 – UDP_SrcPort.....	315
Table 343 – UDP_DstPort.....	315
Table 344 – IP_DstIPAddress	316
Table 345 – IP Multicast DstIPAddress according to RFC 2365	316
Table 346 – Remote primitives issued or received by DNS	317
Table 347 – Local primitives issued or received by DNS	318
Table 348 – Functions, Macros, Timers and Variables used by the DNS	318
Table 349 – Remote primitives issued or received by DHCP	318
Table 350 – Local primitives issued or received by machines.....	319
Table 351 – Functions, Macros, Timers and Variables used by the DHCP.....	319
Table 352 – Enterprise number	319
Table 353 – Remote primitives issued or received by LMPM.....	321
Table 354 – Local primitives issued or received by LMPM	323
Table 355 – LMPM state table	324
Table 356 – Functions, Macros, Timers and Variables used by the LMPM	325
Table 357 – IO APDU substitutions	326

Table 358 – BlockType	343
Table 359 – BlockVersionHigh	354
Table 360 – BlockVersionLow	355
Table 361 – AlarmType	355
Table 362 – AlarmSpecifier.SequenceNumber	356
Table 363 – AlarmSpecifier.SequenceNumber Difference	357
Table 364 – AlarmSpecifier.ChannelDiagnosis	358
Table 365 – AlarmSpecifier.ManufacturerSpecificDiagnosis	358
Table 366 – AlarmSpecifier.SubmoduleDiagnosisState	358
Table 367 – AlarmSpecifier.ARDiagnosticsState	359
Table 368 – API	359
Table 369 – SlotNumber	359
Table 370 – SubslotNumber	360
Table 371 – Expression 1 (subslot specific)	361
Table 372 – Expression 2 (slot specific)	361
Table 373 – Expression 3 (AR specific)	361
Table 374 – Expression 4 (API specific)	361
Table 375 – Expression 5 (device specific)	362
Table 376 – Grouping of DiagnosisData	362
Table 377 – Index (user specific)	362
Table 378 – Index (subslot specific)	363
Table 379 – Index (slot specific)	364
Table 380 – Index (AR specific)	365
Table 381 – Index (API specific)	366
Table 382 – Index (device specific)	367
Table 383 – ARTYPE	368
Table 384 – IOCRMulticastMACAdd using RT_CLASS_UDP	369
Table 385 – IOCRMulticastMACAdd using RT_CLASS_2 or RT_CLASS_3	369
Table 386 – Type 10 OUI	369
Table 387 – ARProperties.State	370
Table 388 – ARProperties.SupervisorTakeoverAllowed	370
Table 389 – ARProperties.ParameterizationServer	370
Table 390 – ARProperties.DeviceAccess	371
Table 391 – ARProperties.CompanionAR	371
Table 392 – ARProperties.AcknowledgeCompanionAR	371
Table 393 – ARProperties.StartupMode	371
Table 394 – ARProperties.PullModuleAlarmAllowed	372
Table 395 – IOCRProperties.RTClass	372
Table 396 – IOCRTagHeader.IOCRVLANID	373
Table 397 – IOCRTagHeader.IOUserPriority	373
Table 398 – IOCRType	373
Table 399 – CMInitiatorActivityTimeoutFactor with ARProperties.DeviceAccess:=0	374

Table 400 – CMInitiatorActivityTimeoutFactor with ARProperties.DeviceAccess:=1 or ARProperties.StartupMode:=1	374
Table 401 – CMInitiatorTriggerTimeoutFactor	374
Table 402 – LengthIOCS.....	375
Table 403 – LengthIOPS.....	376
Table 404 – AlarmCRProperties.Priority.....	376
Table 405 – AlarmCRProperties.Transport.....	376
Table 406 – AlarmCRTagHeaderHigh.AlarmCRVLANID	377
Table 407 – AlarmCRTagHeaderHigh.AlarmUserPriority	377
Table 408 – AlarmCRTagHeaderLow.AlarmCRVLANID	377
Table 409 – AlarmCRTagHeaderLow.AlarmUserPriority.....	378
Table 410 – AlarmSequenceNumber	378
Table 411 – AlarmCRType	378
Table 412 – RTATimeoutFactor	379
Table 413 – RTARetries.....	379
Table 414 – AddressResolutionProperties.Protocol.....	380
Table 415 – AddressResolutionProperties.Factor.....	380
Table 416 – MCITimeoutFactor	380
Table 417 – VendorIDLow.....	381
Table 418 – VendorIDHigh.....	382
Table 419 – ModuleIdentNumber	382
Table 420 – SubmoduleIdentNumber	382
Table 421 – ARUUID	383
Table 422 – ARUUID in conjunction with ARTYPE:= IOCARSR.....	384
Table 423 – TargetARUUID	384
Table 424 – ActualLocalTimeStamp	384
Table 425 – LocalTimeStamp.....	385
Table 426 – NumberOfLogEntries	385
Table 427 – EntryDetail	385
Table 428 – AdditionalValue1 and AdditionalValue2	385
Table 429 – ControlBlockProperties in conjunction with ControlCommand.ApplicationReady with ARProperties.StartupMode:=1	386
Table 430 – ControlBlockProperties in conjunction with ControlCommand.ApplicationReady with ARProperties.StartupMode:=0	386
Table 431 – ControlBlockProperties in conjunction with the other values of the field ControlCommand	386
Table 432 – ControlCommand.PrmEnd	386
Table 433 – ControlCommand.ApplicationReady.....	386
Table 434 – ControlCommand.Release	387
Table 435 – ControlCommand.Done	387
Table 436 – ControlCommand.ReadyForCompanion	387
Table 437 – ControlCommand.ReadyForRT_CLASS_3	387
Table 438 – ControlCommand.PrmBegin	387
Table 439 – DataDescription.Type	388

Table 440 – Values of DataLength	388
Table 441 – Values of SendClockFactor	389
Table 442 – Values of ReductionRatio for RT_CLASS_1 and RT_CLASS_2	390
Table 443 – Values of ReductionRatio for RT_CLASS_3.....	390
Table 444 – Values of ReductionRatio for RT_CLASS_UDP	390
Table 445 – Values of Phase	391
Table 446 – Values of Sequence	391
Table 447 – DataHoldFactor of a frame	392
Table 448 – DataHoldFactor of a Subframe	392
Table 449 – Values of FrameSendOffset.....	392
Table 450 – ModuleState	394
Table 451 – SubmoduleState.AddInfo	394
Table 452 – SubmoduleState.QualifiedInfo	394
Table 453 – SubmoduleState.MaintenanceRequired	395
Table 454 – SubmoduleState.MaintenanceDemanded	395
Table 455 – SubmoduleState.DiagInfo	395
Table 456 – SubmoduleState.ARInfo	395
Table 457 – SubmoduleState.IdentInfo	396
Table 458 – SubmoduleState.FormatIndicator.....	396
Table 459 – SubmoduleState.Detail	396
Table 460 – SubmoduleProperties.Type.....	397
Table 461 – SubmoduleProperties.SharedInput	397
Table 462 – SubmoduleProperties.ReduceInputSubmoduleDataLength	397
Table 463 – SubmoduleProperties.ReduceOutputSubmoduleDataLength.....	398
Table 464 – SubmoduleProperties.DiscardIOXS	398
Table 465 – SubstitutionMode.....	398
Table 466 – SubstituteActiveFlag.....	399
Table 467 – InitiatorUDPRTPort.....	399
Table 468 – ResponderUDPRTPort.....	399
Table 469 – InitiatorRPCServerPort	400
Table 470 – ResponderRPCServerPort.....	400
Table 471 – MaxAlarmDataLength	401
Table 472 – APStructureIdentifier with API := 0	401
Table 473 – APStructureIdentifier with API != 0	401
Table 474 – ExtendedIdentificationVersionHigh	402
Table 475 – ExtendedIdentificationVersionLow	402
Table 476 – Values of ErrorCode for negative responses.....	402
Table 477 – Values of ErrorDecode	403
Table 478 – Coding of ErrorCode1 with ErrorDecode PNIORW	404
Table 479 – Coding of ErrorCode2 with ErrorDecode PNIORW	405
Table 480 – Values of ErrorCode1 and ErrorCode2 for ErrorDecode with the value PNIO (part 1)	405
Table 481 – Values of ErrorCode1 and ErrorCode2 for ErrorDecode with the value PNIO (part 2 – alarm acknowledge)	408

Table 482 – Values of ErrorCode1 and ErrorCode2 for ErrorDecode with the value PNIO (part 3 – machines)	409
Table 483 – Values of ErrorCode1 and ErrorCode2 for ErrorDecode with the value PNIO (part 4 – IO controller)	410
Table 484 – Values of ErrorCode1 and ErrorCode2 for ErrorDecode with the value PNIO (part 5 – IO device)	411
Table 485 – Values of ErrorCode1 and ErrorCode2 for ErrorDecode with the value PNIO (part 6 – abort reasons)	412
Table 486 – Values of ErrorCode2 for ErrorCode1 = RPC	415
Table 487 – Coding of ErrorCode1 for ErrorDecode with the value ManufacturerSpecific	415
Table 488 – Coding of ErrorCode2 for ErrorDecode with the value ManufacturerSpecific	415
Table 489 – IM_Hardware_Revision	416
Table 490 – IM_SWRevision_Functional_Enhancement	416
Table 491 – IM_SWRevision_Bug_Fix	416
Table 492 – IM_SWRevision_Internal_Change	416
Table 493 – IM_Revision_Counter	417
Table 494 – IM_Profile_ID	417
Table 495 – IM_Profile_Specific_Type in conjunction with IM_Profile_ID := 0x0000	417
Table 496 – IM_Profile_Specific_Type in conjunction with IM_Profile_ID range 0x0001 – 0xF6FF	418
Table 497 – IM_Version_Major	418
Table 498 – IM_Version_Minor	418
Table 499 – IM_Supported.I&M1	418
Table 500 – IM_Date	420
Table 501 – UserStructureIdentifier	421
Table 502 – ChannelErrorType	422
Table 503 – ChannelNumber	423
Table 504 – ChannelProperties.Type	424
Table 505 – ChannelProperties.Maintenance	425
Table 506 – Valid combinations within ChannelProperties	425
Table 507 – Valid combinations for Alarmnotification and RecordDataRead(DiagnosisData)	426
Table 508 – ChannelProperties.Specifier	427
Table 509 – ChannelProperties.Direction	427
Table 510 – ExtChannelErrorType	427
Table 511 – Allowed combinations of ChannelErrorType, ExtChannelErrorType, and ExtChannelAddValue	428
Table 512 – ExtChannelErrorType for ChannelErrorType 0 – 0xFF	428
Table 513 – ExtChannelErrorType for ChannelErrorType 0x0100 – 0x7FFF	428
Table 514 – ExtChannelErrorType for ChannelErrorType “Data transmission impossible”	428
Table 515 – ExtChannelErrorType for ChannelErrorType “Remote mismatch”	429
Table 516 – ExtChannelErrorType for ChannelErrorType “Media redundancy mismatch”	429

Table 517 – ExtChannelErrorType for ChannelErrorType “Sync mismatch” and for ChannelErrorType “Time mismatch”	430
Table 518 – ExtChannelErrorType for ChannelErrorType “Isochronous mode mismatch”	430
Table 519 – ExtChannelErrorType for ChannelErrorType “Multicast CR mismatch”	430
Table 520 – ExtChannelErrorType for ChannelErrorType “Fiber optic mismatch”	430
Table 521 – ExtChannelErrorType for ChannelErrorType “Network component function mismatch”	431
Table 522 – ExtChannelErrorType for ChannelErrorType “Dynamic Frame Packing function mismatch”	431
Table 523 – ExtChannelErrorType for ChannelErrorType “Media redundancy with planned duplication mismatch”	432
Table 524 – ExtChannelErrorType for ChannelErrorType “System redundancy mismatch”	432
Table 525 – ExtChannelErrorType for ChannelErrorType “Multiple interface mismatch”	433
Table 526 – ExtChannelErrorType for ChannelErrorType “Nested diagnosis indication”	433
Table 527 – Values for ExtChannelAddValue	433
Table 528 – Values for Accumulative Info	434
Table 529 – Values for “Fiber optic mismatch” – “Power Budget”	434
Table 530 – Values for “Network component function mismatch” – “Frame dropped”	434
Table 531 – Values for “Remote mismatch” – “Peer CableDelay mismatch”	435
Table 532 – Values for “Multiple interface mismatch” – “Conflicting MultipleInterfaceMode.NameOfDevice mode”	435
Table 533 – Values for QualifiedChannelQualifier	435
Table 534 – Values for MaintenanceStatus	436
Table 535 – URRecordIndex	437
Table 536 – URRecordLength	437
Table 537 – MultipleInterfaceMode.NameOfDevice	438
Table 538 – LineDelay.Value with LineDelay.FormatIndicator == 0	439
Table 539 – LineDelay.Value with LineDelay.FormatIndicator == 1	439
Table 540 – LineDelay.FormatIndicator	439
Table 541 – RxPort	440
Table 542 – NumberOfTxPortGroups	440
Table 543 – TxPortEntry	441
Table 544 – FrameDetails.SyncFrame in conjunction with FrameDataProperties.ForwardingMode := “Absolute mode”	442
Table 545 – FrameDetails.SyncFrame in conjunction with FrameDataProperties.ForwardingMode := “Relative mode”	442
Table 546 – FrameDetails.MeaningFrameSendOffset	442
Table 547 – FrameDetails.MediaRedundancyWatchDog	443
Table 548 – FrameDataProperties.ForwardingMode	443
Table 549 – FrameDataProperties.FastForwardingMulticastMACAdd	443
Table 550 – FrameDataProperties.FragmentationMode	443
Table 551 – MAUType	444
Table 552 – Valid combinations between MAUType and LinkState	447
Table 553 – CheckSyncMode.CableDelay	447

Table 554 – CheckSyncMode.SyncMaster	448
Table 555 – MAUTypeMode.Check	448
Table 556 – DomainBoundaryIngress	448
Table 557 – DomainBoundaryEgress	449
Table 558 – DomainBoundaryAnnounce	449
Table 559 – MulticastBoundary	449
Table 560 – PeerToPeerBoundary	450
Table 561 – DCPBoundary.....	450
Table 562 – PreambleLength.Length.....	451
Table 563 – LinkState.Link	451
Table 564 – LinkState.Port	451
Table 565 – MediaType	452
Table 566 – MaxBridgeDelay	452
Table 567 – NumberOfPorts	452
Table 568 – MaxPortTxDelay	453
Table 569 – MaxPortRxDelay.....	453
Table 570 – MaxLineRxDelay	453
Table 571 – YellowTime.....	454
Table 572 – StartOfRedFrameID	456
Table 573 – EndOfRedFrameID	457
Table 574 – Dependencies of StartOfRedFrameID and EndOfRedFrameID.....	457
Table 575 – NumberOfAssignments	457
Table 576 – NumberOfPhases	458
Table 577 – AssignedValueForReservedBegin.....	458
Table 578 – AssignedValueForOrangeBegin.....	458
Table 579 – AssignedValueForReservedEnd	459
Table 580 – Values of RedOrangePeriodBegin	459
Table 581 – Dependencies of RedOrangePeriodBegin, OrangePeriodBegin and GreenPeriodBegin	459
Table 582 – Values of OrangePeriodBegin with ARProperties.StartupMode == Legacy.....	460
Table 583 – Values of OrangePeriodBegin with ARProperties.StartupMode == Advanced	460
Table 584 – Values of GreenPeriodBegin	460
Table 585 – EtherType	460
Table 586 – SyncProperties.Role.....	461
Table 587 – SyncProperties.SyncID	461
Table 588 – ReservedIntervalBegin with ARProperties.StartupMode == Legacy.....	461
Table 589 – ReservedIntervalBegin with ARProperties.StartupMode == Advanced	461
Table 590 – ReservedIntervalEnd with ARProperties.StartupMode == Legacy	462
Table 591 – ReservedIntervalEnd with ARProperties.StartupMode == Advanced	462
Table 592 – Dependencies of ReservedIntervalBegin and ReservedIntervalEnd	462
Table 593 – SyncSendFactor	463
Table 594 – PTCPTimeoutFactor	463
Table 595 – PTCPTakeoverTimeoutFactor.....	464

Table 596 – PTCPMasterStartupTime	465
Table 597 – PLLWindow	465
Table 598 – TimeIObase	467
Table 599 – TimeDataCycle	467
Table 600 – TimeIOInput	467
Table 601 – TimeIOOutput	468
Table 602 – TimeIOInputValid	468
Table 603 – TimeIOOutputValid	468
Table 604 – ControllerApplicationCycleFactor	468
Table 605 – TimePLLWindow	469
Table 606 – TimeMasterPriority1	470
Table 607 – TimeMasterPriority2	470
Table 608 – MRP_RingState	471
Table 609 – MRP_DomainUUID	471
Table 610 – MRP_LengthDomainName	471
Table 611 – MRP_Role	472
Table 612 – MRP_Version	472
Table 613 – MRP_Prio	472
Table 614 – MRP_TOPchgT	472
Table 615 – MRP_TOPNRmax	473
Table 616 – MRP_TSTshortT	473
Table 617 – MRP_TSTdefaultT	473
Table 618 – MRP_TSTNRmax	474
Table 619 – MRP_LNKdownT	474
Table 620 – MRP_LNKupT	474
Table 621 – MRP_LNKNRmax	475
Table 622 – MRP_Check.MediaRedundancyManager	475
Table 623 – MRP_Check.MRP_DomainUUID	475
Table 624 – VendorBlockType	476
Table 625 – FiberOpticType	476
Table 626 – FiberOpticCableType	476
Table 627 – FiberOpticPowerBudgetType.Value	477
Table 628 – FiberOpticPowerBudgetType.CheckEnable	477
Table 629 – NCDropBudgetType.Value	477
Table 630 – NCDropBudgetType.CheckEnable	478
Table 631 – FSHelloMode.Mode	479
Table 632 – FSHelloInterval	480
Table 633 – FSHelloRetry	480
Table 634 – FSHelloDelay	480
Table 635 – FSPParameterMode.Mode	481
Table 636 – FSPParameterUUID	481
Table 637 – NumberOfSubframeBlocks	481
Table 638 – SFIOCRProperties.DistributedWatchDogFactor	482

Table 639 – SFIOCRProperties.RestartFactorForDistributedWD	482
Table 640 – SFIOCRProperties.DFPMODE	483
Table 641 – SFIOCRProperties.DFPDirection	483
Table 642 – SFIOCRProperties.DFPRedundantPathLayout.....	483
Table 643 – SFIOCRProperties.SFCRC16	484
Table 644 – SubframeData.Position	484
Table 645 – SubframeData.DataLength	484
Table 646 – Event function table.....	485
Table 647 – SubframeOffset	485
Table 648 – Event function table.....	486
Table 649 – SCFEntry.....	487
Table 650 – ACCommunicationProperties.DFP	488
Table 651 – ACCommunicationProperties.RTC3	488
Table 652 – ACCommunicationProperties.RTCUDP	488
Table 653 – ACMinDeviceInterval	489
Table 654 – FromOffsetData	489
Table 655 – NextOffsetData.....	489
Table 656 – TotalSize	490
Table 657 – RedundancyInfo.EndPoint1	490
Table 658 – RedundancyInfo.EndPoint2	490
Table 659 – Valid combination of RedundancyInfo.EndPoint1 and RedundancyInfo.EndPoint2.....	490
Table 660 – SRProperties.InputValidOnBackupAR.....	491
Table 661 – SRProperties.ActivateRedundancyAlarm	491
Table 662 – RedundancyDataHoldFactor	491
Table 663 – NumberOfEntries.....	492
Table 664 – ArgsLength check.....	492
Table 665 – ARBlockReq – request check	493
Table 666 – IOCRBlockReq – request check.....	494
Table 667 – AlarmCRBlockReq – request check	498
Table 668 – ExpectedSubmoduleBlockReq – request check	498
Table 669 – PrmServerBlock – request check.....	500
Table 670 – MCRBlockReq – request check	500
Table 671 – ARRPCBlockReq – request check	501
Table 672 – IRInfoBlock – request check	501
Table 673 – SRInfoBlock – request check.....	502
Table 674 – ArgsLength check.....	502
Table 675 – ARBlockRes – response check.....	503
Table 676 – IOCRBlockRes – response check	503
Table 677 – AlarmCRBlockRes – response check.....	504
Table 678 – ModuleDiffBlock – response check	505
Table 679 – ARServerBlockRes – response check.....	506
Table 680 – ArgsLength check.....	506

Table 681 – ControlBlockConnect(PrmEnd) – request check.....	507
Table 682 – ControlBlockPlug(PrmEnd) – request check	507
Table 683 – ControlBlockConnect(PrmBegin) – request check	508
Table 684 – SubmoduleListBlock – request check	508
Table 685 – ArgsLength check.....	508
Table 686 – ControlBlockConnect – response check.....	509
Table 687 – ControlBlockPlug – response check.....	510
Table 688 – ControlBlockConnect(PrmBegin) – response check	510
Table 689 – ArgsLength check.....	511
Table 690 – ControlBlockConnect(ApplRdy) – request check	511
Table 691 – ControlBlockPlug(ApplRdy) – request check.....	512
Table 692 – ArgsLength check.....	512
Table 693 – ControlBlockConnect – response check.....	513
Table 694 – ControlBlockPlug – response check.....	514
Table 695 – ArgsLength check.....	514
Table 696 – ReleaseBlock – request check.....	515
Table 697 – ArgsLength check.....	515
Table 698 – ReleaseBlock – response check	516
Table 699 – ArgsLength check.....	516
Table 700 – IODWriteReqHeader – request check	517
Table 701 – ArgsLength check.....	517
Table 702 – IODWriteResHeader – response check.....	518
Table 703 – ArgsLength check.....	518
Table 704 – ArgsLength check.....	519
Table 705 – ArgsLength check.....	520
Table 706 – IODReadReqHeader – request check	520
Table 707 – RecordDataReadQuery – request check	521
Table 708 – ArgsLength check.....	521
Table 709 – IODReadResHeader – response check.....	522
Table 710 – Primitives issued by AP-Context (FAL user) to FSPMDEV	525
Table 711 – Primitives issued by FSPMDEV to AP-Context (FAL user)	527
Table 712 – Functions, Macros, Timers and Variables used by the AP-Context (FAL user) to FSPMDEV	530
Table 713 – Functions, Macros, Timers and Variables used by the FSPMDEV to AP-Context (FAL user)	531
Table 714 – Primitives issued by AP-Context (FAL user) to FSPMCTL.....	534
Table 715 – Primitives issued by FSPMCTL to AP-Context (FAL user).....	536
Table 716 – Functions, Macros, Timers and Variables used by AP-Context (FAL user) to FSPMCTL	540
Table 717 – Functions, Macros, Timers and Variables used by FSPMCTL to AP-Context (FAL user)	541
Table 718 – Remote primitives issued or received by ALPMI	544
Table 719 – Local primitives issued or received by ALPMI	545
Table 720 – ALPMI state table	546

Table 721 – Functions, Macros, Timers and Variables used by ALPMI	548
Table 722 – Remote primitives issued or received by ALPMR	548
Table 723 – Local primitives issued or received by ALPMR	549
Table 724 – ALPMR state table	551
Table 725 – Functions, Macros, Timers and Variables used by ALPMR	553
Table 726 – Remote primitives issued or received by CMDEV	556
Table 727 – Local primitives issued or received by CMDEV	558
Table 728 – CMDEV state table	560
Table 729 – Functions, Macros, Timers and Variables used by CMDEV	563
Table 730 – Remote primitives issued or received by CMDEV_DA	564
Table 731 – Local primitives issued or received by CMDEV_DA	565
Table 732 – CMDEV_DA state table	566
Table 733 – Functions, Macros, Timers and Variables used by CMDEV(DA)	567
Table 734 – Remote primitives issued or received by CMSU	567
Table 735 – Local primitives issued or received by CMSU	567
Table 736 – CMSU state table	570
Table 737 – Functions, Macros, Timers and Variables used by the CMSU	572
Table 738 – Remote primitives issued or received by CMIO	573
Table 739 – Local primitives issued or received by CMIO	573
Table 740 – CMIO state table	574
Table 741 – Functions used by the CMIO	576
Table 742 – Remote primitives issued or received by CMWRR	576
Table 743 – Local primitives issued or received by CMWRR	577
Table 744 – CMWRR state table	579
Table 745 – Functions, Macros, Timers and Variables used by CMWRR	580
Table 746 – Remote primitives issued or received by CMRDR	581
Table 747 – Local primitives issued or received by CMRDR	581
Table 748 – CMRDR state table	582
Table 749 – Functions, Macros, Timers and Variables used by CMRDR	583
Table 750 – Remote primitives issued or received by CMSM	583
Table 751 – Local primitives issued or received by CMSM	584
Table 752 – CMSM state table	585
Table 753 – Functions, Macros, Timers and Variables used by the CMSM	586
Table 754 – Remote primitives received by CMPBE	586
Table 755 – Local primitives issued or received by CMPBE	587
Table 756 – CMPBE state table	589
Table 757 – Functions, Macros, Timers and Variables used by the CMPBE	591
Table 758 – Remote primitives issued or received by CMDMC	591
Table 759 – Local primitives issued or received by CMDMC	591
Table 760 – CMDMC state table	594
Table 761 – Functions, Macros, Timers and Variables used by the CMDMC	596
Table 762 – Remote primitives issued or received by CMINA	596
Table 763 – Local primitives issued or received by CMINA	597

Table 764 – CMINA state table	598
Table 765 – Functions, Macros, Timers and Variables used by the CMINA	603
Table 766 – Return values of CheckAPDU	603
Table 767 – Remote primitives issued or received by CMRPC	604
Table 768 – Local primitives issued or received by CMRPC	606
Table 769 – CMRPC state table	606
Table 770 – Functions, Macros, Timers and Variables used by the CMRPC	610
Table 771 – Return values of CheckRPC	611
Table 772 – Remote primitives issued or received by CMCTL	614
Table 773 – Local primitives issued or received by CMCTL	615
Table 774 – CMCTL state table	618
Table 775 – Functions, Macros, Timers and Variables used by the CMCTL	621
Table 776 – Remote primitives issued or received by CTLSM	622
Table 777 – Local primitives issued or received by CTLSM	623
Table 778 – CTLSM state table	623
Table 779 – Functions, Macros, Timers and Variables used by the CTLSM	624
Table 780 – Remote primitives issued or received by CTLIO	625
Table 781 – Local primitives issued or received by CTLIO	625
Table 782 – CTLIO state table	626
Table 783 – Functions, Macros, Timers and Variables used by the CTLIO	628
Table 784 – Remote primitives received by CTRLDI	628
Table 785 – Local primitives issued or received by CTRLDI	629
Table 786 – CTRLDI state table	630
Table 787 – Functions, Macros, Timers and Variables used by CTRLDI	631
Table 788 – Remote Primitives received by CTRLDR	631
Table 789 – Local primitives issued or received by CTRLDR	632
Table 790 – CTRLDR state table	632
Table 791 – Functions, Macros, Timers and Variables used by CTRLDR	633
Table 792 – Remote primitives received by CTRLRPC	633
Table 793 – Local primitives issued or received by CTRLRPC	636
Table 794 – CTRLRPC state table	637
Table 795 – Functions, Macros, Timers and Variables used by the CTRLRPC	639
Table 796 – Remote primitives issued or received by CTLSU	639
Table 797 – Local Primitives issued or received by CTLSU	640
Table 798 – CTLSU state table	642
Table 799 – Functions, Macros, Timers and Variables used by the CTLSU	644
Table 800 – Remote primitives issued or received by CTLWRI	645
Table 801 – Local primitives issued or received by CTLWRI	645
Table 802 – CTLWRI state table	647
Table 803 – Functions, Macros, Timers and Variables used by CTLWRI	648
Table 804 – Remote primitives issued or received by CTLWRR	649
Table 805 – Local primitives issued or received by CTLWRR	649
Table 806 – CTLWRR state table	650

Table 807 – Functions, Macros, Timers and Variables used by CTLWRR.....	651
Table 808 – Remote primitives issued or received by CTLPBE	651
Table 809 – Local primitives issued or received by CTLPBE	652
Table 810 – CTLPBE state table	654
Table 811 – Functions, Macros, Timers and Variables used by CTLPBE.....	656
Table 812 – Remote primitives issued or received by CTLDINA	656
Table 813 – Local primitives issued or received by CTLDINA.....	657
Table 814 – CTLDINA state table.....	659
Table 815 – Functions, Macros, Timers and Variables used by the CTLDINA.....	662
Table A.1 – Examples for the AR establishing.....	664
Table B.1 – Examples for compatible AR establishing.....	670
Table I.1 – Priority regeneration and queue usage	685
Table I.2 – Priority regeneration – variant 1	685
Table I.3 – Priority regeneration – variant 2	686
Table R.1 – Truth table	705
Table S.1 – TX-error	706
Table U.1 – List of supported MIBs	708
Table V.1 – Content of archive.....	709

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.

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 third edition cancels and replaces the second edition published in 2010. This edition constitutes a technical revision.

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

- Corrections and Improvements

- Change from MRP integration to MRP reference
- Integration of dynamic frame packing
- Integration of peer to peer fragmentation
- Integration of fast forwarding
- Integration of shared RT_CLASS_3 ARs
- Integration of vendor specific blocks for the connect
- Integration of generic POF diagnosis
- Integration of autoconfiguration
- Integration of seamless media redundancy MRPD
- Integration of the System redundancy basic functionality
- Integration of the Configure in run basic functionality
- Integration of multiple interface support
- Integration of port statistic for error tracking
- Integration of controller to controller communication basic functionality
- Optimization of RT_CLASS_3 startup and forwarding
- Optimization of isochronous startup
- Optimization of the startup time from power down
- Removal of MRRT
- Removal of distributed automation
- Update of the LLDP-EXT-MIB

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

FDIS	Report on voting
65C/764/FDIS	65C/774/RVD

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

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

A list of all the 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.

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

INTRODUCTION

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

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

NOTE 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 standard as follows:

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

WO publication	Title (WO)
WO 02/043336 EP 1388238	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 EP 1368935	Synchronous clocked communication system with decentralized input/output modules and methods for integrating decentralized input/output modules in such a system
WO 03/028258 EP 1430628	Method for synchronizing nodes of a communication system
WO 03/028259 EP 1430627	Communications system and method for synchronizing a communications cycle
WO 04/030284 EP 1540895	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 holders of these patent rights have assured the IEC that they are 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 holders of these patent rights is registered with IEC. Information may be obtained from:

[SI]: Siemens AG
CT IP L&T
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://patents.iec.ch>) 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 standard 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 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 standard 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 standard 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 standard 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 standard 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, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

IEC 61158-1:2014, *Industrial communication networks – Fieldbus specifications – Part 1: Overview and guidance for the IEC 61158 and IEC 61784 series*

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

IEC 61158-5-10:2014, *Industrial communication networks – Fieldbus specifications – Application layer service definition – Type 10 elements*

IEC 61158-6-3:2014, *Industrial communication networks – Fieldbus specifications – Part 6-3: Application layer protocol specification – Type 3 elements*

IEC 61588, *Precision clock synchronization protocol for networked measurement and control systems*

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

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

IEEE 754, *IEEE Standard for Floating-Point Arithmetic*, available at <<http://www.ieee.org>>

IEEE 802, *IEEE Standard for Local and metropolitan area networks: Overview and Architecture*, available at <<http://www.ieee.org>>

IEEE 802.1AB-2005, *IEEE Standard for Local and metropolitan area networks: Station and Media Access Control Connectivity Discovery*, available at <<http://www.ieee.org>>

IEEE 802.1AS, *IEEE Standard for Information technology – Telecommunications and information exchange between systems – 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>>

IEEE 802.1D, *IEEE Standard for Local and metropolitan area networks – Media access control (MAC) Bridges*, available at <<http://www.ieee.org>>

IEEE 802.1Q, *IEEE Standard for Local and metropolitan area networks – Media Access Control (MAC) Bridges and Virtual Bridged Local Area Networks*, available at <<http://www.ieee.org>>

IEEE 802.3, *IEEE Standard for Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Carrier sense multiple access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications*, available at <<http://www.ieee.org>>

IEEE 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>>

IEEE 802.15.1-2005, *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>>

IETF RFC 768, *User Datagram Protocol*, available at <<http://www.ietf.org>>

IETF RFC 791, *Internet Protocol*, available at <<http://www.ietf.org>>

IETF RFC 792, *Internet Control Message Protocol*, available at <<http://www.ietf.org>>

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>>

IETF RFC 1034, *Domain names – concepts and facilities*, available at <<http://www.ietf.org>>

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

IETF RFC 2131, *Dynamic Host Configuration Protocol*, available at <<http://www.ietf.org>>

IETF RFC 2132, *DHCP Options and BOOTP Vendor Extensions*, available at <<http://www.ietf.org>>

IETF RFC 2236, *Internet Group Management Protocol, Version 2*, available at <<http://www.ietf.org>>

IETF RFC 2365, *Administratively Scoped IP Multicast*, available at <<http://www.ietf.org>>

IETF RFC 2474, *Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers*, available at <<http://www.ietf.org>>

IETF RFC 2674, *Definitions of Managed Objects for Bridges with Traffic Classes, Multicast Filtering and Virtual LAN Extensions*, available at <<http://www.ietf.org>>

IETF RFC 2863, *The Interfaces Group MIB*, available at <<http://www.ietf.org>>

IETF RFC 3418, *Management Information Base (MIB) for the Simple Network Management Protocol (SNMP)*, available at <<http://www.ietf.org>>

IETF RFC 3621, *Power Ethernet MIB*, available at <<http://www.ietf.org>>

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

IETF RFC 4363, *Definitions of Managed Objects for Bridges with Traffic Classes, Multicast Filtering, and Virtual LAN Extensions*, available at <<http://www.ietf.org>>

IETF RFC 4836, *Definitions of Managed Objects for IEEE 802.3 Medium Attachment Units (MAUs)*, available at <<http://www.ietf.org>>

IETF RFC 5735, *Special-Use IPv4 Addresses*, available at <<http://www.ietf.org>>

IETF RFC 5890, *Internationalized Domain Names for Applications (IDNA): Definitions and Document Framework*, available at <<http://www.ietf.org>>

The Open Group — Publication C706, *Technical standard DCE1.1: Remote Procedure Call*, available at <<http://www.opengroup.org/onlinepubs/9629399/toc.htm>>