



IEC 61158-6-10

Edition 5.0 2023-03

# INTERNATIONAL STANDARD



---

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

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

---

ICS 25.040.40; 35.100.70; 35.110

ISBN 978-2-8322-6633-5

**Warning! Make sure that you obtained this publication from an authorized distributor.**

## CONTENTS

FOREWORD.....	46
INTRODUCTION.....	48
1 Scope.....	49
1.1 General.....	49
1.2 Specifications .....	49
1.3 Conformance .....	50
2 Normative references .....	50
3 Terms, definitions, abbreviated terms, symbols, and conventions .....	54
3.1 Referenced terms and definitions.....	54
3.1.1 ISO/IEC 7498-1 terms.....	54
3.1.2 ISO/IEC 8822 terms.....	55
3.1.3 ISO/IEC 8824-1 terms.....	55
3.1.4 ISO/IEC 9545 terms.....	55
3.2 Terms and definitions.....	55
3.3 Abbreviated terms and symbols .....	64
3.3.1 Abbreviated terms and symbols for services .....	64
3.3.2 Abbreviated terms and symbols for distributed I/O .....	64
3.3.3 Abbreviated terms and symbols for IEC 62439-2 .....	68
3.3.4 Abbreviated terms and symbols for IEC/IEEE 60802.....	68
3.3.5 Abbreviated terms and symbols for IEEE Std 802.1CB .....	68
3.3.6 Abbreviated terms and symbols for IEEE Std 802.1Q .....	68
3.3.7 Abbreviated terms and symbols for IEEE Std 802.3 .....	69
3.3.8 Abbreviated terms and symbols for IETF RFC 2474.....	69
3.3.9 Abbreviated terms and symbols for IETF RFC 4291.....	69
3.4 Conventions.....	69
3.4.1 General concept .....	69
3.4.2 Conventions for distributed I/O .....	70
3.4.3 Conventions used in state machines.....	78
4 Application layer protocol specification for common protocols.....	83
4.1 FAL syntax description.....	83
4.1.1 DLPDU abstract syntax reference .....	83
4.1.2 Data types .....	85
4.2 Transfer syntax.....	87
4.2.1 Coding of basic data types .....	87
4.2.2 Coding section related to common basic fields .....	95
4.3 Discovery and basic configuration.....	109
4.3.1 DCP syntax description .....	109
4.3.2 DCP protocol state machines.....	143
4.3.3 DLL Mapping Protocol Machines.....	162
4.4 Precision transparent clock protocol .....	162
4.4.1 FAL syntax description .....	162
4.4.2 AP-Context state machine .....	173
4.4.3 FAL Service Protocol Machines .....	173
4.4.4 Application Relationship Protocol Machines.....	173
4.4.5 DLL Mapping Protocol Machines.....	238
4.5 Time synchronization .....	238
4.5.1 General .....	238

4.5.2	GlobalTime .....	241
4.5.3	WorkingClock .....	242
4.6	Media redundancy .....	246
4.6.1	Media redundancy and loop prevention.....	246
4.6.2	Seamless media redundancy .....	249
4.7	Real time cyclic.....	249
4.7.1	FAL syntax description .....	249
4.7.2	FAL transfer syntax .....	250
4.7.3	FAL Service Protocol Machines .....	260
4.7.4	Application Relationship Protocol Machines.....	260
4.7.5	DLL Mapping Protocol Machines.....	282
4.8	Real time acyclic.....	282
4.8.1	RTA syntax description.....	282
4.8.2	RTA transfer syntax.....	284
4.8.3	FAL Service Protocol Machines .....	294
4.8.4	Application Relationship Protocol Machines.....	294
4.8.5	DLL Mapping Protocol Machines.....	339
4.9	Fragmentation.....	340
4.9.1	General .....	340
4.9.2	FRAG syntax description .....	343
4.9.3	FRAG transfer syntax .....	344
4.9.4	FAL Service Protocol Machines .....	346
4.9.5	Application Relationship Protocol Machines.....	346
4.9.6	DLL Mapping Protocol Machines.....	346
4.10	Remote procedure call .....	356
4.10.1	General .....	356
4.10.2	RPC syntax description .....	356
4.10.3	RPC Transfer syntax .....	358
4.10.4	FAL Service Protocol Machines .....	374
4.10.5	Application Relationship Protocol Machines.....	374
4.10.6	DLL Mapping Protocol Machines.....	375
4.11	Link layer discovery .....	375
4.11.1	General .....	375
4.11.2	FAL common syntax description .....	376
4.11.3	LLDP transfer syntax .....	378
4.11.4	FAL Service Protocol Machines .....	388
4.11.5	Application Relation Protocol Machines .....	388
4.11.6	DLL Mapping Protocol Machines.....	388
4.12	End stations and bridges.....	388
4.12.1	General .....	388
4.12.2	Traffic classes .....	390
4.12.3	End station .....	393
4.12.4	Bridge.....	416
4.12.5	Bridged end station.....	461
4.12.6	Q port state machine .....	470
4.12.7	Pruning port state machine .....	476
4.12.8	Bridge extensions .....	478
4.12.9	FAL Service Protocol Machines .....	479
4.12.10	Application Relation Protocol Machines .....	479

4.12.11	DLL Mapping Protocol Machines.....	479
4.13	IP suite .....	516
4.13.1	Overview .....	516
4.13.2	IP/UDP syntax description .....	516
4.13.3	IP/UDP transfer syntax .....	517
4.13.4	ARP.....	520
4.14	Domain name system.....	522
4.14.1	General .....	522
4.14.2	Primitive definitions .....	523
4.14.3	DNS state transition diagram .....	523
4.14.4	State machine description .....	523
4.14.5	DNS state table .....	523
4.14.6	Functions, Macros, Timers and Variables .....	523
4.15	Dynamic host configuration .....	524
4.15.1	General .....	524
4.15.2	Primitive definitions .....	524
4.15.3	DHCP state transition diagram.....	524
4.15.4	State machine description .....	525
4.15.5	DHCP state table.....	525
4.15.6	Functions, Macros, Timers and Variables .....	526
4.16	Simple network management .....	526
4.16.1	General .....	526
4.16.2	MIB overview.....	527
4.16.3	MIB access.....	527
4.16.4	IETF RFC 1213-MIB .....	527
4.16.5	Enterprise number for PNIO MIB .....	528
4.16.6	MIB cross reference .....	528
4.16.7	Behavior in case of modular built bridges .....	529
4.16.8	LLDP EXT MIB .....	529
4.17	Network configuration .....	529
4.17.1	Overview .....	529
4.17.2	NETCONF .....	530
4.17.3	YANG .....	531
4.18	Common DLL Mapping Protocol Machines .....	532
4.18.1	Overview .....	532
4.18.2	Data Link Layer Mapping Protocol Machine .....	533
4.19	Void.....	540
4.20	Additional information .....	540
5	Application layer protocol specification for distributed I/O .....	540
5.1	FAL syntax description.....	540
5.1.1	DLPDU abstract syntax reference .....	540
5.1.2	APDU abstract syntax.....	540
5.2	Transfer syntax.....	567
5.2.1	Coding section related to BlockHeader specific fields .....	567
5.2.2	Coding section related to RTA-SDU specific fields .....	586
5.2.3	Coding section related to common address fields .....	591
5.2.4	Coding section related to AL services .....	613
5.2.5	Coding section related to ARVendorBlock.....	652
5.2.6	Coding section related to PNIOStatus.....	653

5.2.7	Coding section related to I&M Records .....	670
5.2.8	Coding section related to Alarm and Diagnosis Data.....	677
5.2.9	Coding section related to upload and retrieval .....	701
5.2.10	Coding section related to iParameter .....	701
5.2.11	Coding section related to NME .....	702
5.2.12	Coding section related to CIM.....	711
5.2.13	Coding section related to Physical Sync Data .....	776
5.2.14	Coding section related to Physical Time Data .....	781
5.2.15	Coding section related to Isochrone Mode Data .....	786
5.2.16	Coding section related to fast startup.....	788
5.2.17	Coding section related to DFP .....	791
5.2.18	Coding section related to MRPD .....	795
5.2.19	Coding section related to controller to controller communication.....	796
5.2.20	Coding section related to system redundancy .....	797
5.2.21	Coding section related to energy saving .....	800
5.2.22	Coding section related to asset management.....	800
5.2.23	Coding section related to reporting system .....	805
5.2.24	Coding section related to logbook.....	811
5.2.25	Coding section related to Time .....	812
5.2.26	Coding section related to Channel Related Process Alarm Reason.....	812
5.2.27	Void.....	815
5.3	FAL protocol state machines.....	816
5.3.1	Overall structure .....	816
5.4	AP-Context state machine.....	817
5.5	FAL Service Protocol Machines .....	817
5.5.1	Overview .....	817
5.5.2	FAL Service Protocol Machine Power-On .....	817
5.5.3	FAL Service Protocol Machine Device .....	818
5.5.4	FAL Service Protocol Machine Controller.....	828
5.5.5	FAL Service Protocol Machine Network Management Entity .....	839
5.6	Application Relationship Protocol Machines .....	840
5.6.1	Alarm Protocol Machine Initiator .....	840
5.6.2	Alarm Protocol Machine Responder .....	844
5.6.3	Device .....	848
5.6.4	Controller .....	934
5.6.5	Network Management Entity .....	1013
5.7	DLL Mapping Protocol Machines.....	1047
5.8	Checking rules.....	1048
5.8.1	General .....	1048
5.8.2	IODConnectReq .....	1048
5.8.3	IODConnectRes.....	1061
5.8.4	IODControlReq .....	1066
5.8.5	IODControlRes .....	1068
5.8.6	IOXControlReq .....	1072
5.8.7	IOXControlRes .....	1073
5.8.8	IODReleaseReq.....	1075
5.8.9	IODReleaseRes.....	1076
5.8.10	IODWriteReq .....	1077
5.8.11	IODWriteRes .....	1079

5.8.12	IODWriteMultipleReq .....	1081
5.8.13	IODWriteMultipleRes .....	1082
5.8.14	IODReadReq .....	1084
5.8.15	IODReadRes .....	1086
Annex A	(normative) Unified establishing of an AR for all RT classes .....	1089
A.1	General.....	1089
A.2	AR establishing.....	1090
A.3	Startup of Alarm transmitter and receiver .....	1097
A.4	Time-aware systems path establishment.....	1099
A.5	Void.....	1100
A.6	Void.....	1100
Annex B	(normative) Compatible establishing of an AR.....	1101
Annex C	(informative) Establishing of a device access AR.....	1104
Annex D	(informative) Establishing of an AR (accelerated procedure).....	1106
Annex E	(informative) Establishing of an AR (fast startup procedure).....	1109
Annex F	(informative) Example of the upload, storage and retrieval procedure .....	1111
Annex G	(informative) Implementation of send list control.....	1113
G.1	General.....	1113
G.2	Implementation model.....	1114
G.3	Constraints .....	1116
Annex H	(informative) Overview of the IO controller and the IO device state machines ....	1117
Annex I	(informative) Overview of the PTCP synchronization master hierarchy .....	1119
Annex J	(informative) Optimization of bandwidth usage for Time Aware Shaping .....	1121
Annex K	(informative) Time constraints for RT_CLASS_3 bandwidth allocation .....	1123
Annex L	(informative) Time constraints for the forwarding of a frame .....	1125
L.1	Principle .....	1125
L.2	Forwarding.....	1125
Annex M	(informative) Principle of dynamic frame packing.....	1127
Annex N	(informative) Principle of Fragmentation .....	1131
Annex O	(informative) MRPD – Principle of seamless media redundancy.....	1133
Annex P	(normative) Principle of a RED_RELAY without forwarding information in PDIRFrameData .....	1135
Annex Q	(informative) Constraints for Auto-negotiation.....	1138
Q.1	Optimization for fast startup without auto-negotiation .....	1138
Q.2	Gigabit PHYs, 2 pair Ethernet cables, and auto-negotiation .....	1140
Annex R	(informative) Example of a PrmBegin, PrmEnd and ApplRdy sequence.....	1141
Annex S	(informative) List of supported MIBs.....	1142
Annex T	(informative) Structure and content of BLOB .....	1143
Annex U	(normative) Management information bases .....	1144
U.1	Void.....	1144
U.2	LLDP EXT MIB.....	1144
Annex V	(normative) Cross reference to IEC 62439-2 .....	1167
V.1	Cross reference to IEC 62439-2.....	1167
V.1.1	General .....	1167
V.1.2	Ring .....	1167
V.1.3	Interconnection.....	1168

Annex W (normative) Maintaining statistic counters for Ethernet.....	1170
W.1 General.....	1170
W.2 Counting model.....	1170
W.3 Explanation of the IETF RFC defined statistic counters.....	1172
W.4 Value range of the IETF RFC defined statistic counters.....	1173
W.5 VLAN specific statistic counters.....	1173
Annex X (informative) Example of RSI fragmentation.....	1175
Annex Y (informative) Delayed cut through.....	1177
Bibliography.....	1179
Figure 1 – Common structure of specific fields for octet 1.....	71
Figure 2 – Common structure of specific fields for octet 2.....	71
Figure 3 – Common structure of specific fields for octet 3.....	71
Figure 4 – Common structure of specific fields for octet 4.....	72
Figure 5 – Common structure of specific fields for octet 5.....	72
Figure 6 – Common structure of specific fields for octet 6.....	72
Figure 7 – Common structure of specific fields for octet 7.....	73
Figure 8 – Common structure of specific fields for octet 8.....	73
Figure 9 – Common structure of specific fields for octet 9.....	73
Figure 10 – Common structure of specific fields for octet 10.....	74
Figure 11 – Common structure of specific fields for octet 11.....	74
Figure 12 – Common structure of specific fields for octet 12.....	74
Figure 13 – Common structure of specific fields for octet 13.....	75
Figure 14 – Common structure of specific fields for octet 14.....	75
Figure 15 – Common structure of specific fields for octet 15.....	75
Figure 16 – Common structure of specific fields for octet 16.....	76
Figure 17 – Coding of the data type BinaryDate.....	88
Figure 18 – Encoding of TimeofDay with date indication value.....	88
Figure 19 – Encoding of TimeofDay without date indication value.....	89
Figure 20 – Encoding of TimeDifference with date indication value.....	89
Figure 21 – Encoding of TimeDifference without date indication value.....	90
Figure 22 – Encoding of a NetworkTime value.....	90
Figure 23 – Encoding of NetworkTimeDifference value.....	91
Figure 24 – Encoding of TimeStamp value.....	92
Figure 25 – Encoding of TimeStampDifference value.....	93
Figure 26 – Encoding of TimeStampDifferenceShort value.....	94
Figure 27 – FastForwardingMulticastMACAdd.....	100
Figure 28 – Stream Destination MAC Address – StreamDA.....	102
Figure 29 – State transition diagram of DCPUCS.....	145
Figure 30 – State transition diagram of DCPUCR.....	149
Figure 31 – State transition diagram of DCPMCS.....	154
Figure 32 – Basic structure of a DCP Multicast Receiver.....	156
Figure 33 – State transition diagram of DCPMCR.....	157
Figure 34 – State transition diagram of DCPHMCS.....	160

Figure 35 – State transition diagram of DCPHMCR .....	161
Figure 36 – PTCP_SequenceID value range .....	167
Figure 37 – Message timestamp point.....	173
Figure 38 – Timer model .....	174
Figure 39 – Four message timestamps .....	174
Figure 40 – Line delay protocol with follow up.....	175
Figure 41 – Line delay protocol without follow up .....	176
Figure 42 – Line delay measurement .....	178
Figure 43 – Model parameter for GSDML usage .....	180
Figure 44 – Bridge delay measurement.....	181
Figure 45 – Delay accumulation for PTCP.....	182
Figure 46 – Delay accumulation for PTP .....	183
Figure 47 – Worst case accumulated time deviation of synchronization .....	183
Figure 48 – Signal generation for measurement of deviation .....	184
Figure 49 – Measurement of deviation .....	184
Figure 50 – PTCP master sending Sync-Frame without Follow Up-Frame .....	185
Figure 51 – PTCP master sending Sync-Frame with FollowUp-Frame .....	186
Figure 52 – !FU Sync Slave Forwarding Sync-Frame .....	187
Figure 53 – FU Sync Slave Forwarding Sync- and FollowUp-Frame.....	188
Figure 54 – FU Sync Slave Forwarding Sync- and Generating FollowUp-Frame.....	189
Figure 55 – Principle of the monitoring of the line delay measurement.....	190
Figure 56 – State transition diagram of DELAY_REQ .....	192
Figure 57 – State transition diagram of DELAY_RSP .....	200
Figure 58 – Overview of PTCP.....	204
Figure 59 – State transition diagram of SYN_BMA .....	207
Figure 60 – State transition diagram of SYN_MPSM .....	216
Figure 61 – State transition diagram of SYN_SPSM.....	222
Figure 62 – State transition diagram of SYNC_RELAY .....	229
Figure 63 – State transition diagram of SCHEDULER .....	235
Figure 64 – Station clock model.....	240
Figure 65 – End station model with time synchronization .....	241
Figure 66 – GlobalTime timer model .....	242
Figure 67 – WorkingClock timer model.....	243
Figure 68 – Non-time-aware system – WorkingClock and CycleCounter.....	243
Figure 69 – Time-aware system – Queue masking – WorkingClock and CycleCounter .....	244
Figure 70 – Time-aware system – WorkingClock and CycleCounter .....	245
Figure 71 – Media redundancy – Ring.....	246
Figure 72 – Media redundancy – Interconnection .....	248
Figure 73 – CycleCounter value range .....	251
Figure 74 – Structure of the CycleCounter .....	252
Figure 75 – Optimized CycleCounter setting .....	253
Figure 76 – SFCRC16 generation rule .....	257
Figure 77 – SFCycleCounter value range.....	258



Figure 78 – Overview Buffer Lifetime Model.....	261
Figure 79 – PPM Flow Model .....	262
Figure 80 – CPM Flow Model .....	262
Figure 81 – Basic structure of a PPM with frame structure .....	264
Figure 82 – Basic structure of a PPM with subframe structure.....	265
Figure 83 – State transition diagram of PPM.....	267
Figure 84 – Basic structure of a CPM.....	271
Figure 85 – State transition diagram of CPM.....	273
Figure 86 – Addressing scheme of RTA .....	285
Figure 87 – Structure of the APM .....	295
Figure 88 – Structure of the RSI .....	296
Figure 89 – Structure of the APMS.....	297
Figure 90 – State transition diagram of APMS.....	299
Figure 91 – Structure of the APMR .....	304
Figure 92 – State transition diagram of APMR .....	306
Figure 93 – State transition diagram of RSII .....	310
Figure 94 – State transition diagram of RSIIN .....	322
Figure 95 – State transition diagram of RSIR .....	325
Figure 96 – State transition diagram of RSIRN.....	337
Figure 97 – State transition diagram of FRAG_D .....	347
Figure 98 – State transition diagram of FRAG_S.....	350
Figure 99 – State transition diagram of DEFRAG .....	353
Figure 100 – DLL Mapping Protocol Machines (DMPM) .....	389
Figure 101 – Schematic diagram of data flow of control loop.....	390
Figure 102 – End station model with IEEE Std 802.1Q alignment.....	394
Figure 103 – Ethernet interface model with IEEE alignment – transmit direction .....	395
Figure 104 – SendListControl alignment with Ethernet interface model .....	396
Figure 105 – Algorithm for end station ETS model .....	397
Figure 106 – Credit-based shaper algorithm .....	399
Figure 107 – Send List Feed.....	401
Figure 108 – Bandwidth vs. SendClock @ 10 Mbit/s .....	403
Figure 109 – 10 Mbps SendClock adaption .....	403
Figure 110 – Bandwidth vs. SendClock @ 100 Mbit/s .....	403
Figure 111 – Bandwidth vs. SendClock @ 1 Gbit/s .....	404
Figure 112 – Queue masking – time-aware end stations – without time-aware streams.....	408
Figure 113 – Queue masking – time-aware end station – with time-aware streams .....	410
Figure 114 – Queue masking – non-time-aware – without RT_CLASS_3.....	412
Figure 115 – Queue masking – non-time-aware end station – with RT_CLASS_3 .....	414
Figure 116 – End station.....	415
Figure 117 – End station System – with multiple end station components .....	416
Figure 118 – System incorporating a bridge.....	417
Figure 119 – Domain Boundary.....	418
Figure 120 – Domain Boundary – RT_CLASS_STREAM, class RT.....	419

Figure 121 – Domain Boundary – Boundary Port..... 420

Figure 122 – Domain Boundary – Inter NME domain streams..... 421

Figure 123 – LLC protocol flow ..... 425

Figure 124 – Ingress rate limiter – Domain boundary ..... 434

Figure 125 – Ingress rate limiter – Link speed transition ..... 438

Figure 126 – Schematic traffic flow model of a bridge ..... 441

Figure 127 – Time-aware system – Egress port resource model of a bridge..... 445

Figure 128 – Non-time-aware system – Egress port resource model of a bridge ..... 446

Figure 129 – Bridge queue masking usage model ..... 452

Figure 130 – RED\_RELAY – Bridge queue masking usage model..... 453

Figure 131 – TAS setup – Bridge queue masking model ..... 454

Figure 132 – RED\_RELAY setup – Queue masking model ..... 455

Figure 133 – Bridge with end station ..... 458

Figure 134 – Transmit – one port of a bridge ..... 458

Figure 135 – Forwarding process – bridge ..... 459

Figure 136 – Receive – one port of a bridge ..... 459

Figure 137 – Transmit – Management port..... 460

Figure 138 – Receive – Management port..... 461

Figure 139 – Bridged end station ..... 462

Figure 140 – Bridged end station interface model with IEEE alignment ..... 463

Figure 141 – Bridged end station system reference planes ..... 464

Figure 142 – Send List principle..... 465

Figure 143 – Fallback in case of sync loss / resync for WorkingClock ..... 466

Figure 144 – Bridged end station with proprietary interfaces ..... 467

Figure 145 – Internal vs. external reference plane ..... 468

Figure 146 – Forwarding bridge resources vs. dedicated bridge resources ..... 469

Figure 147 – Bridged end station with multiple entities – one end station per bridge component..... 470

Figure 148 – Bridged end station with multiple entities – multiple end station per bridge component..... 470

Figure 149 – State transition diagram of QPSM ..... 471

Figure 150 – State transition diagram of PPSM..... 477

Figure 151 – State transition diagram of RTC3PSM ..... 481

Figure 152 – State transition diagram for generating events ..... 485

Figure 153 – State transition diagram of RED\_RELAY ..... 487

Figure 154 – Scheme of the DFP\_RELAY ..... 491

Figure 155 – Scheme of the DFP\_RELAY\_INBOUND and DFP\_RELAY\_IN\_STORAGE ..... 491

Figure 156 – Scheme of the DFP\_RELAY\_OUTBOUND..... 492

Figure 157 – State transition diagram of DFP\_RELAY ..... 493

Figure 158 – State transition diagram of DFP\_RELAY\_INBOUND ..... 496

Figure 159 – State transition diagram of DFP\_RELAY\_IN\_STORAGE..... 500

Figure 160 – State transition diagram of DFP\_RELAY\_OUTBOUND ..... 504

Figure 161 – State transition diagram of MUX..... 508

Figure 162 – State transition diagram of DEMUX ..... 513

Figure 163 – State transition diagram of ACCM .....	521
Figure 164 – State transition diagram of DHCP.....	524
Figure 165 – Network Management Entity.....	530
Figure 166 – NMDA model for network management.....	531
Figure 167 – YANG models of a bridge component.....	532
Figure 168 – YANG models of an end station component.....	532
Figure 169 – Structuring of the protocol machines within the DMPM (bridge) .....	533
Figure 170 – State transition diagram of LMPM.....	536
Figure 171 – AlarmSpecifier.SequenceNumber value range .....	589
Figure 172 – FrameSendOffset vs. duration of a cycle .....	644
Figure 173 – Severity classification of fault, maintenance and normal operation .....	700
Figure 174 – UpdateInterval measurement.....	706
Figure 175 – Deadline measurement.....	707
Figure 176 – MaxCalculatedLatency .....	709
Figure 177 – Timing model with RR = 1 .....	710
Figure 178 – Timing model with RR = 4 .....	710
Figure 179 – Calculation principle for a cycle.....	718
Figure 180 – Calculation principle for the minimum YellowTime .....	719
Figure 181 – Example IPG behavior of an ideal end station component in case of bursts .....	751
Figure 182 – Example IPG behavior of an end station component in case of bursts .....	752
Figure 183 – Detection of dropped frames – appear.....	761
Figure 184 – Detection of dropped frames – disappear .....	761
Figure 185 – Definition of the reserved interval.....	778
Figure 186 – Toplevel view of the PLL window.....	781
Figure 187 – Definition of PLL window .....	781
Figure 188 – Toplevel view of the time PLL window .....	783
Figure 189 – Definition of time PLL window .....	784
Figure 190 – Detection of DFP late error – appear and disappear .....	794
Figure 191 – MediaRedundancyWatchDog expired – appear and disappear .....	795
Figure 192 – EndPoint1 and Endpoint2 scheme – above and below.....	798
Figure 193 – EndPoint1 and Endpoint2 scheme – left and right.....	798
Figure 194 – Relationship among Protocol Machines .....	816
Figure 195 – State transition diagram of ALPMI .....	841
Figure 196 – State transition diagram of ALPMR.....	845
Figure 197 – Scheme of the IO device CM.....	849
Figure 198 – State transition diagram of the IO device CM.....	851
Figure 199 – State transition diagram of CMDEV .....	855
Figure 200 – Scheme of the IO device CM – device access .....	860
Figure 201 – State transition diagram of CMDEV_DA.....	863
Figure 202 – State transition diagram of CMSU .....	867
Figure 203 – State transition diagram of CMIO .....	872
Figure 204 – State transition diagram of CMRS .....	875

Figure 205 – State transition diagram of CMWRR .....	878
Figure 206 – State transition diagram of CMRDR .....	883
Figure 207 – State transition diagram of CMSM .....	886
Figure 208 – State transition diagram of CMPBE .....	890
Figure 209 – State transition diagram of CMDMC .....	895
Figure 210 – State transition diagram of CMINA .....	899
Figure 211 – State transition diagram of CMRPC .....	904
Figure 212 – Intersection and residual amount using different ARUUID.ConfigIDs .....	912
Figure 213 – Intersection and removed amount using different ARUUID.ConfigIDs .....	912
Figure 214 – State transition diagram of CMSRL .....	914
Figure 215 – Single Input and single Output buffer of CMSRL .....	920
Figure 216 – Dynamic reconfiguration with CMSRL .....	921
Figure 217 – Alarm queue management of CMSRL .....	922
Figure 218 – Reporting System management of CMSRL .....	923
Figure 219 – Primary: Switchover time between two ARs of an ARset .....	923
Figure 220 – Backup: Switchover time between two ARs of an ARset .....	924
Figure 221 – State transition diagram of CMSRL_AL .....	926
Figure 222 – State transition diagram of CMRSI .....	931
Figure 223 – Scheme of the IO controller CM .....	935
Figure 224 – State transition diagram of the IO controller CM .....	937
Figure 225 – State transition diagram of CMCTL .....	941
Figure 226 – State transition diagram of CTLSM .....	949
Figure 227 – State transition diagram of CTLIO .....	951
Figure 228 – State transition diagram of CTRLDI .....	955
Figure 229 – State transition diagram of CTRLDR .....	958
Figure 230 – State transition diagram of CTRLRPC .....	962
Figure 231 – State transition diagram of CTLSU .....	967
Figure 232 – State transition diagram of CTLWRI .....	973
Figure 233 – State transition diagram of CTLWRR .....	978
Figure 234 – State transition diagram of CTLPBE .....	981
Figure 235 – State transition diagram of CTLDINA .....	986
Figure 236 – Automatic NameOfStation assignment .....	992
Figure 237 – State transition diagram of CTLSRL .....	994
Figure 238 – Input and Output buffer of CTLSRL .....	998
Figure 239 – Input and Output buffer with dynamic reconfiguration .....	998
Figure 240 – Alarm queue management of CTLSRL .....	999
Figure 241 – Alarm queue management with dynamic reconfiguration .....	999
Figure 242 – State transition diagram of CTLSC .....	1001
Figure 243 – State transition diagram of CTRLSI .....	1006
Figure 244 – State transition diagram of CTLINA .....	1010
Figure 245 – Scheme of a station hosting CIM and NME .....	1014
Figure 246 – Scheme of the station hosting CIM and Query Stream .....	1014
Figure 247 – Scheme of a station hosting CIM only .....	1015

Figure 248 – State transition diagram of NME .....	1019
Figure 249 – State transition diagram of TDE.....	1025
Figure 250 – State transition diagram of PCE .....	1028
Figure 251 – State transition diagram of NCE .....	1032
Figure 252 – State transition diagram of NUE .....	1036
Figure 253 – State transition diagram of BNME.....	1042
Figure 254 – State transition diagram of NMEINA .....	1045
Figure A.1 – Establishing of an AR using RT_CLASS_1, RT_CLASS_2 or RT_CLASS_3 (Initial connection monitoring w/o RT).....	1090
Figure A.2 – Establishing of an AR using RT_CLASS_1, RT_CLASS_2 or RT_CLASS_3 (Connection monitoring with RT) .....	1091
Figure A.3 – Principle of the data evaluation during startup (RED channel establishment delayed) .....	1092
Figure A.4 – Principle of the data evaluation during startup (RED channel establishment immediately).....	1093
Figure A.5 – Principle of the data evaluation during startup (Special case: Isochronous mode application) .....	1094
Figure A.6 – Establishing of an AR using RSI .....	1095
Figure A.7 – Establishing of an AR using Streams and isochronous mode application.....	1096
Figure A.8 – Startup of Alarm transmitter and receiver without System Redundancy .....	1097
Figure A.9 – Startup of Alarm transmitter and receiver with System Redundancy .....	1098
Figure A.10 – Startup of Alarm transmitter and receiver during a PrmBegin / PrmEnd / ApplRdy sequence .....	1099
Figure A.11 – Time-aware systems path establishment.....	1100
Figure B.1 – Establishing of an AR using RT_CLASS_3 AR with startup mode “Legacy” ...	1102
Figure B.2 – Establishing of an AR using RT_CLASS_1, 2 or UDP AR with startup mode “Legacy” .....	1103
Figure C.1 – Establishing of a device access AR .....	1104
Figure C.2 – Establishing of a device access AR using RSI .....	1105
Figure D.1 – Accelerated establishing of an IOAR without error .....	1107
Figure D.2 – Accelerated establishing of an IOAR with “late error” .....	1108
Figure E.1 – Establishing of an IOAR using fast startup .....	1110
Figure F.1 – Example of upload from storage.....	1111
Figure F.2 – Example of retrieval from storage.....	1112
Figure G.1 – Application queues to implement reduction ratio .....	1114
Figure G.2 – Application queue to implement phases.....	1115
Figure H.1 – Overview of the IO controller state machines .....	1117
Figure H.2 – Overview of the IO device state machines .....	1117
Figure H.3 – Overview of the Network Management Entity state machines.....	1118
Figure H.4 – Overview of the common state machines .....	1118
Figure I.1 – Level model for synchronization master hierarchy .....	1119
Figure I.2 – Two level variant of the synchronization master hierarchy.....	1120
Figure J.1 – Devices built up in a linear structure.....	1121
Figure J.2 – Propagation of frames in linear transmit direction .....	1121
Figure J.3 – Propagation of a frames in receive direction .....	1122

Figure K.1 – Overview of time constraints for bandwidth allocation .....	1123
Figure K.2 – Calculation of the length of a RED period .....	1123
Figure K.3 – Calculation of the length of a GREEN period.....	1124
Figure L.1 – IEEE Std 802.3 definition .....	1125
Figure L.2 – Minimization of bridge delay.....	1125
Figure M.1 – Dynamic frame packing .....	1127
Figure M.2 – Dynamic frame packing – truncation of outputs .....	1128
Figure M.3 – Dynamic frame packing – concatenation of inputs .....	1128
Figure M.4 – End node mode .....	1129
Figure M.5 – DFPPeed definition.....	1129
Figure N.1 – Principle of fragmentation .....	1131
Figure N.2 – Protocol elements of fragments .....	1131
Figure N.3 – Bandwidth allocation using fragmentation .....	1132
Figure N.4 – Guardian for a fragmentation domain.....	1132
Figure O.1 – Principle of seamless media redundancy – IOCR.....	1133
Figure O.2 – Principle of seamless media redundancy – MCR .....	1134
Figure O.3 – Principle of seamless media redundancy – Line.....	1134
Figure P.1 – Generating the FrameSendOffset for a RED_RELAY without forwarding information in PDIRFrameData .....	1135
Figure Q.1 – Scheme of a 2-port switch .....	1138
Figure Q.2 – Scheme of 2-ports .....	1138
Figure Q.3 – 2 pair Ethernet cables .....	1140
Figure Q.4 – 4 pair Ethernet cables .....	1140
Figure R.1 – PrmBegin, PrmEnd and ApplRdy procedure.....	1141
Figure W.1 – IEEE Std 802 structure used for statistic counters.....	1171
Figure W.2 – IEEE Std 802 summary for statistic counters.....	1172
Figure X.1 – Macro FragmentOf() .....	1176
Figure Y.1 – Cut through principle – empty .....	1177
Figure Y.2 – Cut through principle – delayed .....	1178
Figure Y.3 – Cut through principle – blocked.....	1178
Table 1 – One octet .....	76
Table 2 – Two subsequent octets.....	77
Table 3 – Four subsequent octets .....	77
Table 4 – Eight subsequent octets .....	78
Table 5 – Sixteen subsequent octets .....	78
Table 6 – State machine description elements .....	79
Table 7 – Description of state machine elements .....	79
Table 8 – Conventions used in state machines .....	80
Table 9 – Conventions for services used in state machines .....	81
Table 10 – IEEE Std 802.3 DLPDU syntax .....	83
Table 11 – IEEE Std 802.11 DLPDU syntax .....	84
Table 12 – IEEE Std 802.15.1 DLPDU syntax .....	85

Table 13 – Status .....	90
Table 14 – Time source .....	92
Table 15 – SourceAddress.....	95
Table 16 – Single port device.....	95
Table 17 – DCP_MulticastMACAdd for Identify .....	96
Table 18 – DCP_MulticastMACAdd for Hello.....	96
Table 19 – DCP_MulticastMACAdd range 1 .....	96
Table 20 – DCP_MulticastMACAdd range for filterable Identify .....	96
Table 21 – DCP_MulticastMACAdd range 2 .....	96
Table 22 – MulticastMACAdd range 1 .....	97
Table 23 – MulticastMACAdd range 2 .....	97
Table 24 – MulticastMACAdd range 3 .....	97
Table 25 – PTCP_MulticastMACAdd range 2 .....	97
Table 26 – PTCP_MulticastMACAdd range 3 .....	98
Table 27 – PTCP_MulticastMACAdd range 4 .....	98
Table 28 – PTCP_MulticastMACAdd range 5 .....	98
Table 29 – PTCP_MulticastMACAdd range 6 .....	98
Table 30 – PTCP_MulticastMACAdd range 7 .....	99
Table 31 – MulticastMACAdd range 8 .....	99
Table 32 – MulticastMACAdd range 9 .....	99
Table 33 – MulticastMACAdd range 10 .....	99
Table 34 – MulticastMACAdd range 11 .....	99
Table 35 – RT_CLASS_3 destination multicast address .....	100
Table 36 – RT_CLASS_3 invalid frame multicast address .....	101
Table 37 – Stream categories for RT_CLASS_STREAM .....	101
Table 38 – LT (Length/Type).....	102
Table 39 – TCI.VID .....	103
Table 40 – TCI.DEI .....	104
Table 41 – TCI.PCP for time-aware system.....	104
Table 42 – TCI.PCP for non-time-aware system.....	104
Table 43 – RTI.SequenceNumber .....	105
Table 44 – RTI.Reserved .....	105
Table 45 – FrameID range 1 .....	105
Table 46 – FrameID range 2 .....	105
Table 47 – FrameID range 3a .....	106
Table 48 – FrameID range 3b .....	106
Table 49 – FrameID range 4 .....	106
Table 50 – FrameID range 5 .....	106
Table 51 – FrameID range 6 .....	107
Table 52 – FrameID range 7 .....	107
Table 53 – FrameID range 8 .....	107
Table 54 – FrameID range 9 .....	108
Table 55 – FrameID range 10 .....	108

Table 56 – FrameID range 11 .....	108
Table 57 – FrameID range 12 .....	109
Table 58 – FrameID range 13 .....	109
Table 59 – FrameID range 14 .....	109
Table 60 – FragmentationFrameID.FragSequence .....	109
Table 61 – FragmentationFrameID.Constant.....	109
Table 62 – DCP APDU syntax.....	110
Table 63 – DCP substitutions.....	111
Table 64 – ServiceID .....	115
Table 65 – Destination MAC addresses used together with the Identify service.....	115
Table 66 – ServiceType.Selection .....	115
Table 67 – ServiceType.Reserved .....	116
Table 68 – ServiceType.Selection.....	116
Table 69 – ServiceType.Reserved_1.....	116
Table 70 – ServiceType.Response.....	116
Table 71 – ServiceType.Reserved_2.....	117
Table 72 – ResponseDelayFactor .....	117
Table 73 – ResponseDelayTime .....	118
Table 74 – ResponseDelayTimeout.....	119
Table 75 – List of options.....	119
Table 76 – List of suboptions for option IPOption .....	119
Table 77 – List of suboptions for option DevicePropertiesOption.....	120
Table 78 – List of suboptions for option DHCPOption.....	120
Table 79 – List of suboptions for option ControlOption .....	120
Table 80 – List of suboptions for option DeviceInitiativeOption.....	121
Table 81 – List of suboptions for option NMEDomainOption .....	121
Table 82 – List of suboptions for option AllSelectorOption .....	121
Table 83 – List of suboptions for option ManufacturerSpecificOption.....	121
Table 84 – SuboptionDHCP .....	123
Table 85 – Coding of DCPBlockLength in conjunction with SuboptionStart.....	124
Table 86 – Coding of DCPBlockLength in conjunction with SuboptionStop.....	124
Table 87 – Coding of DCPBlockLength in conjunction with SuboptionSignal .....	124
Table 88 – Coding of DCPBlockLength in conjunction with SuboptionFactoryReset .....	125
Table 89 – Alignment between FactoryReset and ResetToFactory .....	125
Table 90 – Coding of DCPBlockLength in conjunction with SuboptionResetToFactory .....	125
Table 91 – Meaning of the different ResetToFactory modes.....	126
Table 92 – Coding of DCPBlockLength in conjunction with SuboptionDeviceInitiative .....	126
Table 93 – Coding of DCPBlockLength .....	127
Table 94 – BlockQualifier with options IPOption, DevicePropertiesOption, DHCPOption and ManufacturerSpecificOption .....	128
Table 95 – BlockQualifier with option ControlOption and suboption SuboptionResetToFactory.....	128
Table 96 – BlockQualifier with option NMEDomainOption .....	129
Table 97 – BlockQualifier with other options .....	129



Table 98 – BlockError .....	130
Table 99 – BlockInfo for SuboptionIPParameter .....	130
Table 100 – Bit 1 and Bit 0 of BlockInfo for SuboptionIPParameter .....	131
Table 101 – Bit 7 of BlockInfo for SuboptionIPParameter .....	131
Table 102 – BlockInfo for all other suboptions.....	131
Table 103 – DeviceInitiativeValue .....	131
Table 104 – SignalValue .....	132
Table 105 – DeviceRoleDetails.IO Device .....	134
Table 106 – DeviceRoleDetails.IOcontroller .....	134
Table 107 – DeviceRoleDetails.IOMultiDevice .....	134
Table 108 – DeviceRoleDetails.IOSupervisor .....	135
Table 109 – IPAddress .....	135
Table 110 – Subnetmask .....	137
Table 111 – StandardGateway .....	138
Table 112 – Correlation between the subfields of IPSuite .....	139
Table 113 – MACAddress as client identifier .....	140
Table 114 – NameOfStation as client identifier.....	140
Table 115 – Arbitrary client identifier .....	140
Table 116 – DHCPParameterValue using DHCP Option 255 .....	141
Table 117 – StandardGatewayValue.StandardGateway .....	142
Table 118 – RsiPropertiesValue.....	142
Table 119 – NMEPrio.....	143
Table 120 – Remote primitives issued or received by DCPUCS .....	144
Table 121 – Local primitives issued or received by DCPUCS .....	144
Table 122 – DCPUCS state table .....	145
Table 123 – Functions, Macros, Timers and Variables used by the DCPUCS .....	148
Table 124 – Remote primitives issued or received by DCPUCR .....	148
Table 125 – Local primitives issued or received by DCPUCR.....	149
Table 126 – DCPUCR state table.....	149
Table 127 – Functions, Macros, Timers and Variables used by the DCPUCR.....	152
Table 128 – Return values for CheckAPDU.....	152
Table 129 – Remote primitives issued or received by DCPMCS .....	153
Table 130 – Local primitives issued or received by DCPMCS.....	154
Table 131 – DCPMCS state table.....	154
Table 132 – Functions used by the DCPMCS.....	156
Table 133 – Remote primitives issued or received by DCPMCR.....	157
Table 134 – Local primitives issued or received by DCPMCR .....	157
Table 135 – DCPMCR state table .....	158
Table 136 – Functions, Macros, Timers and Variables used by the DCPMCR .....	158
Table 137 – Remote primitives issued or received by DCPHMCS .....	159
Table 138 – Local primitives issued or received by DCPHMCS .....	159
Table 139 – DCPHMCS state table .....	160
Table 140 – Functions, Macros, Timers and Variables used by the DCPHMCS .....	161

Table 141 – Remote primitives issued or received by DCPHMCR .....	161
Table 142 – Local primitives issued or received by DCPHMCR .....	161
Table 143 – DCPHMCR state table .....	162
Table 144 – Functions, Macros, Timers and Variables used by the DCPHMCR .....	162
Table 145 – PTCP APDU syntax .....	163
Table 146 – PTCP substitutions .....	163
Table 147 – PTCP_TLVHeader.Type .....	164
Table 148 – PTCP_Delay10ns .....	165
Table 149 – PTCP_Delay1ns_Byte.Value .....	165
Table 150 – PTCP_Delay1ns .....	165
Table 151 – PTCP_Delay1ns_FUP .....	166
Table 152 – PTCP_SequenceID .....	166
Table 153 – PTCP_SubType for OUI (=00-0E-CF) .....	167
Table 154 – PTCP_Seconds .....	168
Table 155 – PTCP_NanoSeconds .....	168
Table 156 – PTCP_Flags.LeapSecond .....	168
Table 157 – Timescale correspondence between PTCP_EpochNumber, PTCP_Second, PTCP_Nanosecond, CycleCounter and SendClockFactor .....	169
Table 158 – PTCP_CurrentUTCOffset .....	169
Table 159 – PTCP_MasterPriority1.Priority for SyncID == 0 and SyncProperties.Role == 2 .....	170
Table 160 – PTCP_MasterPriority1.Priority for SyncID == 0 and SyncProperties.Role == 1 .....	170
Table 161 – PTCP_MasterPriority1.Level .....	170
Table 162 – PTCP_MasterPriority2 .....	171
Table 163 – PTCP_ClockClass for SyncID == 0 (working clock synchronization) .....	171
Table 164 – PTCP_ClockAccuracy .....	171
Table 165 – PTCP_ClockVariance .....	172
Table 166 – PTCP_T2PortRxDelay .....	172
Table 167 – PTCP_T3PortTxDelay .....	172
Table 168 – PTCP_T2TimeStamp .....	173
Table 169 – Remote primitives issued or received by DELAY_REQ .....	191
Table 170 – Local primitives issued or received by DELAY_REQ .....	191
Table 171 – DELAY_REQ state table .....	193
Table 172 – Functions, macros, timers and variables used by the DELAY_REQ .....	197
Table 173 – Remote primitives issued or received by DELAY_RSP .....	199
Table 174 – Local primitives issued or received by DELAY_RSP .....	199
Table 175 – DELAY_RSP state table .....	201
Table 176 – Functions, Macros, Timers and Variables used by the DELAY_RSP .....	203
Table 177 – Remote primitives issued or received by SYN_BMA .....	205
Table 178 – Local primitives issued or received by SYN_BMA .....	205
Table 179 – SYN_BMA state table .....	208
Table 180 – Functions, Macros, Timers and Variables used by the SYN_BMA .....	212
Table 181 – Remote primitives issued or received by SYN_MPSM .....	215

Table 182 – Local primitives issued or received by SYN_MPSM .....	215
Table 183 – SYN_MPSM state table .....	217
Table 184 – Functions, Macros, Timers and Variables used by the SYN_MPSM .....	220
Table 185 – Remote primitives issued or received by SYN_SPSM .....	221
Table 186 – Local primitives issued or received by SYN_SPSM .....	221
Table 187 – SYN_SPSM state table .....	223
Table 188 – Functions, Macros, Timers and Variables used by the SYN_SPSM .....	226
Table 189 – Truth table for one SyncID for receiving sync and follow up frames .....	227
Table 190 – Remote primitives issued or received by SYNC_RELAY .....	228
Table 191 – Local primitives issued or received by SYNC_RELAY .....	228
Table 192 – SYNC_RELAY state table .....	230
Table 193 – Functions, Macros, Timers and Variables used by the SYNC_RELAY .....	231
Table 194 – Truth table for one SyncID for receiving .....	233
Table 195 – Truth table for one SyncID for transmitting .....	234
Table 196 – Remote primitives issued or received by SCHEDULER .....	234
Table 197 – Local primitives issued or received by SCHEDULER .....	235
Table 198 – SCHEDULER state table .....	236
Table 199 – Functions, Macros, Timers and Variables used by the SCHEDULER .....	237
Table 200 – Truth table for RxPeriodChecker of one port .....	238
Table 201 – Truth table for TxPeriodChecker of one port .....	238
Table 202 – Alignment of terms to IEEE Std 802.1AS .....	239
Table 203 – Timescales .....	239
Table 204 – Timescale correspondence between GlobalTime, TAI and UTC .....	241
Table 205 – Timescale correspondence between WorkingClock, TAI and UTC .....	242
Table 206 – Conjunction between supported MRP_Role and default MRP_Prio .....	247
Table 207 – Extended forwarding rule .....	247
Table 208 – Managed Multicast MAC address .....	247
Table 209 – RTC APDU syntax .....	249
Table 210 – RTC substitutions .....	250
Table 211 – CycleCounter Difference .....	251
Table 212 – DataStatus.State .....	253
Table 213 – DataStatus.Redundancy in conjunction with DataStatus.State==Backup .....	254
Table 214 – DataStatus.Redundancy in conjunction with DataStatus.State==Primary .....	254
Table 215 – DataStatus.DataValid .....	254
Table 216 – DataStatus.ProviderState .....	254
Table 217 – DataStatus.StationProblemIndicator .....	255
Table 218 – DataStatus.Ignore of a frame .....	255
Table 219 – DataStatus.Ignore of a sub frame .....	255
Table 220 – TransferStatus for RT_CLASS_3 .....	256
Table 221 – SFPosition.Position .....	257
Table 222 – SFPosition.Reserved .....	257
Table 223 – SFDataLength .....	257
Table 224 – SFCycleCounter Difference .....	259

Table 225 – IOxS.Extension.....	259
Table 226 – IOxS.Instance.....	259
Table 227 – IOxS.DataState .....	260
Table 228 – APDU_Status of a PPM with subframe structure.....	265
Table 229 – Remote primitives issued or received by PPM .....	266
Table 230 – Local primitives issued or received by PPM.....	266
Table 231 – PPM state table .....	268
Table 232 – Functions, Macros, Timers and Variables used by the PPM.....	270
Table 233 – Truth table used by the PPM for TxOption for non-streams.....	270
Table 234 – Truth table used by the PPM for TxOption for streams.....	271
Table 235 – Remote primitives issued or received by CPM .....	272
Table 236 – Local primitives issued or received by CPM.....	272
Table 237 – CPM state table.....	274
Table 238 – Functions, Macros, Timers and Variables used by the CPM.....	277
Table 239 – Truth table used by the CPM for RxOption for non-streams .....	279
Table 240 – Truth table used by the CPM for RxOption for streams .....	279
Table 241 – Truth table for one frame using RT_CLASS_x .....	280
Table 242 – Truth table for one frame using RT_CLASS_UDP .....	280
Table 243 – Truth table for the C_SDU .....	280
Table 244 – Truth table for arranging Dht and data .....	281
Table 245 – Truth table for the Subframe – frame check.....	281
Table 246 – Truth table for the Subframe – sub frame check .....	281
Table 247 – Truth table for the Subframe – sub frame data check.....	282
Table 248 – Truth table for the Subframe – Dht and data .....	282
Table 249 – RTA APDU syntax .....	282
Table 250 – RTA substitutions .....	283
Table 251 – RSI APDU syntax .....	284
Table 252 – RSI substitutions .....	284
Table 253 – AlarmEndpoint in conjunction with PDUType.Version := 1.....	285
Table 254 – AlarmEndpoint in conjunction with PDUType.Version := 2.....	286
Table 255 – PDUType.Type with PDUType.Version := 1 .....	286
Table 256 – PDUType.Type with PDUType.Version := 2 .....	286
Table 257 – PDUType.Version.....	287
Table 258 – AddFlags.WindowSize in conjunction with PDUType.Version := 1.....	287
Table 259 – AddFlags.WindowSize in conjunction with PDUType.Version := 2.....	287
Table 260 – AddFlags.TACK in conjunction with PDUType.Version := 1.....	288
Table 261 – AddFlags.TACK in conjunction with PDUType.Version := 2.....	288
Table 262 – AddFlags.MoreFrag in conjunction with PDUType.Version := 1.....	288
Table 263 – AddFlags.MoreFrag in conjunction with PDUType.Version := 2.....	288
Table 264 – AddFlags.Notification in conjunction with PDUType.Version := 1 .....	289
Table 265 – AddFlags.Notification in conjunction with PDUType.Version := 2 .....	289
Table 266 – SendSeqNum in conjunction with PDUType.Version := 1 .....	289
Table 267 – SendSeqNum in conjunction with PDUType.Version := 2 .....	289

Table 268 – SendSeqNum and AckSeqNum start sequence in conjunction with PDUType.Version := 1 .....	290
Table 269 – SendSeqNum and AckSeqNum start sequence in conjunction with PDUType.Version := 2 .....	290
Table 270 – AckSeqNum in conjunction with PDUType.Version := 1 .....	291
Table 271 – AckSeqNum in conjunction with PDUType.Version := 2 .....	291
Table 272 – VarPartLen .....	291
Table 273 – FopnumOffset.Offset .....	292
Table 274 – FopnumOffset.OpNum .....	292
Table 275 – FopnumOffset.CallSequence .....	293
Table 276 – RspMaxLength .....	293
Table 277 – RsilInterface .....	293
Table 278 – Relationship between OpNum and RsilInterface .....	294
Table 279 – Remote primitives issued or received by APMS .....	298
Table 280 – Local primitives issued or received by APMS .....	299
Table 281 – APMS state table .....	300
Table 282 – Functions, Macros, Timers and Variables used by the APMS .....	303
Table 283 – Remote primitives issued or received by APMR .....	305
Table 284 – Local primitives issued or received by APMR .....	305
Table 285 – APMR state table .....	307
Table 286 – Functions, Macros, Timers and Variables used by the APMR .....	309
Table 287 – Remote primitives issued or received by RSII .....	309
Table 288 – Local primitives issued or received by RSII .....	310
Table 289 – RSII state table .....	311
Table 290 – Functions, Macros, Timers and Variables used by the RSII .....	317
Table 291 – Remote primitives issued or received by RSIIN .....	321
Table 292 – Local primitives issued or received by RSIIN .....	322
Table 293 – RSIIN state table .....	323
Table 294 – Functions, Macros, Timers and Variables used by the RSIIN .....	323
Table 295 – Remote primitives issued or received by RSIR .....	324
Table 296 – Local primitives issued or received by RSIR .....	324
Table 297 – RSIR state table .....	326
Table 298 – Functions, Macros, Timers and Variables used by the RSIR .....	331
Table 299 – Remote primitives issued or received by RSIRN .....	336
Table 300 – Local primitives issued or received by RSIRN .....	336
Table 301 – RSIRN state table .....	337
Table 302 – Functions, Macros, Timers and Variables used by the RSIRN .....	339
Table 303 – TCI.PCP vs. streams .....	340
Table 304 – Lower limit of fragments .....	343
Table 305 – FRAG APDU syntax .....	344
Table 306 – FRAG substitutions .....	344
Table 307 – FragDataLength .....	345
Table 308 – FragStatus.FragmentNumber .....	345
Table 309 – FragStatus.Reserved .....	345

Table 310 – FragStatus.MoreFollows .....	346
Table 311 – Remote primitives issued or received by FRAG_D .....	346
Table 312 – Local primitives issued or received by FRAG_D .....	346
Table 313 – FRAG_D state table (dynamic) .....	348
Table 314 – Functions, Macros, Timers and Variables used by the FRAG_D (dynamic) .....	349
Table 315 – Remote primitives issued or received by FRAG_S .....	350
Table 316 – Local primitives issued or received by FRAG_S .....	350
Table 317 – FRAG_S state table (static) .....	351
Table 318 – Functions, Macros, Timers and Variables used by the FRAG_S (static) .....	352
Table 319 – Remote primitives issued or received by DEFRAG .....	353
Table 320 – Local primitives issued or received by DEFRAG .....	353
Table 321 – DEFRAG state table .....	354
Table 322 – Functions, Macros, Timers and Variables used by the DEFRAG .....	355
Table 323 – Truth table for the DefragGuard – first fragment .....	355
Table 324 – Truth table for the DefragGuard – next fragment .....	356
Table 325 – Truth table for the DefragGuard – last fragment .....	356
Table 326 – RPC APDU syntax .....	357
Table 327 – RPC substitutions .....	357
Table 328 – RPCVersion .....	358
Table 329 – RPCPacketType .....	358
Table 330 – RPCFlags .....	359
Table 331 – RPCFlags2 .....	359
Table 332 – RPCDRep.Character- and IntegerEncoding .....	360
Table 333 – RPCDRep Octet 2 – Floating Point Representation .....	360
Table 334 – RPCObjectUUID.Data4 .....	361
Table 335 – RPCObjectUUID for devices .....	361
Table 336 – RPCInterfaceUUID for PNIO .....	362
Table 337 – RPCInterfaceUUID for the RPC endpoint mapper .....	362
Table 338 – RPCInterfaceVersion.Major .....	363
Table 339 – RPCInterfaceVersion.Minor .....	363
Table 340 – RPCOperationNmb .....	364
Table 341 – RPCOperationNmb for endpoint mapper .....	364
Table 342 – RPCVersionFack .....	365
Table 343 – RPCDataRepresentationUUID – defined value .....	366
Table 344 – RPCInquiryType .....	368
Table 345 – RPCEPMapStatus .....	370
Table 346 – Values of NCAFaultStatus .....	372
Table 347 – Values of NCARejectStatus .....	374
Table 348 – Remote primitives issued or received by RPC .....	374
Table 349 – Local primitives issued or received by RPC .....	375
Table 350 – LLDP APDU syntax .....	376
Table 351 – LLDP substitutions .....	377
Table 352 – LLDP_PNIO_SubType .....	378

Table 353 – PTCP_PortRxDelayLocal .....	379
Table 354 – PTCP_PortRxDelayRemote .....	379
Table 355 – PTCP_PortTxDelayLocal .....	379
Table 356 – PTCP_PortTxDelayRemote .....	379
Table 357 – CableDelayLocal .....	380
Table 358 – RTClass2_PortStatus.State .....	380
Table 359 – RTClass3_PortStatus.State .....	380
Table 360 – RTClass3_PortStatus.Fragmentation .....	381
Table 361 – RTClass3_PortStatus.PreambleLength .....	381
Table 362 – Truth table for shortening of the preamble .....	381
Table 363 – RTClass3_PortStatus.Optimized .....	382
Table 364 – MRRT_PortStatus.State .....	382
Table 365 – IRDataUUID .....	383
Table 366 – LLDP_RedOrangePeriodBegin.Offset .....	383
Table 367 – LLDP_RedOrangePeriodBegin.Valid .....	383
Table 368 – LLDP_OrangePeriodBegin.Offset .....	383
Table 369 – LLDP_OrangePeriodBegin.Valid .....	384
Table 370 – LLDP_GreenPeriodBegin.Offset .....	384
Table 371 – LLDP_GreenPeriodBegin.Valid .....	384
Table 372 – LLDP_LengthOfPeriod.Length .....	385
Table 373 – LLDP_LengthOfPeriod.Valid .....	385
Table 374 – LLDP_ChassisID in conjunction with MultipleInterfaceMode.NameOfDevice == 0 and NameOfStation .....	386
Table 375 – LLDP_ChassisID in conjunction with MultipleInterfaceMode.NameOfDevice == 1 .....	386
Table 376 – LLDP_PortID in conjunction with MultipleInterfaceMode.NameOfDevice .....	386
Table 377 – Traffic classes .....	391
Table 378 – Traffic class usage for time-aware system .....	392
Table 379 – Traffic class usage for non-time-aware system .....	393
Table 380 – Traffic class usage for engineering tools .....	393
Table 381 – TCBandwidth .....	398
Table 382 – Committed burst size .....	398
Table 383 – Committed information rate .....	398
Table 384 – Credit-based shaper parameters .....	399
Table 385 – Enhancements for scheduled traffic .....	400
Table 386 – Enhanced Transmission Selection .....	400
Table 387 – Transmission Selection .....	400
Table 388 – Traffic classes .....	401
Table 389 – Number of entries per SendClock per Ethernet interface at 10 Mbps .....	402
Table 390 – Number of entries per SendClock per Ethernet interface at 100 Mbps .....	402
Table 391 – Number of entries per SendClock per Ethernet interface at > 100 Mbps .....	402
Table 392 – SendClock and ReductionRatio .....	404
Table 393 – Queue usage – time-aware end station – without time-aware streams .....	407
Table 394 – Queue masking – time-aware end station – without time-aware streams .....	408

Table 395 – Queue usage – time-aware end station – with time-aware streams .....	409
Table 396 – Queue masking – time-aware end station – with time-aware streams.....	410
Table 397 – Queue usage – non-time-aware end station – without RT_CLASS_3 .....	411
Table 398 – Queue masking – non-time-aware end station – without RT_CLASS_3.....	412
Table 399 – Queue usage – non-time-aware end station – with RT_CLASS_3 .....	413
Table 400 – Queue masking – non-time-aware end station – with RT_CLASS_3.....	414
Table 401 – Selection of managed objects for ingress .....	418
Table 402 – Selection of managed objects for egress .....	418
Table 403 – Priority remapping at an ingress boundary port connected to a non-time-aware device according to this document.....	420
Table 404 – Priority remapping at a domain ingress boundary port .....	421
Table 405 – Priority remapping at a domain ingress boundary port .....	422
Table 406 – “Active Destination MAC and VLAN Stream identification” at a domain ingress boundary port .....	422
Table 407 – Number of FDB entries .....	423
Table 408 – Neighborhood for hashed entries.....	424
Table 409 – FDB attributes for “Non streams” .....	424
Table 410 – List of MAC address .....	425
Table 411 – Unicast FDB entries .....	426
Table 412 – Multicast FDB entries .....	427
Table 413 – Broadcast FDB entry .....	427
Table 414 – VID, FID and MSTID.....	428
Table 415 – Trees and FDBs .....	429
Table 416 – Number of stream FDB entries .....	429
Table 417 – Neighborhood for Stream entries.....	430
Table 418 – FDB attributes for “Streams”.....	430
Table 419 – Trees and FDBs .....	431
Table 420 – Traffic grouping .....	432
Table 421 – Ingress rate limiter / Flow meter parameter.....	432
Table 422 – Ingress rate limiter / Flow meter identifier .....	432
Table 423 – Flow classification / Flow meter .....	433
Table 424 – Flow classification and metering.....	435
Table 425 – Example values for flow classification and metering – (A) only .....	436
Table 426 – Example values for flow classification and metering – (A) and (B) .....	436
Table 427 – Flow classification and metering.....	439
Table 428 – Example values for flow classification and metering .....	440
Table 429 – Queues and TCI .....	440
Table 430 – MinimumFrameMemory for 10 Mbit/s (50 % @ 8 ms).....	443
Table 431 – MinimumFrameMemory for 100 Mbit/s (50 % @ 1 ms).....	443
Table 432 – MinimumFrameMemory for 1 Gbit/s (20 % @ 1 ms).....	443
Table 433 – MinimumFrameMemory for 2,5 Gbit/s (10 % @ 1 ms).....	444
Table 434 – MinimumFrameMemory for 5 Gbit/s (5 % @ 1 ms).....	444
Table 435 – MinimumFrameMemory for 10 Gbit/s (5 % @ 1 ms).....	444
Table 436 – Minimum Frame Buffer Memory for one egress port (time-aware system) .....	445



Table 437 – Minimum Frame Buffer Memory for one egress port (Non-time-aware system).....	447
Table 438 – Model selection .....	448
Table 439 – Queue usage – time-aware bridge – without queue masking.....	448
Table 440 – Queue usage – time-aware bridge – with queue masking .....	449
Table 441 – Queue usage – non-time-aware bridge – without RT_CLASS_3.....	450
Table 442 – Queue usage – non-time-aware bridge – with RT_CLASS_3 .....	451
Table 443 – Preemption parameter .....	455
Table 444 – Media Types.....	457
Table 445 – Remote primitives issued or received by QPSM.....	471
Table 446 – Local primitives issued or received by QPSM .....	471
Table 447 – QPSM state table .....	472
Table 448 – Functions, Macros, Timers and Variables used by the QPSM .....	473
Table 449 – QPSM Port truth table .....	475
Table 450 – QPSM Port ingress behavior .....	475
Table 451 – QPSM Port egress behavior .....	476
Table 452 – QPSM Port enable and disable behavior .....	476
Table 453 – Remote primitives issued or received by PPSM .....	476
Table 454 – Local primitives issued or received by PPSM.....	477
Table 455 – PPSM state table.....	478
Table 456 – Functions, Macros, Timers and Variables used by the PPSM.....	478
Table 457 – PPSM truth table .....	478
Table 458 – Remote primitives issued or received by MAC_RELAY .....	479
Table 459 – Local primitives issued or received by MAC_RELAY.....	480
Table 460 – Functions, Macros, Timers and Variables used by the MAC_RELAY.....	480
Table 461 – Remote primitives issued or received by RTC3PSM .....	481
Table 462 – Local primitives issued or received by RTC3PSM .....	481
Table 463 – RTC3PSM state table .....	482
Table 464 – Functions, Macros, Timers and Variables used by the RTC3PSM .....	483
Table 465 – Truth table for the RTC3PSM .....	484
Table 466 – RXBeginEndAssignment and TXBeginEndAssignment.....	485
Table 467 – Event function table.....	486
Table 468 – Remote primitives issued or received by RED_RELAY .....	486
Table 469 – Local primitives issued or received by RED_RELAY .....	487
Table 470 – RED_RELAY state table .....	488
Table 471 – Functions, Macros, Timers and Variables used by the RED_RELAY .....	489
Table 472 – Truth table for the RedGuard with full check .....	489
Table 473 – Truth table for the RedGuard with reduced check .....	490
Table 474 – Truth table for the RedGuard with minimal check.....	490
Table 475 – Remote primitives issued or received by DFP_RELAY .....	492
Table 476 – Local primitives issued or received by DFP_RELAY .....	493
Table 477 – DFP_RELAY state table .....	494
Table 478 – Functions, Macros, Timers and Variables used by the DFP_RELAY .....	494

Table 479 – Truth table for the DFPGuard .....	495
Table 480 – Remote primitives issued or received by DFP_RELAY_INBOUND .....	495
Table 481 – Local primitives issued or received by DFP_RELAY_INBOUND .....	496
Table 482 – DFP_RELAY_INBOUND state table.....	497
Table 483 – Functions, Macros, Timers and Variables used by the DFP_RELAY_INBOUND .....	497
Table 484 – Truth table for the InboundGuard – frame check.....	498
Table 485 – Truth table for the InboundGuard – subframe check .....	498
Table 486 – Truth table for the InboundGuard – subframe data check.....	498
Table 487 – Truth table for the InboundGuard – full check .....	499
Table 488 – Remote primitives issued or received by DFP_RELAY_IN_STORAGE.....	499
Table 489 – Local primitives issued or received by DFP_RELAY_IN_STORAGE.....	500
Table 490 – DFP_RELAY_IN_STORAGE state table .....	501
Table 491 – Functions, Macros, Timers and Variables used by the DFP_RELAY_IN_STORAGE .....	502
Table 492 – Remote primitives issued or received by DFP_RELAY_OUTBOUND .....	503
Table 493 – Local primitives issued or received by DFP_RELAY_OUTBOUND .....	504
Table 494 – APDU_Status used if frame is shortened .....	505
Table 495 – DFP_RELAY_OUTBOUND state table .....	505
Table 496 – Functions, Macros, Timers and Variables used by the DFP_RELAY_OUTBOUND.....	506
Table 497 – Truth table for the OutboundGuard – frame check .....	507
Table 498 – Truth table for the OutboundGuard – subframe check.....	507
Table 499 – Remote primitives issued or received by MUX .....	508
Table 500 – Local primitives issued or received by MUX.....	508
Table 501 – MUX state table.....	509
Table 502 – Functions, Macros, Timers and Variables used by MUX.....	511
Table 503 – Truth table for FrameSizeFits .....	511
Table 504 – Truth table for StateChecker.....	512
Table 505 – Remote primitives issued or received by DEMUX .....	512
Table 506 – Local primitives issued or received by DEMUX .....	513
Table 507 – DEMUX state table .....	514
Table 508 – Functions, Macros, Timers and Variables used by the DEMUX.....	516
Table 509 – IP/UDP APDU syntax .....	516
Table 510 – IP/UDP substitutions .....	517
Table 511 – UDP_SrcPort.....	518
Table 512 – UDP_DstPort.....	518
Table 513 – IP_DstIPAddress .....	518
Table 514 – IP Multicast DstIPAddress according to IETF RFC 2365.....	519
Table 515 – IP_DifferentiatedServices.DSCP.....	519
Table 516 – IP_DifferentiatedServices.ECN.....	520
Table 517 – Remote primitives issued or received by ACCM.....	521
Table 518 – Local primitives issued or received by ACCM .....	521
Table 519 – ACCM state table .....	522

Table 520 – Functions, Macros, Timers and Variables used by the ACCM .....	522
Table 521 – Remote primitives issued or received by DNS .....	523
Table 522 – Local primitives issued or received by DNS .....	523
Table 523 – Functions, Macros, Timers and Variables used by the DNS .....	523
Table 524 – Remote primitives issued or received by DHCP .....	524
Table 525 – Local primitives issued or received by machines.....	524
Table 526 – DHCP state table.....	525
Table 527 – Functions, Macros, Timers and Variables used by the DHCP.....	526
Table 528 – Return values of macro CheckAPDU .....	526
Table 529 – SNMP service overview .....	527
Table 530 – List of supported IETF RFC 1213-MIB objects .....	528
Table 531 – Enterprise number .....	528
Table 532 – Cross reference – MIBs .....	528
Table 533 – Cross reference – PDPortDataAdjust.....	528
Table 534 – Remote primitives issued or received by LMPM.....	534
Table 535 – Local primitives issued or received by LMPM .....	536
Table 536 – LMPM state table .....	537
Table 537 – Functions, Macros, Timers and Variables used by the LMPM .....	540
Table 538 – IO APDU substitutions .....	541
Table 539 – IO APDU substitutions for CIM .....	564
Table 540 – IO APDU substitutions for UNI.....	566
Table 541 – IO APDU substitutions for security.....	567
Table 542 – IO APDU substitutions for CIM services.....	567
Table 543 – BlockType .....	568
Table 544 – BlockLength .....	585
Table 545 – BlockVersionHigh .....	585
Table 546 – BlockVersionLow.....	585
Table 547 – AlarmType.....	586
Table 548 – AlarmSpecifier.SequenceNumber .....	589
Table 549 – AlarmSpecifier.SequenceNumber Difference .....	590
Table 550 – AlarmSpecifier.ChannelDiagnosis.....	590
Table 551 – AlarmSpecifier.ManufacturerSpecificDiagnosis .....	590
Table 552 – AlarmSpecifier.SubmoduleDiagnosisState .....	591
Table 553 – AlarmSpecifier.ARDiagnosticsState.....	591
Table 554 – API.....	592
Table 555 – SlotNumber .....	592
Table 556 – SubslotNumber.....	593
Table 557 – Index range .....	595
Table 558 – Expression 1 (subslot specific) .....	595
Table 559 – Expression 2 (slot specific).....	595
Table 560 – Expression 3 (AR specific).....	596
Table 561 – Expression 4 (API specific).....	596
Table 562 – Expression 5 (device specific) .....	596

Table 563 – Grouping of DiagnosisData.....	596
Table 564 – SecurityControlRole.....	597
Table 565 – AccessControlRole .....	597
Table 566 – Index (user specific) .....	598
Table 567 – Index (subslot specific).....	599
Table 568 – Index (slot specific) .....	605
Table 569 – Index (AR specific) .....	606
Table 570 – Index (API specific) .....	608
Table 571 – Index (device specific).....	609
Table 572 – RecordDataLength .....	613
Table 573 – ARType .....	613
Table 574 – IOCRMulticastMACAdd using RT_CLASS_UDP.....	614
Table 575 – IOCRMulticastMACAdd using RT_CLASS_x.....	615
Table 576 – Type 10 OUI.....	615
Table 577 – ARProperties.State.....	616
Table 578 – ARProperties.SupervisorTakeoverAllowed.....	616
Table 579 – ARProperties.ParameterizationServer .....	616
Table 580 – ARProperties.DeviceAccess .....	616
Table 581 – ARProperties.CompanionAR.....	617
Table 582 – ARProperties.AcknowledgeCompanionAR .....	617
Table 583 – ARProperties.RejectDCPsetRequests.....	617
Table 584 – ARProperties.TimeAwareSystem .....	618
Table 585 – ARProperties.CombinedObjectContainer .....	618
Table 586 – ARProperties.StartupMode .....	618
Table 587 – ARProperties.PullModuleAlarmAllowed.....	618
Table 588 – IOCRProperties.RTClass .....	619
Table 589 – IOCRTagHeader.IOCRVLANID .....	620
Table 590 – IOCRTagHeader.IOUserPriority.....	620
Table 591 – IOCRType .....	621
Table 592 – CMInitiatorActivityTimeoutFactor with ARProperties.DeviceAccess == 0.....	621
Table 593 – CMInitiatorActivityTimeoutFactor with ARProperties.DeviceAccess == 1 or ARProperties.StartupMode == Advanced .....	621
Table 594 – CMInitiatorTriggerTimeoutFactor .....	622
Table 595 – IODataObjectFrameOffset .....	623
Table 596 – IOCSFrameOffset.....	623
Table 597 – LengthIOCS.....	623
Table 598 – LengthIOPS.....	624
Table 599 – LengthData.....	624
Table 600 – AlarmCRProperties.Priority.....	624
Table 601 – AlarmCRProperties.Transport.....	625
Table 602 – AlarmCRTagHeaderHigh.AlarmCRVLANID .....	625
Table 603 – AlarmCRTagHeaderHigh.AlarmUserPriority .....	625
Table 604 – AlarmCRTagHeaderLow.AlarmCRVLANID .....	626

Table 605 – AlarmCRTagHeaderLow.AlarmUserPriority .....	626
Table 606 – AlarmSequenceNumber .....	626
Table 607 – AlarmCRType .....	626
Table 608 – RTATimeoutFactor .....	627
Table 609 – RTARetries.....	627
Table 610 – PROFINETIOConstantValue .....	628
Table 611 – PROFINETIOConstantValue.Data1 .....	628
Table 612 – AddressResolutionProperties.Protocol.....	628
Table 613 – AddressResolutionProperties.Factor.....	629
Table 614 – MCITimeoutFactor .....	629
Table 615 – InstanceLow and InstanceHigh .....	630
Table 616 – InstanceHigh .....	630
Table 617 – DeviceIDLow and DeviceIDHigh .....	630
Table 618 – VendorIDLow and VendorIDHigh .....	631
Table 619 – ModuleIdentNumber .....	631
Table 620 – SubmoduleIdentNumber .....	632
Table 621 – ARUUID .....	633
Table 622 – ARUUID in conjunction with ARTYPE==IOCARSR .....	633
Table 623 – Conjunction between ARUUID.Arnumber and Endpoint1 or Endpoint2.....	633
Table 624 – ARUUID.ConfigID generation rule.....	634
Table 625 – TargetARUUID .....	634
Table 626 – AdditionalValue1 and AdditionalValue2 .....	634
Table 627 – ControlBlockProperties in conjunction with ControlCommand.ApplicationReady .....	634
Table 628 – ControlBlockProperties in conjunction with the other values of the field ControlCommand .....	634
Table 629 – ControlCommand.PrmEnd .....	635
Table 630 – ControlCommand.ApplicationReady.....	635
Table 631 – ControlCommand.Release .....	635
Table 632 – ControlCommand.Done .....	635
Table 633 – ControlCommand.ReadyForCompanion .....	636
Table 634 – ControlCommand.ReadyForRT_CLASS_3 .....	636
Table 635 – ControlCommand.PrmBegin .....	636
Table 636 – DataDescription.Type .....	636
Table 637 – Values of DataLength .....	637
Table 638 – Values of SendClockFactor with time-base 31,25 $\mu$ s .....	637
Table 639 – Values of SendClockFactor with time-base 25 $\mu$ s .....	638
Table 640 – Frame size vs. SendClockFactor .....	638
Table 641 – Values of ReductionRatio for RT_CLASS_1, RT_CLASS_2, and RT_CLASS_STREAM .....	639
Table 642 – Values of ReductionRatio for RT_CLASS_3 and SendClockFactor $\geq$ 8.....	640
Table 643 – Values of ReductionRatio for RT_CLASS_3 and SendClockFactor $<$ 8 .....	640
Table 644 – Values of ReductionRatio in conjunction with a non-power of 2 SendClockFactor .....	640

Table 645 – Values of ReductionRatio for RT_CLASS_UDP .....	640
Table 646 – Values of Phase .....	641
Table 647 – Values of Sequence .....	641
Table 648 – Data-RTC-PDUs – DataHoldFactor of a frame .....	642
Table 649 – UDP-RTC-PDUs – DataHoldFactor of a frame .....	642
Table 650 – DataHoldFactor of a Subframe .....	642
Table 651 – Values of FrameSendOffset.....	643
Table 652 – ModuleState .....	644
Table 653 – SubmoduleState.AddInfo .....	645
Table 654 – SubmoduleState.Advice.....	645
Table 655 – SubmoduleState.MaintenanceRequired .....	645
Table 656 – SubmoduleState.MaintenanceDemanded .....	645
Table 657 – SubmoduleState.Fault .....	646
Table 658 – SubmoduleState.ARInfo .....	646
Table 659 – SubmoduleState.IdentInfo .....	646
Table 660 – SubmoduleState.FormatIndicator.....	647
Table 661 – SubmoduleProperties.Type.....	647
Table 662 – SubmoduleProperties.SharedInput .....	647
Table 663 – SubmoduleProperties.ReduceInputSubmoduleDataLength .....	648
Table 664 – SubmoduleProperties.ReduceOutputSubmoduleDataLength.....	648
Table 665 – SubmoduleProperties.DiscardIOXS .....	648
Table 666 – SubstitutionMode.....	649
Table 667 – SubstituteActiveFlag.....	649
Table 668 – InitiatorUDPRTPort.....	650
Table 669 – ResponderUDPRTPort.....	650
Table 670 – InitiatorRPCServerPort .....	650
Table 671 – ResponderRPCServerPort.....	651
Table 672 – MaxAlarmDataLength .....	651
Table 673 – APStructureIdentifier with API==0 .....	652
Table 674 – APStructureIdentifier with API ≠ 0.....	652
Table 675 – ExtendedIdentificationVersionHigh .....	652
Table 676 – ExtendedIdentificationVersionLow .....	653
Table 677 – Values of ErrorCode for negative responses.....	653
Table 678 – Values of ErrorDecode .....	654
Table 679 – Coding of ErrorCode1 with ErrorDecode PNIORW .....	654
Table 680 – Coding of ErrorCode2 with ErrorDecode PNIORW .....	655
Table 681 – Coding of ErrorCode1 with ErrorDecode := PNIO .....	656
Table 682 – Values of ErrorCode2 for ErrorDecode := PNIO and ErrorCode1 (part 1).....	659
Table 683 – Values of ErrorCode2 for ErrorDecode := PNIO and ErrorCode1 (part 2 – alarm acknowledge).....	662
Table 684 – Values of ErrorCode2 for ErrorDecode := PNIO and ErrorCode1 (part 3 – machines).....	663
Table 685 – Values of ErrorCode2 for ErrorDecode := PNIO and ErrorCode1 (part 4 – IO controller) .....	665

Table 686 – Values of ErrorCode2 for ErrorDecode := PNIO and ErrorCode1 (part 5 – IO device) .....	667
Table 687 – Values of ErrorCode2 for ErrorDecode := PNIO and ErrorCode1 (part 6 – abort reasons) .....	668
Table 688 – Values of ErrorCode2 for ErrorDecode := PNIO and ErrorCode1 (part 7 – Reserved) .....	670
Table 689 – Coding of ErrorCode1 for ErrorDecode with the value ManufacturerSpecific .....	670
Table 690 – Coding of ErrorCode2 for ErrorDecode with the value ManufacturerSpecific .....	670
Table 691 – Visible characters .....	671
Table 692 – FactoryReset / ResetToFactory behavior (legacy from IEC 61158-6-3) .....	671
Table 693 – FactoryReset / ResetToFactory behavior (default without IEC 61158-6-3 history) .....	671
Table 694 – FactoryReset / ResetToFactory behavior if used in conjunction with functional safety submodules .....	671
Table 695 – IM_Hardware_Revision .....	672
Table 696 – IM_SWRevision_Functional_Enhancement .....	672
Table 697 – IM_SWRevision_Bug_Fix .....	672
Table 698 – IM_SWRevision_Internal_Change .....	672
Table 699 – IM_Revision_Counter .....	672
Table 700 – IM_Profile_ID .....	673
Table 701 – IM_Profile_Specific_Type in conjunction with IM_Profile_ID == 0x0000 .....	673
Table 702 – IM_Profile_Specific_Type in conjunction with IM_Profile_ID range 0x0001 – 0xF6FF .....	673
Table 703 – IM_Version_Major .....	674
Table 704 – IM_Version_Minor .....	674
Table 705 – IM_Supported.I&M1 .....	674
Table 706 – IM_Date with time .....	676
Table 707 – IM_Date without time .....	676
Table 708 – IM_Annotation .....	676
Table 709 – IM_OrderID .....	677
Table 710 – IM_UniqueIdentifier .....	677
Table 711 – UserStructureIdentifier .....	677
Table 712 – ChannelErrorType – range 1 .....	679
Table 713 – ChannelErrorType – range 2 .....	680
Table 714 – ChannelErrorType – range 3 .....	681
Table 715 – ChannelErrorType – range 4 .....	681
Table 716 – ChannelNumber .....	682
Table 717 – ChannelProperties.Type .....	683
Table 718 – ChannelProperties.Accumulative .....	683
Table 719 – ChannelProperties.Maintenance .....	683
Table 720 – Valid combinations within ChannelProperties .....	684
Table 721 – Valid combinations for AlarmNotification and RecordDataRead(DiagnosisData) .....	685
Table 722 – ChannelProperties.Specifier .....	686

Table 723 – ChannelProperties.Direction .....	686
Table 724 – ExtChannelErrorType .....	686
Table 725 – Allowed combinations of ChannelErrorType, ExtChannelErrorType, and ExtChannelAddValue .....	687
Table 726 – ExtChannelErrorType for ChannelErrorType 0 – 0xFF .....	687
Table 727 – Additional ExtChannelErrorType for ChannelErrorType 0x0F and 0x10 .....	687
Table 728 – ExtChannelErrorType for ChannelErrorType 0x0100 – 0x7FFF .....	688
Table 729 – ExtChannelErrorType for ChannelErrorType “Data transmission impossible” .....	688
Table 730 – ExtChannelErrorType for ChannelErrorType “Remote mismatch” .....	689
Table 731 – ExtChannelErrorType for ChannelErrorType “Media redundancy mismatch – Ring” .....	689
Table 732 – ExtChannelErrorType for ChannelErrorType “Media redundancy mismatch – Interconnection” .....	690
Table 733 – ExtChannelErrorType for ChannelErrorType “Sync mismatch” and for ChannelErrorType “Time mismatch” .....	691
Table 734 – ExtChannelErrorType for ChannelErrorType “Isochronous mode mismatch” .....	691
Table 735 – ExtChannelErrorType for ChannelErrorType “Multicast CR mismatch” .....	691
Table 736 – ExtChannelErrorType for ChannelErrorType “Fiber optic mismatch” .....	692
Table 737 – ExtChannelErrorType for ChannelErrorType “Network component function mismatch” .....	692
Table 738 – ExtChannelErrorType for ChannelErrorType “Dynamic Frame Packing function mismatch” .....	693
Table 739 – ExtChannelErrorType for ChannelErrorType “Media redundancy with planned duplication mismatch” .....	693
Table 740 – ExtChannelErrorType for ChannelErrorType “Multiple interface mismatch” .....	694
Table 741 – ExtChannelErrorType for ChannelErrorType “Power failure over Single Pair Ethernet” .....	694
Table 742 – Values for ExtChannelAddValue .....	695
Table 743 – Values for “Accumulative Info” .....	695
Table 744 – Values for ExtChannelErrorType “Parameter fault detail” .....	696
Table 745 – Values for ExtChannelAddValue.Index .....	696
Table 746 – Values for ExtChannelAddValue.Offset .....	696
Table 747 – Values for ExtChannelErrorType “Consistency fault detail” .....	696
Table 748 – Values for ExtChannelAddValue.Index .....	697
Table 749 – Values for “Fiber optic mismatch” – “Power Budget” .....	697
Table 750 – Values for “Network component function mismatch” – “Frame dropped” .....	697
Table 751 – Values for “Remote mismatch” – “Peer CableDelay mismatch” .....	698
Table 752 – Values for “Multiple interface mismatch” – “Conflicting MultipleInterfaceMode.NameOfDevice mode” .....	698
Table 753 – Values for “Multiple interface mismatch” – “Inactive StandardGateway” .....	698
Table 754 – Values for QualifiedChannelQualifier .....	699
Table 755 – Values for MaintenanceStatus .....	699
Table 756 – URRecordIndex .....	701
Table 757 – URRecordLength .....	701



Table 758 – iPar_Req_Header.....	701
Table 759 – Max_Segm_Size.....	701
Table 760 – Transfer_Index.....	702
Table 761 – Total_iPar_Size.....	702
Table 762 – NMEDomainUUID.....	702
Table 763 – NMENameUUID.....	703
Table 764 – NMEParameterUUID.....	703
Table 765 – NMENameAddressSubtype.....	704
Table 766 – StreamIdentification.....	704
Table 767 – StreamControl.Priority.....	704
Table 768 – StreamControl.Redundancy.....	705
Table 769 – StreamControl.Append.....	705
Table 770 – StreamControl.Dependency.....	705
Table 771 – Values of UpdateInterval.....	706
Table 772 – NetworkDeadline.....	707
Table 773 – Application Interval.....	707
Table 774 – ApplicationDeadline.....	708
Table 775 – PduSize.....	708
Table 776 – StreamTCI.VID.....	708
Table 777 – StreamTCI.PCP.....	708
Table 778 – MaxCalculatedLatency.....	709
Table 779 – StreamType.....	710
Table 780 – RxPort.....	711
Table 781 – NumberOfTxPortGroups.....	711
Table 782 – TxPortEntry.....	712
Table 783 – FrameDetails.SyncFrame in conjunction with FrameDataProperties.ForwardingMode=="Absolute mode".....	713
Table 784 – FrameDetails.SyncFrame in conjunction with FrameDataProperties.ForwardingMode=="Relative mode".....	713
Table 785 – FrameDetails.MeaningFrameSendOffset.....	714
Table 786 – FrameDetails.MediaRedundancyWatchDog.....	714
Table 787 – FrameDataProperties.ForwardingMode.....	714
Table 788 – FrameDataProperties.FastForwardingMulticastMACAdd.....	714
Table 789 – FrameDataProperties.FragmentationMode.....	715
Table 790 – MaxBridgeDelay.....	715
Table 791 – NumberOfPorts.....	715
Table 792 – MaxPortTxDelay.....	716
Table 793 – MaxPortRxDelay.....	716
Table 794 – MaxLineRxDelay.....	716
Table 795 – YellowTime.....	717
Table 796 – StartOfRedFrameID.....	719
Table 797 – EndOfRedFrameID.....	720
Table 798 – Dependencies of StartOfRedFrameID and EndOfRedFrameID.....	720
Table 799 – NumberOfAssignments.....	720

Table 800 – NumberOfPhases .....	721
Table 801 – AssignedValueForReservedBegin.....	721
Table 802 – AssignedValueForOrangeBegin .....	721
Table 803 – AssignedValueForReservedEnd .....	722
Table 804 – Values of RedOrangePeriodBegin .....	722
Table 805 – Dependencies of RedOrangePeriodBegin, OrangePeriodBegin and GreenPeriodBegin .....	722
Table 806 – Values of OrangePeriodBegin.....	723
Table 807 – Values of GreenPeriodBegin .....	723
Table 808 – MultipleInterfaceMode.NameOfDevice .....	723
Table 809 – NumberOfPeers in conjunction with PDPortDataCheck or CIMNetConfExpectedNetworkAttributes .....	724
Table 810 – NumberOfPeers in conjunction with PDPortDataReal or PDPortDataRealExtended.....	724
Table 811 – LineDelay.Value with LineDelay.FormatIndicator == 0 .....	725
Table 812 – LineDelay.Value with LineDelay.FormatIndicator == 1 .....	725
Table 813 – LineDelay.FormatIndicator.....	726
Table 814 – MAUType .....	726
Table 815 – MAUType with MAUTypeExtension.....	733
Table 816 – Valid combinations between MAUType and LinkState.....	733
Table 817 – MAUTypeExtensions and its corresponding MAUTypes .....	734
Table 818 – CheckSyncMode.CableDelay.....	735
Table 819 – CheckSyncMode.SyncMaster .....	735
Table 820 – MAUTypeMode.Check .....	735
Table 821 – DomainBoundaryIngress .....	736
Table 822 – DomainBoundaryEgress .....	736
Table 823 – DomainBoundaryAnnounce .....	736
Table 824 – MulticastBoundary .....	737
Table 825 – PeerToPeerBoundary .....	737
Table 826 – DCPBoundary.....	738
Table 827 – PreambleLength.Length.....	738
Table 828 – LinkState.Link .....	739
Table 829 – LinkState.Port .....	739
Table 830 – MediaType .....	740
Table 831 – NMEDomainVIDConfig.StreamHighVID .....	740
Table 832 – NMEDomainVIDConfig.StreamHighRedVID .....	740
Table 833 – NMEDomainVIDConfig.StreamLowVID .....	741
Table 834 – NMEDomainVIDConfig.StreamLowRedVID .....	741
Table 835 – NMEDomainVIDConfig.NonStreamVID .....	741
Table 836 – NMEDomainVIDConfig.NonStreamVIDB .....	741
Table 837 – NMEDomainVIDConfig.NonStreamVIDC.....	742
Table 838 – NMEDomainVIDConfig.NonStreamVIDD.....	742
Table 839 – NMEDomainQueueConfig.QueueID .....	742
Table 840 – NMEDomainQueueConfig.TciPcp .....	742

Table 841 – NMEDomainQueueConfig.Shaper.....	743
Table 842 – NMEDomainQueueConfig.PreemptionMode.....	743
Table 843 – NMEDomainQueueConfig.UnmaskTimeOffset.....	743
Table 844 – NMEDomainQueueConfig.MaskTimeOffset.....	743
Table 845 – PortQueueEgressRateLimiter.CIR.....	744
Table 846 – PortQueueEgressRateLimiter.CBS.....	744
Table 847 – PortQueueEgressRateLimiter.Envelope.....	744
Table 848 – PortQueueEgressRateLimiter.Rank.....	744
Table 849 – PortQueueEgressRateLimiter.QueueID.....	745
Table 850 – PortQueueEgressRateLimiter.Reserved.....	745
Table 851 – CIMStationPortStatus.PreemptionStatus.....	745
Table 852 – CIMStationPortStatus.BoundaryPortStatus.....	745
Table 853 – PortIngressRateLimiter.CIR.....	746
Table 854 – PortIngressRateLimiter.CBS.....	746
Table 855 – PortIngressRateLimiter.Envelope.....	746
Table 856 – PortIngressRateLimiter.Rank.....	747
Table 857 – GatingCycle.Valid.....	747
Table 858 – NumberOfQueues.....	747
Table 859 – TransferTimeTX.....	748
Table 860 – TransferTimeRX.....	748
Table 861 – PortCapabilities.TimeAware.....	748
Table 862 – PortCapabilities.Preemption.....	748
Table 863 – PortCapabilities.QueueMasking.....	749
Table 864 – ForwardingGroup.....	749
Table 865 – ForwardingDelay.Independent.....	749
Table 866 – ForwardingDelay.Dependent.....	750
Table 867 – MaxSupportedRecordSize.....	750
Table 868 – Traffic classes.....	750
Table 869 – TrafficClassTranslateEntry.VID.....	751
Table 870 – TrafficClassTranslateEntry.PCP.....	751
Table 871 – MinIPGBreakingPoint.....	752
Table 872 – MinIPGFrameSize.....	752
Table 873 – FrameSendOffsetDeviation.....	753
Table 874 – SupportedBurstSize.Frames.....	753
Table 875 – SupportedBurstSize.Octets.....	753
Table 876 – FDBCommand.....	754
Table 877 – StreamClass.....	754
Table 878 – SyncPortRole.....	754
Table 879 – CounterStatus.ifInOctets.....	755
Table 880 – CounterStatus.ifOutOctets.....	755
Table 881 – CounterStatus.ifInDiscards.....	755
Table 882 – CounterStatus.ifOutDiscards.....	755
Table 883 – CounterStatus.ifInErrors.....	755

Table 884 – CounterStatus.ifOutErrors .....	756
Table 885 – CounterStatus.Reserved .....	756
Table 886 – VendorBlockType .....	757
Table 887 – FiberOpticType .....	757
Table 888 – FiberOpticCableType .....	757
Table 889 – FiberOpticPowerBudgetType.Value .....	758
Table 890 – FiberOpticPowerBudgetType.CheckEnable .....	758
Table 891 – MaintenanceDemandedAdminStatus.Temperature .....	758
Table 892 – MaintenanceDemandedAdminStatus.TXBias .....	759
Table 893 – MaintenanceDemandedAdminStatus.TXPower .....	759
Table 894 – MaintenanceDemandedAdminStatus.RXPower .....	759
Table 895 – MaintenanceDemandedAdminStatus.Reserved .....	759
Table 896 – ErrorAdminStatus.TXFaultState .....	759
Table 897 – ErrorAdminStatus.RXLossState .....	760
Table 898 – ErrorAdminStatus.Reserved .....	760
Table 899 – NCDropBudgetType.Value .....	760
Table 900 – NCDropBudgetType.CheckEnable .....	760
Table 901 – MRP_Version .....	761
Table 902 – MRP_RingState .....	762
Table 903 – MRP_DomainUUID .....	762
Table 904 – MRP_LengthDomainName .....	762
Table 905 – MRP_DomainName .....	763
Table 906 – MRP_Role .....	763
Table 907 – MRP_Version .....	763
Table 908 – MRP_Prio .....	763
Table 909 – MRP_TOPchgT .....	764
Table 910 – MRP_TOPNRmax .....	764
Table 911 – MRP_TSTshortT .....	764
Table 912 – MRP_TSTdefaultT .....	765
Table 913 – MRP_TSTNRmax .....	765
Table 914 – MRP_LNKdownT .....	765
Table 915 – MRP_LNKupT .....	766
Table 916 – MRP_LNKNRmax .....	766
Table 917 – MRP_Check.MediaRedundancyManager .....	766
Table 918 – MRP_Check.MRP_DomainUUID .....	767
Table 919 – MRP_NumberOfEntries .....	767
Table 920 – MRP_Instance .....	767
Table 921 – MRPIC_LengthDomainName .....	767
Table 922 – MRPIC_DomainName .....	768
Table 923 – MRPIC_State .....	768
Table 924 – MRPIC_Role .....	768
Table 925 – MRPIC_DomainID .....	768
Table 926 – MRPIC_TOPchgT .....	769

Table 927 – MRPIC_TOPNRmax .....	769
Table 928 – MRPIC_LinkStatusChangeT .....	770
Table 929 – MRPIC_LinkStatusNRmax .....	770
Table 930 – MRPIC_LNKdownT .....	770
Table 931 – MRPIC_LNKupT .....	771
Table 932 – MRPIC_LNKNRmax .....	771
Table 933 – MRPIC_StartDelay .....	772
Table 934 – MRPIC_MICPosition .....	772
Table 935 – MRPIC_Check.MIM .....	772
Table 936 – MRPIC_Check.MRPIC_DomainID .....	773
Table 937 – SNMPControl.SNMPControl .....	773
Table 938 – CommunityNameLength .....	773
Table 939 – CommunityName .....	774
Table 940 – ElectricPowerDeviceVoltage.Voltage .....	774
Table 941 – ElectricPowerDeviceVoltage.Type .....	774
Table 942 – ElectricPowerPortVoltage.Voltage .....	775
Table 943 – ElectricPowerPortVoltage.Type .....	775
Table 944 – ElectricPowerPortCurrent.Current .....	775
Table 945 – ElectricPowerPortCurrent.CurrentLimit .....	776
Table 946 – SyncProperties.Role .....	776
Table 947 – SyncProperties.SyncID .....	777
Table 948 – ReservedIntervalBegin .....	777
Table 949 – ReservedIntervalEnd .....	777
Table 950 – Dependencies of ReservedIntervalBegin and ReservedIntervalEnd .....	777
Table 951 – SyncSendFactor .....	778
Table 952 – PTCPTimeoutFactor .....	779
Table 953 – PTCPTakeoverTimeoutFactor .....	779
Table 954 – PTCPMasterStartupTime .....	780
Table 955 – PLLWindow .....	780
Table 956 – TimeDomainUUID .....	782
Table 957 – TimeDomainNumber .....	782
Table 958 – TimePLLWindow .....	783
Table 959 – TimeMasterPriority1 .....	784
Table 960 – TimeMasterPriority2 .....	784
Table 961 – MessageIntervalFactor .....	785
Table 962 – MessageTimeoutFactor .....	785
Table 963 – TimeSyncProperties.Role .....	786
Table 964 – TimeIOBase .....	786
Table 965 – TimeDataCycle .....	786
Table 966 – TimeIOInput .....	787
Table 967 – TimeIOOutput .....	787
Table 968 – TimeIOInputValid .....	787
Table 969 – TimeIOOutputValid .....	788

Table 970 – ControllerApplicationCycleFactor.....	788
Table 971 – FSHelloMode.Mode .....	788
Table 972 – FSHelloInterval.....	789
Table 973 – FSHelloRetry.....	789
Table 974 – FSHelloDelay .....	790
Table 975 – FSPParameterMode.Mode .....	790
Table 976 – FSPParameterUUID.....	790
Table 977 – NumberOfSubframeBlocks .....	791
Table 978 – SFIOCRProperties.DistributedWatchDogFactor .....	791
Table 979 – SFIOCRProperties.RestartFactorForDistributedWD .....	792
Table 980 – SFIOCRProperties.DFPMMode .....	792
Table 981 – SFIOCRProperties.DFPDirection .....	792
Table 982 – SFIOCRProperties.DFPRedundantPathLayout.....	793
Table 983 – SFIOCRProperties.SFCRC16 .....	793
Table 984 – SubframeData.Position.....	793
Table 985 – SubframeData.DataLength .....	793
Table 986 – Event function table.....	794
Table 987 – SubframeOffset .....	795
Table 988 – Event function table.....	796
Table 989 – FromOffsetData.....	796
Table 990 – NextOffsetData.....	796
Table 991 – TotalSize .....	797
Table 992 – RedundancyInfo.EndPoint1 .....	797
Table 993 – RedundancyInfo.EndPoint2 .....	797
Table 994 – Valid combination of RedundancyInfo.EndPoint1 and RedundancyInfo.EndPoint2.....	797
Table 995 – SRProperties.InputValidOnBackupAR with SRProperties.Mode == 0 .....	798
Table 996 – SRProperties.InputValidOnBackupAR with SRProperties.Mode == 1 .....	798
Table 997 – SRProperties.Reserved_1 .....	799
Table 998 – SRProperties.Mode .....	799
Table 999 – RedundancyDataHoldFactor .....	799
Table 1000 – NumberOfEntries.....	800
Table 1001 – PE_OperationalMode.....	800
Table 1002 – AM_Location.Structure .....	800
Table 1003 – AM_Location.Levelx .....	801
Table 1004 – AM_Location.Reserved1.....	802
Table 1005 – AM_Location.BeginSubslotNumber .....	802
Table 1006 – AM_Location.EndSubslotNumber.....	802
Table 1007 – AM_Location.Reserved2.....	802
Table 1008 – AM_Location.Reserved3.....	802
Table 1009 – AM_Location.Reserved4.....	803
Table 1010 – AM_DeviceIdentification.DeviceSubID .....	803
Table 1011 – AM_DeviceIdentification.DeviceSubID for AM_DeviceIdentification.Organization := 0x0000 .....	804

Table 1012 – AM_DeviceIdentification.DeviceID .....	804
Table 1013 – AM_DeviceIdentification.VendorID .....	804
Table 1014 – AM_DeviceIdentification.Organization .....	804
Table 1015 – RS_Properties.AlarmTransport .....	805
Table 1016 – RS_BlockType used for events .....	806
Table 1017 – RS_BlockType used for adjust .....	806
Table 1018 – RS_BlockLength in conjunction with RS_EventBlock .....	807
Table 1019 – RS_BlockLength in conjunction with other blocks .....	807
Table 1020 – RS_Specifier.SequenceNumber .....	807
Table 1021 – RS_Specifier.Specifier .....	807
Table 1022 – RS_MinusError .....	808
Table 1023 – RS_PlusError .....	808
Table 1024 – RS_ExtensionBlockType .....	808
Table 1025 – RS_ExtensionBlockLength .....	808
Table 1026 – RS_MaxScanDelay .....	809
Table 1027 – RS_AdjustSpecifier.Incident .....	809
Table 1028 – RS_ReasonCode.Reason .....	809
Table 1029 – RS_ReasonCode.Detail .....	810
Table 1030 – RS_DigitalInputCurrentValue.Value .....	810
Table 1031 – RS_DomainIdentification .....	810
Table 1032 – RS_MasterIdentification .....	810
Table 1033 – ActualLocalTimeStamp .....	811
Table 1034 – LocalTimeStamp .....	811
Table 1035 – NumberOfLogEntries .....	811
Table 1036 – EntryDetail .....	811
Table 1037 – Time_TimeStamp .....	812
Table 1038 – Allowed combinations of PRAL_Reason, PRAL_ExtReason, and PRAL_ReasonAddValue .....	812
Table 1039 – PRAL_ChannelProperties.Reserved_1 .....	812
Table 1040 – PRAL_ChannelProperties.Accumulative .....	813
Table 1041 – PRAL_ChannelProperties.Reserved_2 .....	813
Table 1042 – PRAL_ChannelProperties.Direction .....	813
Table 1043 – Values for PRAL_Reason .....	813
Table 1044 – Values for PRAL_ExtReason .....	815
Table 1045 – Usage of PRAL_ReasonAddValue .....	815
Table 1046 – Values for PRAL_ReasonAddValue[0..3] .....	815
Table 1047 – Values for PRAL_ReasonAddValue[0] to [127] .....	815
Table 1048 – Primitives issued by AP-Context (FAL user) to FSPMPON .....	818
Table 1049 – Primitives issued by FSPMPON to AP-Context (FAL user) .....	818
Table 1050 – Primitives issued by AP-Context (FAL user) to FSPMDEV .....	819
Table 1051 – Primitives issued by FSPMDEV to AP-Context (FAL user) .....	821
Table 1052 – Functions, Macros, Timers and Variables used by the AP-Context (FAL user) to FSPMDEV .....	825

Table 1053 – Functions, Macros, Timers and Variables used by the FSPMDEV to AP-Context (FAL user) .....	826
Table 1054 – Primitives issued by AP-Context (FAL user) to FSPMCTL.....	828
Table 1055 – Primitives issued by FSPMCTL to AP-Context (FAL user).....	831
Table 1056 – Functions, Macros, Timers and Variables used by AP-Context (FAL user) to FSPMCTL.....	835
Table 1057 – Functions, Macros, Timers and Variables used by FSPMCTL to AP-Context (FAL user) .....	836
Table 1058 – Primitives issued by AP-Context (FAL user) to FSPMNME.....	839
Table 1059 – Primitives issued by FSPMNME to AP-Context (FAL user).....	839
Table 1060 – Remote primitives issued or received by ALPMI .....	840
Table 1061 – Local primitives issued or received by ALPMI .....	841
Table 1062 – ALPMI state table .....	842
Table 1063 – Functions, Macros, Timers and Variables used by ALPMI.....	843
Table 1064 – Remote primitives issued or received by ALPMR .....	844
Table 1065 – Local primitives issued or received by ALPMR.....	845
Table 1066 – ALPMR state table.....	846
Table 1067 – Functions, Macros, Timers and Variables used by ALPMR .....	848
Table 1068 – Remote primitives issued or received by CMDEV .....	852
Table 1069 – Local primitives issued or received by CMDEV .....	854
Table 1070 – CMDEV state table .....	857
Table 1071 – Functions, Macros, Timers and Variables used by CMDEV.....	860
Table 1072 – Remote primitives issued or received by CMDEV_DA.....	861
Table 1073 – Local primitives issued or received by CMDEV_DA.....	862
Table 1074 – CMDEV_DA state table .....	864
Table 1075 – Functions, Macros, Timers and Variables used by CMDEV_DA .....	864
Table 1076 – Remote primitives issued or received by CMSU.....	865
Table 1077 – Local primitives issued or received by CMSU .....	865
Table 1078 – CMSU state table .....	868
Table 1079 – Functions, Macros, Timers and Variables used by the CMSU .....	871
Table 1080 – Remote primitives issued or received by CMIO.....	871
Table 1081 – Local primitives issued or received by CMIO .....	871
Table 1082 – CMIO state table .....	873
Table 1083 – Functions used by the CMIO.....	874
Table 1084 – Remote primitives issued or received by CMRS.....	874
Table 1085 – Local primitives issued or received by CMRS .....	875
Table 1086 – CMRS state table .....	876
Table 1087 – Functions, Macros, Timers and Variables used by the CMRS .....	876
Table 1088 – Remote primitives issued or received by CMWRR .....	877
Table 1089 – Local primitives issued or received by CMWRR .....	877
Table 1090 – CMWRR state table .....	879
Table 1091 – Functions, Macros, Timers and Variables used by CMWRR.....	881
Table 1092 – Remote primitives issued or received by CMRDR .....	882
Table 1093 – Local primitives issued or received by CMRDR.....	883



Table 1094 – CMRDR state table.....	884
Table 1095 – Functions, Macros, Timers and Variables used by CMRDR.....	884
Table 1096 – Remote primitives issued or received by CMSM .....	885
Table 1097 – Local primitives issued or received by CMSM .....	886
Table 1098 – CMSM state table .....	887
Table 1099 – Functions, Macros, Timers and Variables used by the CMSM .....	888
Table 1100 – Remote primitives received by CMPBE.....	889
Table 1101 – Local primitives issued or received by CMPBE .....	889
Table 1102 – CMPBE state table .....	891
Table 1103 – Functions, Macros, Timers and Variables used by the CMPBE .....	893
Table 1104 – Remote primitives issued or received by CMDMC .....	893
Table 1105 – Local primitives issued or received by CMDMC .....	894
Table 1106 – CMDMC state table .....	896
Table 1107 – Functions, Macros, Timers and Variables used by the CMDMC .....	898
Table 1108 – Remote primitives issued or received by CMINA.....	898
Table 1109 – Local primitives issued or received by CMINA .....	899
Table 1110 – CMINA state table .....	900
Table 1111 – Functions, Macros, Timers and Variables used by the CMINA .....	901
Table 1112 – Return values of CheckDatabase.....	902
Table 1113 – Remote primitives issued or received by CMRPC .....	902
Table 1114 – Local primitives issued or received by CMRPC .....	904
Table 1115 – CMRPC state table .....	905
Table 1116 – Functions, Macros, Timers and Variables used by the CMRPC .....	909
Table 1117 – Return values of CheckRPC .....	911
Table 1118 – Remote primitives issued or received by CMSRL.....	913
Table 1119 – Local primitives issued or received by CMSRL .....	913
Table 1120 – CMSRL state table .....	915
Table 1121 – Functions, Macros, Timers and Variables used by the CMSRL .....	917
Table 1122 – Combinations of DataStatus for Output buffers .....	918
Table 1123 – Combinations of DataStatus for Input buffers.....	919
Table 1124 – Remote primitives issued or received by CMSRL_AL.....	925
Table 1125 – Local primitives issued or received by CMSRL_AL .....	925
Table 1126 – CMSRL_AL state table .....	927
Table 1127 – Functions, Macros, Timers and Variables used by the CMSRL_AL .....	928
Table 1128 – Remote primitives issued or received by CMRSI.....	929
Table 1129 – Local primitives issued or received by CMRSI .....	930
Table 1130 – CMRSI state table .....	931
Table 1131 – Functions, Macros, Timers and Variables used by the CMRSI .....	934
Table 1132 – Remote primitives issued or received by CMCTL .....	938
Table 1133 – Local primitives issued or received by CMCTL.....	939
Table 1134 – CMCTL state table.....	943
Table 1135 – Functions, Macros, Timers and Variables used by the CMCTL.....	947
Table 1136 – Remote primitives issued or received by CTLSM .....	947

Table 1137 – Local primitives issued or received by CTLSM.....	948
Table 1138 – CTLSM state table.....	949
Table 1139 – Functions, Macros, Timers and Variables used by the CTLSM.....	950
Table 1140 – Remote primitives issued or received by CTLIO.....	950
Table 1141 – Local primitives issued or received by CTLIO.....	951
Table 1142 – CTLIO state table.....	952
Table 1143 – Functions, Macros, Timers and Variables used by the CTLIO.....	953
Table 1144 – Remote primitives received by CTRLDI.....	954
Table 1145 – Local primitives issued or received by CTRLDI.....	955
Table 1146 – CTRLDI state table.....	956
Table 1147 – Functions, Macros, Timers and Variables used by CTRLDI.....	957
Table 1148 – Remote Primitives received by CTRLDR.....	957
Table 1149 – Local primitives issued or received by CTRLDR.....	958
Table 1150 – CTRLDR state table.....	958
Table 1151 – Functions, Macros, Timers and Variables used by CTRLDR.....	959
Table 1152 – Remote primitives received by CTRLRPC.....	959
Table 1153 – Local primitives issued or received by CTRLRPC.....	962
Table 1154 – CTRLRPC state table.....	963
Table 1155 – Functions, Macros, Timers and Variables used by the CTRLRPC.....	965
Table 1156 – Remote primitives issued or received by CTLSU.....	966
Table 1157 – Local Primitives issued or received by CTLSU.....	966
Table 1158 – CTLSU state table.....	968
Table 1159 – Functions, Macros, Timers and Variables used by the CTLSU.....	971
Table 1160 – Remote primitives issued or received by CTLWRI.....	971
Table 1161 – Local primitives issued or received by CTLWRI.....	972
Table 1162 – CTLWRI state table.....	974
Table 1163 – Functions, Macros, Timers and Variables used by CTLWRI.....	976
Table 1164 – Remote primitives issued or received by CTLWRR.....	977
Table 1165 – Local primitives issued or received by CTLWRR.....	977
Table 1166 – CTLWRR state table.....	978
Table 1167 – Functions, Macros, Timers and Variables used by CTLWRR.....	979
Table 1168 – Remote primitives issued or received by CTLPBE.....	979
Table 1169 – Local primitives issued or received by CTLPBE.....	980
Table 1170 – CTLPBE state table.....	982
Table 1171 – Functions, Macros, Timers and Variables used by CTLPBE.....	984
Table 1172 – Remote primitives issued or received by CTLDINA.....	984
Table 1173 – Local primitives issued or received by CTLDINA.....	985
Table 1174 – CTLDINA state table.....	987
Table 1175 – Functions, Macros, Timers and Variables used by the CTLDINA.....	990
Table 1176 – Remote primitives issued or received by CTLSRL.....	993
Table 1177 – Local primitives issued or received by CTLSRL.....	993
Table 1178 – CTLSRL state table.....	995
Table 1179 – Functions, Macros, Timers and Variables used by the CTLSRL.....	997

Table 1180 – Remote primitives issued or received by CTLSC.....	1000
Table 1181 – Local primitives issued or received by CTLSC .....	1000
Table 1182 – CTLSC state table .....	1002
Table 1183 – Functions, Macros, Timers and Variables used by CTLSC .....	1003
Table 1184 – Remote primitives received by CTLRSI.....	1003
Table 1185 – Local primitives issued or received by CTLRSI .....	1006
Table 1186 – CTLRSI state table .....	1006
Table 1187 – Functions, Macros, Timers and Variables used by the CTLRSI .....	1009
Table 1188 – Remote primitives issued or received by CTLINA .....	1010
Table 1189 – Local primitives issued or received by CTLINA .....	1010
Table 1190 – CTLINA state table .....	1011
Table 1191 – Functions, Macros, Timers and Variables used by the CTLINA .....	1012
Table 1192 – Return values of CheckDatabase.....	1013
Table 1193 – Remote primitives issued or received by NME .....	1016
Table 1194 – Local primitives issued or received by NME.....	1016
Table 1195 – NME state table.....	1020
Table 1196 – Functions, Macros, Timers and Variables used by NME.....	1024
Table 1197 – Remote primitives issued or received by TDE.....	1024
Table 1198 – Local primitives issued or received by TDE.....	1025
Table 1199 – TDE state table.....	1026
Table 1200 – Functions, Macros, Timers and Variables used by TDE .....	1027
Table 1201 – Remote primitives issued or received by PCE.....	1027
Table 1202 – Local primitives issued or received by PCE .....	1028
Table 1203 – PCE state table .....	1029
Table 1204 – Functions, Macros, Timers and Variables used by PCE .....	1031
Table 1205 – Remote primitives issued or received by NCE.....	1032
Table 1206 – Local primitives issued or received by NCE .....	1032
Table 1207 – NCE state table .....	1033
Table 1208 – Functions, Macros, Timers and Variables used by NCE .....	1034
Table 1209 – Remote primitives issued or received by NUE.....	1034
Table 1210 – Local primitives issued or received by NUE .....	1035
Table 1211 – NUE state table .....	1037
Table 1212 – Functions, Macros, Timers and Variables used by NUE .....	1041
Table 1213 – Remote primitives issued or received by BNME .....	1041
Table 1214 – Local primitives issued or received by BNME.....	1042
Table 1215 – BNME state table.....	1043
Table 1216 – Functions, Macros, Timers and Variables used by BNME .....	1043
Table 1217 – Remote primitives issued or received by NMEINA .....	1044
Table 1218 – Local primitives issued or received by NMEINA .....	1044
Table 1219 – NMEINA state table .....	1046
Table 1220 – Functions, Macros, Timers and Variables used by the NMEINA .....	1047
Table 1221 – Return values of CheckDatabase.....	1047
Table 1222 – ArgsLength check.....	1048

Table 1223 – Offset check .....	1049
Table 1224 – IODConnectReq block structure.....	1049
Table 1225 – ARBlockReq – request check .....	1050
Table 1226 – IOCRBlockReq – request check.....	1051
Table 1227 – AlarmCRBlockReq – request check .....	1056
Table 1228 – ExpectedSubmoduleBlockReq – request check .....	1057
Table 1229 – PrmServerBlock – request check .....	1058
Table 1230 – MCRBlockReq – request check.....	1058
Table 1231 – ARRPCBlockReq – request check .....	1059
Table 1232 – IRInfoBlock – request check .....	1060
Table 1233 – SRInfoBlock – request check.....	1060
Table 1234 – RSInfoBlock – request check.....	1061
Table 1235 – ArgsLength check.....	1061
Table 1236 – Offset check .....	1062
Table 1237 – ARBlockRes – response check .....	1062
Table 1238 – IOCRBlockRes – response check .....	1063
Table 1239 – AlarmCRBlockRes – response check.....	1064
Table 1240 – ModuleDiffBlock – response check .....	1064
Table 1241 – ARServerBlockRes – response check.....	1065
Table 1242 – ArgsLength check.....	1066
Table 1243 – Offset check .....	1066
Table 1244 – ControlBlockConnect(PrmEnd) – request check.....	1067
Table 1245 – ControlBlockPlug(PrmEnd) – request check.....	1067
Table 1246 – ControlBlockConnect(PrmBegin) – request check .....	1068
Table 1247 – SubmoduleListBlock – request check.....	1068
Table 1248 – ArgsLength check.....	1069
Table 1249 – Offset check .....	1069
Table 1250 – ControlBlockConnect – response check.....	1070
Table 1251 – ControlBlockPlug – response check.....	1070
Table 1252 – ControlBlockConnect(PrmBegin) – response check .....	1071
Table 1253 – ArgsLength check.....	1072
Table 1254 – ControlBlockConnect(ApplRdy) – request check .....	1072
Table 1255 – ControlBlockPlug(ApplRdy) – request check .....	1073
Table 1256 – ArgsLength check.....	1073
Table 1257 – ControlBlockConnect – response check.....	1074
Table 1258 – ControlBlockPlug – response check.....	1074
Table 1259 – ArgsLength check.....	1075
Table 1260 – ReleaseBlock – request check.....	1076
Table 1261 – ArgsLength check.....	1076
Table 1262 – ReleaseBlock – response check .....	1077
Table 1263 – ArgsLength check.....	1078
Table 1264 – Offset check .....	1078
Table 1265 – IODWriteReqHeader – request check .....	1079

Table 1266 – ArgsLength check.....	1079
Table 1267 – Offset check .....	1080
Table 1268 – IODWriteResHeader – response check.....	1080
Table 1269 – ArgsLength check.....	1081
Table 1270 – Offset check .....	1082
Table 1271 – ArgsLength check.....	1083
Table 1272 – Offset check .....	1083
Table 1273 – ArgsLength check.....	1084
Table 1274 – Offset check .....	1085
Table 1275 – IODReadReqHeader – request check .....	1085
Table 1276 – RecordDataReadQuery – request check .....	1086
Table 1277 – ArgsLength check.....	1086
Table 1278 – Offset check .....	1087
Table 1279 – IODReadResHeader – response check.....	1087
Table A.1 – Examples for the AR establishing.....	1089
Table A.2 – Startup of Alarm transmitter and receiver .....	1089
Table B.1 – Examples for compatible AR establishing.....	1101
Table L.1 – IEEE Std 802.3 cross reference.....	1125
Table Q.1 – Truth table .....	1139
Table Q.2 – “MAC/PHY configuration/status” with Auto-negotiation disabled.....	1139
Table Q.3 – “MAC/PHY configuration/status” with Auto-negotiation enabled .....	1139
Table Q.4 – Auto-negotiation support within “MAC/PHY configuration/status” .....	1139
Table Q.5 – Auto-negotiation settings .....	1140
Table S.1 – List of supported MIBs .....	1142
Table T.1 – Content of archive.....	1143
Table V.1 – Cross reference IEC 62439-2 “MRP MIB objects” (ring) .....	1167
Table V.2 – Cross reference IEC 62439-2 “Events, created by state machines” (ring).....	1167
Table V.3 – Cross reference IEC 62439-2 “MRM parameter”.....	1168
Table V.4 – Cross reference IEC 62439-2 “MRC parameter” .....	1168
Table V.5 – Cross reference IEC 62439-2 “MRP MIB objects” (interconnection).....	1168
Table V.6 – Cross reference IEC 62439-2 “Events, created by state machines” (interconnection).....	1169
Table V.7 – Cross reference IEC 62439-2 “MIM parameter” .....	1169
Table V.8 – Cross reference IEC 62439-2 “MIC parameter” .....	1169
Table W.1 – Meaning of numbers.....	1171
Table W.2 – Statistic counters – octets .....	1172
Table W.3 – Statistic counters – packets or frames.....	1172
Table W.4 – Statistic counters – errors .....	1173
Table W.5 – VLAN specific Statistic counters.....	1174
Table X.1 – RsiHeaderSize.....	1175
Table X.2 – Fragments of a Connect request.....	1175
Table X.3 – Fragments of a Connect response.....	1175
Table Y.1 – Cut through cases.....	1177

# 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 the IEC 61784-1 series and the IEC 61784-2 series.

IEC 61158-6-10 has been prepared by subcommittee 65C: Industrial networks, of IEC technical committee 65: Industrial-process measurement, control and automation. It is an International Standard.

This fifth edition cancels and replaces the fourth edition published in 2019. This edition constitutes a technical revision.

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

- a) integration of time-aware system basic functionality;
- b) integration of time-aware network functionality;
- c) integration of remote service interface functionality;
- d) integration of SFP diagnosis functionality;
- e) integration of media redundancy ring interconnection basic functionality.

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

Draft	Report on voting
65C/1204/FDIS	65C/1245/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.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at [www.iec.ch/members\\_experts/refdocs](http://www.iec.ch/members_experts/refdocs). The main document types developed by IEC are described in greater detail at [www.iec.ch/publications](http://www.iec.ch/publications).

A list of all the parts of the IEC 61158 series, 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 document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be:

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

**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 can work together in any combination.

The International Electrotechnical Commission (IEC) draws attention to the fact that it is claimed that compliance with this document may involve the use of a patent. IEC takes no position concerning the evidence, validity, and scope of this patent right.

The holder of these patent rights has assured IEC that s/he is willing to negotiate licences 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 the patent database available at <http://patents.iec.ch>.

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



## **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 a 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 document defines in an abstract way the externally visible behavior provided by the Type 10 fieldbus application layer in terms of:

- the abstract syntax defining the application layer protocol data units conveyed between communicating application entities,
- the transfer syntax defining the application layer protocol data units conveyed between communicating application entities,
- the application context state machine defining the application service behavior visible between communicating application entities, and
- 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:

- define the wire-representation of the service primitives defined in IEC 61158-5-10 and
- 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.

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

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

IEC 61158-2:2023, *Industrial communication networks – Fieldbus specifications – Part 2: Physical layer specification and service definition*

IEC 61158-5-10:2023, *Industrial communication networks – Fieldbus specifications – Part 5-10: 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 61158-6-10:2010<sup>1</sup>, *Industrial communication networks – Fieldbus specifications – Part 6-10: Application layer protocol specification – Type 10 elements*

IEC 62439-2:2021, *Industrial communication networks – High availability automation networks – Part 2: Media Redundancy Protocol (MRP)*

IEC TS 60079-47:2021, *Explosive atmospheres – Part 47: Equipment protection by 2-Wire Intrinsically Safe Ethernet concept (2-WISE)*

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 8822:1994, *Information technology – Open Systems Interconnection – Presentation service definition*

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

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

---

<sup>1</sup> This earlier edition is mentioned here and in the text for legacy purposes.

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 60559:2020, *Information technology – Microprocessor Systems – Floating-Point arithmetic*

ISO 8601-1:2019, *Date and time – Representations for information interchange – Part 1: Basic rules*

IEEE Std 802-2014, *IEEE Standard for Local and metropolitan area networks: Overview and Architecture*

IEEE Std 802.1AB-2016, *IEEE Standard for Local and metropolitan area networks: Station and Media Access Control Connectivity Discovery*

IEEE Std 802.1AC-2016, *IEEE Standard for Local and metropolitan area networks – Media Access Control (MAC) Service Definition*

IEEE Std 802.1AS-2020, *IEEE Standard for Local and metropolitan area networks – Timing and Synchronization for Time-Sensitive Applications*

IEEE Std 802.1CB-2017, *IEEE Standard for Local and metropolitan area networks – Frame Replication and Elimination for Reliability*

IEEE Std 802.1Q-2018, *IEEE Standard for Local and metropolitan area networks – Bridges and Bridged Networks*

IEEE Std 802.3-2018, *IEEE Standard for Ethernet*

IEEE Std 802.11-2020, *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*

IEEE Std 802.15.1-2005, *IEEE Standard for Information technology – Local and metropolitan area networks – Specific requirements – Part 15.1a: Wireless Medium Access Control (MAC) and Physical Layer (PHY) specifications for Wireless Personal Area Networks (WPAN)*

IETF RFC 768, J. Postel, "User Datagram Protocol", August 1980, available at <https://www.rfc-editor.org/info/rfc768> [viewed 2022-10-06]

IETF RFC 791, J. Postel, "Internet Protocol", September 1981, available at <https://www.rfc-editor.org/info/rfc791> [viewed 2022-10-06]

IETF RFC 792, J. Postel, "Internet Control Message Protocol", September 1981, available at <https://www.rfc-editor.org/info/rfc792> [viewed 2022-10-06]

IETF RFC 826, D. Plummer, "An Ethernet Address Resolution Protocol: Or Converting Network Protocol Addresses to 48.bit Ethernet Address for Transmission on Ethernet Hardware", November 1982, available at <https://www.rfc-editor.org/info/rfc826> [viewed 2022-10-06]

IETF RFC 1034, P.V. Mockapetris, "Domain names – concepts and facilities", November 1987, available at <https://www.rfc-editor.org/info/rfc1034> [viewed 2022-10-06]

IETF RFC 1213, K. McCloghrie, M. Rose, "Management Information Base for Network Management of TCP/IP-based internets: MIB-II", March 1991, available at <https://www.rfc-editor.org/info/rfc1213> [viewed 2022-10-06]

IETF RFC 2131, R. Droms, "Dynamic Host Configuration Protocol", March 1997, available at <https://www.rfc-editor.org/info/rfc2131> [viewed 2022-10-06]

IETF RFC 2132, S. Alexander, R. Droms, "DHCP Options and BOOTP Vendor Extensions", March 1997, available at <https://www.rfc-editor.org/info/rfc2132> [viewed 2022-10-06]

IETF RFC 2236, W. Fenner, "Internet Group Management Protocol, Version 2", November 1997, available at <https://www.rfc-editor.org/info/rfc2236> [viewed 2022-10-06]

IETF RFC 2365, D. Meyer, "Administratively Scoped IP Multicast", July 1998, available at <https://www.rfc-editor.org/info/rfc2365> [viewed 2022-10-06]

IETF RFC 2474, K. Nichols, S. Blake, F. Baker, D. Black, "Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers", December 1998, available at <https://www.rfc-editor.org/info/rfc2474> [viewed 2022-10-06]

IETF RFC 2475, S. Blake, D. Black, M. Carlson, E. Davies, Z. Wang, W. Weiss, "An Architecture for Differentiated Services"; December 1998, available at <https://www.rfc-editor.org/info/rfc2475> [viewed 2022-10-06]

IETF RFC 2674, E. Bell, A. Smith, P. Langille, A. Rijhsinghani, K. McCloghrie, "Definitions of Managed Objects for Bridges with Traffic Classes, Multicast Filtering and Virtual LAN Extensions", August 1999, available at <https://www.rfc-editor.org/info/rfc2674> [viewed 2022-10-06]

IETF RFC 2863, K. McCloghrie, F. Kastenholz, "The Interfaces Group MIB", June 2000, available at <https://www.rfc-editor.org/info/rfc2863> [viewed 2022-10-06]

IETF RFC 3418, R. Presuhn, Ed., "Management Information Base (MIB) for the Simple Network Management Protocol (SNMP)", December 2002, available at <https://www.rfc-editor.org/info/rfc3418> [viewed 2022-10-06]

IETF RFC 3535, Schoenwaelder, J., *Overview of the 2002 IAB Network Management Workshop*, May 2003, <https://www.rfc-editor.org/info/rfc3535> [viewed 2022-10-21]

IETF RFC 3621, A. Berger, D. Romascanu, "Power Ethernet MIB", December 2003, available at <https://www.rfc-editor.org/info/rfc3621> [viewed 2022-10-06]

IETF RFC 4361, T. Lemon, B. Sommerfeld, "Node-specific Client Identifiers for Dynamic Host Configuration Protocol Version Four (DHCPv4)", February 2006, available at <https://www.rfc-editor.org/info/rfc4361> [viewed 2022-10-06]

IETF RFC 4363, D. Levi, D. Harrington, "Definitions of Managed Objects for Bridges with Traffic Classes, Multicast Filtering, and Virtual LAN Extensions", January 2006, available at <https://www.rfc-editor.org/info/rfc4363> [viewed 2022-10-06]

IETF RFC 4604, H. Holbrook, B. Cain, B. Haberman, "Using Internet Group Management Protocol Version 3 (IGMPv3) and Multicast Listener Discovery Protocol Version 2 (MLDv2) for Source-Specific Multicast", August 2006, available at <https://www.rfc-editor.org/info/rfc4604> [viewed 2022-10-06]

IETF RFC 4632, V. Fuller, T. Li, "Classless Inter-domain Routing (CIDR): The Internet Address Assignment and Aggregation Plan", August 2006, available at <https://www.rfc-editor.org/info/rfc4632> [viewed 2022-10-06]

IETF RFC 4836, E. Beili, "Definitions of Managed Objects for IEEE Std 802.3 Medium Attachment Units (MAUs)", April 2007, available at <https://www.rfc-editor.org/info/rfc4836> [viewed 2022-10-06]

IETF RFC 4949, R. Shirey, "Internet Security Glossary, Version 2", August 2007, available at <https://www.rfc-editor.org/info/rfc4949> [viewed 2022-10-06]

IETF RFC 5227, S. Cheshire, "IPv4 Address Conflict Detection", July 2008, available at <https://www.rfc-editor.org/info/rfc5227> [viewed 2022-10-06]

IETF RFC 5277, Chisholm, S. and H. Trevino, *NETCONF Event Notifications*, July 2008, <https://www.rfc-editor.org/info/rfc5277> [viewed 2022-10-21]

IETF RFC 5539, Badra, M., *NETCONF over Transport Layer Security (TLS)*, May 2009, <https://www.rfc-editor.org/info/rfc5539> [viewed 2022-10-21]

IETF RFC 5890, J. Klensin, "Internationalized Domain Names for Applications (IDNA): Definitions and Document Framework", August 2010, available at <https://www.rfc-editor.org/info/rfc5890> [viewed 2022-10-06]

IETF RFC 5905, D. Mills, J. Martin, Ed., J. Burbank, W. Kasch, "Network Time Protocol Version 4: Protocol and Algorithms Specification", June 2010, available at <https://www.rfc-editor.org/info/rfc5905> [viewed 2022-10-06]

IETF RFC 6020, Bjorklund, M., Ed., *YANG – A Data Modeling Language for the Network Configuration Protocol (NETCONF)*, October 2010, <https://www.rfc-editor.org/info/rfc6020> [viewed 2022-10-21]

IETF RFC 6021, Schoenwaelder, J., Ed., *Common YANG Data Types*, October 2010, <https://www.rfc-editor.org/info/rfc6021> [viewed 2022-10-21]

IETF RFC 6087, Bierman, A., *Guidelines for Authors and Reviewers of YANG Data Model Documents*, January 2011, <https://www.rfc-editor.org/info/rfc6087> [viewed 2022-10-21]

IETF RFC 6110, Lhotka, L., Ed., *Mapping YANG to Document Schema Definition Languages and Validating NETCONF Content*, February 2011, <https://www.rfc-editor.org/info/rfc6110> [viewed 2022-10-21]

IETF RFC 6151, S. Turner, L. Chen, "Updated Security Considerations for the MD5 Message-Digest and the HMAC-MD5 Algorithms", March 2011, available at <https://www.rfc-editor.org/info/rfc6151> [viewed 2022-10-06]

IETF RFC 6241, Enns, R., Ed., Bjorklund, M., Ed., Schoenwaelder, J., Ed., and A. Bierman, Ed., *Network Configuration Protocol (NETCONF)*, June 2011, <https://www.rfc-editor.org/info/rfc6241> [viewed 2022-10-21]

IETF RFC 6243, Bierman, A. and B. Lengyel, *With-defaults Capability for NETCONF*, June 2011, <https://www.rfc-editor.org/info/rfc6243> [viewed 2022-10-21]

IETF RFC 6244, Shafer, P., *An Architecture for Network Management Using NETCONF and YANG*, June 2011, <https://www.rfc-editor.org/info/rfc6244> [viewed 2022-10-21]

IETF RFC 6470, Bierman, A., *Network Configuration Protocol (NETCONF) Base Notifications*, February 2012, <https://www.rfc-editor.org/info/rfc6470> [viewed 2022-10-21]

IETF RFC 6536, Bierman, A. and M. Bjorklund, *Network Configuration Protocol (NETCONF) Access Control Model*, March 2012, <https://www.rfc-editor.org/info/rfc6536> [viewed 2022-10-21]

IETF RFC 6890, M. Cotton, L. Vegoda, R. Bonica, Ed., B. Haberman, "Special-Purpose IP Address Registries", April 2013, available at <https://www.rfc-editor.org/info/rfc6890> [viewed 2022-10-06]

IETF RFC 6918, F. Gont, C. Pignataro, "Formally Deprecating Some ICMPv4 Message Types", April 2013, available at <https://www.rfc-editor.org/info/rfc6918> [viewed 2022-10-06]

IETF RFC 8342, Bjorklund, M., Schoenwaelder, J., Shafer, P., Watsen, K., and R. Wilton, *Network Management Datastore Architecture (NMDA)*, March 2018, <https://www.rfc-editor.org/info/rfc8342> [viewed 2022-10-21]

ITU-T G.781, *Synchronization layer functions for frequency synchronization based on the physical layer*; available at <http://www.itu.int/rec/T-REC-G.781> [viewed 2022-10-06]

The Open Group, Publication C706, *Technical standard DCE1.1: Remote Procedure Call*, available at <http://www.opengroup.org/onlinepubs/9629399/toc.htm> [viewed 2022-10-06]

Metro Ethernet Forum – MEF 10.4:2018, *Subscriber Ethernet Service Attributes*, available at <https://www.mef.net/resources/mef-10-4-subscriber-ethernet-services-attributes> [viewed 2022-10-06]

NIST FIPS PUB 180-4, *FEDERAL INFORMATION PROCESSING STANDARDS PUBLICATION, Secure Hash Standard (SHS)*, August 2015, available at <http://dx.doi.org/10.6028/NIST.FIPS.180-4> [viewed 2022-10-06]

NIST FIPS PUB 186-4, *FEDERAL INFORMATION PROCESSING STANDARDS PUBLICATION, Digital Signature Standard (DSS)*, July 2013, available at <http://dx.doi.org/10.6028/NIST.FIPS.186-4> [viewed 2022-10-06]