SLOVENSKI STANDARD

SIST EN 61158-2:2010

01-december-2010

Nadomešča:

SIST EN 61158-2:2008

Industrijska komunikacijska omrežja - Specifikacije za procesna vodila - 2. del: Specifikacija fizičnega nivoja in definicija opravil (IEC 61158-2:2010)

Industrial communication networks - Fieldbus specifications - Part 2: Physical layer specification and service definition (IEC 61158-2:2010)

Réseaux de communication industriels - Spécifications des bus de terrain - Partie 2: Spécification des couches physiques et définition des services (IEC 61158-2:2010)

Réseaux de communication industriels - Spécifications des bus de terrain - Partie 2: Spécification des couches physiques et définition des services (CEI 61158-2:2010)

Ta slovenski standard je istoveten z: **EN 61158-2:2010**

ICS:

25.040.40	Merjenje in krmiljenje industrijskih postopkov	Industrial process measurement and control
35.100.10	Fizični sloj	Physical layer
35.110	Omreževanje	Networking

SIST EN 61158-2:2010 **en**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 61158-2

October 2010

ICS 25.040; 35.100; 35.240.50

Supersedes EN 61158-2:2008

English version

Industrial communication networks - Fieldbus specifications - Part 2: Physical layer specification and service definition

(IEC 61158-2:2010)

Réseaux de communication industriels - Spécifications des bus de terrain - Partie 2: Spécification des couches physiques et définition des services (CEI 61158-2:2010)

Industrielle Kommunikationsnetze - Feldbusse - Teil 2: Spezifikation und Dienstfestlegungen des Physical Layer (Bitübertragungsschicht) (IEC 61158-2:2010)

This European Standard was approved by CENELEC on 2010-09-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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

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

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

CENELEC

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

Management Centre: Avenue Marnix 17, B - 1000 Brussels

Ref. No. EN 61158-2:2010 E

Foreword

The text of document 65C/598/FDIS, future edition 5 of IEC 61158-2, prepared by SC 65C, Industrial networks, of IEC TC 65, Industrial-process measurement, control and automation, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61158-2 on 2010-09-01.

This European Standard supersedes EN 61158-2:2008.

This EN 61158-2:2010 includes the following significant technical changes with respect to EN 61158-2:2008:

– for Type 18, Table 157 reduced tolerance to 5 %;

– for Type 18, in 32.5.3.1 removed minimum cable length;

– for Type 18, in 32.5.4. and R.2.2 cable reference removed;

– for Type 18, Table 160 and 161 terminating resistor value changed to 680 Ω.

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

The following dates were fixed:

– latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2011-06-01

– latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 2013-09-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61158-2:2010 was approved by CENELEC as a European Standard without any modification.

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

IEC 60079-0	NOTE	Harmonized as EN 60079-0.
IEC 60079-27	NOTE	Harmonized as EN 60079-27.
IEC 60875-1	NOTE	Harmonized as EN 60875-1.
IEC 60947-5-2	NOTE	Harmonized as EN 60947-5-2.
IEC/TR 61158-1	NOTE	Harmonized as CLC/TR 61158-1.
IEC 61158-4-1:2007	NOTE	Harmonized as EN 61158-4-1:2008 (not modified).
IEC 61158-4-4:2007	NOTE	Harmonized as EN 61158-4-4:2008 (not modified).
IEC 61158-4-7:2007	NOTE	Harmonized as EN 61158-4-7:2008 (not modified).
IEC 61158-4-8:2007	NOTE	Harmonized as EN 61158-4-8:2008 (not modified).
IEC 61158-4-16:2007	NOTE	Harmonized as EN 61158-4-16:2008 (not modified).
IEC 61300-3-4	NOTE	Harmonized as EN 61300-3-4.

IEC 61491	NOTE	Harmonized as EN 61491.
IEC 61596	NOTE	Harmonized as EN 61596.
IEC 61784-1	NOTE	Harmonized as EN 61784-1.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following referenced documents are indispensable for the application 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 When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60050-731	-	International Electrotechnical Vocabulary (IEV) - Chapter 731: Optical fibre communication	-	-
IEC 60079-11	-	Explosive atmospheres - Part 11: Equipment protection by intrinsic safety "i"	EN 60079-11	-
IEC 60079-14	2002	Electrical apparatus for explosive gas atmospheres - Part 14: Electrical installations in hazardous areas (other than mines)	EN 60079-14 [1)]	2003
IEC 60079-25	-	Explosive atmospheres - Part 25: Intrinsically safe electrical systems	EN 60079-25	-
IEC 60169-17	1980	Radio-frequency connectors - Part 17: R.F. coaxial connectors with inner diameter of outer conductor 6,5mm (0,256 in) with screw coupling - Characteristic impedance 50 ohms (type TNC)	-	-
IEC 60189-1	2007	Low-frequency cables and wires with PVC insulation and PVC sheath - Part 1: General test and measuring methods	-	-
IEC 60255-22-1 (mod)	1988	Electrical relays - Part 22: Electrical disturbance tests for measuring relays and protection equipment - Section 1: 1 MHz burst disturbance tests	-	-
IEC 60364-4-41 (mod)	-	Low-voltage electrical installations - Part 4-41: Protection for safety - Protection against electric shock	HD 60364-4-41	-
IEC 60364-5-54 (mod)	-	Electrical installations of buildings - Part 5-54: Selection and erection of electrical equipment - Earthing arrangements, protective conductors and protective bonding conductors	HD 60364-5-54	-
IEC 60529	-	Degrees of protection provided by enclosures (IP Code)	-	-

[1)] EN 60079-14 is superseded by EN 60079-14:2008, which is based on IEC 60079-14:2007.

Publication	Year	Title	EN/HD	Year
IEC 60603-7-4	-	Connectors for electronic equipment - Part 7-4: Detail specification for 8-way, unshielded, free and fixed connectors, for data transmissions with frequencies up to 250 MHz	EN 60603-7-4	-
IEC 60760	-	Flat, quick-connect terminations	-	-
IEC 60793	Series	Optical fibres	-	-
IEC 60794-1-2	2003	Optical fibre cables - Part 1-2: Generic specification - Basic optical cable test procedures	EN 60794-1-2	2003
IEC 60807-3	-	Rectangular connectors for frequencies below 3 MHz - Part 3: Detail specification for a range of connectors with trapezoidal shaped metal shells and round contacts - Removable crimp types with closed crimp barrels, rear insertion/rear extraction	-	-
IEC 60874-10-1	-	Connectors for optical fibres and cables - Part 10-1: Detail specification for fibre optic connector type BFOC/2,5 terminated to multimode fibre type A1	-	-
IEC 61000-4-2	-	Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test	EN 61000-4-2	-
IEC 61000-4-3	-	Electromagnetic compatibility (EMC) - Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test	EN 61000-4-3	-
IEC 61000-4-4	-	Electromagnetic compatibility (EMC) - Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity test	EN 61000-4-4	-
IEC 61131-2	-	Programmable controllers - Part 2: Equipment requirements and tests	EN 61131-2	-
IEC 61156-1	2007	Multicore and symmetrical pair/quad cables for digital communications - Part 1: Generic specification	-	-
IEC 61158-4-2	-	Industrial communication networks - Fieldbus specifications - Part 4-2: Data-link layer protocol specification - Type 2 elements	EN 61158-4-2	-
IEC 61158-4-3	2010	Industrial communication networks - Fieldbus specifications - Part 4-3: Data-link layer protocol specification - Type 3 elements	-	-
IEC 61169-8	2007	Radio-frequency connectors - Part 8: Sectional specification - RF coaxial connectors with inner diameter of outer conductor 6,5 mm (0,256 in) with bayonet lock - Characteristics impedance 50 ohms (type BNC)	EN 61169-8	2007
IEC 61754-2	-	Fibre optic connector interfaces - Part 2: Type BFOC/2,5 connector family	EN 61754-2	-

Publication	Year	Title	EN/HD	Year
IEC 61754-13	-	Fibre optic connector interfaces - Part 13: Type FC-PC connector	EN 61754-13	-
IEC 61754-22	-	Fibre optic connector interfaces - Part 22: Type F-SMA connector family	EN 61754-22	-
ISO/IEC 7498	Series	Information technology - Open Systems Interconnection - Basic Reference Model: The Basic Model	-	-
ISO/IEC 8482	-	Information technology - Telecommunications and information exchange between systems - Twisted pair multipoint interconnections	-	-
ISO/IEC 8802-3	-	Information technology - Telecommunications and information exchange between systems - Local and metropolitan area networks - Specific requirements - Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications	-	-
ISO/IEC 9314-1	-	Information Processing Systems - Fibre distributed data interface (FDDI) - Part 1: Token Ring physical layer protocol (PHY)	-	-
ISO/IEC 10731	-	Information technology - Open Systems Interconnection - Basic reference model - Conventions for the definition of OSI services	-	-
ANSI TIA/EIA-232-F	-	Interface between data terminal equipment and data circuit - Terminating equipment employing serial binary data interchange	-	-
ANSI TIA/EIA-422-B	-	Electrical characteristics of balanced voltage digital interface circuits	-	-
ANSI TIA/EIA-485-A	-	Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems	-	-
ANSI TIA/EIA-644-A	-	Electrical Characteristics of Low Voltage Differential Signaling (LVDS) Interface Circuits	-	-

IEC 61158-2

Edition 5.0 2010-07

INTERNATIONAL STANDARD

Industrial communication networks – Fieldbus specifications – Part 2: Physical layer specification and service definition

INTERNATIONAL ELECTROTECHNICAL COMMISSION

PRICE CODE XN

ICS, 25.040, 35.100, 35.240.50

ISBN 978-2-88912-051-2

CONTENTS

FOREWORD 14
0 Introduction 16
1 Scope 20
2 Normative references 20
3 Terms and definitions 22
4 Symbols and abbreviations 45
5 DLL – PhL interface 56
6 Systems management – PhL interface 77
7 DCE independent sublayer (DIS) 91
8 DTE – DCE interface and MIS-specific functions 93
9 Medium dependent sublayer (MDS) 114
10 MDS – MAU interface 135
11 Types 1 and 7: Medium attachment unit: voltage mode, linear-bus-topology 150 Ω twisted-pair wire medium 143
12 Types 1 and 3: Medium attachment unit: 31,25 kbit/s, voltage-mode with low-power option, bus- and tree-topology, 100 Ω wire medium 158
13 Type 1: Medium attachment unit: current mode, twisted-pair wire medium 175
14 Type 1: Medium attachment unit: current mode (1 A), twisted-pair wire medium 185
15 Types 1 and 7: Medium attachment unit: dual-fiber optical media 194
16 Type 1: Medium attachment unit: 31,25 kbit/s, single-fiber optical medium 201
17 Type 1: Medium attachment unit: radio signaling 204
18 Type 2: Medium attachment unit: 5 Mbit/s, voltage-mode, coaxial wire medium 214
19 Type 2: Medium attachment unit: 5 Mbit/s, optical medium 226
20 Type 2: Medium attachment unit: network access port (NAP) 231
21 Type 3: Medium attachment unit: synchronous transmission, 31,25 kbit/s, voltage mode, wire medium 234
22 Type 3: Medium attachment unit: asynchronous transmission, wire medium 251
23 Type 3: Medium attachment unit: asynchronous transmission, optical medium 268
24 Type 4: Medium attachment unit: RS-485 277
25 Type 4: Medium attachment unit: RS-232 279
26 Type 6: *This clause has been removed* 280
27 Type 8: Medium attachment unit: twisted-pair wire medium 280
28 Type 8: Medium attachment unit: optical media 285
29 Type 12: Medium attachment unit: electrical medium 292
30 Type 16: Medium attachment unit: optical fiber medium at 2, 4, 8 and 16 Mbit/s 294
31 Type 18: Medium attachment unit: basic medium 307
32 Type 18: Medium attachment unit: powered medium 311
Annex A (normative) Type 1: Connector specification 320
Annex B (informative) Types 1 and 3: Cable specifications and trunk and spur lengths for the 31,25 kbit/s voltage-mode MAU 328
Annex C (informative) Types 1 and 7: Optical passive stars 330
Annex D (informative) Types 1 and 7: Star topology 331

Annex E (informative) Type 1: Alternate fibers 335
Annex F (normative) Type 2: Connector specification 336
Annex G (normative) Type 2: Repeater machine sublayers (RM, RRM) and redundant PhLs 339
Annex H (informative) Type 2: Reference design examples 350
Annex I (normative) Type 3: Connector specification 356
Annex J (normative) Type 3: Redundancy of PhL and medium 363
Annex K (normative) Type 3: Optical network topology 364
Annex L (informative) Type 3: Reference design examples for asynchronous transmission, wire medium, intrinsically safe 373
Annex M (normative) Type 8: Connector specification 375
Annex N (normative) Type 16: Connector specification 380
Annex O (normative) Type 16: Optical network topology 381
Annex P (informative) Type 16: Reference design example 386
Annex Q (normative) Type 18: Connector specification 390
Annex R (normative) Type 18: Media cable specifications 395
Bibliography 399

Figure 1 – General model of physical layer 17
Figure 2 – Mapping between data units across the DLL – PhL interface 57
Figure 3 – Data service for asynchronous transmission 62
Figure 4 – Interactions for a data sequence of a master: identification cycle 67
Figure 5 – Interactions for a data sequence of a master: data cycle 68
Figure 6 – Interactions for a data sequence of a slave: identification cycle 69
Figure 7 – Interactions for a data sequence of a slave: data cycle 70
Figure 8 – Interactions for a check sequence of a master 71
Figure 9 – Interactions for a check sequence of a slave 72
Figure 10 – Reset, Set-value, Get-value 81
Figure 11 – Event service 81
Figure 12 – Interface between PhL and PNM1 in the layer model 86
Figure 13 – Reset, Set-value, Get-value PhL services 87
Figure 14 – Event PhL service 87
Figure 15 – Allocation of the interface number 88
Figure 16 – Configuration of a master 92
Figure 17 – Configuration of a slave with an alternative type of transmission 93
Figure 18 – Configuration of a bus coupler with an alternative type of transmission 93
Figure 19 – DTE/DCE sequencing machines 98
Figure 20 – State transitions with the ID cycle request service 107
Figure 21 – MIS-MDS interface: identification cycle request service 108
Figure 22 – MIS-MDS interface: identification cycle request service 109
Figure 23 – State transitions with the data cycle request service 109
Figure 24 – MIS-MDS interface: data cycle request service 110
Figure 25 – State transitions with the data sequence classification service 110
Figure 26 – Protocol machine for the message transmission service 111

Figure 27 – Protocol machine for the data sequence identification service 112
Figure 28 – Protocol machine for the message receipt service 113
Figure 29 – Protocol data unit (PhPDU) 114
Figure 30 – PhSDU encoding and decoding 115
Figure 31 – Manchester encoding rules 115
Figure 32 – Preamble and delimiters 117
Figure 33 – Manchester coded symbols 118
Figure 34 – PhPDU format, half duplex 119
Figure 35 – PhPDU format, full duplex 121
Figure 36 – Data sequence PhPDU 125
Figure 37 – Structure of the header in a data sequence PhPDU 125
Figure 38 – Check sequence PhPDU 126
Figure 39 – Structure of a headers in a check sequence PhPDU 126
Figure 40 – Structure of the status PhPDU 127
Figure 41 – Structure of the header in a status PhPDU 127
Figure 42 – Structure of the medium activity status PhPDU 128
Figure 43 – Structure of the header in a medium activity status PhPDU 128
Figure 44 – Reset PhPDU 129
Figure 45 – Configuration of a master 130
Figure 46 – Configuration of a slave 130
Figure 47 – Configuration of a bus coupler 130
Figure 48 – Protocol data unit 131
Figure 49 – PhSDU encoding and decoding 131
Figure 50 – Manchester encoding rules 131
Figure 51 – Example of an NRZI-coded signal 134
Figure 52 – Fill signal 134
Figure 53 – Jitter tolerance 141
Figure 54 – Transmit circuit test configuration 147
Figure 55 – Output waveform 148
Figure 56 – Transmitted and received bit cell jitter (zero crossing point deviation) 149
Figure 57 – Signal polarity 150
Figure 58 – Receiver sensitivity and noise rejection 151
Figure 59 – Power supply ripple and noise 154
Figure 60 – Fieldbus coupler 156
Figure 61 – Transition from receiving to transmitting 163
Figure 62 – Power supply ripple and noise 167
Figure 63 – Test circuit for single-output power supplies 168
Figure 64 – Test circuit for power distribution through an IS barrier 169
Figure 65 – Test circuit for multiple output supplies with signal coupling 170
Figure 66 – Fieldbus coupler 172
Figure 67 – Protection resistors 172
Figure 68 – Test configuration for current-mode MAU 178
Figure 69 – Transmitted and received bit cell jitter (zero crossing point deviation) 179

Figure 70 – Noise test circuit for current-mode MAU 181
Figure 71 – Transmitted and received bit cell jitter (zero crossing point deviation) 189
Figure 72 – Power supply harmonic distortion and noise 192
Figure 73 – Optical wave shape template 197
Figure 74 – Cellular radio topology and reuse of frequencies 208
Figure 75 – Radio segment between wired segments topology 209
Figure 76 – Mixed wired and radio medium fieldbus topology 210
Figure 77 – Components of 5 Mbit/s, voltage-mode, coaxial wire PhL variant 215
Figure 78 – Coaxial wire MAU block diagram 215
Figure 79 – Coaxial wire MAU transmitter 216
Figure 80 – Coaxial wire MAU receiver operation 217
Figure 81 – Coaxial wire MAU transmit mask 218
Figure 82 – Coaxial wire MAU receive mask 219
Figure 83 – Transformer symbol 220
Figure 84 – 5 Mbit/s, voltage-mode, coaxial wire topology example 222
Figure 85 – Coaxial wire medium topology limits 223
Figure 86 – Coaxial wire medium tap electrical characteristics 224
Figure 87 – MAU block diagram 5 Mbit/s, optical fiber medium 227
Figure 88 – NAP reference model 231
Figure 89 – Example of transient and permanent nodes 232
Figure 90 – NAP transceiver 233
Figure 91 – NAP cable 234
Figure 92 – Circuit diagram of the principle of measuring impedance 239
Figure 93 – Definition of CMRR 240
Figure 94 – Block circuit diagram of the principle of measuring CMRR 240
Figure 95 – Power supply ripple and noise 243
Figure 96 – Output characteristic curve of a power supply of the category EEx ib 250
Figure 97 – Output characteristic curve of a power supply of the category EEx ia 250
Figure 98 – Repeater in linear bus topology 253
Figure 99 – Repeater in tree topology 253
Figure 100 – Example for a connector with integrated inductance 255
Figure 101 – Interconnecting wiring 255
Figure 102 – Bus terminator 256
Figure 103 – Linear structure of an intrinsically safe segment 258
Figure 104 – Topology example extended by repeaters 259
Figure 105 – Bus terminator 261
Figure 106 – Waveform of the differential voltage 262
Figure 107 – Test set-up for the measurement of the idle level for devices with an integrated termination resistor 264
Figure 108 – Test set-up for the measurement of the idle level for devices with a connectable termination resistor 264
Figure 109 – Test set-up for measurement of the transmission levels 265
Figure 110 – Test set-up for the measurement of the receiving levels 265
Figure 111 – Fieldbus model for intrinsic safety 266

Figure 112 – Communication device model for intrinsic safety 266
Figure 113 – Connection to the optical network 269
Figure 114 – Principle structure of optical networking 270
Figure 115 – Definition of the standard optical link 270
Figure 116 – Signal template for the optical transmitter 275
Figure 117 – Recommended interface circuit 279
Figure 118 – MAU of an outgoing interface 280
Figure 119 – MAU of an incoming interface 281
Figure 120 – Remote bus link 281
Figure 121 – Interface to the transmission medium 282
Figure 122 – Wiring 285
Figure 123 – Terminal resistor network 285
Figure 124 – Fiber optic remote bus cable 286
Figure 125 – Optical fiber remote bus link 286
Figure 126 – Optical wave shape template optical MAU 288
Figure 127 – Optical transmission line 294
Figure 128 – Optical signal envelope 296
Figure 129 – Display of jitter (J_{noise}) 297
Figure 130 – Input-output performance of a slave 299
Figure 131 – Functions of a master connection 302
Figure 132 – Valid transmitting signals during the transition from fill signal to telegram delimiters 304
Figure 133 – Valid transmitting signals during the transition from telegram delimiter to fill signal 305
Figure 134 – Functions of a slave connection 306
Figure 135 – Network with two slaves 307
Figure 136 – Minimum interconnecting wiring 308
Figure 137 – Dedicated cable topology 309
Figure 138 – T-branch topology 309
Figure 139 – Communication element isolation 311
Figure 140 – Communication element and I/O isolation 311
Figure 141 – Minimum interconnecting wiring 312
Figure 142 – Flat cable topology 313
Figure 143 – Dedicated cable topology 313
Figure 144 – T-branch topology 313
Figure 145 – Type 18-PhL-P power distribution 316
Figure 146 – Type 18-PhL-P power distribution 316
Figure 147 – Type 18-PhL-P power supply filtering and protection 318
Figure 148 – Communication element isolation 318
Figure 149 – Communication element and i/o isolation 318
Figure 150 – PhL-P power supply circuit 319
Figure A.1 – Internal fieldbus connector 320
Figure A.2 – Contact designations for the external connector for harsh industrial environments 322

Figure A.3 – External fieldbus connector keyways, keys, and bayonet pins and grooves 322
Figure A.4 – External fieldbus connector intermateability dimensions 323
Figure A.5 – External fieldbus connector contact arrangement 324
Figure A.6 – Contact designations for the external connector for typical industrial environments 325
Figure A.7 – External fixed (device) side connector for typical industrial environments: dimensions 325
Figure A.8 – External free (cable) side connector for typical industrial environments: dimensions 326
Figure A.9 – Optical connector for typical industrial environments (FC connector) 326
Figure A.10 – Optical connector for typical industrial environments (ST connector) 327
Figure C.1 – Example of an optical passive reflective star 330
Figure C.2 – Example of an optical passive transmitive star 330
Figure D.1 – Example of star topology with 31,25 kbit/s, single fiber mode, optical MAU 331
Figure D.2 – Multi-star topology with an optical MAU 331
Figure D.3 – Example of mixture between wire and optical media for a 31,25 kbit/s bit rate 333
Figure D.4 – Example of mixture between wire and optical media 334
Figure F.1 – Pin connector for short range optical medium 337
Figure F.2 – Crimp ring for short range optical medium 337
Figure G.1 – PhL repeater device reference model 339
Figure G.2 – Reference model for redundancy 342
Figure G.3 – Block diagram showing redundant coaxial medium and NAP 343
Figure G.4 – Block diagram showing ring repeaters 344
Figure G.5 – Segmentation query 345
Figure G.6 – Segmentation response 345
Figure G.7 – Main switch state machine 347
Figure G.8 – Port 1 sees network activity first 348
Figure G.9 – Port 2 sees network activity first 349
Figure H.1 – Coaxial wire MAU RxDATA detector 351
Figure H.2 – Coaxial wire MAU RxCARRIER detection 352
Figure H.3 – Redundant coaxial wire MAU transceiver 352
Figure H.4 – Single channel coaxial wire MAU transceiver 353
Figure H.5 – Coaxial wire medium tap 354
Figure H.6 – Non-isolated NAP transceiver 355
Figure H.7 – Isolated NAP transceiver 355
Figure I.1 – Schematic of the station coupler 356
Figure I.2 – Pin assignment of the male and female connectors IEC 60947-5-2 (A coding) 357
Figure I.3 – Connector pinout, front view of male and back view of female respectively 358
Figure I.4 – Connector pinout, front view of female M12 connector 360
Figure I.5 – Connector pinout, front view of male M12 connector 360
Figure I.6 – M12 Tee 361
Figure I.7 – M12 Bus termination 362
Figure J.1 – Redundancy of PhL MAU and Medium 363