

INTERNATIONAL STANDARD

IEC
61375-1

Second edition
2007-04

**Electric railway equipment –
Train bus –**

**Part 1:
Train communication network**

iTech Standards

(<https://standards.iteh.ai>)

Document Preview

IEC 61375-1:2007

<https://standards.iteh.ai/en/standards/iec/25af274-dca3-4e0b-8ecb-a724f6a3c458/iec-61375-1-2007>



Reference number
IEC 61375-1:2007(E)



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2007 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester.

If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

- Catalogue of IEC publications: www.iec.ch/searchpub

The IEC on-line Catalogue enables you to search by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, withdrawn and replaced publications.

- IEC Just Published: www.iec.ch/online_news/justpub

Stay up to date on all new IEC publications. Just Published details twice a month all new publications released. Available on-line and also by email.

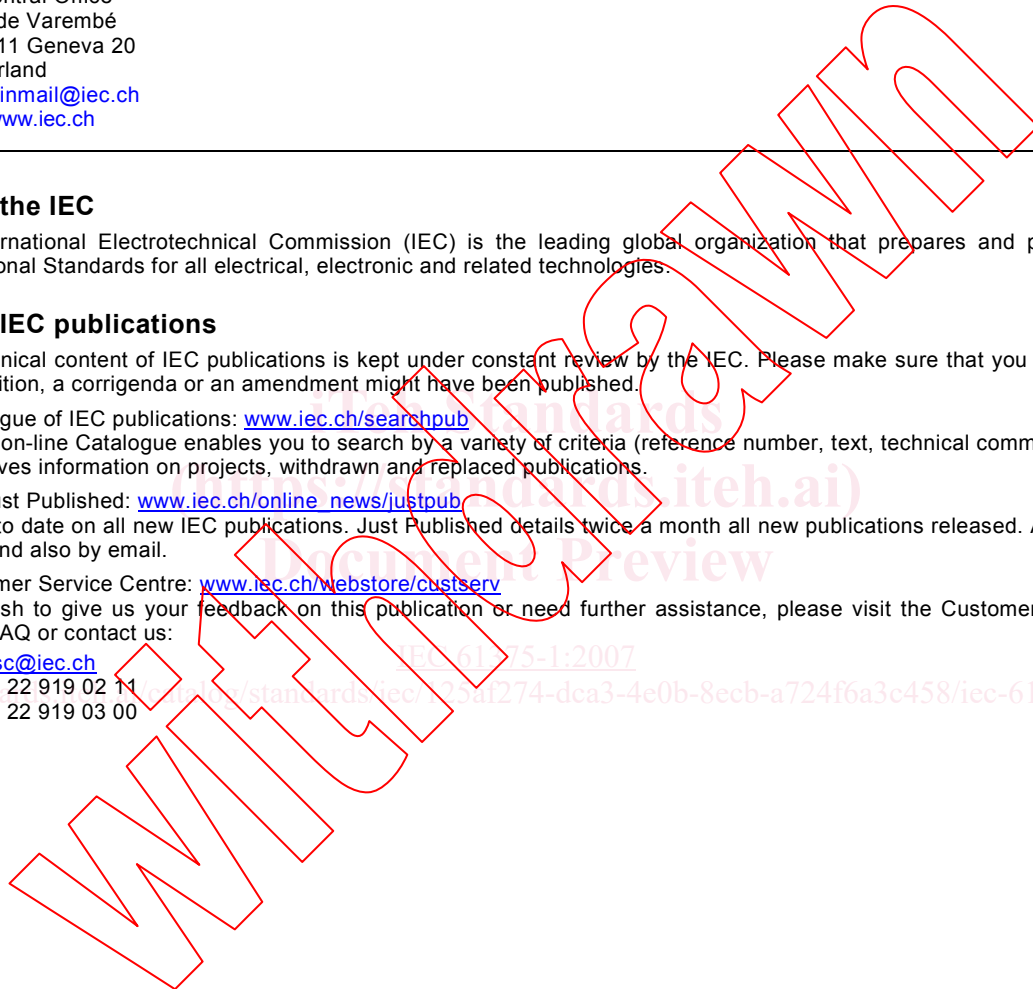
- Customer Service Centre: www.iec.ch/webstore/custserv

If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:

Email: csc@iec.ch

Tel.: +41 22 919 02 11

Fax: +41 22 919 03 00



https://standards.iec.ch/standards/iec/125ul274-dca3-4e0b-8ecb-a724f6a3c458/iec-61375-1-2007

INTERNATIONAL STANDARD

IEC 61375-1

Second edition
2007-04

**Electric railway equipment –
Train bus –**

**Part 1:
Train communication network**

iTech Standards

(<https://standards.iteh.ai>)

Document Preview

IEC 61375-1:2007

<https://standards.iteh.ai/catalog/standards/iec/25af274-dca3-4e0b-8ecb-a724f6a3c458/iec-61375-1-2007>



Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

PRICE CODE **XH**

For price, see current catalogue

CONTENTS

FOREWORD.....	13
INTRODUCTION.....	15
1 General.....	17
1.1 Scope.....	17
1.2 Normative references.....	17
1.3 Terms and definitions.....	18
1.4 Abbreviations.....	35
1.5 Conventions.....	37
1.6 General considerations.....	43
1.7 Conformance Test.....	48
2 Real-Time protocols.....	49
2.1 General.....	49
2.2 Variables – Services and Protocols.....	51
2.3 Messages Services and Protocols.....	72
2.4 Presentation and encoding of transmitted and stored data.....	173
3 Multifunction Vehicle Bus.....	193
3.1 General.....	193
3.2 Physical Layer.....	195
3.3 Medium-dependent signalling.....	229
3.4 Frames and telegrams.....	236
3.5 Link Layer Control.....	242
3.6 Medium allocation.....	248
3.7 Mastership transfer.....	260
3.8 Link Layer Interface.....	265
4 Wire Train Bus (WTB).....	273
4.1 General.....	273
4.2 Physical layer.....	275
4.3 Medium-dependent signalling.....	296
4.4 Frames and telegrams.....	304
4.5 Link Layer Control.....	308
4.6 Medium allocation.....	329
4.7 Inauguration.....	331
4.8 Link layer interface.....	380
5 Train Network Management.....	393
5.1 General.....	393
5.2 Manager, Agents and interfaces.....	394
5.3 Managed objects.....	397
5.4 Services and management messages.....	407
5.5 Interface Procedures.....	469
Annex A (informative) Tutorial on the TCN architecture.....	473
Annex B (normative) Guidelines for conformance testing.....	599
Bibliography.....	600

Figure 1 – Layering of the TCN.....	16
Figure 2 – State transition example	42
Figure 3 – Interfaces between equipment	43
Figure 4 – Interfaces between vehicles	43
Figure 5 – Train Bus and Vehicle Bus	44
Figure 6 – TCN configurations	45
Figure 7 – TCN device configuration options.....	46
Figure 8 – Structure of the Train Communication Network	49
Figure 9 – Real-Time Protocols layering	50
Figure 10 – LPI primitives exchange	54
Figure 11 – Check_Variable	59
Figure 12 – Individual access	63
Figure 13 – Set access.....	67
Figure 14 – Cluster access.....	70
Figure 15 – Terminal station.....	72
Figure 16 – Router station between WTB and MVB.....	73
Figure 17 – Packet format	75
Figure 18 – Link layer data transmission.....	77
Figure 19 – Link_Message_Data_Interface (LMI)	78
Figure 20 – Example of MVB Message_Data frame	79
Figure 21 – Example of WTB Message_Data frame	80
Figure 22 – LMI primitives.....	81
Figure 23 – Network layer on a Node.....	88
Figure 24 – Encoding of the Network_Address.....	91
Figure 25 – Building of the addresses in an outbound packet.....	93
Figure 26 – Network address encoding on the vehicle bus (example MVB).....	95
Figure 27 – Network address encoding on the train bus (example with WTB).....	96
Figure 28 – Transport packet exchange.....	102
Figure 29 – Packet formats (transport layer body).....	105
Figure 30 – State transition diagram of the MTP	114
Figure 31 – Time-out SEND_TMO	118
Figure 32 – Time-out ALIVE_TMO	118
Figure 33 – Transport interface	127
Figure 34 – Multicast message with no retransmission.....	134
Figure 35 – Short multicast message with no BD packets and no loss.....	135
Figure 36 – Exchange with lost packets	136
Figure 37 – Packet formats	138
Figure 38 – Protocol machine states.....	139
Figure 39 – Session layer transfer	150
Figure 40 – Session_Header in Call_Message (of type Am_Result).....	151
Figure 41 – Application_Messages_Interface.....	152
Figure 42 – Encoding of AM_ADDRESS.....	156

Figure 43 – Reference device and structure of the document.....	195
Figure 44 – MVB configuration	196
Figure 45 – Transceiver interface	199
Figure 46 – Example of ESD segment	201
Figure 47 – Example of terminator.....	202
Figure 48 – ESD backplane section (double-line).....	204
Figure 49 – ESD connector arrangement.....	205
Figure 50 – ESD terminator connector arrangement	206
Figure 51 – Example of start of frame (ESD)	207
Figure 52 – End of an ESD frame (both cases).....	208
Figure 53 – EMD medium.....	209
Figure 54 – Shielding (single-line segment).....	211
Figure 55 – Single-line device attachment	212
Figure 56 – Double-line device attachment to EMD.....	213
Figure 57 – EMD connectors arrangement.....	214
Figure 58 – EMD terminator strapping	215
Figure 59 – Measurement of an EMD device.....	216
Figure 60 – Attenuation measurement.....	216
Figure 61 – Example of start of an EMD frame.....	217
Figure 62 – EMD transmitter test circuits.....	218
Figure 63 – Example of pulse waveform at EMD transmitter	220
Figure 64 – Example of end of EMD frame.....	221
Figure 65 – EMD receiver test signal.....	222
Figure 66 – Optical link.....	224
Figure 67 – Optical connector (dimensions in millimeters).....	225
Figure 68 – Example of start of OGF frame	226
Figure 69 – Edge jitter.....	227
Figure 70 – Example of active star coupler	228
Figure 71 – Example of a duplicated star coupler.....	229
Figure 72 – "0" and "1" data encoding.....	229
Figure 73 – Non_Data symbols encoding.....	230
Figure 74 – Master Start Delimiter	230
Figure 75 – Slave Start Delimiter	231
Figure 76 – Example of End Delimiter for EMD medium.....	231
Figure 77 – Example of a valid frame (OGF medium).....	232
Figure 78 – Signal skew	233
Figure 79 – Example of repeater for single-line attachment.....	235
Figure 80 – Example of repeater connecting a double-line to a single line segment.....	236
Figure 81 – Master Frame Format	236
Figure 82 – Slave Frames	237
Figure 83 – Telegram timing.....	238
Figure 84 – Example of Reply delay.....	239
Figure 85 – Frame spacing at the source side	240

Figure 86 – Frame spacing at the destination(s)	240
Figure 87 – Frame spacing at the master side	241
Figure 88 – Master Frame contents	243
Figure 89 – Word ordering in a Slave Frame.....	245
Figure 90 – Process Data telegram	245
Figure 91 – Message Data telegram	247
Figure 92 – Supervisory Data telegram	248
Figure 93 – Basic Periods	249
Figure 94 – Example of construction of the Macro_Cycle	251
Figure 95 – General_Event_Request frame format	255
Figure 96 – Group_Event_Request frame (M = 6, C = ABCDEF).....	256
Figure 97 – Single_Event_Request frame	256
Figure 98 – Event_Identifier_Response frame	257
Figure 99 – Device_Status_Request	257
Figure 100 – Device_Status_Response	258
Figure 101 – Device_Status of Class 1 device	258
Figure 102 – Device_Status of Class 2/3/4/5 device.....	258
Figure 103 – Device_Status of a device with Bus Administrator capability	259
Figure 104 – Device_Status of a device with Gateway capability	259
Figure 105 – Mastership Transfer states	263
Figure 106 – Device_Status_Request (sent by current master)	264
Figure 107 – Device_Status_Response (sent by proposed master)	264
Figure 108 – Mastership_Transfer_Request (sent by current master).....	265
Figure 109 – Mastership_Transfer_Response (sent by proposed next master)	265
Figure 110 – Link Layer Layering.....	266
Figure 111 – Wire Train Bus.....	273
Figure 112 – Reference model of the WTB	275
Figure 113 – Train Composition (two Intermediate Nodes shown)	276
Figure 114 – Vehicle measurement	277
Figure 115 – Connected nodes in regular operation	278
Figure 116 – Double-line attachment	278
Figure 117 – Grounded shield concept	281
Figure 118 – Floating shield concept	282
Figure 119 – Terminator	282
Figure 120 – Direct node attachment (optional double-line).....	283
Figure 121 – Indirect attachment	284
Figure 122 – WTB connector, front view	285
Figure 123 – Example of MAU Structure	286
Figure 124 – Node with redundant Line Units.....	288
Figure 125 – Attenuation measurement	289
Figure 126 – Shield grounding in the Line Unit.....	290
Figure 127 – Fritting source and load	290
Figure 128 – Transmitter test circuits	292

Figure 129 – Pulse wave form at transmitter.....	293
Figure 130 – Signal and idling at transmitter.....	294
Figure 131 – Receiver signal envelope	295
Figure 132 – Receiver edge distortion	296
Figure 133 – Idealised frame on the line (16 bit Preamble shown).....	297
Figure 134 – Bit encoding.....	297
Figure 135 – Preamble.....	298
Figure 136 – End Delimiter.....	298
Figure 137 – Valid frame, RxS, CS and SQE signals.....	299
Figure 138 – Garbled frame, RxS, CS, SQE signals.....	300
Figure 139 – Redundant Lines (as seen at a receiver).....	300
Figure 140 – Line_Disturbance signals.....	301
Figure 141 – HDLC Frame structure.....	304
Figure 142 – Telegram timing.....	305
Figure 143 – Example of Interframe spacing.....	306
Figure 144 – Frame spacing measured at the master side.....	307
Figure 145 – Frame spacing at the slave.....	307
Figure 146 – HDLC Data format.....	308
Figure 147 – Format of HDLC Data.....	309
Figure 148 – Process Data telegram.....	313
Figure 149 – Format of Process Data Request.....	314
Figure 150 – Format of Process Data Response.....	315
Figure 151 – Message Data telegram.....	315
Figure 152 – Format of Message Data Request.....	315
Figure 153 – Format of Message Data Response.....	316
Figure 154 – Supervisory telegram.....	316
Figure 155 – Detection telegram.....	317
Figure 156 – Format of Detect Request.....	318
Figure 157 – Format of Detect Response.....	318
Figure 158 – Presence telegram.....	319
Figure 159 – Format of Presence Request.....	319
Figure 160 – Format of Presence Response.....	320
Figure 161 – Status telegram.....	320
Figure 162 – Format of Status Request.....	321
Figure 163 – Format of Status Response.....	322
Figure 164 – Set-to-Intermediate telegram.....	322
Figure 165 – Format of SetInt Request.....	322
Figure 166 – Format of SetInt Response.....	323
Figure 167 – Naming telegram.....	323
Figure 168 – Format of Naming Request.....	324
Figure 169 – Format of Naming Response.....	324
Figure 170 – Unnaming telegram.....	325
Figure 171 – Format of Unname Request.....	325

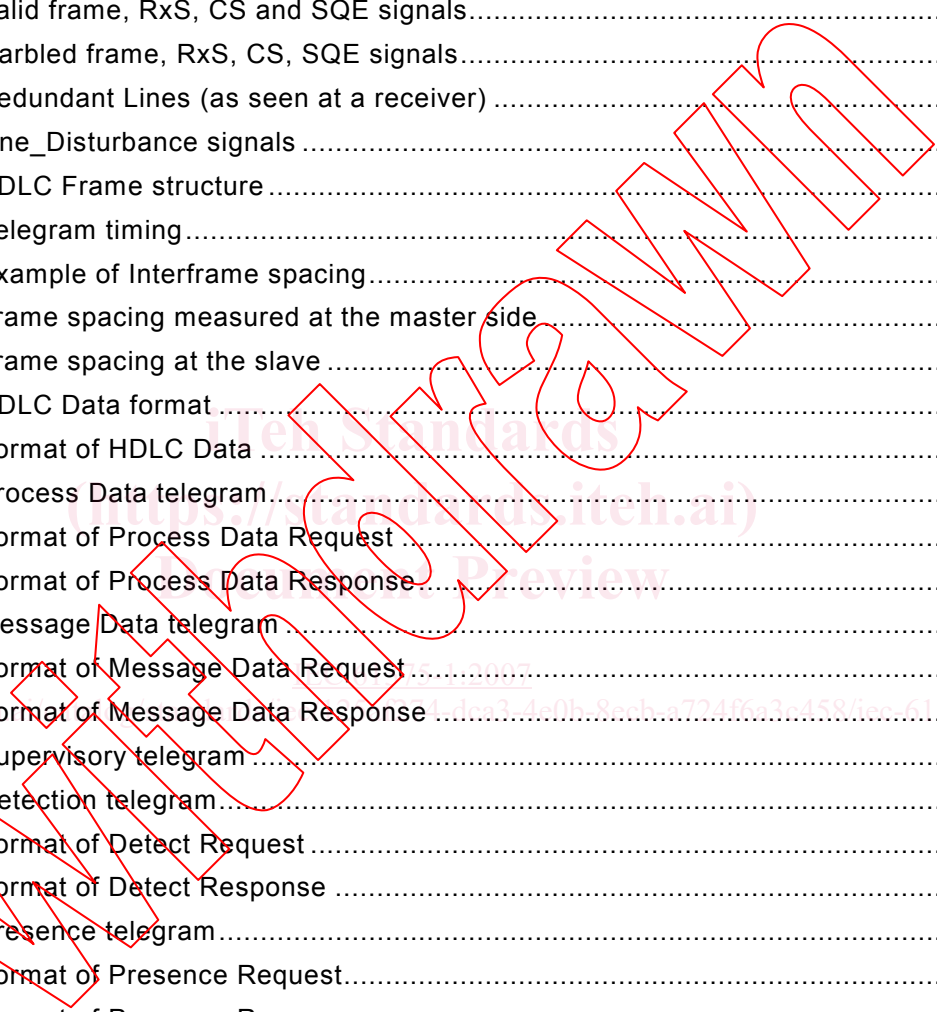


Figure 172 – Set to End telegram	325
Figure 173 – Format of SetEnd Request	326
Figure 174 – Format of SetEnd Response	326
Figure 175 – Topography telegram	327
Figure 176 – Format of Topography Request	327
Figure 177 – Format of Topography Response	328
Figure 178 – Structure of the Basic Period	329
Figure 179 – Node position numbering	332
Figure 180 – Format of Node Descriptor	333
Figure 181 – Format of Node Report	334
Figure 182 – Format of User Report	334
Figure 183 – Format of Composition Strength	335
Figure 184 – Master_Report	336
Figure 185 – Format of Topo Counter	336
Figure 186 – Format of Master Topo	336
Figure 187 – Timing Diagram of detection protocol	339
Figure 188 – Major node states and application settings	340
Figure 189 – Node processes (End Setting)	341
Figure 190 – AUXILIARY_PROCESS states	347
Figure 191 – NAMING_RESPONSE macro	348
Figure 192 – States of MAIN_PROCESS	349
Figure 193 – Macro 'START_NODE'	352
Figure 194 – Procedure REQUEST_RESPONSE	354
Figure 195 – Procedures 'SET_TO_INT' and 'SET_TO_END'	355
Figure 196 – Macro 'INIT_MASTER'	356
Figure 197 – Macro 'NAMING_MASTER'	357
Figure 198 – Macro ASK_END	358
Figure 199 – Procedure NAME_ONE	361
Figure 200 – Macro TEACHING_MASTER	363
Figure 201 – Macro 'UNNAMING_MASTER'	364
Figure 202 – Macro 'REGULAR_MASTER'	366
Figure 203 – Macro CHECK_DESC	367
Figure 204 – Macro PERIODIC_POLL	369
Figure 205 – Macro MESSAGE_POLL	370
Figure 206 – States 'UNNAMED_SLAVE'	372
Figure 207 – States 'NAMED_SLAVE'	374
Figure 208 – Macro 'LEARNING_SLAVE'	376
Figure 209 – Macro 'REGULAR_SLAVE'	378
Figure 210 – Link layer layering	380
Figure 211 – Management messages	395
Figure 212 – Agent Interface on a (gateway) Station	396
Figure 213 – Station_Status	398
Figure A.1 – Train_Bus and Vehicle_Busses	475

Figure A.2 – Data transfer over the Train Communication Network	477
Figure A.3 – Example of Periodic_Data and Sporadic_Data transmission.....	478
Figure A.4 – TCN Services	479
Figure A.5 – Application Tasks and TCN services.....	480
Figure A.6 – Layering of the Real-Time Protocols	480
Figure A.7 – Variable transmission and Ports	482
Figure A.8 – Broadcasting of source-addressed Process_Data	483
Figure A.9 – Port and Traffic_Store	484
Figure A.10 – Ports on the Wire_Train_Bus.....	486
Figure A.11 – Dataset	487
Figure A.12 – Validity bits.....	488
Figure A.13 – Multiple Process_Variable instances	489
Figure A.14 – Instances of a Process_Variable.....	490
Figure A.15 – Transmission of Periodic_Data through the network.....	491
Figure A.16 – Individual copying	494
Figure A.17 – Cluster transfer	495
Figure A.18 – Application_Layer and Link_Layer Interface to Process_Variables.....	496
Figure A.19 – Several Applications access the same Traffic_Store.....	496
Figure A.20 – Application access to several Traffic_Stores.....	497
Figure A.21 – Two-level hierarchy	498
Figure A.22 – Call_Message/Reply_Message exchange.....	500
Figure A.23 – Example of actual architecture.....	501
Figure A.24 – Message_Data transmission over queues	502
Figure A.25 – Link_Layer in the OSI hierarchy.....	503
Figure A.26 – Message_Data format.....	504
Figure A.27 – Node position numbering.....	504
Figure A.28 – Vehicle numbering according to UIC 556 – not TCN.....	505
Figure A.29 – Example of vehicle types	506
Figure A.30 – Nodes and Vehicle_Bus Devices.....	507
Figure A.31 – Vehicle_Bus spanning several vehicles.....	507
Figure A.32 – System view of communication	508
Figure A.33 – Station_Directory.....	509
Figure A.34 – Actual Station location	510
Figure A.35 – Dual-processor Node.....	511
Figure A.36 – Further hierarchical level	512
Figure A.37 – Functions within a passenger coach.....	512
Figure A.38 – Mapping of Functions to Devices	513
Figure A.39 – Function view of communication	514
Figure A.40 – Function_Directory	514
Figure A.41 – Function Directories in a three-level hierarchy.....	515
Figure A.42 – End-to-end Message_Data transfer.....	516
Figure A.43 – Packet forwarding over the network	517
Figure A.44 – Network_Address (origin or final) for messages	517

Figure A.45 – WTB and MVB Message_Data frame with Network_Addresses	518
Figure A.46 – Routing messages over the Train_Bus	520
Figure A.47 – Execution of the transport control.	521
Figure A.48 – Message Transport_Layer in the OSI model.....	522
Figure A.49 – Sliding window protocol	523
Figure A.50 – Frame exchange at the transport level	524
Figure A.51 – Packet formats (bus-independent)	526
Figure A.52 – Multicast transmission	527
Figure A.53 – Remote Procedure Call.....	529
Figure A.54 – Call nesting	530
Figure A.55 – Example of message exchange at the session level.....	531
Figure A.56 – Message Software structure	532
Figure A.57 – Multifunction_Vehicle_Bus in a locomotive.....	537
Figure A.58 – Multifunction_Vehicle_Bus in a coach	537
Figure A.59 – Electrical Short Distance medium	539
Figure A.60 – MVB spanning three vehicles.....	540
Figure A.61 – Vehicle_Bus optical star configuration.....	540
Figure A.62 – Topology of the Vehicle_Bus.....	541
Figure A.63 – Bus_Controller	542
Figure A.64 – Bus interface for class 1 device	543
Figure A.65 – Bus Interface for Class 2/3 devices.....	544
Figure A.66 – Frame delimiter, Manchester-encoded data and Check_Sequence.....	545
Figure A.67 – Telegram.....	545
Figure A.68 – Master_Frame and Slave_Frame formats	546
Figure A.69 – MVB Process_Data Telegram.....	548
Figure A.70 – MVB Message_Data Telegram.....	548
Figure A.71 – MVB Supervisory_Data Telegram	549
Figure A.72 – Ports in the Traffic_Store.....	550
Figure A.73 – MVB Traffic.....	551
Figure A.74 – Periodic traffic configuration	551
Figure A.75 – Single response to a General_Event_Request (Start) frame	553
Figure A.76 – Event_Round with single response (no arbitration).....	553
Figure A.77 – First Event_Arbitration	554
Figure A.78 – Group_Event_Request.....	555
Figure A.79 – Event_Arbitration tree.....	555
Figure A.80 – Fully redundant bus	558
Figure A.81 – MVB redundant optical layout	558
Figure A.82 – Mastership transfer with multiple masters	559
Figure A.83 – Wire_Train_Bus	560
Figure A.84 – WTB topology.....	561
Figure A.85 – WTB cable arrangement (top view).....	562
Figure A.86 – Medium_Attachment_Unit (switches shown for an End_Node).....	563
Figure A.87 – WTB MAU with duplicated Line_Unit.....	564

Figure A.88 – WTB signal encoding.....	564
Figure A.89 – WTB Frame (extended ISO/IEC 13239).....	565
Figure A.90 – WTB Telegram.....	566
Figure A.91 – WTB Process_Data Telegram.....	567
Figure A.92 – Message_Data Telegram.....	567
Figure A.93 – Supervisory_Data Telegram.....	568
Figure A.94 – WTB Periodic and Sporadic Transmission.....	569
Figure A.95 – Summary of frames for regular operation.....	570
Figure A.96 – Node position addressing scheme.....	571
Figure A.97 – MAU elements for inauguration (single line attachment).....	573
Figure A.98 – Typical named composition.....	574
Figure A.99 – An additional Node is connected to a named composition.....	574
Figure A.100 – Unnamed Nodes.....	575
Figure A.101 – Status and Detection.....	576
Figure A.102 – Set-to-intermediate.....	576
Figure A.103 – Naming.....	576
Figure A.104 – Topography.....	577
Figure A.105 – Meeting of two compositions.....	578
Figure A.106 – Composition strength exchanges.....	579
Figure A.107 – Detection exchange.....	580
Figure A.108 – Telegram exchanges when two compositions meet.....	582
Figure A.109 – Bus shortening.....	583
Figure A.110 – Supervisory frames for inauguration.....	586
Figure A.111 – Master redundancy.....	588
Figure A.112 – Management environment.....	589
Figure A.113 – Class 2 Station configuration.....	592
Figure A.114 – Manager and Agent on two Stations.....	593
Figure A.115 – Management Messages.....	594
Figure A.116 – Packet format.....	595
Figure A.117 – Summary of managed objects.....	596
Table 1 – Template for the specification of an interface procedure.....	39
Table 2 – Example of message structure.....	40
Table 3 – Example of textual message form (corresponding to Table 2).....	41
Table 4 – State transitions table.....	42
Table 5 – Interoperability testing.....	48
Table 6 – LPI primitives.....	54
Table 7 – Var_Size and Var_Type encoding in a PV_Name.....	61
Table 8 – LMI primitives.....	82
Table 9 – Routing situations.....	97
Table 10 – Routing of packets coming from the transport layer.....	99
Table 11 – Routing of packets coming from a vehicle bus.....	100
Table 12 – Routing of packets coming from the train bus.....	101

Table 13 – Message Transport Control encoding	106
Table 14 – Connect_Request	109
Table 15 – Connect_Confirm	109
Table 16 – Disconnect_Request	110
Table 17 – Disconnect_Confirm	110
Table 18 – Data_Packet	110
Table 19 – Ack_Packet	111
Table 20 – Nak_Packet	111
Table 21 – Broadcast_Connect (BC1, BC2, BC3)	111
Table 22 – Broadcast_Data	112
Table 23 – Broadcast_Repeat	112
Table 24 – Broadcast_Stop (BSC, BSO)	113
Table 25 – MTP states	113
Table 26 – MTP incoming events	115
Table 27 – MTP outgoing events	115
Table 28 – MTP control parameters	116
Table 29 – MTP auxiliary variables	117
Table 30 – MTP time-outs (worst case)	119
Table 31 – Implicit actions	119
Table 32 – Compound actions	120
Table 33 – Producer states and transitions	121
Table 34 – Consumer states and transitions	124
Table 35 – TMI primitives	128
Table 36 – States of the MCP machine	139
Table 37 – Incoming Events	140
Table 38 – Outgoing Events	140
Table 39 – Control fields in packets	141
Table 40 – Auxiliary variables	142
Table 41 – MCP constants	143
Table 42 – MCP time-outs	143
Table 43 – MCP Compound actions	144
Table 44 – Filtering of BR packets	145
Table 45 – MCP Producer state event table	146
Table 46 – MCP Consumer state event table	148
Table 47 – AMI primitives	153
Table 48 – Address constants	155
Table 49 – System Address and User Address	158
Table 50 – MVB devices capabilities	197
Table 51 – Pin assignment for the ESD connector	205
Table 52 – Pin assignment for the EMD connector	214
Table 53 – Master Frame types and F_code	244
Table 54 – LS_RESULT encoding	268
Table 55 – MVB_Status object	268

Table 56 – MVB_Control object	269
Table 57 – MVB_Devices object	270
Table 58 – MVB_Administrator object	271
Table 59 – LS_V_REPORT encoding	273
Table 60 – WTB connector pin assignment	285
Table 61 – Signals of the Line Unit Interface	303
Table 62 – Link Control encoding	310
Table 63 – NodeControl data structure	342
Table 64 – MyStatus data structure	343
Table 65 – Shared Variables of a node	344
Table 66 – Variables of Main Process	344
Table 67 – Lists of Main Process	345
Table 68 – ‘START_NODE’	350
Table 69 – ‘MASTER STATES’	350
Table 70 – ‘SLAVE STATES’	351
Table 71 – Time constant values	379
Table 72 – Example of mvb_administrator_list	429
Table A.1 – Summary of the Train Communication Network	474
Table A.2 – Summary of the Real-Time Protocols	481
Table A.3 – Packet formats (bus-independent)	525
Table A.4 – Summary of data types	535
Table A.5 – Type equivalence	536
Table A.6 – Summary of the Multifunction_Vehicle_Bus	538
Table A.7 – MVB throughput for 20 m and 2000 m (physical layer)	547
Table A.8 – F_codes of the MVB (Master_Frame types)	548
Table A.9 – Example of Event_Round	556
Table A.10 – Arbitration delay in function of the number of simultaneous events	557
Table A.11 – Summary of the WTB	560
Table A.12 – Parameters for supervisory frames	587
Table A.13 – Summary of the Train Network Management	590