IEC 62591

Edition 2.0 2016-03

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Industrial networks – Wireless communication network and communication profiles – WirelessHART™

iTeh STANDARD PREVIEW
(standards.iteh.ai)

Réseaux industriels – Réseau de communications sans fil et profils de communication – WirelessHART™

IEC 62591:2016
https://standards.iteh.ai/catalog/standards/sist/40de45f5-f70d-4e65-bf28-174b96a1829d/iec-62591-2016

IEC 62591:2016-03(en-fr)

THIS PUBLICATION IS COPYRIGHT PROTECTED
Copyright © 2016 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.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
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.

IEC Catalogue - webstore.iec.ch/catalogue
The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - www.iec.ch/searchpub
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

Electropedia - www.electropedia.org
The world's leading online dictionary of electronic and electrical terms containing 20 000 terms and definitions in English and French, with equivalent terms in 15 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary
65 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

iTeh STANDARD PREVIEW
(standards.iteh.ai)
IEC 62591:2016
https://standards.iteh.ai/catalog/standards/sist/40de45f5-f70d-4e65-bf28-174b96a1829d/iec-62591-2016

A propos de l'IEC
La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC
Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Catalogue IEC - webstore.iec.ch/catalogue
Application autonome pour consulter tous les renseignements bibliographiques sur les Normes internationales, Spécifications techniques, Rapports techniques et autres documents de l'IEC. Disponible pour PC, Mac OS, tablettes Android et iPad.

Recherche de publications IEC - www.iec.ch/searchpub
La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études,…). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished
Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et aussi une fois par mois par email.

Electropedia - www.electropedia.org
Le premier dictionnaire en ligne de termes électroniques et électriques. Il contient 20 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans 15 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

Glossaire IEC - std.iec.ch/glossary
65 000 entrées terminologiques électrotechniques, en anglais et en français, extraites des articles Termes et Définitions des publications IEC parues depuis 2002. Plus certaines entrées antérieures extraites des publications des CE 37, 77, 86 et CISPR de l'IEC.

Service Clients - webstore.iec.ch/csc
Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: csc@iec.ch.

IEC 62591

Edition 2.0 2016-03

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Industrial networks – Wireless communication network and communication profiles – WirelessHART™

iTeh STANDARD PREVIEW
(standards.iteh.ai)

Réseaux industriels – Réseau de communications sans fil et profils de communication – WirelessHART™

IEC 62591:2016
https://standards.iteh.ai/catalog/standards/sist/40de45f5-f70d-4e65-bf28-174b96a1829d/iec-62591-2016

INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

ICS 25.040.40; 35.100.05

ISBN 978-2-8322-3174-6

Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.

® Registered trademark of the International Electrotechnical Commission
Marque déposée de la Commission Electrotechnique Internationale

CONTENTS

FOREWORD 24
INTRODUCTION 26
1 Scope 28
2 Normative references 28
3 Terms, definitions, symbols, abbreviations and conventions 29
3.1 Reference model terms and definitions 29
3.1.1 Terms and definitions from ISO/IEC 7498-1 terms and ISO/IEC 7498-3 terms 29
3.1.2 Terms and definitions from ISO/IEC 9545 30
3.1.3 Terms and definitions from ISO/IEC 8824 30
3.1.4 Terms and definitions from ISO/IEC 8825-1 31
3.2 Specific terms and definitions 31
3.3 Abbreviations 40
3.4 Conventions 42
3.4.1 Conventions used for DL-services 42
3.4.2 Conventions used for DL-protocol (state machine) 43
3.4.3 Conventions for Application Layer service 44
3.4.4 Conventions for the AL-protocol 47
4 Physical layer specification and service definition 51
4.1 General 51
4.2 Physical layer service definition 51
4.2.1 General overview 51
4.2.2 Physical layer services 52
4.3 Physical layer protocol specification 56
5 Data-link layer service definition – Type 20 elements 56
5.1 General 56
5.2 Data-link layer services 56
5.2.1 Facilities of the data-link layer services 56
5.2.2 QoS for message service 57
5.2.3 Sequence of primitives 58
5.2.4 DL-TRANSMIT service 60
5.2.5 DL-RECEIVE service 62
5.2.6 DL-DISCONNECT service 63
5.2.7 DL-PATH-FAILURE service 63
5.2.8 DL-ADVERTISE service 63
5.2.9 DL-NEIGHBOR service 64
5.2.10 DLM-SET 64
5.2.11 DLM-GET 65
5.2.12 DLM-ACTION 66
5.2.13 DLM-EVENT 67
5.3 Network layer services 67
5.3.1 Facilities of the network layer services 67
5.3.2 QoS for message service 67
5.3.3 Sequence of primitives 68
5.3.4 NL-TRANSMIT Service 68
5.3.5 NLM-SET 70

iTeh STANDARD PREVIEW
(standards.iteh.ai)
IEC 62591:2016
https://standards.iteh.ai/catalog/standards/sist/40de45f5-f70d-4e65-bf28-f74696a1829d/iec-62591-2016

5.3.6 NLM-GET 71
5.3.7 NLM-ACTION 71
5.4 Transport layer services 72
5.4.1 Facilities of the transport layer services 72
5.4.2 QoS for message service 73
5.4.3 Sequence of primitives 73
5.4.4 TL-DATA-TRANSFER Service 74
5.4.5 TL-DATA-EXCHANGE Service 76
5.4.6 TLM-SET 78
5.4.7 TLM-GET 78
6 Data-link layer protocol specification – Type 20 elements 79
6.1 General 79
6.2 Overview 79
6.2.1 Data-link layer operation 79
6.2.2 Network layer operation 82
6.2.3 Device procedures 84
6.3 Logical link control 84
6.3.1 General DLPDU structure 84
6.3.2 DLPDU-specific structure, encoding and elements of procedure 88
6.3.3 DLPDU Priority and Flow Control 92
6.3.4 Error detection and security 93
6.4 Medium Access Control 95
6.4.1 Function 95
6.4.2 Slot timing 95
6.4.3 Communication tables and buffers 98
6.4.4 Link scheduling 104
6.4.5 MAC operation 108
6.5 DL-management-information 118
6.5.1 General 118
6.5.2 DL attributes 118
6.5.3 DLM actions 119
6.6 Network layer 119
6.6.1 Two level model of NL 119
6.6.2 NPDU structure 122
6.6.3 Security function 125
6.6.4 Network layer tables 130
6.6.5 NLE machine 132
6.6.6 NLE elements of procedure 135
6.6.7 NL-management information 138
6.7 Transport layer 139
6.7.1 General 139
6.7.2 TPDU structure 139
6.7.3 Transport pipe table 140
6.7.4 TLE elements of procedure 141
6.7.5 TLE state machines 144
6.7.6 TL-management information 147
7 Application layer service definition – Type 20 elements 148
7.1 Common concepts 148
7.2 General 148

iTeh STANDARD PREVIEW
(standards.iteh.ai)
IEC 62591:2016
https://standards.iteh.ai/catalog/standards/sist/40dc45f5-f70d-4c65-bf28-174b96a1829d/iec-62591-2016

7.3 Data type ASE 148
7.3.1 Overview 148
7.3.2 Formal definition of data type objects 150
7.3.3 FAL defined data types 152
7.3.4 Data type ASE service specification 155
7.3.5 Summary of data types 155
7.4 Communication model specification 156
7.4.1 Common parameters 156
7.4.2 ASEs 157
7.4.3 ARs 230
7.4.4 Summary of classes 233
7.4.5 Permitted services by AREP role 233
8 Application layer protocol specification – Type 20 elements 234
8.1 General 234
8.2 Abstract syntax 234
8.3 Transfer syntax 234
8.3.1 Common APDU fields 234
8.3.2 Common APDU structure 235
8.3.3 Device application service-specific APDU structures 238
8.3.4 Layer management service specific APDU structures 263
8.3.5 Gateway and network manager specific APDU structures 306
8.3.6 Network management configuration specific APDU structures 328
8.3.7 Data coding rules 346
8.4 Common procedures 350
8.4.1 Delayed response 350
8.4.2 Response time 354
8.5 FAL service protocol machine (FSPM) 355
8.5.1 General 355
8.5.2 FSPM state tables 355
8.5.3 Functions used by FSPM 357
8.5.4 Parameters of FSPM/ARPM primitives 358
8.6 Application relationship protocol machines (ARPMs) 359
8.6.1 AREP mapping to transport layer 359
8.6.2 Application relationship protocol machines (ARPMs) 360
8.6.3 AREP state machine primitive definitions 362
8.6.4 AREP state machine functions 363
8.7 TL mapping protocol machine (TMPM) 363
8.7.1 TMPM states 363
8.7.2 TMPM state machines 363
8.7.3 Primitives exchanged between transport layer and TMPM 364
8.7.4 Functions used by TMPM 365
9 Communication Profile Family 9 (HART™) 365
9.1 General Overview 365
9.2 Profile 9/1 366
9.3 Profile 9/2 366
9.3.1 Conformance statement 366
9.3.2 Device types 367
9.3.3 Device worldwide applicability 369
9.3.4 Physical layer 370

iTeh STANDARD PREVIEW
(standards.iteh.ai)
IEC 62591:2016
https://standards.iteh.ai/catalog/standards/sist/40dc45f5-f70d-4c65-bf28-174b96a1829d/iec-62591-2016

9.3.5 Data-link layer 373
9.3.6 Application layer 374
Annex A (normative) Security 385
A.1 General 385
A.2 Joining 386
A.2.1 The join sequence 386
A.2.2 The network layer join process 392
A.2.3 The data-link layer join process 393
A.3 Network key change operation 396
A.4 Security management 397
A.5 Maintenance Port 397
Annex B (normative) Wireless procedures 399
B.1 Initializing a wireless network 399
B.2 Neighbor Discovery 399
B.3 Path failure 400
B.4 Device leaving the network 401
Annex C (normative) Network management 403
C.1 Overview 403
C.2 Network manager functions 404
Annex D (normative) Gateway 406
D.1 Overview 406
D.2 Access point 406
D.3 Functions 408
D.3.1 General requirements 408
D.3.2 Adding new network devices 409
D.3.3 Device configuration change status notifications 409
D.3.4 Gateway change notification function 409
D.3.5 Cached response messages 409
D.3.6 Service access point 410
D.3.7 Communication between gateway and network manager 410
Annex E (normative) Command response codes 411
E.1 Overview 411
E.1.1 General 411
E.1.2 Response code classifications 411
E.1.3 Reserved values 411
E.1.4 Unimplemented command 412
E.1.5 Busy 412
E.2 Response code definitions 412
E.2.1 General 412
E.2.2 Value ‘0’ 412
E.2.3 Value ‘1’ – single-definition error 412
E.2.4 Value ‘2’ – single-definition error 412
E.2.5 Value ‘3’ – single-definition error 412
E.2.6 Value ‘4’ – single-definition error 412
E.2.7 Value ‘5’ – single-definition error 412
E.2.8 Value ‘6’ – single-definition error 413
E.2.9 Value ‘7’ – single-definition error 413
E.2.10 Value ‘8’ – multi-definition warning 413

iTeh STANDARD PREVIEW
(standards.iteh.ai)
IEC 62591:2016
https://standards.iteh.ai/catalog/standards/sist/40de45f5-f70d-4e65-bf28-174b96a1829d/iec-62591-2016

E.2.11 Value ‘9’ – multi-definition error 413
E.2.12 Value ‘10’ – multi-definition error 414
E.2.13 Value ‘11’ – multi-definition error 414
E.2.14 Value ‘12’ – multi-definition error 414
E.2.15 Value ‘13’ – multi-definition error 414
E.2.16 Value ‘14’ – multi-definition warning 415
E.2.17 Value ‘15’ – multi-definition error 415
E.2.18 Value ‘16’ – single-definition error 415
E.2.19 Value ‘17’ – single-definition error 415
E.2.20 Value ‘18’ – single-definition error 415
E.2.21 Value ‘19’ – single-definition error 415
E.2.22 Value ‘20’ – single-definition error 415
E.2.23 Values ‘21’to ‘23’ – single-definition error 416
E.2.24 Values ‘24’to ‘27’ – single-definition warning 416
E.2.25 Value ‘28’ – multi-definition error 416
E.2.26 Value ‘29’ – multi-definition error 416
E.2.27 Value ‘30’ – multi-definition warning 416
E.2.28 Value ‘31’ – multi-definition warning 416
E.2.29 Value ‘32’ – single-definition error 416
E.2.30 Value ‘33’ – single-definition error 416
E.2.31 Value ‘34’ – single-definition error 416
E.2.32 Value ‘35’ – single-definition error 417
E.2.33 Value ‘36’ – single-definition error 417
E.2.34 Values ‘37’ to ‘59’ – single-definition error 417
E.2.35 Value ‘60’ – single-definition error 417
E.2.36 Value ‘61’ – single-definition error 417
E.2.37 Value ‘62’ – single-definition error 417
E.2.38 Value ‘63’ – single-definition error 417
E.2.39 Value ‘64’ – single-definition error 417
E.2.40 Value ‘65’ – multi-definition error 417
E.2.41 Value ‘66’ – multi-definition error 418
E.2.42 Value ‘67’ – multi-definition error 418
E.2.43 Value ‘68’ – multi-definition error 419
E.2.44 Value ‘69’ – multi-definition error 419
E.2.45 Value ‘70’ – multi-definition error 419
E.2.46 Value ‘71’ – multi-definition error 419
E.2.47 Values ‘72’ to ‘95’ – multi-definition error 419
E.2.48 Values ‘96’ to ‘111’ – single-definition warning 419
E.2.49 Values ‘112’ to ‘127’ – multi-definition warning 419
Annex F (normative) Common tables 420
F.1 Overview 420
F.1.1 General 420
F.1.2 Enumeration 420
F.1.3 Bit Field 420
F.2 Table definitions 421
F.2.1 Publish mode control codes 421
F.2.2 Write device variable codes 421
F.2.3 Device variable family codes 422
F.2.4 Device variable classification codes 422

iTeh STANDARD PREVIEW
(standards.iteh.ai)
IEC 62591:2016
https://standards.iteh.ai/catalog/standards/sist/40de45f5-f70d-4e65-bf28-174b90a1829d/iec-62591-2016

F.2.5 Analog channel saturated codes 423
F.2.6 Analog channel fixed codes 424
F.2.7 Standardized status 0 codes 424
F.2.8 Standardized status 1 codes 424
F.2.9 Standardized status 2 codes 425
F.2.10 Standardized status 3 codes 425
F.2.11 Publish trigger mode codes 426
F.2.12 Event notification control codes 426
F.2.13 Event status codes 426
F.2.14 Timetable request codes 426
F.2.15 Timetable application domain codes 427
F.2.16 Synchronous action control codes 427
F.2.17 Real-time clock flags codes 427
F.2.18 Wireless timer codes 427
F.2.19 Device power source codes 428
F.2.20 Link_type codes 428
F.2.21 Link option flags codes 428
F.2.22 Superframe mode flags codes 429
F.2.23 Session_type codes 429
F.2.24 Timetable deletion reason codes 429
F.2.25 Disconnect cause codes 429
F.2.26 Wireless operation codes 430
F.2.27 Join process status codes 430
F.2.28 Security type codes 430
F.2.29 Device list codes 431
F.2.30 Network access mode codes 431
F.2.31 Device profile codes 432
F.2.32 Device power status codes 432
F.2.33 Neighbor flags codes 432
F.2.34 Notification mask codes 433
F.2.35 Join mode codes 433
F.2.36 Device scheduling flags codes 433
F.2.37 Network optimization flags codes 433
F.2.38 Wireless capabilities codes 434
F.2.39 CCA mode codes 434
F.2.40 Wireless device connection status 434
F.2.41 Wireless device health status 434
F.2.42 Change key flag codes 435
F.2.43 Join key mode code 435
Annex G (informative) Application of publish data mode and event commands 436
G.1 Publish data mode operation 436
G.1.1 Overview 436
G.1.2 Configuring a device for publish data mode operation 436
G.1.3 Response for publish data mode operation 437
G.1.4 Publish data mode update periods 437
G.2 Event notification operation 438
G.2.1 Overview 438
G.2.2 Configuring a device event notification operation 438
G.2.3 Handling of Event Notification in a Device 438

iTeh STANDARD PREVIEW
(standards.iteh.ai)
IEC 62591:2016
https://standards.iteh.ai/catalog/standards/sist/40de45f5-f70d-4e63-bf28-1748f8dfb829d/iec-62591-2016

Annex H (informative) Network redundancy 440
Annex I (informative) Network manager implementation 441
I.1 Overview 441
I.2 Network manager model 441
I.2.1 General 441
I.2.2 Initializing the network manager 443
I.2.3 Types of network devices 443
I.2.4 Network routing 444
I.2.5 Network schedule 445
I.2.6 Security manager 449
I.2.7 Detailed model of the network manager 449
I.3 Routing 451
I.3.1 General 451
I.3.2 Routing requirements 451
I.3.3 Routing strategy 451
I.4 Scheduling 452
I.4.1 General 452
I.4.2 Scheduling requirements 452
I.4.3 Scheduling strategy 453
I.4.4 Networking scheduling example 454
I.5 Network manager interface 459
I.5.1 General 459
I.5.2 Initializing a wireless network 460
I.5.3 Allocating communication resources 461
I.5.4 Adjusting network schedule 462
I.5.5 Health reports 463
Annex J (informative) Gateway implementation 464
J.1 Overview 464
J.2 Gateway model 464
J.2.1 General 464
J.2.2 Host interface 465
J.2.3 Logical network device 465
J.2.4 Physical network device 466
J.2.5 Communication interface 466
J.2.6 Cached response messages 467
J.3 Gateway management 468
J.3.1 Addressing 468
J.3.2 Retry mechanisms 468
J.3.3 Power-on-reset 468
J.3.4 Network access point reset 469
J.3.5 Gateway reset 469
J.3.6 Re-build publish data periodic data 469
J.3.7 Gateway self test 470
J.3.8 Adding new network device 470
J.3.9 Device configuration change status notifications 470
J.4 Gateway superframe 470
J.5 Gateway change notification services 470
J.6 HART™ commands interface 472
J.6.1 General 472

iTeh STANDARD PREVIEW
(standards.iteh.ai)
IEC 62591:2016
https://standards.iteh.ai/catalog/standards/sist/40de45f5-f70d-4e65-bf28-174b96a1829d/iec-62591-2016

J.6.2 Host to gateway command request and response 472
J.6.3 Pass-through of HART™ command request and response 473
J.6.4 Caching publish data command response messages 473
J.6.5 Gateway status error flag bits 473
J.6.6 Gateway additional status flags 473
J.6.7 Gateway capacities 474
J.6.8 Gateway commands 474
Annex K (informative) Handheld device 475
K.1 Overview 475
K.2 Maintenance port connection 475
K.3 Network device connection 475
K.3.1 General 475
K.3.2 Install session keys 476
K.3.3 View network diagnostics and health reports 476
K.4 Network connection as a maintenance device 476
Annex L (informative) Application of WirelessHART Commands 477
L.1 Provisioning 477
L.1.1 General 477
L.1.2 Basic Provisioning 477
L.1.3 Joining 477
L.1.4 Enabling Faster Network Detection and Joining 478
L.1.5 Adjusting Transmit Power 478
L.2 Managing Superframes and Links 478
L.3 WirelessHART Handheld Support 479
L.4 Specifying and Managing Routes 480
L.5 Security 481
L.5.1 General 481
L.5.2 TDMA Data-Link Key Management 481
L.5.3 Session Key Management 481
L.5.4 Access Control 482
L.5.5 Simple Key Management 483
L.6 Device Lists 483
L.7 Network Management Commands 484
L.7.1 General 484
L.7.2 Bandwidth Management 484
L.7.3 Network Maintenance 485
L.7.4 Coexistence 486
L.7.5 Device Management 486
L.8 Network Health Reporting and Status 487
L.9 Gateway Commands 488
L.9.1 General 488
L.9.2 Device Identification 488
L.9.3 Network Information and Statistics 488
L.9.4 Network Management 489
L.9.5 Cache Management 489
Annex M (informative) Regional modification for compliance with ETSI standards 491
M.1 General 491
M.2 Compliance with EN 300 440-2 491
M.3 Compliance with EN 300 328 491

iTeh STANDARD PREVIEW
(standards.iteh.ai)
IEC 62591:2016
https://standards.iteh.ai/catalog/standards/sist/40de45f5-f70d-4e65-bf28-174b96a1829d/iec-62591-2016

M.3.1 General 491
M.3.2 Adaptive 492
M.3.3 Non-Adaptive 492
Bibliography 496

Figure 1 – Superframe class example 49
Figure 2 – Inheritance example 50
Figure 3 – Basic aggregation example 50
Figure 4 – Composition aggregation example 51
Figure 5 – Physical layer service sequences 53
Figure 6 – Message service error-free sequences 59
Figure 7 – Message service sequences with errors 60
Figure 8 – Receive only message service 60
Figure 9 – NLL Data transfer service sequences 68
Figure 10 – Data transfer service error-free sequences 74
Figure 11 – Data transfer service sequences with errors 74
Figure 12 – A TDMA slot and superframe 80
Figure 13 – Channel hopping 81
Figure 14 – Wireless network 83
Figure 15 – DLPDU Structure 84
Figure 16 – Address specifier 85
Figure 17 – Construction of 8-octet EUI-64 Address 86
Figure 18 – DLPDU specifier 86
Figure 19 – Slot timing details 96
Figure 20 – DLE tables and relationship 98
Figure 21 – Relationships used for link scheduling 105
Figure 22 – MAC components 108
Figure 23 – TDMA state machine 109
Figure 24 – XMIT state machine 113
Figure 25 – RECV state machine 115
Figure 26 – ACK transmission state machine 117
Figure 27 – Graph routing 121
Figure 28 – Source routing 122
Figure 29 – NPDU Structure 123
Figure 30 – NPDU control octet 123
Figure 31 – Security control octet 124
Figure 32 – NLE tables and relationship 130
Figure 33 – NLE state machine 133
Figure 34 – Routing decision of the NPDU 137
Figure 35 – TPDU Structure 139
Figure 36 – TPDU control octet 140
Figure 37 – Transition diagram of the client data transfer state machine 144
Figure 38 – Transition diagram of the client data exchange state machine 145

iTeh STANDARD PREVIEW
(standards.iteh.ai)
IEC 62591:2016
https://standards.iteh.ai/catalog/standards/sist/40de45f5-f70d-4e65-bf28-174b96a1829d/iec-62591-2016

Figure 39 – Transition diagram of the server state machine 146
Figure 40 – Data type class hierarchy 149
Figure 41 – Request APDU format from master to slave 235
Figure 42 – Normal response APDU format from slave to master 236
Figure 43 – Command error response APDU format from slave to master 236
Figure 44 – Aggregated command APDU 237
Figure 45 – Windowed trigger mode 250
Figure 46 – Windowed trigger mode with maximum update time expired 250
Figure 47 – Level trigger mode 251
Figure 48 – Coding without identification 346
Figure 49 – Coding of Integer type data 346
Figure 50 – Coding of Unsigned type data 347
Figure 51 – Coding of single precision floating point type data 347
Figure 52 – Coding of double precision floating point type data 348
Figure 53 – Coding of Date type data 348
Figure 54 – Normal DR operation 352
Figure 55 – Command responses during DR processing 353
Figure 56 – Slaves with multiple DR buffers 354
Figure 57 – State transition diagram of FSPM 355
Figure 58 – State transition diagram of the client ARPM 361
Figure 59 – State transition diagram of the server ARPM 362
Figure 60 – State transition diagram of TMPM 363
Figure 61 – Wireless network components 367
Figure A.1 – Join sequence 388
Figure A.2 – Network layer join procedure 392
Figure A.3 – Data-link layer join procedure 394
Figure A.4 – Network Key change operation 397
Figure B.1 – Neighbor Discovery 400
Figure B.2 – Path failure 401
Figure B.3 – Device leaving the network 402
Figure C.1 – Network manager in wireless network 403
Figure D.1 – Single network access point with clock 407
Figure D.2 – Multiple network access points with clocks 407
Figure D.3 – Network access point not providing clock 408
Figure G.1 – Enabling or disabling publishing sequence 437
Figure H.1 – Network routing 440
Figure I.1 – General model for network manager 442
Figure I.2 – Device type data model 443
Figure I.3 – Network routing 444
Figure I.4 – Network schedule 446
Figure I.5 – Example of a three-slot superframe 447
Figure I.6 – Multiple superframes in a network 447
Figure I.7 – Security manager 449

iTeh STANDARD PREVIEW
(standards.iteh.ai)
IEC 62591:2016
https://standards.iteh.ai/catalog/standards/sist/40de45f5-f70d-4e65-bf28-174890a1829d/iec-62591-2016

Figure I.8 – Detailed model of the network manager 450
Figure I.9 – Four network device wireless network 455
Figure I.10 – APDU sequences 459
Figure I.11 – Initializing a wireless network 461
Figure I.12 – Allocating and using network resources 462
Figure I.13 – Adjusting network schedule 463
Figure I.14 – Health reports 463
Figure J.1 – General model for gateway 465
Figure J.2 – Logical network device 466
Figure J.3 – Physical network device 466
Figure J.4 – Managing notification services 471
Figure M.1 – Consecutive Transmit Sequence 494
Figure M.2 – ACK-Transmit Sequence 495

Table 1 – Conventions used for state machines 47
Table 2 – Class relationship notation 49
Table 3 – Multiplicity notation 51
Table 4 – PH-ENABLE primitives and parameters 53
Table 5 – PH-CCA primitives and parameters 54
Table 6 – PH-DATA primitives and parameters 54
Table 7 – PHM-SET primitive and parameters 55
Table 8 – PHM-GET primitive and parameters 56
Table 9 – DL-Transmit primitives and parameters 61
Table 10 – DL-RECEIVE primitive and parameters 62
Table 11 – DL-DISCONNECT primitive and parameters 63
Table 12 – DL-PATH-FAILURE primitive and parameters 63
Table 13 – DL-ADVERTISE primitive and parameters 64
Table 14 – DL-NEIGHBOR primitive and parameters 64
Table 15 – DLM-SET primitive and parameters 65
Table 16 – DLM-GET primitive and parameters 65
Table 17 – DLM-ACTION primitive and parameters 66
Table 18 – NL-TRANSMIT primitives and parameters 69
Table 19 – NLM-SET primitive and parameters 70
Table 20 – NLM-GET primitive and parameters 71
Table 21 – NLM-ACTION primitive and parameters 71
Table 22 – TL-DATA-TRANSFER primitives and parameters 75
Table 23 – TL-DATA-EXCHANGE primitives and parameters 76
Table 24 – TLM-Set primitive and parameters 78
Table 25 – TLM-Get primitive and parameters 79
Table 26 – Network_ID Allocation 85
Table 27 – Contents of the ACK DLPDU payload 88
Table 28 – ACK response-code 89
Table 29 – Contents of the Advertise DLPDU payload 90

iTeh STANDARD PREVIEW
(standards.iteh.ai)
IEC 62591:2016
https://standards.iteh.ai/catalog/standards/sist/40de45f5-f70d-4e65-bf28-1144b8a1e2a1/iec-62591-2016

Table 30 – Beginning of the superframe 90
Table 31 – The next field after the last superframe size 90
Table 32 – Repeated for each link 91
Table 33 – Channel and frequency assignments 91
Table 34 – Slot timing definitions and values 96
Table 35 – Minimum DLE Table and buffer space requirement 98
Table 36 – Superframe attributes 99
Table 37 – Link attributes 100
Table 38 – Neighbor attributes and variables 101
Table 39 – Graph attributes 103
Table 40 – Packet record 103
Table 41 – Example Backoff_cntr selection sets 106
Table 42 – TDMA state machine 110
Table 43 – XMIT state transitions 113
Table 44 – RECV state machine 116
Table 45 – ACK transmission state machine 118
Table 46 – DL attributes 119
Table 47 – DL actions 119
Table 48 – Counter value 125
Table 49 – Session attributes 126
Table 50 – NPDU nonce 128
Table 51 – Minimum NLE Table space requirement 131
Table 52 – Route attributes 131
Table 53 – Source route attributes 132
Table 54 – TimeTable attributes 132
Table 55 – NLE states 133
Table 56 – NPDU construction 135
Table 57 – Routing actions 137
Table 58 – NL attributes 138
Table 59 – NL actions 139
Table 60 – Transport pipe attributes 141
Table 61 – Transport control encoding for TL-DATA-TRANSFER request 141
Table 62 – Transport control encoding for TL-DATA-EXCHANGE request 142
Table 63 – Transport control encoding for TL-DATA-EXCHANGE response 143
Table 64 – Client data transfer state table 145
Table 65 – Client data exchange state table 146
Table 66 – Server state table 147
Table 67 – Data type summary 156
Table 68 – Response code values 157
Table 69 – Read service parameters 160
Table 70 – Write service parameters 162
Table 71 – Information report service parameters 163
Table 72 – Action service parameters 165

iTeh STANDARD PREVIEW
(standards.iteh.ai)
IEC 62591:2016
https://standards.iteh.ai/catalog/standards/sist/40de45f5-f70d-4e65-bf28-174b96a1829d/iec-62591-2016