IEEE STANDARDS ASSOCIATION

IEEE Standard for Exchanging Information Between Networks Implementing IEC 61850 and IEEE Std 1815™ [Distributed Network Protocol (DNP3)]

IEEE Power and Energy Society

Sponsored by the
Substations Committee

IEEE
3 Park Avenue
New York, NY 10016-5997
USA

IEEE Std 1815.1™-2015
(Incorporates
IEEE Std 1815.1-2015/Cor 1-2016)

IEEE Std 1815.1™-2015
(Incorporates
IEEE Std 1815.1-2015/Cor 1-2016)

IEEE Standard for Exchanging Information Between Networks Implementing IEC 61850 and IEEE Std 1815™ [Distributed Network Protocol (DNP3)]

Sponsor

Substations Committee
of the
IEEE Power and Energy Society

Approved 5 December 2015

IEEE-SA Standards Board

Acknowledgments

The IEEE Substations Working Group (IEEE WG C14) gratefully acknowledges important contributions and assistance in the development of this standard from the following:

- H. Lee Smith, who was the past Chair of WG C14 and who passed away in 2015.
- National Institute of Standards and Technology (NIST).
- Smart Grid Interoperability Panel (SGIP).
- DNP User Group.
- Electric Power Research Institute (EPRI).

IEEE WG C14 thanks the International Electrotechnical Commission (IEC) for permission to reproduce information from its International Publication IEC 61850-7-2 ed.2.0 (2010), IEC 61850-7-3 ed.2.0 (2010), and IEC 61850-80-1 ed.1.0 (2008).

Abstract: This document specifies the standard approach for mapping between IEEE Std 1815™ [Distributed Network Protocol (DNP3)] and IEC 61850 (Communications Networks and Systems for Power Utility Automation). Two primary use cases are addressed: a) mapping between an IEEE 1815-based master and an IEC 61850-based remote site and b) mapping between an IEC 61850-based master and an IEEE 1815-based remote site. Mapping aspects included in the standard are: conceptual architecture; general mapping requirements; the mapping of Common Data Classes, Constructed Attribute Classes and Abstract Communication Service Interface (ACSI); cyber security requirements, the architecture of a gateway used for translation and requirements for embedding mapping configuration information into IEC 61850 System Configuration Description Language (SCL) and DNP3 Device Profile. This standard addresses a selection of features, data classes, and services of the two standards.

Keywords: automation, communications, DNP3, evolution, feeder, gateway, IEC 61850, IEEE 1815™, mapping, network, power system, substation, upgrade, utility

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

PDF: ISBN 978-1-5044-0598-0 STD20754
Print: ISBN 978-1-5044-0599-7 STDPD20754

Important Notices and Disclaimers Concerning IEEE Standards Documents

IEEE documents are made available for use subject to important notices and legal disclaimers. These notices and disclaimers, or a reference to this page, appear in all standards and may be found under the heading "Important Notice" or "Important Notices and Disclaimers Concerning IEEE Standards Documents."

Notice and Disclaimer of Liability Concerning the Use of IEEE Standards Documents

IEEE Standards documents (standards, recommended practices, and guides), both full-use and trial-use, are developed within IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association ("IEEE-SA") Standards Board. IEEE ("the Institute") develops its standards through a consensus development process, approved by the American National Standards Institute ("ANSI"), which brings together volunteers representing varied viewpoints and interests to achieve the final product. Volunteers are not necessarily members of the Institute and participate without compensation from IEEE. While IEEE administers the process and establishes rules to promote fairness in the consensus development process, IEEE does not independently evaluate, test, or verify the accuracy of any of the information or the soundness of any judgments contained in its standards.

IEEE does not warrant or represent the accuracy or content of the material contained in its standards, and expressly disclaims all warranties (express, implied and statutory) not included in this or any other document relating to the standard, including, but not limited to, the warranties of: merchantability; fitness for a particular purpose; non-infringement; and quality, accuracy, effectiveness, currency, or completeness of material. In addition, IEEE disclaims any and all conditions relating to: results; and workmanlike effort. IEEE standards documents are supplied "AS IS" and "WITH ALL FAULTS."

Use of an IEEE standard is wholly voluntary. The existence of an IEEE standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard.

In publishing and making its standards available, IEEE is not suggesting or rendering professional or other services for, or on behalf of, any person or entity nor is IEEE undertaking to perform any duty owed by any other person or entity to another. Any person utilizing any IEEE Standards document, should rely upon his or her own independent judgment in the exercise of reasonable care in any given circumstances or, as appropriate, seek the advice of a competent professional in determining the appropriateness of a given IEEE standard.

IN NO EVENT SHALL IEEE BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO: PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE PUBLICATION, USE OF, OR RELIANCE UPON ANY STANDARD, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE AND REGARDLESS OF WHETHER SUCH DAMAGE WAS FORESEEABLE.

Translations

The IEEE consensus development process involves the review of documents in English only. In the event that an IEEE standard is translated, only the English version published by IEEE should be considered the approved IEEE standard.

Official statements

A statement, written or oral, that is not processed in accordance with the IEEE-SA Standards Board Operations Manual shall not be considered or inferred to be the official position of IEEE or any of its committees and shall not be considered to be, or be relied upon as, a formal position of IEEE. At lectures, symposia, seminars, or educational courses, an individual presenting information on IEEE standards shall make it clear that his or her views should be considered the personal views of that individual rather than the formal position of IEEE.

Comments on standards

Comments for revision of IEEE Standards documents are welcome from any interested party, regardless of membership affiliation with IEEE. However, IEEE does not provide consulting information or advice pertaining to IEEE Standards documents. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Since IEEE standards represent a consensus of concerned interests, it is important that any responses to comments and questions also receive the concurrence of a balance of interests. For this reason, IEEE and the members of its societies and Standards Coordinating Committees are not able to provide an instant response to comments or questions except in those cases where the matter has previously been addressed. For the same reason, IEEE does not respond to interpretation requests. Any person who would like to participate in revisions to an IEEE standard is welcome to join the relevant IEEE working group.

Comments on standards should be submitted to the following address:

Secretary, IEEE-SA Standards Board
445 Hoes Lane
Piscataway, NJ 08854 USA

Laws and regulations

Users of IEEE Standards documents should consult all applicable laws and regulations. Compliance with the provisions of any IEEE Standards document does not imply compliance to any applicable regulatory requirements. Implementers of the standard are responsible for observing or referring to the applicable regulatory requirements. IEEE does not, by the publication of its standards, intend to urge action that is not in compliance with applicable laws, and these documents may not be construed as doing so.

Copyrights

Photocopies

Updating of IEEE Standards documents

Users of IEEE Standards documents should be aware that these documents may be superseded at any time by the issuance of new editions or may be amended from time to time through the issuance of amendments, corrigenda, or errata. An official IEEE document at any point in time consists of the current edition of the document together with any amendments, corrigenda, or errata then in effect.

Every IEEE standard is subjected to review at least every ten years. When a document is more than ten years old and has not undergone a revision process, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE standard.

In order to determine whether a given document is the current edition and whether it has been amended through the issuance of amendments, corrigenda, or errata, visit the IEEE Xplore at http://ieeexplore.ieee.org/ or contact IEEE at the address listed previously. For more information about the IEEE-SA or IEEE's standards development process, visit the IEEE-SA Website at http://standards.ieee.org.

Errata

Errata, if any, for all IEEE standards can be accessed on the IEEE-SA Website at the following URL: http://standards.ieee.org/findstds/errata/index.html. Users are encouraged to check this URL for errata periodically.

Patents

Attention is called to the possibility that implementation of this standard may require use of subject matter covered by patent rights. By publication of this standard, no position is taken by the IEEE with respect to the existence or validity of any patent rights in connection therewith. If a patent holder or patent applicant has filed a statement of assurance via an Accepted Letter of Assurance, then the statement is listed on the IEEE-SA Website at http://standards.ieee.org/about/sasb/patcom/patents.html. Letters of Assurance may indicate whether the Submitter is willing or unwilling to grant licenses under patent rights without compensation or under reasonable rates, with reasonable terms and conditions that are demonstrably free of any unfair discrimination to applicants desiring to obtain such licenses.

Essential Patent Claims may exist for which a Letter of Assurance has not been received. The IEEE is not responsible for identifying Essential Patent Claims for which a license may be required, for conducting inquiries into the legal validity or scope of Patents Claims, or determining whether any licensing terms or conditions provided in connection with submission of a Letter of Assurance, if any, or in any licensing agreements are reasonable or non-discriminatory. Users of this standard are expressly advised that determination of the validity of any patent rights, and the risk of infringement of such rights, is entirely their own responsibility. Further information may be obtained from the IEEE Standards Association.

Participants

At the time this IEEE standard was completed, the Substations Working Group had the following membership:

Ronald Farquharson, *Chair*
Grant Gilchrist, *Working Group Editor*
Ed Cenzon, *Secretary*

William Ackerman
Christoph Brunner
Panitarn (Joseph) Chongfuangprinya
Mason Clark
Jim Coats
Lorene Cunningham
Mike Dood
Kevin Easley
Derek R. Flickinger
David Goughnour
Yi Hu
Randy D. Kimura
Ronald Landheer-Cieslak
Gregory Luri
Parker McCauley
Rick Murphy
Bruce Muschlitz
Paul Myrda
Rodolfo Pellizzoni
Bogdan Popescu
Craig M. Preuss
Grant Ringham
Sam Sciacca
H. Lee Smith†
Michael S. Smith
Marcus Steel
John T. Tengdin
Eric Thibodeau
Jay Vellore
Vinoo S. Warrier
Andrew West

†Deceased

The following members of the individual balloting committee voted on this standard. Balloters may have voted for approval, disapproval, or abstention.

William Ackerman
Mark Adamiak
S. Aggarwal
Ali Al Awazi
Mihaela Albu
Jay Anderson
Galina Antonova
Ficheux Arnaud
James Baker
John Banting
Martin Baur
Philip Beaumont
Paul Bishop
William Bloethe
Christoph Brunner
Paul Cardinal
Keith Chow
Frances Cleveland
Jim Coats
Stephen Conrad
Charles Cook
Lorene Cunningham
Alireza Daneshpooy
Ratan Das
Em Delahostria
Michael Dood
P. Eastman
David Farmer
Ronald Farquharson
Keith Flowers
Dan Friedman
Grant Gilchrist
Mietek Glinkowski
Jalal Gohari
Edwin Goodwin
David Goughnour
Roman Graf
Stephen Grier
Randall Groves
Erich Gunther
Jeffrey Helzer
Mariana Hentea
Gary Heuston
Werner Hoelzl
Gary Hoffman
Dennis Holstein
Yi Hu
C. Huntley
Richard Jackson
Innocent Kamwa
Piotr Karocki
John Kay
Jeffrey Kester
Yuri Khersonsky
Morteza Khodaie
Stanley Klein
J. Koepfinger
Mieczyslaw Kokar
Bruce Kraemer
Jim Kulchisky
Marc Lacroix
Chung-Yiu Lam
Jeremy Landt
Federico Lopez
Greg Luri
Elvis Maculuba
Kenneth Martin
Pierre Martin
Edward McCall
John McDonald
Hank McGlynn
Michael Meisinger
Jeffery Mizener
Jose Morales
Adi Mulawarman
R. Murphy
Bruce Muschlitz
Paul Myrda
Pratap Mysore
Arthur Neubauer
Michael Newman
Gary Nissen
Yoshihiro Ohba
Lorraine Padden
Donald Parker
Bansi Patel
Bogdan Popescu
Craig Preuss
Farnoosh Rahmatian
John Randolph
Grant Ringham
Michael Roberts
Charles Rogers

Oleg Roizman
Benjamin Rolfe
William Rose
Bob Saint
Steven Sano
Sergio Santos
Bartien Sayogo
Thomas Schossig
Samuel Sciacca
Devki Sharma
Yasuro Shobatake
Gil Shultz
Cheong Siew
Mark Simon
Herbert Sinnock
Jerry Smith
Michael Smith
John Spare
Thomas Starai
Marcus Steel
Scott Sternfeld
Gary Stoedter
Ryan Stone
Raymond Strittmatter
Walter Struppler
Charles Sufana
William Taylor
John Tengdin
Eric Thibodeau
Joe Uchiyama
Eric Udren
Luis Vargas
John Vergis
Jane Verner
Ilia Voloh
Daniel Ward
Solveig Ward
Joseph Weiss
Andrew West
Oren Yuen

When the IEEE-SA Standards Board approved this standard on 5 December 2015, it had the following membership:

John D. Kulick, *Chair*
Jon Walter Rosdahl, *Vice Chair*
Richard H. Hulett, *Past Chair*
Konstantinos Karachalios, *Secretary*

Masayuki Ariyoshi
Ted Burse
Stephen Dukes
Jean-Philippe Faure
J. Travis Griffith
Gary Hoffman
Michael Janezic
Joseph L. Keopfinger*
David Law
Hung Ling
Andrew Myles
T. W. Olsen
Glenn Parsons
Ronald C. Petersen
Annette D. Reilly
Stephen J. Shellhammer
Adrian P. Stephens
Yatin Trivedi
Philip Winston
Don Wright
Yu Yuan
Daidi Zhong

*Member Emeritus

Introduction

This introduction is not part of IEEE Std 1815.1-2015, IEEE Standard for Exchanging Information Between Networks Implementing IEC 61850 and IEEE Std 1815™ [Distributed Network Protocol (DNP3)].

This standard has been developed to address requirements identified by the Smart Grid Interoperability Panel (SGIP) The SGIP is a public/private partnership initiated in 2009 by the National Institute of Standards and Technology (NIST) of the United States of America. NIST initiated the SGIP to support NIST in fulfilling its responsibility, under the U.S. Energy Independence and Security Act of 2007, to coordinate standards development for the Smart Grid. The term "Smart Grid" is used by the SGIP to refer to a power system that uses information and communication technology to make the delivery of electricity more efficient, reliable, secure, and resilient while minimizing costly investments in new generation capacity.

The purpose of the SGIP is to define requirements for the communication protocols and other common specifications that are considered essential to the creation of a Smart Grid. It coordinates development of these standards with collaborating organizations such as IEEE. The development of the IEEE Project Allocation Request (PAR) for this standard and the use case requirements found in Clause 5 of this standard were initiated through a Priority Action Plan (PAP) of the SGIP. The SGIP identifies a PAP to address either a gap where a new standard or standard extension is needed, or an overlap where two complementary standards have non-equivalent methods of addressing the same Smart Grid function.

In this case, the SGIP created a working group to address PAP12, entitled "Mapping IEEE Std 1815 (DNP3) to IEC 61850 Objects." The charter for PAP12 is stated as follows (in italics):

"IEEE Std 1815 (DNP3 – Distributed Network Protocol) is the de facto communication protocol used at the distribution and transmission level in the North American power grid. However, DNP3 is not fully capable of enabling all foreseen Smart Grid functions. Nevertheless the Smart Grid must accommodate and build upon the legacy systems of today's power grid. The tasks of this PAP include developing IEEE Std 1815 (DNP3) and IEC 61850 mapping documents including guidelines for achieving interoperable integration of equipment using DNP3 with equipment using IEC 61850 by Q4 - 2011.

Bridging the power delivery communication standards from current standards to more feature rich standards will accelerate the implementation of the Smart Grid. Expected benefits include reduced capital and lifecycle costs, improved reliability and the enablement of new applications."

With this purpose in mind, the members of the PAP12 Working Group began by sponsoring and assisting the adoption of DNP3 as IEEE Std 1815™-2010. It was important to complete this step so that the eventual mapping standard (this document) would describe the mapping between two officially recognized standards, not one standard and a "de facto" standard.

In parallel with this work, the PAP12 Working Group helped to initiate IEEE Std 1815.1™. Members of the PAP12 Working Group developed the PAR that created IEEE project P1815.1 and the IEEE Substations Committee Working Group C14 that was responsible for it. Members of the PAP12 Working Group also developed the use cases, use case diagrams, and the requirements for this standard as described in Clause 5. PAP12 members are providing coordination between Working Group C14 and Substations Committee Working Group C12 so that any changes required to IEEE Std 1815 that would facilitate the mapping to IEC 61850 can be incorporated as quickly as possible.

The intent of IEEE WG C14 and the PAP12 Working Group is to submit the final version of IEEE Std 1815.1 to the appropriate working group of the International Electrotechnical Commission (IEC) with the proposal that it be recognized as a "dual logo" standard. In this way, the mapping rules will be captured as an official part of both the IEEE Std 1815 series of standards and the IEC 61850 series of standards.

Contents

1. Overview 1
1.1 Scope 1
1.2 Objective 2
1.3 Background 2
1.4 Purpose and intended use 2
1.5 Use with other versions of the standards 5

2. Normative references 6

3. Definitions, acronyms, and abbreviations 7
3.1 Definitions 7
3.2 Acronyms and abbreviations 8

4. Conceptual architecture 11
4.1 Overview 11
4.2 Gateway device 14
4.3 Conceptual architecture of configuration tools 16

5. Use cases for configuring the gateway 19
5.1 Overview 19
5.2 Scope of use cases 19
5.3 Documentation of use cases 19
5.4 Use Case (a) scenario (a1): integration engineer configures a DNP3 gateway to a new IEC 61850 substation 20
5.5 Use Case (a) scenario (a2): integration engineer configures a DNP3 gateway to a retrofit IEC 61850 substation 26
5.6 Use Case (b): Integration engineer configures an IEC 61850 gateway to a DNP3 substation 32

6. Mapping of a device-oriented information model to DNP3 40
6.1 Overview 40
6.2 Logical device mapping 40
6.3 Object mapping 40

7. Mapping of data structure 41
7.1 Overview 41
7.2 Mapping principles 41
7.3 Mapping of constructed attribute classes 55
7.4 Mapping of the common data classes (CDC) 75

8. Mapping of abstract communications service interface (IEC 61850-7-2:2010) 182
8.1 Principles of service mappings 182
8.2 Error codes and indications 185
8.3 Server and logical device class mapping 189
8.4 Association class mapping 190
8.5 Logical node class mapping 191
8.6 Data class mapping 192
8.7 Data set mapping 192
8.8 Service tracking mapping 193
8.9 Setting group class mapping 193
8.10 Report control block class mapping 195
8.11 Control class mapping 196

8.12 Log mapping 243
8.13 GSE mapping 244
8.14 Sampled values mapping 244
8.15 Time synchronization mapping 244
8.16 File transfer mapping 244

9. Describing the DNP3/IEC 61850 mapping using XML 245
9.1 Overview 245
9.2 XML and XML schemas 245
9.3 XPath 246
9.4 DNP3 XML device profile document 246
9.5 DNP3 to IEC 61850 mapping elements 247
9.6 Embedding mapping information into DNP3 and IEC 61850-6 configuration files 255

10. Security Requirements 259
10.1 Overview 259
10.2 User and role management requirements 260
10.3 Translation function requirements 260
10.4 Data requirements 261
10.5 Service requirements 261
10.6 Security credential and algorithm requirements 262
10.7 Compliance with IEEE Std 1686-2007 262

Annex A (normative) Leaf level mapping rules and conformance table 264

Annex B (informative) Recommended implementation levels 282

Annex C (informative) Recommended mapping of IINs to IEC 61850-7-4 ed2.0 [B3] 288

Annex D (informative) Time synchronization security 290
D.1 Scope 290
D.2 Requirements 290
D.3 Environment 291
D.4 Run-time 291

Annex E (informative) Example XML files 292
E.1 Introduction 292
E.2 Example SCL file 292
E.3 Chosen data attributes 322
E.4 Resulting DNP3-XML mapping 323

Annex F (informative) Mapping to NISTIR 7628 [B9] 336

Annex G (informative) Bibliography 339

Table of Figures

Figure 1—Use Case (a) topology 4
Figure 2—Use Case (b) topology 5
Figure 3—Use Case (a) context 12
Figure 4—Use Case (b) context 13
Figure 5—Combining Use Case (a) and Use Case (b) 14
Figure 6—Use Case (a) conceptual architecture 15
Figure 7—Use Case (b) Conceptual architecture 16
Figure 8—Example configuration tool architectures 17
Figure 9—Use Case (a) scenario (a1) sequence of steps 23
Figure 10—Use Case (a) scenario (a2) sequence of steps 28
Figure 11—Use Case (b) sequence of steps 35
Figure 12—Object mapping 41
Figure 13—Mapping of enumerated CDC [Use Case (a)] 43
Figure 14—Mapping of enumerated CDC [Use Case (b)] 43
Figure 15—Mapping of CODED ENUM attribute [Use Case (a)] 44
Figure 16—Mapping of CODED ENUM attribute [Use Case (b)] 44
Figure 17—Mapping of originator [Use Case (a)] 45
Figure 18—Mapping of enumerated configuration information with two options 48
Figure 19—Mapping of enumerated configuration information with more than two options 48
Figure 20—Mapping of floating point configuration information 49
Figure 21—Mapping of integer configuration information 49
Figure 22—Mapping of Boolean configuration information 50
Figure 23—Mapping of ScaledValueConfig configuration information 50
Figure 24—Mapping of ctlModels configuration information 51
Figure 25—Mapping of sboClasses configuration information 51
Figure 26—Mapping of unit configuration information 52
Figure 27—Mapping of cell configuration information 52
Figure 28—Mapping of deadbanding configuration information 53
Figure 29—Direct control, normal security, Use Case (a) – positive case 200
Figure 30—Direct control, normal security, Use Case (a) – negative case, no Oper_resp 201
Figure 31—Direct control, normal security, Use Case (a) – negative case, Oper_resp 202
Figure 32—Direct control, normal security, Use Case (a) – negative case, no status change 203
Figure 33—Direct control, normal security, Use Case (b) – positive case 204
Figure 34—Direct control, normal security, Use Case (b) – negative case, no response 205
Figure 35—Direct control, normal security, Use Case (b) – negative case, operate error 206
Figure 36—Direct control, normal security, Use Case (b) – negative case, no status change 207
Figure 37—Direct control, enhanced security, Use Case (a) – positive case 208
Figure 38—Direct control, enhanced security, Use Case (a) – negative case, no Oper_resp 209
Figure 39—Direct control, enhanced security, Use Case (a) – negative case, Oper_resp 210
Figure 40—Direct control, enhanced security, Use Case (a) – negative case, no status change 211
Figure 41—Direct control, enhanced security, Use Case (a) – negative case, no CmdTerm_req 212
Figure 42—Direct control, enhanced security, Use Case (a) – negative case, CmdTerm_req 213
Figure 43—Direct control, enhanced security, Use Case (b) – positive case 214
Figure 44—Direct control, enhanced security, Use Case (b) – negative case, no response 215
Figure 45—Direct control, enhanced security, Use Case (b) – negative case, operate error 216
Figure 46—Direct control, enhanced security, Use Case (b) – negative case, no status change 217
Figure 47—SBO control, normal security, Use Case (a) – positive case 218
Figure 48—SBO control, normal security, Use Case (a) – negative case, no SelVal_resp 219
Figure 49—SBO control, direct security, Use Case (a) – negative case, SelVal_resp 220
Figure 50—SBO control, normal security, Use Case (a) – negative case, no Oper_resp 221
Figure 51—SBO control, direct security, Use Case (a) – negative case, Oper_resp 222
Figure 52—SBO control, normal security, Use Case (a) – negative case, no status change 223
Figure 53—SBO control, normal security, Use Case (b) – positive case 224

Figure 54—Direct control, enhanced security, Use Case (b) – negative case, no select response 225
Figure 55—SBO control, normal security, Use Case (b) – negative case, select error 226
Figure 56—Direct control, enhanced security, Use Case (b) – negative case, no operate response.....227
Figure 57—SBO control, normal security, Use Case (b) – negative case, operate error.....228
Figure 58—SBO control, normal security, Use Case (b) – negative case, no status change.....229
Figure 59—SBO control, enhanced security, Use Case (a) – positive case 230
Figure 60—SBO control, enhanced security, Use Case (a) – negative case, no SelVal_resp 231
Figure 61—SBO control, enhanced security, Use Case (a) – negative case, SelVal_resp 232
Figure 62—SBO control, enhanced security, Use Case (a) – negative case, no Oper_resp 233
Figure 63—SBO control, enhanced security, Use Case (a) – negative case, Oper_resp 234
Figure 64—SBO control, enhanced security, Use Case (a) – negative case, no Status Change.....235
Figure 65—SBO control, enhanced security, Use Case (a) – negative case, no CmdTerm_req 236
Figure 66—SBO control, enhanced security, Use Case (a) – negative case, CmdTerm_req 237
Figure 67—SBO control, enhanced security, Use Case (b) – positive case 238
Figure 68—SBO control, enhanced security, Use Case (b) – negative case, no select response 239
Figure 69—SBO control, enhanced security, Use Case (b) – negative case, select error.....240
Figure 70—SBO control, enhanced security, Use Case (b) – negative case, no operate response.....241
Figure 71—SBO control, enhanced security, Use Case (b) – negative case, operate error.....242
Figure 72—SBO control, enhanced security, Use Case (b) – negative case, no status change 243

Table of Tables

Table 1—Actors in Use Case (a) scenario (a1) 21
Table 2—Information exchanged in Use Case (a) scenario (a1) 22
Table 3—Steps of Use Case (a) scenario (a1) 24
Table 4—Functional objectives arising from Use Case (a) scenario (a1) 26
Table 5—Information exchanged in Use Case (a) scenario (a2) 27
Table 6—Steps of Use Case (a) scenario (a2) 29
Table 7—Functional objectives arising from Use Case (a) scenario (a2) 32
Table 8—Actors in Use Case (b) 33
Table 9—Information exchanged in Use Case (b) 34
Table 10—Steps of Use Case (b) 36
Table 11—Functional objectives arising from Use Case (b) 39
Table 12—Mapping table note definitions 54
Table 13—Point type column 56
Table 14—DNP3 flag bits and rules applied 57
Table 15—Quality and quality mapping 58
Table 16—AnalogueValue 59
Table 17—AnalogueValue mapping 60
Table 18—ScaledValueConfig 61
Table 19—ScaledValueConfig mapping 61
Table 20—RangeConfig 62
Table 21—RangeConfig mapping 63
Table 22—Step position with transient indication (ValWithTrans) 63
Table 23—ValWithTrans mapping 64
Table 24—Pulse configuration 65
Table 25—Pulse configuration mapping 65
Table 26—CROB mapping, Use Case (a) 66
Table 27—CROB mapping, Use Case (b) 67
Table 28—Originator 68
Table 29—Originator mapping 68
Table 30—Unit 69
Table 31—Unit mapping 69
Table 32—Vector 70
Table 33—Vector mapping 70
Table 34—Point 70
Table 35—Point mapping 71
Table 36—Cell 71
Table 37—Cell mapping 72
Table 38—CalendarTime 72
Table 39—CalendarTime mapping 73
Table 40—TimeStamp 74
Table 41—TimeStamp mapping 74
Table 42—TimeQuality 75
Table 43—TimeQuality mapping 75
Table 44—CDC: single point status (SPS) 76
Table 45—CDC: single point status (SPS) mapping 77
Table 46—CDC double point status (DPS) 78
Table 47—CDC double point status (DPS) mapping 79
Table 48—CDC integer status (INS) 80
Table 49—CDC integer status (INS) mapping 81
Table 50—CDC enumerated status (ENS) 82
Table 51—CDC enumerated status (ENS) mapping 83
Table 52—CDC protection activated information (ACT) 84
Table 53—CDC protection activated information (ACT) mapping 85

Table 54—CDC directional protection activation information (ACD) 87
Table 55—CDC directional protection activation information (ACD) mapping 88
Table 56—CDC security violation counting (SEC) 89
Table 57—CDC security violation counting (SEC) mapping 90
Table 58—DNP3 and IEC 61850 frozen counter operations 91
Table 59—CDC binary counter reading (BCR) 91
Table 60—CDC binary counter reading (BCR) 92
Table 61—CDC histogram (HST) 94
Table 62—CDC histogram (HST) mapping 95
Table 63—CDC visible string status (VSS) 97
Table 64—CDC visible string status (VSS) mapping 98
Table 65—CDC measured value (MV) 99
Table 66—CDC measured value (MV) mapping 100
Table 67—CDC complex measured value (CMV) 102
Table 68—CDC complex measured value (CMV) mapping 103
Table 69—CDC phase to ground related measured values of a three phase system (WYE) 106
Table 70—CDC phase to ground related measured values of a three phase system (WYE) mapping 107
Table 71—CDC phase to phase related measured values of a three phase system (DEL) 109
Table 72—CDC phase to phase related measured values of a three phase system (DEL) mapping 110
Table 73—CDC sequence (SEQ) 111
Table 74—CDC sequence (SEQ) mapping 112
Table 75—CDC harmonic value (HMV) 114
Table 76—CDC harmonic value (HMV) mapping 115
Table 77—CDC harmonic value for WYE (HWYE) 117
Table 78—CDC harmonic value for WYE (HWYE) mapping 118
Table 79—CDC harmonic value for DEL (HDEL) 121
Table 80—CDC harmonic value for DEL (HDEL) mapping 122
Table 81—CDC controllable single point (SPC) 124
Table 82—CDC controllable single point (SPC) mapping 125
Table 83—CDC controllable double point (DPC) 128
Table 84—CDC controllable double point (DPC) mapping 129
Table 85—CDC controllable integer status (INC) 132
Table 86—CDC controllable integer status (INC) mapping 133
Table 87—CDC controllable enumerated status (ENC) 136
Table 88—CDC controllable enumerated status (ENC) mapping 137
Table 89—CDC binary controlled step position information (BSC) 139
Table 90—CDC binary controlled step position information (BSC) mapping 140
Table 91—CDC integer controlled step position information (ISC) 143
Table 92—CDC integer controlled step position information (ISC) mapping 144
Table 93—CDC controllable analogue process value (APC) 148
Table 94—CDC controllable analogue process value (APC) mapping 149
Table 95—CDC binary controlled analog process value (BAC) 153
Table 96—CDC binary controlled analog process value (BAC) mapping 154
Table 97—CDC single point setting (SPG) 156
Table 98—CDC single point setting (SPG) mapping 157
Table 99—CDC integer status setting (ING) 158
Table 100—CDC integer status setting (ING) mapping 159
Table 101—CDC enumerated status setting (ENG) 160
Table 102—CDC enumerated status setting (ENG) mapping 160
Table 103—CDC object reference setting group (ORG) 161
Table 104—CDC object reference setting group (ORG) mapping 162
Table 105—CDC time setting group (TSG) 163
Table 106—CDC time setting group (TSG) mapping 164
Table 107—CDC currency setting group (CUG) 165
Table 108—CDC currency setting group (CUG) mapping 166
Table 109—CDC visible string setting (VSG) 167

Table 110—CDC visible string setting (VSG) mapping 167
Table 111—CDC analogue settings (ASG) 168
Table 112—CDC analogue settings (ASG) mapping 169
Table 113—CDC setting curve (CURVE) 170
Table 114—CDC setting curve (CURVE) mapping 171
Table 115—CDC curve shape setting (CSG) 172
Table 116—CDC curve shape setting (CSG) mapping 173
Table 117—CDC device name plate (DPL) 176
Table 118—CDC device name plate (DPL) mapping 177
Table 119—CDC logical node name plate (LPL) 178
Table 120—CDC logical node name plate (LPL) mapping 179
Table 121—CDC curve shape description (CSD) 180
Table 122—CDC curve shape description (CSD) mapping 181
Table 123—Services requiring client/server communication profile 184
Table 124—Types of error codes 185
Table 125—ServiceError to IIN and status code mapping in Use Case (a) 186
Table 126—AddCause to IIN and status code mapping in Use Case (a) 187
Table 127—Mapping DNP3 IIN to IEC 61850-7-2 ServiceError and AddCause in Use Case (b) 188
Table 128—Mapping DNP3 status codes to IEC 61850-7-2 ServiceError/AddCause Use Case (b) 189
Table 129—Server and logical device services mapping 190
Table 130—Association services mapping 191
Table 131—Logical nodes services mapping 191
Table 132—Data services mapping 192
Table 133—Comparison of data set services 192
Table 134—Setting group services mapping 193
Table 135—Settings group control block (SGCB) 194
Table 136—Settings group control block mapping 195
Table 137—Report control block services mapping 196
Table 138—Mapping of CmdTerm and DNP3 output events 197
Table 139 – Mapping of IEC 61850-7-2 control service parameters 198
Table 140—Security requirements in IEEE Std 1686-2007 and IEEE Std 1815.1 263
Table A.1—Leaf mapping 265
Table A.2—Rule list 280
Table B.1—Recommended implementation levels 282
Table C.1—Recommended IIN to data object mapping 289
Table F.1—Possible NISTIR 7628 actors representing the gateway 336
Table F.2—NISTIR 7628 logical interfaces associated with a gateway 337
Table F.3—EEE Std 1815.1 mapping to NISTIR 7628 security requirements 338

IEEE Standard for Exchanging Information Between Networks Implementing IEC 61850 and IEEE Std 1815™ [Distributed Network Protocol (DNP3)]

1. Overview

1.1 Scope

This document specifies the standard approach for mapping between IEEE Std 1815™, IEEE Standard for Electric Power Systems Communications – Distributed Network Protocol (DNP3)[1,2,3] and IEC 61850, Communication networks and systems for power utility automation.[4]

Two primary use cases are addressed:

— Mapping between an IEEE Std 1815-based master and an IEC 61850-based server.

— Mapping between an IEC 61850-based client and an IEEE Std 1815-based outstation.

[1] Information on normative references can be found in Clause 2.
[2] IEEE publications are available from the Institute of Electrical and Electronics Engineers (http://standards.ieee.org/).
[3] The IEEE standards or products referred to in this clause are trademarks of the Institute of Electrical and Electronics Engineers, Inc.
[4] IEC publications are available from the International Electrotechnical Commission (http://www.iec.ch/). IEC publications are also available in the United States from the American National Standards Institute (http://www.ansi.org/).

Mapping aspects included in the standard are: conceptual architecture; general mapping requirements; the mapping of Common Data Classes, Constructed Attribute Classes and Abstract Communication Service Interface (ACSI); cyber security requirements, the architecture of a gateway used for translation and requirements for embedding mapping configuration information into IEC 61850 System Configuration Language (SCL) and DNP3 Device Profile. This standard addresses a selection of features, data classes, and services of the two standards.

1.2 Objective

The objective of this standard is to document and make available requirements for exchanging data between IEEE Std 1815 and IEC 61850 protocols using a gateway. While a primary focus of this standard is for the electric utility industry, other industries that deliver energy and water could also use this document if they also plan to use both IEEE Std 1815 and IEC 61850 in their systems. The intent of this standard is to meet the goals established by the U.S. National Institute of Standards and Technology (NIST) for a Smart Grid:

— Provide a standard way to map between two standards from recognized standards institutions.

— Provide interoperability within hundreds of operational systems and between thousands of IEEE Std 1815 and IEC 61850 devices.

Vendors may use this standard to implement and test their gateway products and be assured of a high degree of interoperability. Users may use this document to specify their respective systems. System integrators may use this standard to assist in system integration and testing of user systems utilizing both protocols and gateways.

1.3 Background

IEC 61850 covers multiple aspects of a Supervisory Control and Data Acquisition (SCADA) system:

a) The definition of data structures. These data structures contain the information about the current state of the system (e.g., status information, measurements), the information required to operate the system, as well as parameters that can change the behavior of the system. These data structures are implemented in the devices.

b) The definition of communication services to access the data including the protocols to realize these communication services.

c) The definition of a model that describes the configuration of the system. That model is used during the system design to exchange information between different engineering tools.

IEEE Std 1815 covers the same aspects, but does not provide the same level of detail with regard to the data structures.

IEC 61850 uses a hierarchical object model, in which the different objects are identified with a name that also provides information about the semantic (meaning and usage) of the data.

IEEE Std 1815 uses numbers to identify the objects and does not define the semantic behind the objects.

1.4 Purpose and intended use

This standard defines rules and methods for the exchange of information between networks implementing IEC 61850 and IEEE Std 1815™-2012 by describing the following: