IEEE SA
STANDARDS ASSOCIATION

IEEE Standard for Broadband over Power Line Networks: Medium Access Control and Physical Layer Specifications

Developed by the

Power Line Communications Standards Committee
of the
IEEE Communications Society

IEEE Std 1901™-2020
(Revision of IEEE Std 1901-2010)

IEEE

IEEE Std 1901™-2020
(Revision of
IEEE Std 1901-2010)

IEEE Standard for Broadband over Power Line Networks: Medium Access Control and Physical Layer Specifications

Developed by the

Power Line Communications Standards Committee
of the
IEEE Communications Society

Approved

IEEE SA Standards Board

Abstract: Physical (PHY) and media access control (MAC) layers of a broadband powerline communication technology for local area networks (LANs), Smart Energy, Smart Grid, Internet of Things, transportation platforms (vehicle) applications, and other data distribution are defined in this standard. The balanced and efficient use of the power line communications channel by all classes of BPL devices is the main focus of this standard, defining detailed mechanisms for coexistence and interoperability between different BPL devices, and ensuring that desired bandwidth and quality of service may be delivered. The necessary security questions are addressed to ensure the privacy of communications between users and to allow the use of BPL for security sensitive services.

Keywords: access devices, adaptive power management, broadband over power lines (BPLs), coexistence protocol (CXP), convolutional turbo code, cosine modulated filter banks, extended ISP (E-ISP), fast Fourier transform orthogonal frequency division multiplexing (FFT OFDM), flexible channel wavelet (FCW) PHY/MAC , IEEE 1901™, in-home devices, Internet of Things (IoT), intersystem protocol (ISP), low-density parity check code (LDPC), medium access control (MAC), power line communication (PLC), physical layer (PHY), privacy, quality of service (QoS), security, sine modulated filter banks, wavelet orthogonal frequency division multiplexing (wavelet OFDM)

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

PDF: ISBN 978-1-5044-7080-3 STD24420
Print: ISBN 978-1-5044-7081-0 STDPD24420

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. IEEE Standards are documents developed through scientific, academic, and industry-based technical working groups. Volunteers in IEEE working groups 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 Standards do not guarantee or ensure safety, security, health, or environmental protection, or ensure against interference with or from other devices or networks. Implementers and users of IEEE Standards documents are responsible for determining and complying with all appropriate safety, security, environmental, health, and interference protection practices and all applicable laws and regulations.

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 comply with 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

IEEE draft and approved standards are copyrighted by IEEE under US and international copyright laws. They are made available by IEEE and are adopted for a wide variety of both public and private uses. These include both use, by reference, in laws and regulations, and use in private self-regulation, standardization, and the promotion of engineering practices and methods. By making these documents available for use and adoption by public authorities and private users, IEEE does not waive any rights in copyright to the documents.

Photocopies

Subject to payment of the appropriate fee, IEEE will grant users a limited, non-exclusive license to photocopy portions of any individual standard for company or organizational internal use or individual, non-commercial use only. To arrange for payment of licensing fees, please contact Copyright Clearance Center, Customer Service, 222 Rosewood Drive, Danvers, MA 01923 USA; +1 978 750 8400. Permission to photocopy portions of any individual standard for educational classroom use can also be obtained through the Copyright Clearance Center.

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 10 years. When a document is more than 10 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 IEEE Xplore at https://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 IEEE standards can be accessed via https://standards.ieee.org/findstds/index.html. Search for standard number and year of approval to access the web page of the published standard. Errata links are located under the Additional Resources Details section. Errata are also available in IEEE Xplore: https://ieeexplore.ieee.org/browse/standards/collection/ieee/. Users are encouraged to periodically check for errata.

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 https://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

This entity-based standard was created under the leadership of the following individuals:

Jean-Philippe Faure, *Chair*

Markus Rindchen, *Vice Chair*

At the time this standard was approved, the Broadband Over Power Lines PHY/MAC Working Group had the following entity membership:

ACN Advanced Communications Networks SA
HD-PLC Alliance
Panasonic
Power Plus Communications AG

The Working Group gratefully acknowledges the contributions of the following entities and participants. Without their assistance and dedication, this standard would not have been completed:

Organization	*Participant*
ACN Advanced Communications Networks SA	Stephan Horvath David Naughton
HD-PLC Alliance	Kaiyun Cheng Jean-Philippe Faure Hisao Koga Ryo Sakaji
Panasonic	Michimasa Aramaki Naohiro Kawabata
Power Plus Communications AG	Eugen Mayer Markus Rindchen C. Scott Willy

In Memory of Sherman L. Gavette 1941–2018

Historical participants

This standard was prepared by the Power Line Communications Standards Committee of the IEEE Communications Society. This publication represents a group effort on a large scale. The major contributors to IEEE Std 1901-2010 were as follows:

Jean-Philippe Faure, *Chair*

James D. Allen, *Vice Chair, PHY/MAC Technical Sub Group Chair*

Michael Stelts, *Coexistence Technical Sub Group Chair*

Purva Rajkotia, *GC PHY/MAC Technical Sub Group Chair*

Roger C. vonDoenhoff, *Transportation Sub Group Chair*

Stephan Horvath, *BPL/VDSL Sub Group Chair*

Sherman Gavette, *Technical Editor*

Organization	*Participant*
Acbel Polytech	Allen Cruz Rick Hung Arthur Lui Choli Teng Tony Wan Frank Yu

ACN Advanced Communications Networks, Inc. ..... Antoine Boss
David Harper
Stephan Horvath
Ambient Corporation ..... Jay Ganson
Ram Rao
Aron Viner
Analog Devices, Inc. ..... Dale Stolitzka
Analogies, SA ..... John Kikidis
AnSem ..... Paul Picazo
AOPEN America ..... Laura Diaz
Frank Huang
Wei Jim Lai
Luke G. [illegible]n
Chris Ra[illegible]lin
Arkados, Inc. ..... James D. Al[illegible]n
D[illegible]ve Law[illegible]nce
[illegible]ke [illegible]sc[illegible]luso
Sandeep M[illegible]ankumar
Jim Reeber
G[illegible]orge Rigopoulos
Bo Zhang
Ascom ..... Manu Sharma
Asoka USA ..... Songly Mu
Atheros Communications ..... Kaywan Afkhamie
Ron Glibbery
Chris Henningsen
Srinivas Katar
Manjunath Krishnam
Andy Melder
Purva Rajkotia
Sid Schrum
Faisal Shad
Larry Yonge
Jim Zyren
Broadcom Corporation ..... Stephen Palm
Buffalo Inc. ..... Akihito Hibi
Kato Masato
Center Point Energy ..... Gregory Angst
P. J. Donner
Consumer Electronics Powerline Comm[illegible]ion Alliance (CEPCA) ..... Lee Gould
Toshihiro Inokuchi
Akio Kurobe
Michael Stelts
Cisco Systems ..... Ivar Beljaars
Jon Cave
Allen J. Huotari
Communications Societ[illegible] ..... Alex Gelman
Component Distribution fo[illegible]LC S.L. ..... Sylwia Hadaj
Horst Hadi Mahmoudi
H. Prasad
Comtrend ..... Sophie Chen
Frank Chuang
Tomas Hubeny
Oscar Matteo
Rick Snelling
James Wu
Conexant ..... Wilfrid d'Angelo
George Dobrowski
Nimesh Doshi
Roger Hu
Hajime Kambayashi
Morio Kizawa

Akira Miyamoto
Lee Morling
Charles Raasch
Massimo Sorbara
Consumers Energy ..... Bradley Singletary
Corinex ..... Steve Baker
Eric Barker
Norbert Benko
Geert Blondeel
Scott Despot
Brian Donnelly
Tsutomu Katano
Andreas Kos[illegible]r
Joe [illegible]ier
Manuel Ruiz Mo[illegible]
Sam[illegible] Mo[illegible]vati
[illegible]ek[illegible]otka
Current Technologies ..... John Boot
Jim Mollenkopf
Defidev ..... José Maria Bosch
Ken Imai
Jea[illegible]-Pierre Lobert
Chris Vora
devolo AG ..... Michael Himmels
Michael Koch
DS2 ..... Augustin Badenes
Jorge Blasco
Eivind Christensen
Victor Dominguez
John Egan
Ramon Garcia
Chano Gomez
Salvador Iranzo
Jose Maria Llopis
Carl Stevenson
Luis Manuel Torres
Duke Energy ..... Gary Stuebing
Earthlink ..... Kevin Brand
Francois Marot
Eaton Corporation ..... Vehbi Cagri Gungor
Carlos Rentel
Echostar ..... Ren Finley
Elmeg Spain ..... Santiago Bellmunt
Miguel Garcia
Takumi Kikuchi
Diana Quesada
Endesa ..... Carlos Rodenas Garcia
Laura Corbeira Graell
Bruno Larvol
Kaoru Sugamato
EPRI ..... Tim Godfrey
Craig Rodine
EX[illegible]CO[illegible]S ..... Seong An Lee
Chanil Park
Brian Wenger
F[illegible]rn Consulting LLC ..... Jay Bain
France Telecom ..... Nakano Asako
John Benko
Sylvie Bokshorn
Thomas Derham
Ed Mitukiewitz
Julien Tronel

Gigle Networks	Jose Abad
	Jed Hurwitz
	Jose Ogara
	David Ruiz
	David Sorensen
	Michael Wilson
Grupo Premo	Pablo Farreras
	Tom McGrew
	Takashi Takeuchi
HD-PLC Alliance	Michimasa Aramaki
	Chenyi Chiu
	Eiji Kobayashi
	Hisao K[illegible]a
Hewlett Packard	Steve [illegible]
Hisilicon/Huawei	Paul Di[illegible]
	Haibo Liu
HomePlug Powerline Alliance, Inc.	[illegible]
	Bob Ranck
International Broadband Electric Communications, Inc. (IBEC)	Michael Goldston
	Scott Lee
	Kazumi Tanaka
	Steve Turner
	Brent Zitting
International Business Machines (IBM)	Charlie Arteaga
	Raymond Blair
Ikanos Communications	Ed Eckert
	Sam Heidari
	Tanoue Takeshi
Ilevo--Schneider Electric Powerline Communications	Jean-Philippe Faure
	Eric Morel
IMC Innovation	Thierry Fallet
Intel Corporation	Edward Butler
	Kosaka Hatanaka
	Barry O'Mahony
	Matthew Theall
Itochu	Imai Kenichi
	Peter Perera
	Hirosuke Seki
	Ichiro Shimizu
	Tsuguhito Shimpo
Kanematsu Corporation	Hideo Koshirae
	Takahito Shibayama
	Motoyoshi Sobajima
	Hidekai Yasuoka
Kawasaki Microelectronics, Inc.	Tommy Aizawa
	Joseph Choghi
	Sadahiro Kan
	Ryo Nakamura
	Norimitsu Sako
	Joel Silverman
	Hideki Yoneda
Korea Electrotechnology Research Institute	Jimyung Kang
	Yonghwa Kim
	Jae-Jo Lee
	Hui-Myoung Oh
	Jee-Sik Park
Kyushu Electric Power	Takashi Fujimura
	Kazuto Hamasaki
	Shuhei Horimoto
	Hironobu Iwabuchi
	Shuji Kaizaki
	Hiroyoki Ozou

Lantiq ..... Neal J. King
Kash Mirfakhrazi
Kazuhiko Morikawa
Vladimir Oksman
Jun Sato
Jens Wenzel
LEA ..... Jeff Biggs
Vincent Buchoux
Thierry Fernandez
Abdelrazak Younes
MainNet Communications Ltd ..... Merav Ben-Elia
Erez Geva
Shmuel Goldfisher
Rami Refaeli
Marvell Switzerland Sarl ..... Patrick Clement
Lydi Smaini
Mitsubishi Electric Corporation ..... Herve Bonneville
Johnas Cukier
Daniel Garcia
Juro Hara
Akira Horiguchi
Shigeo Kishimoto
Tsuyoshi Kobayashi
Kunio Kodaka
Kazuumi Koguchi
Richard Lynn
Christophe Mangin
Tadashi Matsuzaki
Tetsuya Mishuku
Yoshinori Mizugai
Hiromu Okamoto
Kiyotaka Saito
Hiroshi Shimada
Shinji Tanabe
Satoru Tokiya
Hirotoshi Yamada
Gyota Yasoda
Jin Zhang
Mitsubishi Materials Corporation ..... Shin Inui
Kenzo Nakamara
ModiTeleco ..... Cristobel Cledera
Adolfo Montalvo
Jorge Salvador
Motorola, Inc. ..... Mark Hickson
Jed Johnson
Ted Michaud
Shinichiro Okai
Gordon Shorten
Nishiyama Corporation ..... Hirokazu Horikoshi
Hiroshi Iwao
Eiichiro Nagahama
Takahiro Watanabe
Satoshi Yokoyama
NTT Advanced Technology Corporation ..... Tsukasa Kagamihara
Junichi Kishima
Yoshihiro Kondo
Motomu Matsumiya
Ryota Sumiya
Oki Electric ..... Yasubumi Chimura
Hideaki Kanno
Yichihiro Kitamura
Toshihisa Nakai

	Atsushi Notoya
	Noriyuki Sato
	Hiei Takazawa
OPERA	Inigo Berganza
	Philippe Conq
Panasonic Corporation of America	Akira Atsuta
	Jean-Philippe Faure
	Stefano Galli
	Takao Gondo
	David Hunter
	Yuji Igata
	Koji Ikeda
	Yohei Koide
	Masato Ohura
	Ritsuo Shirahama
	Kensuke Yoshizawa
Pioneer	Hirokazu Oishi
PLC Utilities Alliance	Laurent Feltin
	Christelle Xotto
PLC Ventures	Sergio Angeli
	Marianne Hernandez
	Maruyama Tomoko
Power Monitors, Inc	Chris Mullins
	Glen Shomo
Power Plus Communications AG	Markus Rindchen
	Bernd Wirth
Radio Shack	Dwayne Campbell
	Steven Collins
	Pete Griffin
	Yoshitane Kato
San Diego Gas and Electric	Terry Snow
Sharp	Sherman Gavette
	Morgan Hirosuke Miki
	Dan Park
	Vincent Roger
	Zhamping (Walter) Yin
SiConnect	Trevor Sokell
	Peter Strong
Siemens AG	Karl Dietrich
	Robert Stoklasek
Sigma Designs	David Baum
	Yael Birk
	Mileend Gadkari
	Boaz Kol
	Richard Nesin
	George Peponides
	Michael Weissman
	Eran Yakar
Sistemas Y Comunicaciones Skybel S.L.	Juan Andrés Gimeno
	Masaru Hishiki
	Carlos Puchol
	Pedro Sánchez
Soces Gestion	Jose M. Cuevas
	Emma Vaughnie
	Jose Villena
Sony Corporation	Mark Eyer
	Yasuhisa Nakajima
	Andreas Schwager
	Lothar Stadelmeier
	Takehiro Sugita
	Shigeru Takasu

SPiDCOM Technologies SA ..... Fred Onado
C. Scott Willy
Sumitomo Electric Industries Ltd. ..... Yoshihisa Asao
Kenichi Hirotsu
Kan Kinoshita
Masashi Kuwabara
Hidekazu Miyoshi
Henry Naoi
Randy Shaw
Takefumi Shimoguchi
Telcordia (representing AT&T) ..... Ken Kerpez
Ron Menendez
Telixx ..... Jatinder Anand
Kimura Horoshi
William Picken
Texas Instruments ..... Michael Bourton
Les Brown
Jalil Kamali
Badri Varadrajan
The Boeing Company ..... Barriet De Bose
Roger C. vonDoenhoff
Thomson Telecom Belgium ..... Alex DeSmedt
Tokyo Electric Power Co. ..... Tatsuya Kato
Osamu Ogawa
Yuji Omori
Takeo Osawa
Hitoshi Tanaka
Takashi Yanase
Toshiba Corporation ..... Kaoru Haruyama
Toyo Network Systems Co. Ltd. ..... Yukio Akegamiyama
Makoto Hasegawa
Takashi Umeda
United Power Line Council ..... Brett Kilbourne
Universal Powerline Association ..... Serafin Arroyo
Jose Calero
Daniel Drolet
Pablo Gagliardo
Watteco sas ..... Paul Bertrand
Michael Gaeta
Xeline ..... Jiyong Chun
Peter Lee
Yamaha ..... Kazuhiko Honda
Sadayuki Narusawa
Nobuyuki Sato
Yasuyoshi Sekizuka
Makoto Shiraki

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

0xSenses Corporation. ..... Yu Yuan
ACN Advanced Communications Networks, Inc. ..... Stephan Horvath
Beckhoff Automation..... Karl Weber
HD-PLC Alliance. ..... Hisao Koga
Huawei Technologies..... W. Adams
IoTecha Corporation ..... Oleg Logvinov
Panasonic Corporation of America ..... Naohiro Kawabata
Power Plus Communications AG..... Markus Rindchen
Qingdao Eastsoft Corporation..... Liu Fangfang

When the IEEE SA Standards Board approved this standard on 24 September 2020, it had the following membership:

Gary Hoffman, *Chair*
Jon Walter Rosdahl, *Vice Chair*
John D. Kulick, *Past Chair*
Konstantinos Karachalios, *Secretary*

Ted Burse
Doug Edwards
J. Travis Griffith
Grace Gu
Guido R. Hiertz
Joseph L. Koepfinger*
David J. Law
Howard Li
Dong Liu
Kevin Lu
Paul Nikolich
Damir Novosel
Dorothy Stanley
Mehmet Ulema
Lei Wang
Sha Wei
Philip B. Winston
Daidi Zhong
Jingyi Zhou

*Member Emeritus

Introduction

This introduction is not part of IEEE Std 1901-2020, IEEE Standard for Broadband over Power Line Networks: Medium Access Control and Physical Layer Specifications.

This revision gives users, in one document, IEEE Std 1901 for Broadband over Power Line Networks with all the amendments that have been published to date.

IEEE Std 1901 was developed on requirements collected from a large diversity of entities [semiconductors, integrators, consumer electronics (CE) companies, utilities, telcos, information technology (IT) companies, and transportation companies] that participated in the project. It provides a flexible architecture supporting integrated access, Smart Grid, building, in-home, and transportation platforms (vehicle) applications. It addresses a large diversity of topologies. It operates on physical media such as, but not limited to, electric power lines (AC or DC) and coaxial cables.

The physical layer (PHY) procedures specify either a wavelet orthogonal frequency division multiplexing (wavelet OFDM) or a fast Fourier transform orthogonal frequency division multiplexing (FFT OFDM) modulation scheme. It also specifies different modes for operations in different wavelet channels (frequency bands) with different values of carrier spacing (flexible channel wavelet FCW) for Internet of Things applications (IoTPLC).

The coexistence procedures allow the fair and efficient coexistence of the broadband over power line (BPL) systems. The intersystem protocol (ISP) enables various BPL systems to share power line communication resources in time (time domain multiplex), in frequency (frequency domain multiplex), or both.

Incorporating published amendments

The original standard was published in 2010. The current revision, IEEE Std 1901-2020, incorporates the following amendment into the 2010 revision:

— IEEE Std 1901a™-2019, IEEE Standard for Broadband over Power Line Networks: Medium Access Control and Physical Layer Specifications—Amendment: Enhancement for Internet of Things Applications.

Technical corrections, clarifications, and enhancements

In addition, this revision specifies technical corrections and clarifications to IEEE Std 1901™-2010.
See Annex Z.

New clauses from 2010 revision to 2020 revision

Clause 17 and Clause 18 were added according to IEEE Std 1901a-2019.

Acknowledgments

Portions of material used with permission: HomePlug AV Specification version 1.1, Copyright © 2007, HomePlug Powerline Alliance, Inc. Nonexclusive, irrevocable, royalty-free permission to use this material is granted for world rights distribution, with permission to modify and reprint in all future revisions and editions of the resulting draft and approved IEEE standard, and in derivative works based on the standard, in all media known or hereinafter known. HomePlug copyrighted material and derivatives may be contained in the following clauses, excluding any content related to wavelet and ISP:

4.3, General description of an IEEE 1901 network architecture
5, MAC service definitions
6, Frame formats
7, Security, excluding RSN and Camellia
8, MAC sublayer functional description
9, Layer management
10, MLME
11, Multiple networks using the FFT PHY
12, PHY service specification
13, FFT physical layer
Annex C.3, BT FFT TDMA scheduling example 3
Annex G, (Informative) Priority mapping
Annex I, (Informative) DSN in-home security—state transition diagrams
Annex J, (Informative) DSN in-home security—test vectors
Annex K, (Informative) Bridging and routing that use IEEE 1901 FFT stations as one or more of their portals
Annex L, (Informative) FFT parameters
Annex M, (Informative) IEEE 1901 FFT and TIA-1113 coexistence
Annex N, (Informative) Fair share between IEEE 1901 access and IEEE 1901 in-home using the same PHY
Annex O, (Informative) IEEE 1901 access and IEEE 1901 in-home synchronization and interoperability
Annex V, (Informative) Transmit spectrum mask example

Contents

IEEE Standard for Broadband over Power Line Networks: Medium Access Control and Physical Layer Specifications

1 Overview

1.1 Scope

The scope of this standard is to define medium access control (MAC) and physical layer (PHY) specifications for high-speed (>100 Mb/s at the physical layer) communication devices via electric power lines, so-called broadband over power line (BPL) devices as well as lower speed Internet of Things communication devices. This standard uses transmission frequencies below 100 MHz. It is usable by all classes of BPL devices, including BPL devices used for the first-mile/last-mile connection (<1500 m to the premise) to broadband services as well as BPL devices used in buildings for local area networks (LANs), Smart Energy/Smart Grid applications, transportation platform (vehicle) applications, Internet of Things applications, and other data distribution (<100 m between devices). This standard focuses on the balanced and efficient use of the power line communications channel by all classes of BPL devices, defining detailed mechanisms for coexistence and interoperability between different BPL devices, and assuring that desired bandwidth and quality of service may be delivered. The standard addresses the necessary security questions to provide privacy of communications between users and allow the use of BPL for security-sensitive services. It is limited to the physical layer and the medium access sublayer of the data link layer, as defined by the International Organization for Standardization (ISO) Open Systems Interconnection (OSI) Basic Reference Model.

1.2 Purpose

New modulation techniques offer the possibility to use the power lines for high-speed communications. This new high-speed medium is open and locally shared by several BPL devices. Without an independent, openly defined standard, BPL devices serving different applications will conflict with one another and provide unacceptable service to all parties. The standard will provide a minimum implementation subset that allows fair coexistence of the BPL devices. The full implementation will provide interoperability among BPL devices, as well as interoperability with other networking protocols, such as bridging for seamless interconnection via IEEE Std 802.1X™-2020.[1] It is also the intent of this effort to progress quickly toward a robust standard so power line applications may begin to impact the marketplace. The standard also complies with electromagnetic compatibility (EMC) limits set by national regulators, so as to enable successful coexistence with wireless and telecommunications systems.

1.3 Protocols

The defined protocols provide connectivity over power lines to automatic machinery, equipment, or stations that are connected to power lines, including:

— Functions and services required by an IEEE-1901-conformant device to operate within networks as well as the aspects of station portability (relocation) within those networks.

[1] Information on references can be found in Clause 2.