

# 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)

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

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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)

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

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

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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:

<i>Organization</i>	<i>Participant</i>
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

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## 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**

<i>Organization</i>	<i>Participant</i>
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 Stoltzka
Analogies, SA .....	John Kikidis
AnSem .....	Paul Picazo
AOPEN America .....	Laura Diaz Frank Huang Wei Jim Lai Luke G. Lin Chris Rawlins
Arkados, Inc. ....	James D. Allen Dave Lawrence Mike Macaluso Sandeep Mohankumar Jim Reeber George Rigopoulos Bo Zhang
Ascom .....	Manu Sharma
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Broadcom Corporation .....	Stephen Palm
Buffalo Inc. ....	Akihito Hibi Kato Masato
Center Point Energy .....	Gregory Angst P. J. Donner
Consumer Electronics Powerline Communication Alliance (CEPCA) .....	Lee Gould Toshihiro Inokuchi Akio Kurobe Michael Stelts
Cisco Systems .....	Ivar Beljaars Jon Cave Allen J. Huotari
Communications Society .....	Alex Gelman
Component Distribution for PLC S.L. ....	Sylvia 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 Kossler
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	Manuel Ruiz Molina
	Sam Morovati
	Peter Sobotka
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Defidev.....	José Maria Bosch
	Ken Imai
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DS2.....	Augustin Badenes
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	Victor Dominguez
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	Chano Gomez
	Salvador Iranzo
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	Francois Marot
Eaton Corporation.....	Vehbi Cagri Gungor
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Echostar.....	Ren Finley
Elmeg Spain.....	Santiago Bellmunt
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Endesa.....	Carlos Rodenas Garcia
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	Bruno Larvol
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EPRI.....	Tim Godfrey
	Craig Rodine
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France Telecom.....	Nakano Asako
	John Benko
	Sylvie Bokshorn
	Thomas Derham
	Ed Mitukiewicz
	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 Koga
Hewlett Packard .....	Steve Mills
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HomePlug Powerline Alliance, Inc. ....	Oleg Logvinov Rob 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
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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 Shimpō
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 Hirotohi 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
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	Yohei Koide
	Masato Ohura
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PLC Ventures.....	Sergio Angeli
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Power Monitors, Inc.....	Chris Mullins
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Radio Shack.....	Dwayne Campbell
	Steven Collins
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	Yoshitane Kato
San Diego Gas and Electric.....	Terry Snow
Sharp.....	Sherman Gavette
	Morgan Hirotsuke Miki
	Dan Park
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SiConnect.....	Trevor Sokell
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	Yael Birk
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	Masaru Hishiki
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	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
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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

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OxSenses Corporation ..... Yu Yuan  
ACN Advanced Communications Networks, Inc. .... Stephan Horvath  
Beckhoff Automation..... Karl Weber  
HD-PLC Alliance. .... Hisao Koga  
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## 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<sup>TM</sup>-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<sup>TM</sup>-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.

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- 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

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# 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.<sup>1</sup> 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.

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<sup>1</sup> Information on references can be found in Clause 2.