IEEE SA
STANDARDS ASSOCIATION

IEEE Standard for Adoption of MIPI Alliance Specification for A-PHY Interface (A-PHY) Version 1.0

STANDARDS

Developed by the
IEEE Board of Governors Corporate Advisory Group (CAG)

IEEE SA Industry Affiliate Network (IAN)
base specification contributed by MIPI Alliance

mipi® alliance

IEEE

IEEE Standard for Adoption of MIPI Alliance Specification for A-PHY Interface (A-PHY) Version 1.0

Developed by the

Corporate Advisory Group (BOG/CAG)
of the
IEEE SA Board of Governors

Approved 16 June 2021

IEEE SA Standards Board

Abstract: This standard adopts MIPI Alliance—MIPI A-PHY Specification Version 1.0 as an IEEE Standard. The adopted standard provides an asymmetric data link in a point-to-point or daisy-chain topology, with high-speed unidirectional data, embedded bidirectional control data and optional power delivery over a single cable. In this way, it reduces wiring, cost and weight, as high-speed data, control data and optional power share the same physical wiring. For integration with existing network backbones, it complements Ethernet, Controller Area Network (CAN), FlexRay, and other interfaces.

Keywords: 8B/10B PCS, ACMD, ACMP, adoption, advanced driver assistance systems, A-Header, A-Packet, A-Payload, APDLL, A-PHY, APPI, asymmetric, automotive, autonomous driving systems, camera, car noise, Clock Forwarding Service, coaxial cable, Control and Management System Architecture, CSE, CSI, CSI-2, descrambler, Display, DSE, DSI, DSI-2, Duplication Table, Eye Diagram, functional safety, gear, high-speed uni-directional data stream, I2C, I3C, infotainment, inline connectors, IEEE 2977, ISO 26262, jitter, Lidar, Local Functions, long reach, low-speed bi-directional command and control data, MIPI Alliance, Multi Point, NRZ, optimal wiring cost and weight, Packet Duplication, Packet Forwarding, PAL/CSI-2, PAL/DSI-2, PAL/eDP-DP, PAL/GPIO, PAL/I2C, PAM, PAM16, PAM-X PCS, Phy, Physical layer, PMD, power distribution, power over coax, Power over Differential Line, Profile, protocol adaptation layer, Radar, Routing Table, scrambler, sensor, SerDes, Serial interface, serializer deserializer, Shielded Differential Pair (SDP), Shielded Parallel Pair (SPP), Shielded Twisted Pair (STP), test modes

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

PDF: ISBN 978-1-5044-7698-0 STD24794
Print: ISBN 978-1-5044-7699-7 STDPD24794

Important Notices and Disclaimers Concerning IEEE Standards Documents

IEEE Standards documents are made available for use subject to important notices and legal disclaimers. These notices and disclaimers, or a reference to this page (https://standards.ieee.org/ipr/disclaimers.html), appear in all standards and may be found under the heading "Important Notices and Disclaimers Concerning IEEE Standards Documents."

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

IEEE Standards documents are developed within the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (IEEE SA) Standards Board. IEEE develops its standards through an accredited consensus development process, which brings together volunteers representing varied viewpoints and interests to achieve the final product. IEEE Standards are documents developed by volunteers with scientific, academic, and industry-based expertise in technical working groups. Volunteers are not necessarily members of IEEE or IEEE SA, 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 completeness 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. In addition, IEEE does not warrant or represent that the use of the material contained in its standards is free from patent infringement. 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: THE NEED TO PROCURE 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 is 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, nor 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 the presenter's views should be considered the personal views of that individual rather than the formal position of IEEE, IEEE SA, the Standards Committee, or the Working Group.

Comments on standards

Comments for revision of IEEE Standards documents are welcome from any interested party, regardless of membership affiliation with IEEE or IEEE SA. However, **IEEE does not provide interpretations, 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 evaluating comments or in revisions to an IEEE standard is welcome to join the relevant IEEE working group. You can indicate interest in a working group using the Interests tab in the Manage Profile & Interests area of the IEEE SA myProject system. An IEEE Account is needed to access the application.

Comments on standards should be submitted using the Contact Us form.

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 constitute 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.

Data privacy

Users of IEEE Standards documents should evaluate the standards for considerations of data privacy and data ownership in the context of assessing and using the standards in compliance with applicable laws and regulations.

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, neither IEEE nor its licensors waive any rights in copyright to the documents.

Photocopies

Subject to payment of the appropriate licensing fees, 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; https://www.copyright.com/. 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 or contact IEEE. For more information about the IEEE SA or IEEE's standards development process, visit the IEEE SA Website.

Errata

Errata, if any, for all IEEE standards can be accessed on the IEEE SA Website. 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. Users are encouraged to periodically check for errata.

Patents

IEEE Standards are developed in compliance with the IEEE SA Patent Policy.

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

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.

This IEEE standard is based on a technical specification developed by a consortium. Patent declarations may have been provided to the consortium as a membership requirement, or in compliance with the consortium's intellectual property rights (IPR) policies and procedures. Normative references in this standard may contain material subject to patent claims that are also subject to the consortium's or other organizations' IPR policies and procedures. Additional information about declarations may be available from the consortium's website:

MIPI Alliance—http:// www.mipi.org/

IMPORTANT NOTICE

IEEE Standards do not guarantee or ensure safety, security, health, or environmental protection, or ensure against interference with or from other devices or networks. IEEE Standards development activities consider research and information presented to the standards development group in developing any safety recommendations. Other information about safety practices, changes in technology or technology implementation, or impact by peripheral systems also may be pertinent to safety considerations during implementation of the standard. 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.

Participants

At the time this IEEE standard was completed, the MIPI A-PHY Adoption Working Group had the following membership:

Richard Wietfeldt, *Chair*
Zahy Madgar, *Vice Chair*
Peter Lefkin, *Secretary*

Rob Anhofer
Rich Boyer
Hezi Saar
Leonid Smolyansky
David Woolf

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

Philip E. Beecher
Liu Fangfang
Jefferson Hall
Daozhuang Lin
Ruben E. Salazar Cardozo
Kunal Shah
Gary Stuebing
Karl Weber
Yu Yuan

When the IEEE SA Standards Board approved this standard on 16 June 2021, it had the following membership:

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

Edward A. Addy
Doug Edwards
Ramy Ahmed Fathy
J. Travis Griffith
Thomas Koshy
Joseph L. Koepfinger*
David J. Law
Howard Li
Daozhuang Lin
Kevin Lu
Daleep C. Mohla
Chenhui Niu
Damir Novosel
Annette Reilly
Dorothy Stanley
Mehmet Ulema
Lei Wang
F. Keith Waters
Karl Weber
Sha Wei
Howard Wolfman
Daidi Zhong

*Member Emeritus

Introduction

This introduction is not part of IEEE Std 2977-2021, IEEE Standard for Adoption of MIPI Alliance Specification for A-PHY Interface (A-PHY) Version 1.0.

This IEEE standard is based on a technical specification developed by a consortium. Patent declarations may have been provided to the consortium as a membership requirement, or in compliance with the consortium's intellectual property rights (IPR) policies and procedures. Normative references in this standard may contain material subject to patent claims that are also subject to the consortium's or other organizations' IPR policies and procedures. Additional information about declarations may be available from the consortium's website:

MIPI Alliance—http:// www.mipi.org/

The A-PHY v1.0 specification was developed in 2018–2020 by member companies of the MIPI Alliance and adopted by the MIPI Board of Directors in September 2020. MIPI Alliance is a collaborative global organization serving industries that develop mobile and mobile-influenced devices.

In October 2020 a memorandum of understanding between MIPI Alliance and IEEE was announced, with the purpose of facilitating a MIPI A-PHY v1.0 adoption process within IEEE. IEEE Std 2977 is intended to bring MIPI A-PHY to a broader ecosystem beyond MIPI's membership, which in turn will foster greater interoperability, choice, and economies of scale for the global automotive industry. For IEEE, the contribution of MIPI A-PHY will add a new asymmetric approach to its existing portfolio of IEEE automotive standards.

MIPI A-PHY v1.0 is a long-reach serializer-deserializer (SerDes) physical layer interface for automotive applications, including Advanced Driver-Assistance Systems (ADAS), Automated Driving Systems (ADS), and other surround-sensor applications.

Ongoing development of the A-PHY specification will remain with MIPI Alliance.

Users should note that the only normative reference listed in the Reference clause of this adoption is to Section 4.5 of M-PHY Specification [MIPI08]. The referenced section is provided in Annex B.

Trademarks and service marks in this standard identify materials provided for the convenience of users and do not constitute an endorsement by IEEE of these products. Equivalent products may be used if they can be shown to lead to the same results.

Contents

Figures

Tables

Release History

Date	Version	Description
06-Aug-2020	v1.0	Initial Board adopted release.

This page intentionally left blank.

1 Introduction

This document specifies MIPI A-PHY, a serial interface technology with high bandwidth capabilities developed particularly for long reach (e.g., automotive) applications, enabling low pin count and a high level of power efficiency.

A-PHY is designed for a wide range of long reach applications, and specifically for automotive market, to carry multiple protocols from MIPI Alliance such as CSI-2 for cameras, and DSI and DSI-2 for displays. Non-MIPI protocols are also supported using a generic Data Link Layer Interface (APPI).

A-PHY features include:

- Long reach capability – optimized to support cables up to 15 m with up to 4 inline connectors
- Multiple speed gears ranging from 2 Gbps up to 16 Gbps
- Support for multiple cable types commonly used in automotive
- Strong noise immunity for the harsh automotive environment
- Generic Data Link Layer, supporting multiple protocols from MIPI Alliance and external entities

1.1 Scope

1.1.1 In Scope

This A-PHY Specification document specifies the implementation of the A-PHY, including its layering, electrical characteristics, and its optional features.

1.1.2 Out of Scope

Protocol Adaptation Layers (PALs)

A single A-PHY can serve multiple protocols at the same time, and each protocol has its own interface to the Data Link Layer, called a Protocol Adaptation Layer (PAL). PALs are not part of this document.

Specific Channel Configurations

Different protocols employing A-PHY technology can have different constraints, which can require the use of different approaches for operation control. Therefore, while this document provides the features to enable stable, optimized Link configuration, it does not mandate specific configurations for specific channels.

1.2 Purpose

Long reach devices, and specifically automotive devices, face increasing bandwidth demands for each of their functions, as well as an increase in the number of functions integrated into the system.

Addressing this demand requires wide bandwidth, low pin count (serial), highly power-efficient (network) interfaces with sufficient flexibility to be attractive for multiple applications, while employing just a single physical layer technology.

A-PHY complements MIPI Alliance's existing D-PHY and C-PHY interfaces by addressing the long reach automotive channel.