

IEEE Standard for High Data Rate Wireless Multi-Media Networks

Amendment 2: 100 Gb/s Wireless Switched Point-to-Point Physical Layer

IEEE Computer Society

Sponsored by the
LAN/MAN Standards Committee

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

IEEE Std 802.15.3d™-2017
(Amendment to
IEEE Std 802.15.3™-2016
as amended by
IEEE Std 802.15.3e™-2017)

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Approved 28 September 2017

IEEE-SA Standards Board

Abstract: An alternative physical layer (PHY) at the lower THz frequency range between 252 GHz and 325 GHz for switched point-to-point links is defined in this amendment. Two PHY modes are defined that enable data rates of up to 100 Gb/s using eight different bandwidths between 2.16 GHz and 69.12 GHz.

Keywords: 300 GHz, fixed point-to-point, IEEE 802.15.3™, IEEE 802.15.3d™, submillimeter waves, THz, wireless

The Institute of Electrical and Electronics Engineers, Inc.
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Print: ISBN 978-1-5044-4246-6 STD22732
PDF: ISBN 978-1-5044-4245-9 STDPD22732

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Introduction

This introduction is not part of IEEE Std 802.15.3d-2017, IEEE Standard for High Data Rate Wireless Multi-Media Networks—Amendment 2: 100 Gb/s Wireless Switched Point-to-Point Physical Layer.

IEEE Std 802.15.3d-2017 is an amendment to IEEE Std 802.15.3-2016 that defines an alternative physical layer (PHY) at the lower THz frequency range, between 252 GHz and 325 GHz, for switched point-to-point links, along with the necessary MAC changes to support this PHY. This amendment builds on the concept of pairnet, introduced in IEEE Std 802.15.3e-2017, and inherits the corresponding MAC changes defined there. Some of the key features and additions are as follows:

- Operation in the THz frequency band.
- Usage of eight different bandwidths between 2.16 GHz and 69.12 GHz.
- Designed for data rates of up to 100 Gb/s.
- Use of a pairnet structure supporting wireless links for intra-device communication (e.g., board-to-board communication), close proximity communication, wireless data centers, and backhaul/fronthaul links.
- Selectable PHY modes (single carrier and on-off keying) to achieve either ultra high-speed operation or system simplicity.

Interest in developing a wireless communication system at THz frequencies started in 2008 with the establishment of the THz Interest Group. In May 2014, Task Group 3d was formed, covering switched point-to-point connections operating in the frequencies from 60 GHz up to the lower THz bands. The Task Group started to work on four supporting documents: the Application Requirements Document, the Technical Requirements Document, the Channel Modeling Document, and the Evaluation Criteria Document. In September 2014, discussions split the Task Group into two, leading to the development of an amendment for close proximity links at 60 GHz as the separate Task Group 3e. The first meeting of Task Group 3e was in May 2015. In November 2015, the required PAR change for Task Group 3d to limit the activities to the lower THz frequency ranges was approved. During the March 2016 meeting, the supporting documents were approved and the call for proposals was issued. Proposals were reviewed during the July and September 2016 meetings. The group entered working group letter ballot in January 2017. After one working group recirculation ballot, the sponsor ballot started in March 2017. A total of two sponsor recirculation ballots were held, leading to approval of IEEE Std 802.15.3d-2017 by the IEEE-SA Standards Board on 28 September 2017.

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IEEE Standard for High Data Rate Wireless Multi-Media Networks

Amendment 2: 100 Gb/s Wireless Switched Point-to-Point Physical Layer

(This amendment is based on IEEE Std 802.15.3-2016™ as amended by IEEE Std 802.15.3e™-2017)

NOTE—The editing instructions contained in this amendment define how to merge the material contained therein into the existing base standard and its amendments to form the comprehensive standard.

The editing instructions are shown in ***bold italic***. Four editing instructions are used: change, delete, insert, and replace. ***Change*** is used to make corrections in existing text or tables. The editing instruction specifies the location of the change and describes what is being changed by using ~~strike through~~ (to remove old material) and underscore (to add new material). ***Delete*** removes existing material. ***Insert*** adds new material without disturbing the existing material. Deletions and insertions may require renumbering. If so, renumbering instructions are given in the editing instruction. ***Replace*** is used to make changes in figures or equations by removing the existing figure or equation and replacing it with a new one. Editing instructions, change markings, and this NOTE will not be carried over into future editions because the changes will be incorporated into the base standard.¹

3. Definitions, acronyms, and abbreviations

3.2 Acronyms and abbreviations

Insert the following acronym in alphabetical order:

PW pilot word

¹Notes in text, tables, and figures are given for information only, and do not contain requirements needed to implement the standard.

4. General description

4.1a Pairnet

Change 4.1a as indicated:

A pairnet consists of at most two DEVs, as shown in Figure 4-0a. Typical communication distance is 10 cm or less for a pairnet DEV (PRDEV) with a high rate close proximity (HRCP) PHY. For a PRDEV with a THz PHY, typical communication distance is from a few centimeters up to several hundred meters. A PRDEV always connects as a pairnet.

4.2 Components of an IEEE 802.15.3 piconet

Change the fourth paragraph of 4.2 as indicated:

For HRCP PHYs and THz PHYs, the IEEE 802.15.3 piconet is not used.

4.5a Characteristics of HRCP PHY

4.5a.2 Pairnet using HRCP PHY

Insert new subclauses as 4.5b, 4.5b.1, and 4.5b.2, after 4.5a.2, as follows:

4.5b Characteristics of THz PHY

4.5b.1 THz PHY characteristics

The THz PHY, as described in Clause 13, is designed as an extension for wireless switched point-to-point applications, operating at a nominal PHY data rate of 100 Gb/s with fallbacks to lower data rates as needed. The frequency band is from 252 GHz to 325 GHz. The THz PHY supports a range of channel bandwidths from 2 GHz to 70 GHz.

The following two PHY modes are defined for the THz PHY:

- THz single carrier mode PHY (THz-SC PHY), as described in 13.2
- THz on-off keying mode PHY (THz-OOK PHY), as described in 13.3

For DEVs that implement the THz PHY, at least one of the PHY modes is required.

The THz-SC PHY is designed for extremely high PHY-SAP payload data rates up to 100 Gb/s, depending on the combination of modulation, bandwidth, and coding used. The THz-SC PHY supports a wide range of modulations: $\pi/2$ BPSK, $\pi/2$ QPSK, $\pi/2$ 8-PSK, $\pi/2$ 8-APSK, 16-QAM, and 64-QAM. The FEC consists of two low-density parity-check (LDPC) codes with rates of 14/15 and 11/15.

The THz-OOK PHY is designed for cost effective DEVs that require low complexity and simple design. The THz-OOK PHY supports a single modulation scheme, OOK, and three FEC schemes. The Reed Solomon (RS) code is mandatory and allows simple decoding without soft decision information. The LDPC codes with rates of 14/15 and 11/15 are optional and allow the use of soft-decision information.

4.5b.2 Pairnet using THz PHY

When a PRC-capable DEV starts a pairnet, the type of pairnet it starts depends on the supported PHY modes. For example, if the PRC-capable DEV supports only the THz-SC mode, it will start a THz-SC pairnet in which the Beacon frame is sent with the THz-SC mode. DEVs that support only the THz-SC mode are able to find and connect to the pairnet in THz-SC mode. The same process is used for a PRC-capable DEV that supports only THz-OOK mode.

If a PRC-capable DEV supports more than one THz PHY mode, then it is able to select the type of pairnet it starts. It allows connection from each type of DEV by transmitting both the THz-SC mode Beacon frame and the THz-OOK mode Beacon frame. Figure 4-3a is an example of transmitting dual mode Beacon frames. The number and duration of the access slots and the superframe duration for each PHY mode are indicated by the Beacon frame with the corresponding PHY mode.

The switched point-to-point nature of the connection means that the pairnet connection can be terminated and a new pairnet connection can be set up with a different destination device. The process of switching and the determination of the direction to the new access point is out of the scope of this standard.

5. Layer management

5.3 MLME SAP interface

5.3.2 Scanning for piconets and pairnets

Change Table 5-6a (the entire table is not shown) as indicated:

Table 5-6a—Elements of PairnetDescription

Name	Type	Valid range	Description
PrcCapability	PRC Capability, as defined in 6.4.11a for HRC PHY and 6.4.11d for THz PHY	As defined in 6.4.11a for HRC PHY and 6.4.11d for THz PHY	Capability of the PRC in the Beacon frame.
PhyMode	Enumeration	HRCP_SC_PHY, HRCP_OOK_PHY, HRCP_BOTH_PHY, THZ_SC_PHY, THZ_OOK_PHY, THZ_BOTH_PHY	The PHY mode that is being used in the pairnet that was found.

5.3.3 Starting a piconet or pairnet

Change Table 5-8 (the entire table is not shown) as indicated:

Table 5-8—MLME-START primitive parameters

Name	Type	Valid range	Description
PhyMode	Enumeration	2.4_GHZ, SC_MMWAVE, HSI_MMWAVE, AV_MMWAVE, HRCP_SC_PHY, HRCP_OOK_PHY, HRCP_BOTH_PHY, THZ_SC_PHY, THZ_OOK_PHY, THZ_BOTH_PHY	The PHY mode that will be used for the Beacon frames and CP(s) in the piconet or pairnet that will be started.
PrcCapabilityIe	PRC Capability, as defined in 6.4.11a for HRC PHY and 6.4.11d for THz PHY	As defined in 6.4.11a for HRC PHY and 6.4.11d for THz PHY	Capability of the PRC in the Beacon frame.

5.3.5 Associating with a piconet or pairnet

Change Table 5-10 (the entire table is not shown) as indicated:

Table 5-10—MLME-ASSOCIATE primitive parameters

Name	Type	Valid range	Description
PrdevCapabilityIe	PRDEV Capability, as defined in 6.4.11b for HRCPPHY and 6.4.11e for THzPHY	As defined in 6.4.11b for HRCPPHY and 6.4.11e for THzPHY	Capability of the PRDEV in the Association Request command.
PairnetOperationParametersIe	As defined in 6.4.11c for HRCPPHY and 6.4.11f for THzPHY	As defined in 6.4.11c for HRCPPHY and 6.4.11f for THzPHY	Capability of the PRDEV in the Association Response command.

5.5 MAC SAP

Change the second paragraph of 5.5 as indicated:

The IEEE 802.15.3 MAC SAP primitives are summarized in Table 5-30. The same primitives used for the HRCPPHY are also used for the THzPHY.

Change Table 5-31 (the entire table is not shown) as indicated:

Table 5-31—MAC-ISOCH-DATA, MAC-ASYNC-DATA, MAC-HRCPPHY-DATA, and MAC-HRCPPHY-MUL-DATA primitive parameters

Name	Type	Valid range	Description
MCSIdentifier	Enumeration	Any valid MCS identifier, as defined in Table 11a-6 for HRCPPHY, Table 13-8 for THzPHY, or Table 13-12 for THzOOKPHY	MCS used in the transmitted PHY frame. Only applicable ~~for~~ to HRCPPHY, THzPHY, and THzOOKPHY.
ChIdentifier	Enumeration	Any valid combinations of channels, as defined in Figure 11a-1 for HRCPPHY, or any channel defined in Table 13-1 for THzPHY and THzOOKPHY	The frequency channel used in the transmitted PHY frame. Only applicable ~~for~~ to HRCPPHY, THzPHY, and THzOOKPHY.

Change 5.5.7 to 5.5.12 as indicated:

5.5.7 MAC-HRCPPHY-DATA.request

This primitive is used to initiate the transfer of an MSDU from one MAC entity to another MAC entity or entities using the HRCPPHY or the THzPHY. The semantics of this primitive are as follows:

```
MAC-HRCPPHY-DATA.request (
    RequestID,
    LogicalChannel,
    ACKRequested,
    ConfirmRequested,
```