Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: Enhancements to the Physical Layer of IEEE 802.15.3d Follow-up: Questions and Suggestions for Implementation

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Re: Enhancements to the Physical Layer of IEEE 802.15.3d for Increased Data Rate and Coexistence/0125-01

Abstract: The necessary edits and discussion points are highlighted in order to implement the three enhancements to IEEE 802.15.3d that were proposed to the physical layer.

Purpose: For discussion and consideration to edit IEEE 802.15.3d Standard

IEEE P802.15.3ma Proposal Follow-up:

Questions and Suggestions for Implementation

Outline

- Line Edits
- THz-SS Mode Suggestions & Questions
- THz-HBM Mode Suggestions & Questions

Line Edits

In-Line Edits

Introduction (p. 8)

Not sure if we are writing a new one, but if we pull from this one…

Currently in Standard

— 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

Proposed Edit

Selectable PHY modes (single carrier, on-off keying, spread spectrum, and hierarchical bandwidth) to achieve ultra high-speed operation, system simplicity, coexistence with passive devices, improved performance in the presence of absorption, or receiver flexibility in varying channels.

In-Line Edits

4.5b.1 THz PHY characteristics

Currently in Standard

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.

Proposed Edit

The following four 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
- THz spread spectrum mode PHY (THz-SS PHY), as described in 13.4
- THz hierarchical bandwidth mode PHY (THz-HBM PHY), as described in 13.5

In-Line Edits

4.5b.1 THz PHY characteristics

Currently in Standard

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: π/2 BPSK, π/2 QPSK, π/2 8-PSK, π/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.

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Proposed Edit

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-APSK, 32-APSK, 16-QAM, and 64-QAM…

Question for the Group: Why are all the PSKs shifted by $\pi/2$?

In-Line Edits

4.5b.1 THz PHY characteristics

Currently in Standard

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: π/2 BPSK, π/2 QPSK, π/2 8-PSK, π/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.

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Proposed Addition

The THz-SS PHY is designed for coexistence with passive sensing devices and transmission across absorption lines. THz-SS PHY supports direct sequence spread modulations for *[modulation schemes]* for coexistence. THz-SS PHY also supports chirp spread phase shift keying modulations for the transmission over absorption lines. The FEC consists of...

In-Line Edits

4.5b.1 THz PHY characteristics

Currently in Standard

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: π/2 BPSK, π/2 QPSK, π/2 8-PSK, π/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.

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Proposed Addition

The THz-HBM PHY is designed for receiver flexibility in backhaul channels to allow data rates between ___ and ___ GHz. The THz-HBM PHY supports *[modulation schemes]*. The FEC consists of…

In-Line Edits

4.5b.2 Pairnet using THz PHY – *Beacon Frames*

Currently in Standard

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 na

and a new pairnet connection c

Decision for Discussion: Since we are introducing two additional modes, we could…

- **keep the current structure of transmitting all beacon frames**
- **pull from the 802.15.3d-2016 as shown in proposed edit**

Proposed Edit

The same process is used for a PRC-capable DEV that supports only THz-OOK mode, THz-SS mode, or THz-HBM 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, potentially starting more than one Pairnet, each with a different PHY mode. Alternatively, the multi-mode PNC is able to have a single Pairnet using any mode that is supported by both DEVs.

In-Line Edits

5.3.2 Scanning for piconets and pairnets

Currently in Standard

Table 5-6a—Elements of PairnetDescription

Name	Type	Valid range	Description
PrcCapability	PRC Capability, as defined in 6.4.11a for HRCP PHY and 6.4.11d for THz PHY	As defined in 6.4.11a for HRCP 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.

Proposed Edit

THz_SC_PHY
THz_OOK_PHY
THz_SS_PHY
THz_HBM_PHY

Question for the Group: Why is there a "BOTH" option in the PHY mode to describe the PHY mode that is being used in the pairnet that was found? Can a single pairnet use multiple modes simultaneously?

In-Line Edits

5.3.3 Starting a piconet or pairnet

Currently in Standard

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 HRCP PHY and 6.4.11d for THz PHY	As defined in 6.4.11a for HRCP PHY and 6.4.11d for THz PHY	Capability of the PRC in the Beacon frame.

Proposed Edit

THz_SC_PHY
THz_OOK_PHY
THz_SS_PHY
THz_HBM_PHY

This edit will depend on the earlier discussion of beacon frames

In-Line Edits

5.5 MAC SAP

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

Currently in Standard

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

Proposed Edit

Any valid MCS identifier as defined in Table 11a-6 for HRCP-SC PHY, Table 13-8 for THz-SC, Table 13-12 for THz-OOK PHY, Table 13-XX for THz-SS PHY, or Table 13-YY for THz-HBM PHY	MCS used in the transmitted PHY frame. Only applicable to HRCP-SC PHY, THz-SC PHY, THz-OOK PHY, THz-SS PHY, and THz-HBM PHY.
Any valid combinations of channels, as defined in Figure 11a-1 for HRCP-SC PHY, or any channel defined in Table 13-1 for THz-SC PHY, THz-OOK PHY, THz-SS PHY, and THz-HBM PHY	The frequency channel used in the transmitted PHY frame. Only applicable to HRCP-SC PHY. THz-SC PHY, THz-OOK PHY, THz-SS PHY, and THz-HBM PHY.

In-Line Edits

6.2.6 MAC header validation

Currently in Standard

Change the dashed list after the first paragraph of 6.2.6 as follows:

— 10.2.9 for the 2.4 GHz PHY
— 11.2.3.2.2 for the SC PHY mode
— 11.3.3.4 for the HSI PHY mode
— 11.4.1.4 for the AV PHY mode
— 11a.2.3.2.2 for the HRCP-SC PHY mode, the THz-SC PHY mode, and the THz-OOK PHY mode
— 11a.3.3.2.2 for HRCP-OOK PHY mode

Proposed Edit

11a.2.3.22 for the HRCP-SC PHY mode, and all THz PHY modes

In-Line Edits

6.4.11d THz PRC Capability IE

Currently in Standard

Table 6-17h—SC Supported Modulations field format

Bit	Description
0	π/2 8-PSK
1	π/2 8-APSK
2	16-QAM
3	64-QAM

Proposed Edit

Have to include 16-APSK and 32-APSK

Decision for Discussion:

- We could add two additional bits
  - There are the same 2 reserved bits later in the field (b28 & b29). (Is this what they were reserved for?)
- Make it mandatory to support the 8-PSK modulation (only solves half the problem)
- Other ideas…?

In-Line Edits

6.4.11d THz PRC Capability IE

Currently in Standard

The PRC Capability field shall be formatted as illustrated in Figure 6-87o.

The SC Capable field shall be set to one if the DEV supports the THz-SC PHY, as defined in 13.2, and shall be set to zero otherwise.

The OOK Capable field shall be set to one if the DEV supports the THz-OOK PHY, as defined in 13.3, and shall be set to zero otherwise.

Decision for Discussion:

- **We could add two additional bits for the SS and HBM capability**
  - **There are 2 reserved bits later in the field (b28 & b29). Are they reserved for anything?**
- **We could use the b0 and b1 together to indicate the desired PHY mode for transmission**
- **Other ideas…?**

In-Line Edits

6.4.11f THz Pairnet Operation parameter IE

Currently in Standard

Figure 6-87o—PRC Capability field format

Bits: b16	b17	b18	b19	b20	b21	b22	b23
Preferred Payload Size		Preferred Total Aggregation Size			Supported Unit of Subframe Padding		Pilot Symbol Capable

Bits: b24	b25	b26	b27	b28	b29	b30	b31
SC Supported Modulations				Reserved	Reserved	OOK Supported FEC	

Proposed Edit

Have to include 16-APSK and 32-APSK

Decision for Discussion (same as before):

- We could add two additional bits
  - There are the same 2 reserved bits later in the field (b28 & b29). (Is this what they were reserved for?)
- Make it mandatory to support the 8-PSK modulation (only solves half the problem)
- Other ideas…?

In-Line Edits

6.4.11e THz PRDEV Capability IE

Currently in Standard

Figure 6-87r—Operation Parameters field format

Bits: b0	b1	b2	b3	b4	b5	b6	b7
PHY Mode		Supported SIFS					Multi-protocol Support
Bits: b8	b9	b10	b11	b12	b13	b14	b15
Reserved							
Bits: b16	b17	b18	b19	b20	b21	b22	b23
Preferred Payload Size		Preferred Total Aggregation Size			Reserved		Reserved
Bits: b24	b25	b26	b27	b28	b29	b30	b31
SC Supported Modulations				Reserved	Reserved	OOK Supported FEC	
Bits: b32	b33	b34	b35	b36	b37	b38	b39
				andwidths			

Proposed Edit

Have to include 16-APSK and 32-APSK

Similar issues here as well…

- **Can we use b8-15, b21-b22, or b28-29 now?**

In-Line Edits

6.4.11f THz Pairnet Operation Parameter IE

Currently in Standard

Table 6-17k—PHY Mode field values

Bits: b0	b1	PHY Mode
1	0	SC
0	1	OOK
0	0	Reserved
1	1	Reserved

Proposed Edit

0	0	SS
1	1	HBM

In-Line Edits

6.4.11f THz Pairnet Operation Parameter IE

Currently in Standard

The SC Supported Modulations field is defined in 6.4.11d. Each bit in this field shall be set to one if both of the bits in the SC Supported MCS fields in the PRC Capability IE and the PRDEV Capability IE are set to one and shall be set to zero otherwise.

Proposed Edit

Depends on decisions from slides 15 - 18

In-Line Edits

7.4.1 Interframe space (IFS)

Currently in Standard

SIFS, BIFS, and RIFS are PHY dependent and are defined as follows:

- — In 10.2.7.1 for the 2.4 GHz PHY
- — In 11.2.6 for the SC PHY
- — In 11.3.5.5 for the HSI PHY
- — In 11.4.1.2 for the AV PHY

Added in 802.15.3d

- — In 13.2.6.1 for the THz-SC PHY
- — In 13.3.6.1 for the THz-OOK PHY

All Imm-ACK frames, frames sent as a response frame for Imp-ACK, and Dly-ACK frames shall start transmission over the medium a SIFS after the end of the transmission of the previous frame that requested

Proposed Edit

- In 13.4.6.1 for the THz-SS PHY
- In 13.5.6.1 for the THz-OOK PHY

In-Line Edits

7.13 Multi-rate support

Currently in Standard

and the mandatory base rate are PHY dependent and defined as follows:

- In 10.3 for the 2.4 GHz PHY
- In 11.2.2.1 for the SC PHY mode
- In 11.3.2.1 for the HSI PHY mode
- In 11.4 for the AV PHY mode

Added in 802.15.3d

- In 13.2 for the THz-SC PHY mode
- In 13.3 for the THz-OOK PHY mode

In order to determine the rates that are supported by a target DEV in the piconet, the DEV shall use one of

Proposed Edit

- In 13.4 for the THz-SS PHY
- In 13.5 for the THz-OOK PHY

In-Line Edits

7.16 MAC sublayer parameters

Currently in Standard

Change the title of Table 7-10a as indicated:

Table 7-10a—MAC sublayer parameters—~~for~~ HRCP-SC PHY, ~~and~~ HRCP-OOK PHY, THz-SC PHY, and THz-OOK PHY dependent

Change the title of Table 7-10b as indicated:

Table 7-10b—MAC sublayer parameters—HRCP-SC PHY, THz-SC PHY, and THz-OOK PHY dependent

Proposed Edit

Table 7-10a – MAC sublayer parameters – HRCP-SC PHY and THZ PHY dependent

Table 7-10b – MAC sublayer parameters – HRCP-SC PHY and THZ PHY dependent

In-Line Edits

13. PHY specification for THz

Currently in Standard

13.1 General requirements

A compliant THz PHY shall implement at least one of the following PHY modes:

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

Proposed Addition

- THz spread spectrum mode PHY (THz-SS PHY), as defined in 13.4
- THz hierarchical bandwidth modulation mode PHY (THz-HBM PHY), as defined in 13.5

In-Line Edits

13.1.3 Transmit PSD mask

Currently in Standard

The transmitted spectrum for the THz-SC PHY shall adhere to the transmit PSD mask shown in Figure 13-1. The transmitted spectrum for the THz-OOK PHY shall adhere to the transmit PSD mask shown in Figure 13-2. The additional single line spectrum of 40 dB above the 0 dB line in Figure 13-2 is within the frequency band of (–6MHz, +6MHz) from the carrier frequency. For all transmit mask measurements, the resolution bandwidth is set to 3 MHz and the video bandwidth is set to 300 kHz.

Decision for Discussion:

- **The PSD mask should probably be adjusted for coexistence (ie THz-SS), but otherwise I think the THz-SC mask should be good for HBM as well…**

Proposed Edit

The transmitted spectrum for the THz-SC PHY and THz-HBM PHY shall adhere to the transmit…

The transmitted spectrum for the THz-SS PHY shall adhere to the transmit PSD mask shown in Figure 13-3.

In-Line Edits

13.1.5.1 THz PHY PIB

Currently in Standard

Table 13-3—PHY PIB characteristics group parameters

Managed Object	Octets	Definition	Access
phyType	1	0x03 = THz PHY	Read/Write
phyMode	1	bit 1 = THz-SC PHY bit 2 = THz-OOK PHY bit 3–8 = Reserved A bit is set to one if the associated PHY is supported and is set to zero otherwise.	Read/Write

Proposed Edit

bit 3 = THz-SS PHY
bit 4 = THz-HBM PHY
bit 5-8 = Reserved

Question for the Group: Are these bits reserved for something else or can we use them?

In-Line Edits

13.1.5.1 THz PHY PIB

Currently in Standard

Table 13-3—PHY PIB characteristics group parameters

phyDataRateVector	Variable	One octet for each supported MCS. The MSB indicates the THz PHY mode: MSB 0 = 0 for THz-SC PHY and MSB 0 = 1 for THz OOK PHY. MSB 1–3 indicate the bandwidth identifier described in Table 13-9. For the THz-SC PHY mode, the four LSBs indicate the MCS supported for that mode using the encoding described in Table 13-8. For the THz-OOK PHY mode, the two LSBs indicate the MCS supported for that mode using the encoding described in Table 13-16.	Read/Write

Proposed Edit

The two MSB indicate the THz PHY mode:
MSB 0-1 = 00 for THz-SC PHY
MSB 0-1 = 01 for THz-OOK PHY
MSB 0-1 = 10 for THz-SS PHY
MSB 0-1 = 11 for THz-HBM PHY

… ***Need more info on the MCS identifiers to adjust second half of table entry***

**Question for the Group:
Where is the frame structure this is referring to? I think we will need another bit here…**

In-Line Edits

13.2.2.1 Modulation

Currently in Standard

The constellation diagram of π/2 8-APSK is shown in Figure 13-3. The π/2 8-APSK shall encode 3 bits per symbol, with input bit d_1 being the earliest in the stream. The π/2-rotation is performed in the same manner as in 11.2.2.5.1.

The normalization factors for π/2 QPSK, π/2 8-PSK, π/2 8-APSK, 16-QAM, and 64-QAM are 1, 1, $\sqrt{2}/\sqrt{11}$, $1/(\sqrt{10})$, and $1/\sqrt{42}$, respectively. The purpose of the normalization factor is to achieve the same average power for all mappings. In practical implementations, an approximate value of the normalization can be used as long as the DEV conforms to the modulation accuracy requirements described in 13.2.4.1.

All modulation schemes are used for payload, and π/2 BPSK is also used for preamble and header sequences. The modulations of π/2 BPSK and π/2 QPSK are mandatory for THz-SC PHY; other modulations are optional.

Proposed Edit

The constellation diagrams of $\pi/2$ 8-APSK, 16-APSK, and 32-APSK are shown in Figure 13-3, Figure 13-4, and 13-5 respectively.

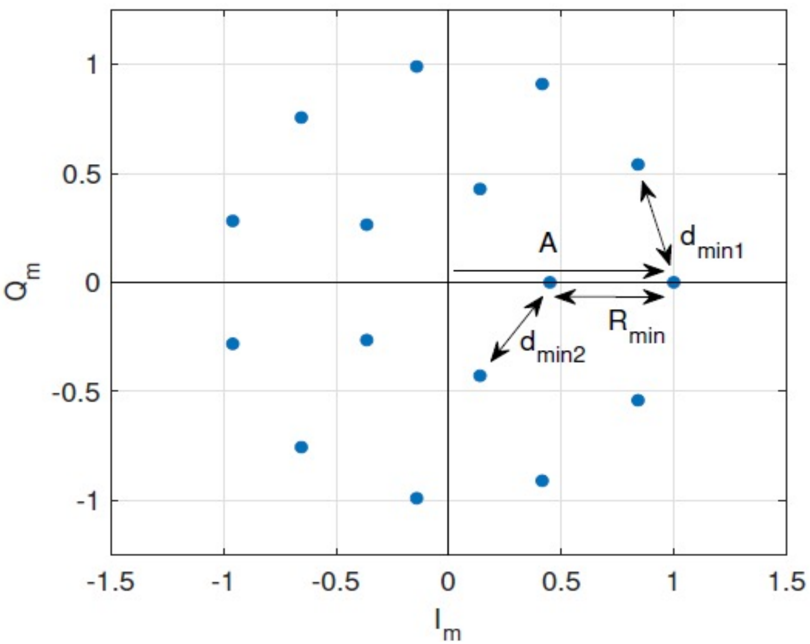
The normalization factors for $\pi/2$ QPSK, $\pi/2$ 8-PSK, $\pi/2$ 8-APSK, 16-APSK, 32-APSK, 16-QAM 64-QAM are 1, 1, $\sqrt{2}/\sqrt{11}$, ____ , _____ , $1/\sqrt{10}$, and $1/\sqrt{42}$ respectively.

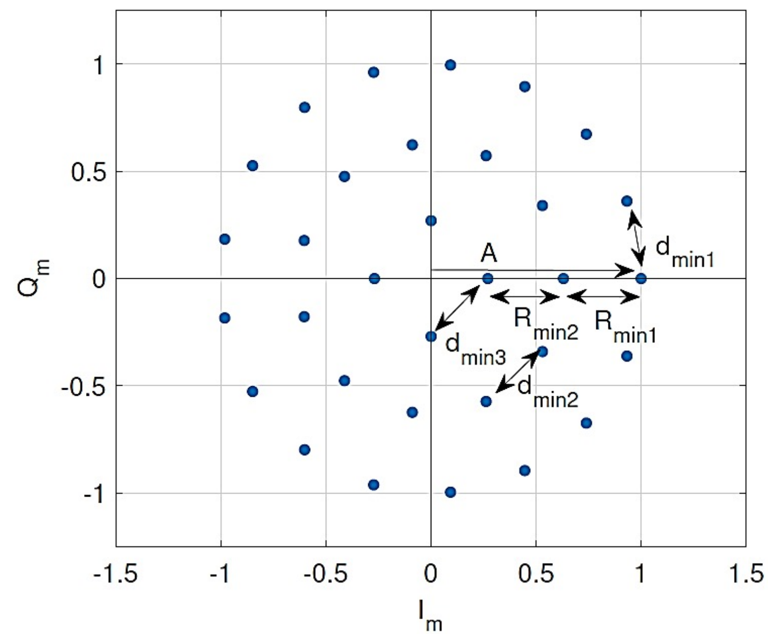
Questions for the Group:
Why do you specify 3 bits per symbol? What do you mean by the input bit d1? Also are the parenthesis around sqrt(10) intentional?

Insert Figures

13.2.2.1 Modulation

Insert Figures 12-4 and 13-5





Questions for the Group:

- **Would we like to standardize the 3-ring or the 2-ring 32-APSK or both? (I think 3-ring to help with phase noise)**

In-Line Edits

13.2.2.1 Modulation

Currently in Standard

Table 13-4—MCS dependent parameters for the THz-SC PHY

MCS identifier	Modulation	FEC rate	Bandwidth 2.16 GHz		Bandwidth 4.32 GHz		Bandwidth 8.64 GHz		Bandwidth 12.96 GHz		Bandwidth 17.28 GHz		Bandwidth 25.92 GHz		Bandwidth 51.84 GHz		Bandwidth 69.12 GHz	
			Data rate (Gb/s)		Data rate (Gb/s)		Data rate (Gb/s)		Data rate (Gb/s)		Data rate (Gb/s)		Data rate (Gb/s)		Data rate (Gb/s)		Data rate (Gb/s)	
			with out PW	with PW	with out PW	with PW	with out PW	with PW	with out PW	with PW	with out PW	with PW	with out PW	with PW	with out PW	with PW	with out PW	with PW
0	BPSK	11/15	1.29	1.13	2.58	2.26	5.16	4.52	7.74	6.78	10.33	9.04	15.49	13.55	30.98	27.11	41.30	36.14
1	BPSK	14/15	1.64	1.44	3.29	2.87	6.57	5.75	9.86	8.62	13.14	11.50	19.71	17.25	39.42	34.50	52.56	45.99
2	QPSK	11/15	2.58	2.26	5.16	4.52	10.33	9.03	15.49	13.55	20.65	18.07	30.98	27.10	61.95	54.21	82.60	72.28
3	QPSK	14/15	3.29	2.87	6.57	5.75	13.14	11.50	19.71	17.25	26.28	23.00	39.42	34.50	78.85	68.99	105.13	91.99
4	8-PSK	11/15	3.87	3.39	7.74	6.78	15.49	13.55	23.23	20.33	30.98	27.11	46.47	40.66	92.93	81.32	123.91	108.42
5	8-PSK	14/15	4.93	4.31	9.86	8.62	19.71	17.25	29.57	25.87	39.42	34.50	59.13	51.74	118.27	103.49	157.69	137.98
6	8-APSK	11/15	3.87	3.39	7.74	6.78	15.49	13.55	23.23	20.33	30.98	27.11	46.47	40.66	92.93	81.32	123.91	108.42
7	8-APSK	14/15	4.93	4.31	9.86	8.62	19.71	17.25	29.57	25.87	39.42	34.50	59.13	51.74	118.27	103.49	157.69	137.98

IEEE Std 802.15.3d-2017
IEEE Standard for High Data Rate Wireless Multi-Media
Amendment 2: 100 Gb/s Wireless Switched Point-to-Point Phys

Questions for the Group:
How exactly are you calculating these data rates? Do you take the headers into account?
Where can I find Section 11a.2.3.22?

13.2.3. THz-SC PHY frame format

The PHY preamble is described in 13.2.3.1. The MAC header is defined in 6.2. The PHY header is defined in 13.2.3.2.1, and the header check sequence (HCS) is defined in 11a.2.3.2.2. The header FEC is defined in 11a.2.3.2.3. The PHY Payload field consisting of the MAC frame body, the pilot preamble (PPRE), and stuff bits is described in 13.2.3.3. The PPRE is described in 13.2.3.4.2. The stuff bits are described in 11a.2.2.7.

In-Line Edits

13.2.2.6 Frame Related Parameters

Currently in Standard

modulation schemes are 1, 2, 3, 3, 4, and 6 for BPSK, QPSK, 8-PSK, 8-APSK, 16-QAM and 64-QAM, respectively.

Table 13-7—MCS dependent coded bits per block for the THz-SC PHY

MCS identifier	N_{CBPB} (PW length = 0)	N_{CBPB} (PW length = 8)
0,1	64	56
2,3	128	112
4,5,6,7	192	168
8,9	256	224
10,11	384	336

Table 13-8—MCS field definition for the THz-SC PHY

MCS field value	MCS identifier
0b0000	0
0b0001	1
0b0010	2
0b0011	3
0b0100	4
[illegible]	[illegible]

Questions for the Group:
Is there a reason we have two 3s and skip 5?

Proposed Edit

modulation schemes are 1, 2, 3, 4, 5, 6, 7, and 8 for BPSK, QPSK, 8-PSK, 8-APSK, 16-APSK, 32-APSK, 16-QAM, 64-QAM, respectively.

In-Line Edits

13.2.4.1 EVM Requirement

Currently in Standard

Table 13-10—Max EVM

MCS identifier	Modulation	FEC rate	Max. EVM (dB)
0	BPSK	11/15	–3
1	BPSK	14/15	–6
2	QPSK	11/15	–6
3	QPSK	14/15	–9
4	8-PSK	11/15	–11
5	8-PSK	14/15	–14
6	8-APSK	11/15	–11
7	8-APSK	14/15	–14
8	16-QAM	11/15	–13

Questions for the Group:
How do you calculate the maximum EVM?

Proposed Edit

Add the higher order APSKs

In-Line Edits

13.2.5.2 Receiver sensitivity

Currently in Standard

Table 13-11—Reference sensitivity levels for MCS for the THz-SC PHY

MCS identifier	Modulation	FEC rate	Receiver Sensitivity (dBm) depending on the bandwidth							
			2.16 GHz	4.32 GHz	8.64 GHz	12.96 GHz	17.28 GHz	25.92 GHz	51.84 GHz	69.12 GHz
0	BPSK	11/15	–67	–64	–61	–59	–58	–56	–53	–52
1	BPSK	14/15	–63	–60	–57	–55	–54	–52	–49	–48
2	QPSK	11/15	–64	–61	–58	–56	–55	–53	–50	–49
3	QPSK	14/15	–60	–57	–54	–52	–51	–49	–46	–45
4	8-PSK	11/15	–59	–56	–53	–51	–50	–48	–45	–44
5	8-PSK	14/15	–57	–54	–51	–49	–48	–46	–43	–42

Questions for the Group:
How do you calculate the receiver sensitivity?

Proposed Edit

Add the higher order APSKs

In-Line Edits

E.7.1 Major roles for IEEE 802.15.3 DEVs (Annex E)

Currently in Standard

Table E-1a—Functional PRDEV types

Item number	Item description	References	Status	Support		
				N/A	Yes	No
FHD5	Supports THz-SC PHY	13.2	O.1			
FHD6	Supports THz-OOK PHY	13.3	O.1			

Questions for the Group:
How do you calculate the receiver sensitivity?

Proposed Edit

Add THz-HBM & THz-SS

In-Line Edits

E.7.2 PHY Functions (Annex E)

Currently in Standard

Table E-2c—THz-SC PHY functions

Item number	Item description	References	Status	Support		
				N/A	Yes	No
SC-TPLF1	Conforms to general requirements (e. g., timing, frequency)	13.1	FHD5: M			
SC-TPLF2.1	Supports a bandwidth of 2.16 GHz	13.1.2	FHD5: O			
SC-TPLF2.2	Supports a bandwidth of 4.32 GHz	13.1.2	FHD5: M			
SC-TPLF2.3	Supports a bandwidth of 8.64 GHz	13.1.2	FHD5: O			
SC-TPLF2.4	Supports a bandwidth of 12.96 GHz	13.1.2	FHD5: O			
SC-TPLF2.5	Supports a bandwidth of 17.28 GHz	13.1.2	FHD5: O			
SC-TPLF2.6	Supports a bandwidth of 25.92 GHz	13.1.2	FHD5: O			
SC-TPLF2.7	Supports a bandwidth of 51.84 GHz	13.1.2	FHD5: O			
SC-TPLF2.8	Supports a bandwidth of 69.12 GHz	13.1.2	FHD5: O			

Questions for the Group:
What exactly are these functions for? Will we need them for the new modes as well?

13.3 THz-SS PHY Layer

THz-SS PHY Layer Main Discussion Points & Questions

- Channelization process to accommodate coexistence and absorption lines
- Picking codes, coding rates, and receiver sensitivities depending on required BER threshold

13.4.1 Channelization of THz-SS PHY

- Do we know the bands that require coexistence within the spectrum allocated to this standard?
  - Do we know the receiver sensitivity of those passive devices? Do we know where they are (i.e. height of satellites)?
- Which channels should be utilized for chirp spread?
  - There is currently one absorption line at the very edge of the spectrum (~325 GHz), we suggest standardizing chirp spread as an option for channels that include the edge of the spectrum
    - If the spectrum is increased as was proposed, there may be other bands where we would want to use chirp spread

13.4.2 Modulation and Coding THz-SS PHY

- How have you chosen the possible modulation orders, FEC codes, and coding rates?
  - Is it the maximum coding rate and modulation order that allows for the required BER (< 10e-12) at a given SNR?
  - If so, is there an assumption about the processing for the decoding process (i.e. number of iterations)?

13.4 THz-HBM PHY Layer

THz-HBM PHY Layer Main Discussion Points & Questions

- Channelization process to accommodate hierarchical bandwidth
- Picking codes, coding rates, and receiver sensitivities depending on required BER threshold
- Does single-receiver HBM make sense for this standard?
  - Only if the transmitter is unaware of the receiver's resolution.

13.4.1 Channelization of THz-HBM PHY

- For HBM ideally we would have two pre-defined channels (one twice the bandwidth of the other), centered at the same frequency… we do not currently have that.
  - *See Table 13-1 THz PHY channelization*
- One possible solution: we use only channel indices 33 and above for HBM, and since it will be known that we are in HBM, the receiver should know to use the corresponding center frequency with half the usual bandwidth.

Not sure if this ideal since we would want the header, to modulated at the smaller bandwidth (slower rate)

13.4.2 Modulation and Coding THz-HBM PHY

- How have you chosen the possible modulation orders, FEC codes, and coding rates?
  - Is it the maximum coding rate and modulation order that allows for the required BER (< 10e-12) at a given SNR?
  - If so, is there an assumption about the processing for the decoding process (i.e. number of iterations)?