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IEEE Standard for Low-Rate Wireless Networks

Amendment 5: Enabling/Updating the Use of Regional Sub-GHz Bands

IEEE Computer Society

Sponsored by the
LAN/MAN Standards Committee

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

IEEE Std 802.15.4v™-2017
(Amendment to
IEEE Std 802.15.4™-2015
as amended by IEEE Std 802.15.4n™-2016,
IEEE Std 802.15.4q™-2016, IEEE Std 802.15.4u™2016,
and IEEE Std 802.15.4t™-2017)

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Approved 12 May 2017

IEEE-SA Standards Board

Abstract: The smart utility network (SUN) physical layers (PHYs) in IEEE Std 802.15.4™-2015 are changed by this amendment to enable the use of the 870–876 MHz and 915–921 MHz bands in Europe, the 902–928 MHz band in Mexico, the 902–907.5 MHz and 915–928 MHz bands in Brazil, and the 915–928 MHz band in Australia and New Zealand. Additional Asian regional frequency bands are also specified in this amendment. Furthermore, the amendment changes the channel parameters listed for the SUN PHYs, the low energy critical infrastructure monitoring (LECIM) PHY, and the television white space (TVWS) PHY for the 470–510 MHz band in China and the 863–870 MHz band in Europe and aligns these channel parameters with regional requirements. The amendment includes channel access and/or timing changes to the medium access control (MAC) necessary for conformance to regional requirements for these bands.

Keywords: 470–510 MHz band, 863–870 MHz band, 870–876 MHz band, 902–927.5 MHz band, 902–928 MHz band, 915–921 MHz band, 915–928 MHz band, IEEE 802.15.4™, low data rate, low power, wireless personal area network, WPAN

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Introduction

This introduction is not part of IEEE Std 802.15.4v-2017, IEEE Standard for Low-Rate Wireless Networks—Amendment 5: Enabling/Updating the Use of Regional Sub-GHz Bands.

This amendment defines changes to the smart utility network (SUN) physical layers (PHYs) in IEEE Std 802.15.4™-2015 that enable the use of the 870–876 MHz and 915–921 MHz bands in Europe, the 902–928 MHz band in Mexico, the 902–907.5 MHz and 915–928 MHz bands in Brazil, the 915–928 MHz band in Australia and New Zealand, and additional Asian regional frequency bands. This amendment also changes the channel parameters listed in the SUN PHYs, the low energy critical infrastructure monitoring (LECIM) PHY, and the television white space (TVWS) PHY for the 470–510 MHz band in China and the 863–870 MHz band in Europe and aligns these channel parameters with regional requirements. The amendment includes channel access and/or timing changes to the medium access control (MAC) necessary for conformance to regional requirements for these bands.

With the rapid growth in applications for short-range devices in Europe, the Conference of Postal and Telecommunications Administrations (CEPT) Electronic Communications Committee (ECC) has designated the 870–876 MHz and 915–921 MHz spectrum for short-range device use. The new spectrum has also been opened up in various other regions, including the 902–928 MHz band in Mexico, the 902–907.5 MHz and 915–928 MHz bands in Brazil, the 915–928 MHz band in Australia and New Zealand, and additional Asian regional frequency bands. The availability of this additional spectrum will bring considerable benefits, as it supports applications such as smart metering and new uses in the automotive industry.

This amendment also aligns the 470–510 MHz band in China and the 863–870 MHz band in Europe and their channel parameters specified in IEEE Std 802.15.4-2015 with the updated regional requirements.

Contents

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[This amendment is based on IEEE Std 802.15.4™-2015, as amended by IEEE Std 802.15.4n™-2016, IEEE Std 802.15.4q™-2016, IEEE Std 802.15.4u™-2016, and IEEE Std 802.15.4t™-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 ~~strikethrough~~ (to remove old material) and underscore (to add new material). ***Delete*** removes existing material. ***Insert*** adds new material without disturbing the existing material. 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. Editorial 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]

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

7. MAC frame formats

7.4 IEs

7.4.4 Nested IEs

7.4.4.10 SUN Device Capabilities IE

Replace Figure 7-61 with the following figure:

Octets: 1	2/4	Variable
SUN Features	Frequency Bands Supported	PHY Type Descriptor(s)

Figure 7-61—SUN Devices Capabilities IE Content field format

Replace Figure 7-62 with the following figure:

Bits: 0	1	2	3	4	5	6	7
Enh-Ack	Data Whitening	Interleaving	SFD G1	NRNSC FEC	RSC FEC	Mode Switch	Extended Band Identifier

Figure 7-62—SUN Features field format

Insert the following paragraph after the ninth paragraph ("The Mode Switch field....") of 7.4.4.10:

If Extended Band Identifier field is set to zero, then the Frequency Band Supported field in Figure 7-61 is 2 octets long with the frequency band identifier values given in Table 7-19. Otherwise, if Extended Band Identifier field is set to one, then the Frequency Band Supported field in Figure 7-61 is 4 octets long with the extended frequency band identifier values given in Table 7-19 and Table 7-19a.

Change the first sentence of the now 11th paragraph of 7.4.4.10 as indicated:

The Frequency Bands Supported field is a bitmap indexed by the frequency band identifier values given in Table 7-19 and Table 7-19a.

Change the following row of Table 7-19 as indicated:

Table 7-19—Frequency band identifier values

Frequency band identifier	Band ~~D~~designation
15	~~Reserved~~ 870 MHz

Insert Table 7-19a into 7.4.4.10 after Table 7-19:

Table 7-19a—Frequency band identifier values—extended

Frequency band identifier—extended	Band designation
16	915 MHz-a
17	915 MHz-b
18	915 MHz-c
19	915 MHz-d
20	915 MHz-e
21	919 MHZ
22	920 MHz-a
23	920 MHz-b
24	867 MHz
25–31	Reserved

Replace Figure 7-63 with the following figure:

Bits: 0–3	4	5–15	Octets: 2/4
PHY Type	All Frequency Bands	PHY Modes Supported (PHY Mode ID bitmap: b0...b10)	Specific Frequency Bands (only present if All Frequency Bands = 0)

Figure 7-63—PHY Type Descriptor field format

Change the now 16th paragraph of 7.4.4.10 as indicated:

The optional Specific Frequency Bands field is encoded in the same manner as the Frequency Bands Supported field of the SUN ~~d~~<u>D</u>evice ~~c~~<u>C</u>apabilities IE.

Change the following row of Table 7-22 as indicated:

Table 7-22—PSK-B PHY mode encoding

PHY Mode ID	FSK PHY mode
10	~~Reserved~~ <u>300 kb/s; 2-FSK; mod. index = 0.5; channel spacing = 400 kHz</u>

10. General PHY requirements

10.1 General requirements and definitions

10.1.1 Operating frequency range

Insert the following rows into Table 10-1:

Table 10-1—Frequency band designations

Band designation	Frequency band (MHz)
867 MHz	866–869
870 MHz	870–876
915 MHz-a	902–928(alternate)
915 MHz-b	902–907.5 & 915–928
915 MHz-c	915–928
915 MHz-d	915–921
915 MHz-e	915–918
919 MHz	919–923
920 MHz-a	920.5–924.5
920 MHz-b	920–925

Insert the following note into 10.1.1 after Table 10-1:

NOTE—The 915 MHz-a, 915 MHz-b, and 915 MHz-c frequency bands provide additional PHY parameter definitions to the 915 MHz band.

10.1.2 Channel assignments

10.1.2.8 Channel numbering for SUN and TVWS PHYs

Change the following rows of Table 10-10 as indicated:

Table 10-10—Channel numbering for SUN PHYs

Frequency band (MHz)	Modulation	*ChanSpacing* (MHz)	TotalNumChan	*ChanCenterFreq$_0$* (MHz)
470–510	SUN FSK operating modes #1, #2, and #3	0.2	199	470.2
	~~SUN FSK operating modes #2 and #3~~	~~0.4~~	~~99~~	~~470.4~~
	SUN OFDM Option 4	0.2	199	470.2
	SUN O-QPSK	~~0.4~~ 0.2	~~99~~ 199	~~470.4~~ 470.2

Table 10-10—Channel numbering for SUN PHYs *(continued)*

Frequency band (MHz)	Modulation	*ChanSpacing* (MHz)	TotalNumChan	*ChanCenterFreq₀* (MHz)
863–870	SUN FSK operating mode #1	~~0.2~~ 0.1	~~34~~ 69	~~863.125~~ 863.1
	SUN FSK operating modes #2 and #3	~~0.4~~ 0.2	~~17~~ 35	~~863.225~~ 863.1
	SUN OFDM Option 4	0.2	~~34~~ 35	~~863.125~~ 863.1
	SUN O-QPSK	0.2	35	863.1
	~~OFDM Option 3~~	~~0.4~~	~~17~~	~~863.225~~
	~~OFDM Option 2~~	~~0.8~~	~~8~~	~~863.425~~
	~~OFDM Option 1~~	~~1.2~~	~~5~~	~~863.625~~

Insert the following rows into Table 10-10:

Table 10-10—Channel numbering for SUN PHYs

Frequency band (MHz)	Modulation	*ChanSpacing* (MHz)	TotalNumChan	*ChanCenterFreq₀* (MHz)
866–869[d]	SUN FSK operating mode #1	0.1	29 (channels 30–58 are used)	863.1 (first frequency used is 866.1)
	SUN FSK operating modes #2 and #3	0.2	15 (channels 15–29 are used)	863.1 (first frequency used is 866.1)
	SUN FSK operating modes #4 and #5	0.4	7 (channels 8–14 are used)	863.2 (first frequency used is 866.4)
	SUN OFDM Option 4	0.2	15 (channels 15–29 are used)	863.1 (first frequency used is 866.1)
	SUN OFDM Option 3	0.4	7 (channels 8–14 are used)	863.2 (first frequency used is 866.4)
	SUN O-QPSK	0.2	15 (channels 15–29 are used)	863.1 (first frequency used is 866.1)
870–876	SUN FSK operating mode #1	0.1	59	870.1
	SUN FSK operating modes #2 and #3	0.2	30	870.1
	SUN OFDM Option 4	0.2	30	870.1
	SUN O-QPSK	0.2	30	870.1

Table 10-10—Channel numbering for SUN PHYs *(continued)*

Frequency band (MHz)	Modulation	*ChanSpacing* (MHz)	TotalNumChan	*ChanCenterFreq$_0$* (MHz)
902–928 (alternate)[e]	SUN FSK operating modes #1, #2, and #3	0.2	129	902.2
	SUN FSK operating modes #4 and #5	0.4	64	902.4
	SUN OFDM Option 4	0.2	129	902.2
	SUN OFDM Option 3	0.4	64	902.4
	SUN OFDM Option 2	0.8	31	902.8
	SUN OFDM Option 1	1.2	20	903.2
	SUN O-QPSK	2	12	904
902–907.5 & 915–928[e]	SUN FSK operating modes #1, #2, and #3	0.2	91 (channels 0–26 and 65–128 are used)	902.2
	SUN FSK operating modes #4 and #5	0.4	45 (channels 0–12 and 32–63 are used)	902.4
	SUN OFDM Option 4	0.2	91 (channels 0–26 and 65–128 are used)	902.2
	SUN OFDM Option 3	0.4	45 (channels 0–12 and 32–63 are used)	902.4
	SUN OFDM Option 2	0.8	21 (channels 0–5 and 16–30 are used)	902.8
	SUN OFDM Option 1	1.2	13 (channels 0–3 and 11–19 are used)	903.2
	SUN O-QPSK	2	8 (channels 0, 1, and 6–11 are used)	904

Table 10-10—Channel numbering for SUN PHYs *(continued)*

Frequency band (MHz)	Modulation	*ChanSpacing* (MHz)	TotalNumChan	$ChanCenterFreq_0$ (MHz)
915–928[e]	SUN FSK operating modes #1, #2, and #3	0.2	64 (channels 65–128 are used)	902.2 (first frequency used is 915.2)
	SUN FSK operating modes #4 and #5	0.4	32 (channels 32–63 are used)	902.4 (first frequency used is 915.2)
	SUN OFDM Option 4	0.2	64 (channels 65–128 are used)	902.2 (first frequency used is 915.2)
	SUN OFDM Option 3	0.4	32 (channels 32–63 are used)	902.4 (first frequency used is 915.2)
	SUN OFDM Option 2	0.8	15 (channels 16–30 are used)	902.8 (first frequency used is 915.6)
	SUN OFDM Option 1	1.2	9 (channels 11–19 are used)	903.2 (first frequency used is 916.4)
	SUN O-QPSK	2	6 (channels 6–11 are used)	904 (first frequency used is 916)
915–921[e]	SUN FSK operating modes #1, #2, and #3	0.2	29 (channels 65–93 are used)	902.2 (first frequency used is 915.2)
	SUN FSK operating modes #4 and #5	0.4	15 (channels 32–46 are used)	902.4 (first frequency used is 915.2)
	SUN OFDM Option 4	0.2	29 (channels 65–93 are used)	902.2 (first frequency used is 915.2)
	SUN OFDM Option 3	0.4	15 (channels 32–46 are used)	902.4 (first frequency used is 915.2)
	SUN O-QPSK	0.2	29 (channels 65–93 are used)	902.2 (first frequency used is 915.2)

Table 10-10—Channel numbering for SUN PHYs *(continued)*

Frequency band (MHz)	Modulation	*ChanSpacing* (MHz)	TotalNumChan	*ChanCenterFreq$_0$* (MHz)
915–918[e]	SUN FSK operating modes #1, #2, and #3	0.2	14 (channels 65–78 are used)	902.2 (first frequency used is 915.2)
	SUN FSK operating modes #4 and #5	0.4	7 (channels 32–38 are used)	902.4 (first frequency used is 915.2)
	SUN OFDM Option 4	0.2	14 (channels 65–78 are used)	902.2 (first frequency used is 915.2)
	SUN OFDM Option 3	0.4	7 (channels 32–38 are used)	902.4 (first frequency used is 915.2)
	SUN OFDM Option 2	0.8	3 (channels 16–18 are used)	902.8 (first frequency used is 915.6)
	SUN OFDM Option 1	1.2	1 (channel 11 is used)	903.2 (first frequency used is 916.4)
	SUN O-QPSK	0.2	14 (channels 65–78 are used)	902.2 (first frequency used is 915.2)
919–923[e]	SUN FSK operating modes #1, #2, and #3	0.2	19 (channels 85–103 are used)	902.2 (first frequency used is 919.2)
	SUN FSK operating modes #4 and #5	0.4	10 (channels 42–51 are used)	902.4 (first frequency used is 919.2)
	SUN OFDM Option 4	0.2	19 (channels 85–103 are used)	902.2 (first frequency used is 919.2)
	SUN OFDM Option 3	0.4	10 (channels 42–51 are used)	902.4 (first frequency used is 919.2)
	SUN OFDM Option 2	0.8	4 (channels 21–24 are used)	902.8 (first frequency used is 919.6)
	SUN OFDM Option 1	1.2	3 (channels 14–16 are used)	903.2 (first frequency used is 920)
	SUN O-QPSK	0.2	19 (channels 85–103 are used)	902.2 (first frequency used is 919.2)

Table 10-10—Channel numbering for SUN PHYs *(continued)*

Frequency band (MHz)	Modulation	*ChanSpacing* (MHz)	TotalNumChan	*ChanCenterFreq$_0$* (MHz)
920.5–924.5[e]	SUN FSK operating modes #1, #2, and #3	0.2	20 (channels 92–111 are used)	902.2 (first frequency used is 920.6)
	SUN OFDM Option 4	0.2	20 (channels 92–111 are used)	902.2 (first frequency used is 920.6)
	SUN O-QPSK	0.2	20 (channels 92–111 are used)	902.2 (first frequency used is 920.6)
920–925[e]	SUN FSK operating modes #1, #2, and #3	0.2	24 (channels 90–113 are used)	902.2 (first frequency used is 920.2)
	SUN FSK operating modes #4 and #5	0.4	12 (channels 45–56 are used)	902.4 (first frequency used is 920.2)
	SUN OFDM Option 4	0.2	24 (channels 90–113 are used)	902.2 (first frequency used is 920.2)
	SUN OFDM Option 3	0.4	12 (channels 45–56 are used)	902.4 (first frequency used is 920.2)
	SUN OFDM Option 2	0.8	6 (channels 22–27 are used)	902.8 (first frequency used is 920.4)
	SUN OFDM Option 1	1.2	3 (channels 15–17 are used)	903.2 (first frequency used is 921.2)
	SUN O-QPSK	0.2	24 (channels 90–113 are used)	902.2 (first frequency used is 920.2)

[d]Channel numbering based on 863–870 MHz numbering.
[e]Channel numbering based on 902–928 MHz numbering.

10.2 General radio specifications

10.2.7 Clear channel assessment (CCA)

Insert the following list item at the end of 10.2.7:

c) For SUN FSK PHY, when operating with channel spacing that is less than twice the symbol rate, use of CCA Mode 1 and CCA Mode 3 may not be recommended.

20. SUN FSK PHY

20.1 Introduction

Insert the following rows into Table 20-1:

Table 20-1—SUN FSK symbol period used for MAC and PHY timing parameters

Frequency band (MHz)	symbol period used for MAC and PHY timing parameters (µs)
866–869	20
870–876	20
902–928(alternate)	20
902–907.5 & 915–928	20
915–928	20
915–921	20
915–918	20
919–923	20
920.5–924.5	20
920–925	20

20.3 Modulation and coding for SUN FSK

Change the following rows of Table 20-6 as indicated:

Table 20-6—SUN FSK modulation and channel parameters[a]

Frequency band (MHz)	Parameter	Operating mode #1	Operating mode #2	Operating mode #3
470–510	Data rate (kb/s)	50	100	~~200~~ 150
	Modulation	2-FSK	2-FSK	~~4-FSK~~ 2-FSK
	Modulation index	1.0	~~1.0~~ 0.5	~~0.33~~ 0.5
	Channel spacing (kHz)	200	~~400~~ 200	~~400~~ 200
863–870	Data rate (kb/s)	50	100	~~200~~ 150
	Modulation	2-FSK	2-FSK	~~4-FSK~~ 2-FSK
	Modulation index	~~1.0~~ 0.5	~~1.0~~ 0.5	~~0.33~~ 0.5
	Channel spacing (kHz)	~~200~~ 100	~~400~~ 200	~~400~~ 200

[a]Data rates shown are over-the-air data rates (the data rate transmitted over the air regardless of whether the FEC is enabled).

Change the third paragraph of 20.3 as indicated:

Table 20-7 shows the modulation and channel parameters for the standard-defined PHY operating modes for the 867 MHz, 870 MHz, 915 MHz-a, 915 MHz-b, 915 MHz-c, 915 MHz-d, 915 MHz-e, 919 MHz, 920 MHz, 920 MHz-a, and 920 MHz-b ~~Japanese~~ bands. For these bands, a device shall support both operating modes #1 and #2 and may additionally support operating modes #3, ~~and~~ #4, and #5.

Change the following row and the title of Table 20-7 as indicated:

Table 20-7—SUN FSK modulation and channel parameters for additional sub-GHz bands ~~Japanese band~~[a]

Frequency band (MHz)	Parameter	Operating mode #1	Operating mode #2	Operating mode #3	Operating mode #4	Operating mode #5
920–928	Data rate (kb/s)	50	100	200	400	—
	Modulation	2-FSK	2-FSK	2-FSK	4-FSK	—
	Modulation index	1.0	1.0	1.0	0.33	—
	Channel spacing (kHz)[b]	200	400	600	600	—

[a]Data rates shown are over-the-air data rates (the data rate transmitted over the air regardless of whether the FEC is enabled).
[b]Channel separation of 200 kHz is used. Channel spacing shows bundling of 200 kHz channels.

Insert the following rows into Table 20-7:

Table 20-7—SUN FSK modulation and channel parameters for additional sub-GHz bands[a]

Frequency band (MHz)	Parameter	Operating mode #1	Operating mode #2	Operating mode #3	Operating mode #4	Operating mode #5
866–869	Data rate (kb/s)	50	100	150	200	300
	Modulation	2-FSK	2-FSK	2-FSK	2-FSK	2-FSK
	Modulation index	0.5	0.5	0.5	0.5	0.5
	Channel spacing (kHz)	100	200	200	400	400
870–876	Data rate (kb/s)	50	100	150	—	—
	Modulation	2-FSK	2-FSK	2-FSK	—	—
	Modulation index	0.5	0.5	0.5	—	—
	Channel spacing (kHz)	100	200	200	—	—

Table 20-7—SUN FSK modulation and channel parameters for additional sub-GHz bands[a]

Frequency band (MHz)	Parameter	Operating mode #1	Operating mode #2	Operating mode #3	Operating mode #4	Operating mode #5
902–928 (alternate)	Data rate (kb/s)	50	100	150	200	300
	Modulation	2-FSK	2-FSK	2-FSK	2-FSK	2-FSK
	Modulation index	1.0	0.5	0.5	0.5	0.5
	Channel spacing (kHz)	200	200	200	400	400
902–907.5 & 915–928	Data rate (kb/s)	50	100	150	200	300
	Modulation	2-FSK	2-FSK	2-FSK	2-FSK	2-FSK
	Modulation index	1.0	0.5	0.5	0.5	0.5
	Channel spacing (kHz)	200	200	200	400	400
915–928	Data rate (kb/s)	50	100	150	200	300
	Modulation	2-FSK	2-FSK	2-FSK	2-FSK	2-FSK
	Modulation index	1.0	0.5	0.5	0.5	0.5
	Channel spacing (kHz)	200	200	200	400	400
915–921	Data rate (kb/s)	50	100	150	200	300
	Modulation	2-FSK	2-FSK	2-FSK	2-FSK	2-FSK
	Modulation index	1.0	0.5	0.5	0.5	0.5
	Channel spacing (kHz)	200	200	200	400	400
915–918	Data rate (kb/s)	50	100	150	200	300
	Modulation	2-FSK	2-FSK	2-FSK	2-FSK	2-FSK
	Modulation index	1.0	0.5	0.5	0.5	0.5
	Channel spacing (kHz)	200	200	200	400	400
919–923	Data rate (kb/s)	50	100	150	200	300
	Modulation	2-FSK	2-FSK	2-FSK	2-FSK	2-FSK
	Modulation index	1.0	0.5	0.5	0.5	0.5
	Channel spacing (kHz)	200	200	200	400	400

Table 20-7—SUN FSK modulation and channel parameters for additional sub-GHz bands[a]

Frequency band (MHz)	Parameter	Operating mode #1	Operating mode #2	Operating mode #3	Operating mode #4	Operating mode #5
920.5–924.5	Data rate (kb/s)	50	100	150	—	—
	Modulation	2-FSK	2-FSK	2-FSK	—	—
	Modulation index	1.0	0.5	0.5	—	—
	Channel spacing (kHz)	200	200	200	—	—
920–925	Data rate (kb/s)	50	100	150	200	300
	Modulation	2-FSK	2-FSK	2-FSK	2-FSK	2-FSK
	Modulation index	1.0	0.5	0.5	0.5	0.5
	Channel spacing (kHz)	200	200	200	400	400

[a]Data rates shown are over-the-air data rates (the data rate transmitted over the air regardless of whether the FEC is enabled).

20.6 SUN FSK PHY RF requirements

20.6.6 Transmit spectral mask

Insert the following paragraphs after the first paragraph ("The transmit spectral content is....") of 20.6.6:

When operating mode #1 with 100 kHz channel spacing or operating mode #3 with 200 kHz channel spacing or operating mode #5 with 400 kHz channel spacing is used as specified in Table 20-6 and Table 20-7, offset frequencies M_1 and M_2 and the integrated bandwidth (with respect to the M_1 and M_2 offset frequencies) are defined as follows:

The integration bandwidth shall be equal to $5/8 \times S$, where S is the channel spacing, expressed in units of hertz.

$$M_1 = 9/16 \times S \times (1 + h)$$

$$M_2 = 9/8 \times S \times (1 + h)$$

where h is the modulation index for 2-level modulation.

The transmit spectral content at M_1 and M_2 for the above specified operating modes shall be less than –20 dB and –35 dB, respectively.

Otherwise, for all other operating modes specified in Table 20-6 and Table 20-7, the 1 offset frequencies M_1 and M_2 and the integrated bandwidth shall be defined as follows:

21. SUN OFDM PHY

21.5 SUN OFDM PHY RF requirements

21.5.1 Operating frequency range

Insert the following into the list of operating bands in 21.5.1:

- 866–869 MHz
- 870–876 MHz
- 902–928(alternate) MHz
- 902–907.5 MHz and 915–928 MHz
- 915–928 MHz
- 915–921 MHz
- 915–918 MHz
- 919–923 MHz
- 920.5–924.5 MHz
- 920–925 MHz

22. SUN O-QPSK PHY

22.1 Introduction

Change the second paragraph of 22.1 as indicated:

For all frequency bands, spreading is obtained by direct sequence spread spectrum (DSSS) applying various spreading factors. For the 780 MHz, 915 MHz, 915 MHz-a, 915 MHz-b, 915 MHz-c, 917 MHz, and 2450 MHz frequency bands, the SUN O-QPSK PHY may support an alternative spreading factor for the PSDU, called multiplexed direct sequence spread spectrum (MDSSS).

22.2 PPDU format for SUN O-QPSK

22.2.1 SHR field format

22.2.1.1 Preamble field format

Change 22.2.1.1 as indicated:

The Preamble field shall contain a sequence of 56 bits, all zero, for the 780 MHz, 915 MHz, 915 MHz-a, 915 MHz-b, 915 MHz-c, 917 MHz, and 2450 MHz frequency bands. It shall contain a sequence of 32 bits, all zero, for the 470 MHz, 866 MHz, 867 MHz, 868 MHz, 870 MHz, 915 MHz-d, 915 MHz-e, 919 MHz, ~~and~~ 920 MHz, 920 MHz-a, and 920 MHz-b frequency bands.

22.2.2 PHR field format

Change the second paragraph of 22.2.2 as indicated:

For the 780 MHz, 915 MHz, 915 MHz-a, 915 MHz-b, 915 MHz-c, 917 MHz, and 2450 MHz frequency bands, the Spreading Mode field shall be set to one if MDSSS is used for PSDU spreading, as described in 22.3.5. Otherwise, the Spreading Mode field shall be set to zero if DSSS is used for PSDU spreading, as described in 22.3.4. For the 470 MHz, 866 MHz, 867 MHz, 868 MHz, 870 MHz, 915 MHz-d, 915 MHz-e, 919 MHz, ~~and~~ 920 MHz, 920 MHz-a, and 920 MHz-b frequency bands, the Spreading Mode field shall be set to zero, i.e., MDSSS is not supported.

22.3 Modulation and coding for SUN O-QPSK

22.3.2 SHR coding and spreading

Insert the following rows into Table 22-2:

Table 22-2—SHR coding and spreading parameters

Frequency band (MHz)	Chip rate (kchip/s)	BDE	Spreading mode
866–869	100	yes	$(32,1)_0$-DSSS
870–876	100	yes	$(32,1)_0$-DSSS
902–928(alternate)	1000	yes	(64,1)-DSSS

Table 22-2—SHR coding and spreading parameters *(continued)*

Frequency band (MHz)	Chip rate (kchip/s)	BDE	Spreading mode
902–907.5 & 915–928	1000	yes	(64,1)-DSSS
915–928	1000	yes	(64,1)-DSSS
915–921	100	yes	$(32,1)_0$-DSSS
915–918	100	yes	$(32,1)_0$-DSSS
919–923	100	yes	$(32,1)_0$-DSSS
920.5–924.5	100	yes	$(32,1)_0$-DSSS
920–925	100	yes	$(32,1)_0$-DSSS

22.3.3 PHR coding and spreading

Insert the following rows into Table 22-3:

Table 22-3—PHR coding and spreading parameters

Frequency band (MHz)	Chip rate (kchip/s)	BDE	rate ½ FEC + interleaver	Spreading mode
866–869	100	yes	yes	$(8,1)_{0/1}$-DSSS
870–876	100	yes	yes	$(8,1)_{0/1}$-DSSS
902–928(alternate)	1000	yes	yes	$(16,1)_{0/1}$-DSSS
902–907.5 & 915–928	1000	yes	yes	$(16,1)_{0/1}$-DSSS
915–928	1000	yes	yes	$(16,1)_{0/1}$-DSSS
915–921	100	yes	yes	$(8,1)_{0/1}$-DSSS
915–918	100	yes	yes	$(8,1)_{0/1}$-DSSS
919–923	100	yes	yes	$(8,1)_{0/1}$-DSSS
920.5–924.5	100	yes	yes	$(8,1)_{0/1}$-DSSS
920–925	100	yes	yes	$(8,1)_{0/1}$-DSSS

22.3.4 PSDU coding and spreading for DSSS

Insert the following rows into Table 22-4:

Table 22-4—PSDU parameters for spreading mode DSSS

Frequency band (MHz)	Chip rate (kchip/s)	Rate mode	BDE	Spreading mode	rate ½ FEC + interleaver	Data rate (kb/s)
866–869	100	0	yes	$(8,1)_{0/1}$-DSSS	yes	6.25
		1	yes	(4,1)-DSSS	yes	12.5
		2	yes	(2,1)-DSSS	yes	25
		3	no	none	yes	50
870–876	100	0	yes	$(8,1)_{0/1}$-DSSS	yes	6.25
		1	yes	(4,1)-DSSS	yes	12.5
		2	yes	(2,1)-DSSS	yes	25
		3	no	none	yes	50
902–928 (alternate)	1000	0	yes	$(16,1)_{0/1}$-DSSS	yes	31.25
		1	no	(16,4)-DSSS	yes	125
		2	no	(8,4)-DSSS	yes	250
		3	no	none	yes	500
902–907.5 & 915–928	1000	0	yes	$(16,1)_{0/1}$-DSSS	yes	31.25
		1	no	(16,4)-DSSS	yes	125
		2	no	(8,4)-DSSS	yes	250
		3	no	none	yes	500
915–928	1000	0	yes	$(16,1)_{0/1}$-DSSS	yes	31.25
		1	no	(16,4)-DSSS	yes	125
		2	no	(8,4)-DSSS	yes	250
		3	no	none	yes	500
915–921	100	0	yes	$(8,1)_{0/1}$-DSSS	yes	6.25
		1	yes	(4,1)-DSSS	yes	12.5
		2	yes	(2,1)-DSSS	yes	25
		3	no	none	yes	50
915–918	100	0	yes	$(8,1)_{0/1}$-DSSS	yes	6.25
		1	yes	(4,1)-DSSS	yes	12.5
		2	yes	(2,1)-DSSS	yes	25
		3	no	none	yes	50

Table 22-4—PSDU parameters for spreading mode DSSS *(continued)*

Frequency band (MHz)	Chip rate (kchip/s)	Rate mode	BDE	Spreading mode	rate ½ FEC + interleaver	Data rate (kb/s)
919–923	100	0	yes	$(8,1)_{0/1}$-DSSS	yes	6.25
		1	yes	(4,1)-DSSS	yes	12.5
		2	yes	(2,1)-DSSS	yes	25
		3	no	none	yes	50
920.5–924.5	100	0	yes	$(8,1)_{0/1}$-DSSS	yes	6.25
		1	yes	(4,1)-DSSS	yes	12.5
		2	yes	(2,1)-DSSS	yes	25
		3	no	none	yes	50
920–925	100	0	yes	$(8,1)_{0/1}$-DSSS	yes	6.25
		1	yes	(4,1)-DSSS	yes	12.5
		2	yes	(2,1)-DSSS	yes	25
		3	no	none	yes	50

22.3.5 PSDU coding and spreading for MDSSS

Insert the following rows into Table 22-5:

Table 22-5—PSDU parameters for spreading mode MDSSS

Frequency band (MHz)	Chip rate (kchip/s)	Rate mode	BDE	Spreading mode	rate ½ FEC + interleaver	Data rate (kb/s)
866–869	not supported					
870–876	not supported					
902–928 (alternate)	1000	0	no	(64,8)-MDSSS	yes	62.5
		1	no	(32,8)-MDSSS	yes	125
		2	no	(32,8)-MDSSS	no	250
		3	no	(16,8)-MDSSS	no	500
902–907.5 & 915–928	1000	0	no	(64,8)-MDSSS	yes	62.5
		1	no	(32,8)-MDSSS	yes	125
		2	no	(32,8)-MDSSS	no	250
		3	no	(16,8)-MDSSS	no	500

Table 22-5—PSDU parameters for spreading mode MDSSS *(continued)*

Frequency band (MHz)	Chip rate (kchip/s)	Rate mode	BDE	Spreading mode	rate ½ FEC + interleaver	Data rate (kb/s)
915–928	1000	0	no	(64,8)-MDSSS	yes	62.5
		1	no	(32,8)-MDSSS	yes	125
		2	no	(32,8)-MDSSS	no	250
		3	no	(16,8)-MDSSS	no	500
915–921	not supported					
915–918	not supported					
919–923	not supported					
920.5–924.5	not supported					
920–925	not supported					

22.3.11 Chip whitening

Insert the following rows into Table 22-19:

Table 22-19—Chip whitening for DSSS

Frequency band (MHz)	Rate mode
866–869	1 and 2 and 3
870–876	1 and 2 and 3
902–928(alternate)	2 and 3
902–907.5 & 915–928	2 and 3
915–928	2 and 3
915–921	1 and 2 and 3
915–918	1 and 2 and 3
919–923	1 and 2 and 3
920.5–924.5	1 and 2 and 3
920–925	1 and 2 and 3

22.3.12 Pilot insertion

Insert the following rows into Table 22-20:

Table 22-20—Pilot length, spacing and chip sequences

Frequency band (MHz)	Length N_p (# of chips)	Spacing M_p (# of chips)	Chip sequence $p = (p_0, p_1, \ldots, p_{Np-1})$
866–869	32	512	1101 1110 1010 0010 0111 0000 0110 0101
870–876	32	512	1101 1110 1010 0010 0111 0000 0110 0101
902–928 (alternate)	64	1024	1011 0010 0010 0101 1011 0001 1101 0000 1101 0111 0011 1101 1111 0000 0010 1010
902–907.5 & 915–928	64	1024	1011 0010 0010 0101 1011 0001 1101 0000 1101 0111 0011 1101 1111 0000 0010 1010
915–928	64	1024	1011 0010 0010 0101 1011 0001 1101 0000 1101 0111 0011 1101 1111 0000 0010 1010
915–921	32	512	1101 1110 1010 0010 0111 0000 0110 0101
915–918	32	512	1101 1110 1010 0010 0111 0000 0110 0101
919–923	32	512	1101 1110 1010 0010 0111 0000 0110 0101
920.5–924.5	32	512	1101 1110 1010 0010 0111 0000 0110 0101
920–925	32	512	1101 1110 1010 0010 0111 0000 0110 0101

22.3.13 Modulation parameters for SUN O-QPSK

Change the first part of the second and third paragraphs of 22.3.13 as indicated:

In the 915 MHz, 915 MHz-a, 915 MHz-b, 915 MHz-c, and 2450 MHz bands, the half-sine pulse shape is used to represent each baseband chip and is as follows:

In the 470 MHz, 780 MHz, 866 MHz, 867 MHz, 868 MHz, 870 MHz, 915 MHz-d, 915 MHz-e, 917 MHz, ~~and~~ 919 MHz, 920 MHz, 920 MHz-a, and 920 MHz-b bands, a raised cosine pulse shape with roll-off factor of $r = 0.8$ is used to represent each baseband symbol and is described as follows:

22.5 SUN O-QPSK PHY RF requirements

22.5.1 Operating frequency range

Insert the following into the list of operation bands in 22.5.1:

— 866–869 MHz
— 870–876 MHz
— 902–928(alternate) MHz
— 902–907.5 MHz and 915–928 MHz
— 915–928 MHz
— 915–921 MHz

— 915–918 MHz
— 919–923 MHz
— 920.5–924.5 MHz
— 920–925 MHz

22.5.3 Receiver sensitivity

Insert the following rows into Table 22-21:

Table 22-21—Required receiver sensitivity for spreading mode DSSS [dBm]

Frequency band (MHz)	Rate mode			
	0	1	2	3
866–869	–110	–105	–100	–95
870–876	–110	–105	–100	–95
902–928(alternate)	–105	–100	–95	–90
902–907.5 & 915–928	–105	–100	–95	–90
915–928	–105	–100	–95	–90
915–921	–110	–105	–100	–95
915–918	–110	–105	–100	–95
919–923	–110	–105	–100	–95
920.5–924.5	–110	–105	–100	–95
920–925	–110	–105	–100	–95

Insert the following rows into Table 22-22:

Table 22-22—Required receiver sensitivity for spreading mode MDSSS [dBm]

Frequency band (MHz)	Rate mode			
	0	1	2	3
866–869	not supported			
870–876	not supported			
902–928(alternate)	–105	–100	–95	–90
902–907.5 & 915–928	–105	–100	–95	–90
915–928	–105	–100	–95	–90
915–921	not supported			
915–918	not supported			

Table 22-22—Required receiver sensitivity for spreading mode MDSSS [dBm] *(continued)*

Frequency band (MHz)	Rate mode			
	0	1	2	3
919–923	not supported			
920.5–924.5	not supported			
920–925	not supported			

22.5.4 Adjacent channel rejection

Insert the following rows into Table 22-23:

Table 22-23—Minimum interference-to-signal ratio (ISR) requirements depending on $|\Delta f|$

Frequency band (MHz) 866–869	$|\Delta f|$ (MHz)	0.2	0.4
	ISR (dB)	10	30
Frequency band (MHz) 870–876	$|\Delta f|$ (MHz)	0.2	0.4
	ISR (dB)	10	30
Frequency band (MHz) 902–928(alternate)	$|\Delta f|$ (MHz)	2	4
	ISR (dB)	10	30
Frequency band (MHz) 902–907.5 & 915–928	$|\Delta f|$ (MHz)	2	4
	ISR (dB)	10	30
Frequency band (MHz) 915–928	$|\Delta f|$ (MHz)	2	4
	ISR (dB)	10	30
Frequency band (MHz) 915–921	$|\Delta f|$ (MHz)	0.2	0.4
	ISR (dB)	10	30
Frequency band (MHz) 915–918	$|\Delta f|$ (MHz)	0.2	0.4
	ISR (dB)	10	30
Frequency band (MHz) 919–923	$|\Delta f|$ (MHz)	0.2	0.4
	ISR (dB)	10	30
Frequency band (MHz) 920.5–924.5	$|\Delta f|$ (MHz)	0.2	0.4
	ISR (dB)	10	30
Frequency band (MHz) 920–925	$|\Delta f|$ (MHz)	0.2	0.4
	ISR (dB)	10	30

22.5.13 CCA

Insert the following rows into Table 22-24:

Table 22-24—CCA duration for SUN O-QPSK PHY

Frequency band (MHz)	*aCcaTime* (# of symbols)
866–869	4
870–876	4
902–928(alternate)	8
902–907.5 & 915–928	8
915–928	8
915–921	4
915–918	4
919–923	4
920.5–924.5	4
920–925	4

Insert Annex G after Annex F:

Annex G

(informative)

Geographic regional frequency band details

Geographic regions are listed in Table G.1 according to their frequency bands.

Table G.1—Frequency bands with geographic information

Band designation	Frequency band (MHz)	Country or region
470 MHz	470–510	China
863 MHz	863–870	Europe
866 MHz	865–867	India
867 MHz	866–869	Singapore
870 MHz	870–876	Europe
915 MHz	902–928	North America
915 MHz-a	902–928(alternate)	North America and Mexico
915 MHz-b	902–907.5 & 915–928	Brazil
915 MHz-c	915–928	Australia and New Zealand
915 MHz-d	915–921	Europe
915 MHz-e	915–918	Philippines
919 MHz	919–923	Malaysia
920 MHz	920–928	Japan
920 MHz-a	920.5–924.5	China
920 MHz-b	920–925	Hong Kong, Singapore, Thailand, and Vietnam

NOTE—The PHY parameters as defined for the 902–928(alternate) MHz band can be used in addition to the existing 902–928 MHz band.

Consensus

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