IEEE P802.11
Wireless LANs

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| TGbe Coexistence Assessment Document |
| Date: 2022-09-08 |
| Author(s): |
| Name | Affiliation | Address | Phone | Email |
| Sigurd Schelstraete | MaxLinear |  |  | sschelstraete@maxlinear.com |
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Abstract

This serves as the Coexistence Assessment document for TGbe.

R0: Initial version. Includes several comments identifying areas for feedback.

R1: Renamed to “Coexistence Assessment Document” per latest IEEE 802 Operations Manual, added VLP.

R2: updated with comments received during 4/28 Joint TGbe call

R3: updated with comments received during 5/12 Joint TGbe call

R4: updated with comments received during CC37

R5: updated with approved comment resolutions (see 11-21/1059r1), as motioned on 8/25/2021 (see Motion 235, 11-21/1982r37)

R6: updated with proposed resolutions of CA comments received during LB266

# Introduction

This document addresses coexistence of IEEE P802.11be [1] following the PAR [2] and CSD [3].

The P802.11be PAR [2] contains the following statement about the spectrum use of P802.11be:

This amendment defines standardized modifications to both the IEEE Std 802.11 physical layers (PHY) and the Medium Access Control Layer (MAC) that enable at least one mode of operation capable of supporting a maximum throughput of at least 30 Gbps, as measured at the MAC data service access point (SAP), with carrier frequency operation between 1 and 7.250 GHz while ensuring backward compatibility and coexistence with legacy IEEE Std 802.11 compliant devices operating in the 2.4 GHz, 5 GHz, and 6 GHz bands.

The following excerpt of the CSD [3] confirms that the WG will produce a Coexistence Assurance (CA) document for P802.11be[[1]](#footnote-2):

### 1.1.2 Coexistence

A WG proposing a wireless project shall demonstrate coexistence through the preparation of a Coexistence Assurance (CA) document unless it is not applicable.

a) Will the WG create a CA document as part of the WG balloting process as described in Clause 13? YES

b) If not, explain why the CA document is not applicable.

# Frequency Bands of Operation defined in IEEE P802.11be

Though the PAR [2] specifies the frequency range between 1 GHz and 7.250 GHz, P802.11be intends to operate in the unlicensed 2.4 GHz, 5 GHz and 6 GHz[[2]](#footnote-3) bands.

The P802.11be channelization in 2.4 GHz and 5 GHz is identical to the one specified in 802.11-2020 [9]. For channel bandwidths up to 160 MHz, the P802.11be channelization in 6 GHz is identical to the one specified in the 802.11ax amendment [4].

A new channelization is introduced for 320 MHz BW operation in the 6 GHz band. P802.11be defines six 320 MHz channels, spaced 160 MHz apart. The 320 MHz channel center frequencies are given as:

Channel center frequency = Channel starting frequency + 5 × *nch* (MHz),

where:

* Channel starting frequency is 5950 MHz
* *nch*: center frequency index, taking values 31, 63, 95, 127, 159, 191

# Active IEEE 802 wireless standards operating in the same frequency bands of operation as IEEE P802.11be

IEEE 802.15 standards and amendments specifically in the 2.4, 5, and 6 GHz bands are listed below:

Table 1: IEEE 802.15 Standards and Amendments

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Identifier** | **Standards/Amendment** | **Clause**  | **PHY Name** | **Frequency Band** |
| 3-1 | 802.15.3-2016 | 10 | PHY for 2.4 GHz | 2.4 – 2.485 GHz |
| 3-2 | 802.15.4-2020 | 12 | O-QPSK PHY | 2450, 868, 915, 780, 2380 MHz |
| 3-3 | 802.15.4-2020 | 14 | CSS PHY | 2450 MHz |
| 3-4 | 802.15.4-2020 | 15 | HRP UWB PHY | 249.6 – 749.6 MHz, 3.1 – 4.8 GHz and 6.0 – 10.6 GHz |
| 3-5 | 802.15.4-2020 | 17 | MSK PHY | 433.05 – 434.79 MHz and 2400 – 2483 MHz  |
| 3-6 | 802.15.4-2020 | 18 | LRP UWB PHY | 6.2826 – 9.1856 GHz  |
| 3-7 | 802.15.4-2020 | 19 | SUN FSK PHY | 169, 450, 470, 863, 901, 915, 928, 1427, 2450 MHz |
| 3-8 | 802.15.4-2020 | 20 | SUN OFDM PHY | 470–510, 779–787, 863–870, 902–928, 917–923.5, 920–928, 2400–2483.5 MHz |
| 3-9 | 802.15.4-2020 | 21 | SUN O-QPSK PHY | 470, 780, 868, 915, 917, 920, and 2450 MHz |
| 3-10 | 802.15.4q-2016 | 31 | TASK PHY | 433.050-434.790, 470-510, 779-787, 863-876, 902–928, 2400-2483.5 MHz |
| 3-11 | 802.15.4q-2016 | 32 | RS-GFSK PHY | 915 and 2450 MHz |
| 3-12 | 802.15.4t-2017 | 18 | MSK PHY | 433.05 – 434.79 MHz and 2400 – 2483 MHz |
| 3-13 | 802.15.4z-2020 | Amendment | HRP UWB PHYLRP UWB PHY | 6-10 GHz |
| 3-14 | 802.15.4-2020 | 22 | LECIM DSSS | 2.4 – 2.485 GHz |

# Selected non-IEEE 802 market relevant standards operating in the same frequency bands as IEEE P802.11be

|  |  |  |
| --- | --- | --- |
| **Identifier** | **Standards/Amendment** | **Frequency Band (GHz)** |
| 4-1 | 3GPP LTE LAA | 5GHz/6GHz |
| 4-2 | 3GPP NR-U | 5GHz/6GHz |

# Existing Licensed Services in the 6 GHz band [10][[3]](#footnote-4)

|  |  |  |
| --- | --- | --- |
| **Identifier** | **Standards/Amendment** | **Frequency Band (GHz)** |
| 5-1 | Fixed Services (FS) | 5925 – 6425 MHz and 6525 – 7125 MHz |
| 5-2 | Fixed Satellite Services (FSS) | 5925 – 7125 MHz |
| 5-3 | Mobile Services | 6425 – 6525 MHz and 6875 – 7125 MHz |

# Mechanisms supporting Coexistence with non-IEEE 802.11 systems

The mechanism defined in IEEE 802.11 standards for 802.11 devices to coexist with non-802.11 devices (other than licensed services in the 6 GHz band or radar operation in 5 GHz) is carrier sense multiple access with collision avoidance (CSMA/CA). P802.11be continues to use clear channel assessment (CCA) rules in the 2.4, 5 and 6 GHz bands.

The current draft P802.11be CCA rules are described in 36.3.20.6 (CCA sensitivity) of [1].

According to these rules, a PHY must set its CCA indication to busy if:

* A non-HT, HT\_MF, HT\_GF, VHT, HE, or EHT PPDU is present with power measured within the primary 20 MHz channel at or above –82 dBm
* A signal is present with power measured within the primary 20 MHz channel at or above –62 dBm[[4]](#footnote-5).

For signals with bandwidth greater than 20 MHz, the PHY shall also provide a per-20 MHz CCA indication, which shall individually be set to busy if:

* A non-HT, HT\_MF, HT\_GF, VHT, HE, or EHT PPDU is present for which the power measured within the 20 MHz subchannel is at or above -72 dBm
* A signal is present within the 20 MHz subchannel at or above a threshold of –62 dBm.

For licensed services in the 6 GHz band, operation of P802.11be in the 6 GHz band further complies with the regulatory rules specified for this band [5]. This includes the ability to reduce transmit power and rules for selecting channels under the direction of an Automated Frequency Coordination (AFC) system. AFC is under consideration by the FCC and other regulatory domains.

For coexistence with radar operation in 5 GHz, P802.11be uses DFS as specified in 802.11-2020 [9].

# Coexistence analysis: non-IEEE 802.11 systems

IEEE 802.15 standards 3-1 through 3-3, 3-5, 3-7 and 3-12 (see Table 1) overlap with IEEE 802.11 and P802.11be operation in the 2.4 GHz band only. CSMA/CA is the mechanism used by existing IEEE 802.11 standards for coexistence in the 2.4 GHz band and will also be used by P802.11be. No significant changes to coexistence are anticipated with P802.11be operation in the 2.4 GHz band.

IEEE 802.15 standards 3-4 and 3-6 and the amendment 3-13 (see Table 1) overlap with planned IEEE P802.11be operation in the 6 GHz band. IEEE P802.11be shall operate in the band under new regulations (see [5] for FCC rules). IEEE 802.15 standards 3-4 and 3-6 and the 3-13 ultra-wideband (low power spectral density) systems (see Table 1) operate beneath the noise floor of systems operating in the 6 GHz band. The Electronic Communications Committee (www.cept.org/ecc) has produced a report on sharing and compatibility between proposed radio local area networks (RLANs) and current systems in the band including UWB, see [6].

CSMA/CA is used to provide coexistence in the 5 GHz and 6 GHz bands including the specifications identified in section 4 of this document.

Note -- This CSMA/CA mechanism is not effective as a coexistence mechanism with IEEE 802.15 UWB radios since the UWB signals will typically be below the CSMA detection threshold. Conversely, UWB does not require 802.11-like CSMA/CA mechanisms.

For coexistence with licensed users of the 6 GHz bands identified in section 5 of this document, three modes of operation are defined:

1. Standard Power operation
	* Only allowed in 5.925 – 6.425 GHz (FCC U-NII-5) and 6.525 – 6.875 GHz (FCC U-NII-7)
	* Operation only under direction of an AFC system that identifies allowed spectrum and transmit power as a function of AP location, height above ground level (AGL) and the known location of licensed services in the area
	* Client device must limit its power to no more than 6 dB below its associated standard power access point's authorized transmit power
2. Low Power Indoors operation
	* Allowed in full 6 GHz band (i.e. 5.950 to 7.125 GHz)
	* Only indoors at reduced power to avoid interference with licensed users
3. Very Low Power operation[[5]](#footnote-6)
	* Envisioned for indoors and outdoors in the full 6 GHz band
	* Operates at significantly reduced maximum power to avoid interference with fixed and mobile licensed users.

P802.11be implements the mechanisms needed to communicate the transmit power restrictions to the P802.11be devices, specifically through the use of Transmit Power Envelope (TPE) element in Beacons, Probe Responses, etc.

# Mechanisms supporting Coexistence with legacy 802.11 systems

P802.11be continues to use a common legacy preamble, i.e., the non-HT short training field, non-HT long training field, and non-HT signal field as the initial fields in all new P802.11be PPDUs for coexistence with legacy 802.11 systems. This is the same mechanism that was implemented in mixed-format 802.11n, 802.11ac and 802.11ax PPDUs. Therefore PHY-level coexistence with legacy devices will be similar to 802.11n, 802.11ac and 802.11ax (Refer to [8] for further explanation on PHY-level coexistence).

# New IEEE P802.11be features which may affect coexistence

The following features introduced in P802.11be may affect P802.11be coverage area and transmitted RF energy in the operating environment:

* 320 MHz operation in 6 GHz band
* New preamble puncturing modes
* Multi-Link Operation

Each of these features and their potential impact on coexistence is described below.

## 320 MHz operation

IEEE P802.11be for the first time specifies a channel bandwidth of 320 MHz. Within the channel BW, the devices continue to use CSMA/CA and CCA to coexist with both 802.11 and non-802.11 technologies. A Power Spectral Density (PSD) mask is specified for 320 MHz operation to limit to out-of-band leakage.

320 MHz operation is only allowed in the 6 GHz band in certain regulatory domains.

## Preamble Puncturing

IEEE 802.11ax defined preamble puncturing, creating PPDUs for which only part of the full spectrum was used during transmission (creating “holes” in the spectrum). P802.11be has added a number of additional preamble puncturing modes and also allows its use for transmissions to a single user (whereas IEEE 802.11ax only defined preamble puncturing for OFDMA transmissions).

In a downlink transmission, an AP may choose to not populate certain sub-channels of its 80, 160 or 320 MHz channel bandwidth if it finds the sub-channels busy. In the EHT-STF, EHT-LTF and data field that are transmitted in EHT format, this is performed by only assigning the free sub-channels to users. The L-STF, L-LTF, L-SIG, RL-SIG, and EHT-SIG and U-SIG preamble fields are transmitted in legacy mode and utilize the technique termed Preamble Puncturing to not transmit preamble fields in the corresponding 20 MHz sub-channels.

A new PSD mask is defined for the “holes” in the spectrum created by preamble puncturing, depending on the full BW of the signal and the specific part of the spectrum that has been punctured. These spectral masks reduce the interference towards other users in parts of the spectrum that are not used by the EHT transmission.

## Multi-Link Operation (MLO)

In MLO, an IEEE 802.11be device operates concurrently on multiple 802.11 channels, multiplexing its data dynamically over the various links. From an interference point of view, this is no different from concurrent multi-channel operation where independent networks are established on each of the channels. Concurrent multi-channel operation is already widely deployed today, therefore the use of MLO does not present any novel interference scenario.

## Other notable features

P802.11be reuses a number of features that were first introduced in 802.11ax, such as:

* Uplink multi-user operation
* Spatial reuse
* New OFDM waveform design
* Operation in 6 GHz

The possible impact and coexistence of these features was discussed in the TGax Coexistence Assurance Document [7]. No changes are expected for P802.11be.

# Definitions

* Orthogonal frequency-division multiple access (OFDMA) - users are allocated different subsets of subcarriers which can change from one PPDU to the next

# References

[1] IEEE P802.11be D2.0

[2] <https://www.ieee802.org/11/PARs/P802_11be_PAR_Detail.pdf>

[3] IEEE 802.11 EHT draft Proposed CSD, IEEE 802.11-18/1233r7. <https://mentor.ieee.org/802.11/dcn/18/11-18-1233-07-0eht-eht-draft-proposed-csd.docx>

[4] IEEE Std 802.11ax-2021

[5] FCC Rules Part 15, subpart E (Unlicensed National Information Infrastructure Devices), <https://www.ecfr.gov/current/title-47/chapter-I/subchapter-A/part-15#subpart-E>

[6] Sharing and compatibility studies related to Wireless Access Systems including Radio Local Area Networks (WAS/RLAN) in the frequency band 5925-6425 MHz, ECC Report 302, CEPT ECC, [https://cept.org/files/9522/Draft%20ECC%20Report%20302rev..docx](https://urldefense.proofpoint.com/v2/url?u=https-3A__cept.org_files_9522_Draft-2520ECC-2520Report-2520302rev..docx&d=DwMGaQ&c=C5b8zRQO1miGmBeVZ2LFWg&r=CJpcKjV7C3TczgWxHrsFmPscm1VuXKM-giLBsGdAZJk&m=i3Xw2ZPlZqLehRXO1WKeeMT68mo8u1Yuo4S2bxPohs8&s=UARqQgc-kmo67ikGQVCJkqodqWbENbRgzBpCjczFxAw&e=)

[7] TGax Coexistence Assurance Document, IEEE 802.11-16/1348r7

[8] E. Perahia, R. Stacey, “Next Generation Wireless LANs: 802.11n and 802.11ac”, Cambridge University Press, 2013

[9] IEEE Std 802.11-2020: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications

[10] Title 47 of the Code of Federal Regulations (CFR), <https://www.fcc.gov/wireless/bureau-divisions/technologies-systems-and-innovation-division/rules-regulations-title-47>

1. The 802.11be CSD still refers to it as “Coexistence Assurance” document. The IEEE 802 Operations Manual now uses the term “Coexistence Assessment” document. [↑](#footnote-ref-2)
2. The spectrum referred to as “the 6 GHz band” covers frequencies from 5.950 to 7.125 GHz [↑](#footnote-ref-3)
3. This describes North-American spectrum only [↑](#footnote-ref-4)
4. -62 dBm is the value used in IEEE 802.11be. ETSI has specified a value of -72 dBm. [↑](#footnote-ref-5)
5. NOTE: VLP is still under discussion in some regulatory domains [↑](#footnote-ref-6)