IEEE P802.11
Wireless LANs

|  |
| --- |
| TGbe Coexistence Assurance Document |
| Date: 2021-04-20 |
| Author(s): |
| Name | Affiliation | Address | Phone | Email |
| Sigurd Schelstraete | MaxLinear |  |  | sschelstraete@maxlinear.com |
|  |  |  |  |  |

Abstract

This serves as the coexistence assurance document for TGbe.

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

# Introduction

This document addresses coexistence of IEEE 802.11be [1] following the PAR [2] and CSD [3].

The 802.11be 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 802.11be:

### 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 802.11be

Though the PAR specifies the frequency range between 1 GHz and 7.125 GHz, 802.11be intends to operate in the unlicensed 2.4 GHz (2400 – 2500 MHz), 5 GHz (5170 – 5855 MHz) and 6 GHz (5925 – 7125 MHz) bands.

For channel bandwidths up to 160 MHz, the Wi-Fi channelization for 2.4 GHz, 5 GHz and 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. 802.11be 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 802.11be

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

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Identifier** | **Standards/Amendment** | **Clause**  | **PHY Name** | **Frequency Band (GHz)** |
| 3-1 | 802.15.3-2016 | 10 | PHY for 2.4 GHz | 2.4 – 2.485 GHz |
| 3-2 | 802.15.4-2015 | 12 | O-QPSK PHY | 2450, 868, 915, 780, 2380 MHz |
| 3-3 | 802.15.4-2015 | 15 | CSS PHY | 2450 MHz |
| 3-4 | 802.15.4-2015 | 16 | HRP UWB PHY | 249.6 – 749.6 MHz, 3.1 – 4.8 GHz and 6.0 – 10.6 GHz |
| 3-5 | 802.15.4-2015 | 18 | MSK PHY | 433.05 – 434.79 MHz and 2400 – 2483 MHz  |
| 3-6 | 802.15.4-2015 | 19 | LRP UWB PHY | 6.2826 – 9.1856 GHz  |
| 3-7 | 802.15.4-2015 | 20 | SUN FSK PHY | 169, 450, 470, 863, 901, 915, 928, 1427, 2450 MHz |
| 3-8 | 802.15.4-2015 | 21 | SUN OFDM PHY | 470–510, 779–787, 863–870, 902–928, 917–923.5, 920–928, 2400–2483.5 MHz |
| 3-9 | 802.15.4-2015 | 22 | 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 |

# Selected non-802 market relevant standards operating in the same frequency bands as IEEE 802.11be

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

# Existing Licensed Services in the 6 GHz band

|  |  |  |
| --- | --- | --- |
| **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-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) is carrier sense multiple access with collision avoidance (CSMA/CA). 802.11be continues to use clear channel assessment (CCA) rules in the 2.4, 5, and 6 GHz bands.

The 802.11be CCA rules are described in 36.3.20.6 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

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 this 20 MHz subchannel is at or above -72 dBm
* A signal is present on the 20 MHz subchannel at or above a threshold of –62 dBm

In addition to the CCA rules, operation 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 AFC system.

# Coexistence analysis: non 802.11 systems

Section 3 standards 3-1 through 3-3, 3-5, 3-7 and 3-12 overlap with IEEE 802.11 and 802.11be 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 802.11be. No significant changes to coexistence are anticipated with 802.11be operation in the 2.4 GHz band.

Section 3 standards 3-4 and 3-6 and the amendment 3-13 overlap with planned IEEE 802.11be operation in the 6 GHz band. IEEE 802.11be is expected to operate in the band under new regulations [5]. The 3-4 and 3-6 and the 3-13 ultra-wideband (low power spectral density) systems operate beneath the noise floor of systems operating in the 6 GHz band and are generally required by regulation to accept all interferers. The Electronic Communications Committee (www.cept.org/ecc) has produced a report on sharing and compatibility between proposed radio local area networks 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 with the specifications identified in section 4 of this document.

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

1. Standard Power operation
	* Only allowed in U-NII-5 and 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 and the known location of licensed services in the area
2. Low Power Indoors operation
	* Allowed in full 6 GHz band
	* Only indoors at reduced power to avoid interference with licensed users

802.11be will implement the mechanisms needed to communicate the transmit power restrictions to the 802.11be devices.

# Mechanisms supporting Coexistence with legacy 802.11 systems

802.11be continues to use a common preamble, the non-HT short training field, non-HT long training field, and non-HT signal field as the initial fields in all new 802.11be PPDUs for coexistence with legacy 802.11 systems as 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 802.11be features which may affect coexistence

The following features introduced in 802.11be may affect 802.11be coverage area and transmitted RF energy in the operating environment:

* Uplink multi-user operation
* Spatial reuse
* New OFDM waveform design
* Preamble Puncturing
* Operation in 6 GHz band
* 320 MHz operation in 6 GHz band
* Multi-AP joint and coordinated operation
* SST operation

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

## Uplink Multi-User Operation

With uplink multi-user operation, multiple client devices will transmit simultaneously to the AP during an uplink transmission. With uplink OFDMA operating in 80 MHz, up to 37 STA (client) devices could be transmitting simultaneously. Furthermore, with uplink OFDMA, an individual client device could transmit on a resource unit as narrow as ~2 MHz, resulting in a potentially substantially higher power spectral density permissible within the regulatory limits of the regulatory domain.

With uplink MU-MIMO, up to 8 client devices could be transmitting simultaneously. The aggregate RF energy on the air during an uplink multi-user transmission will be the sum of all the client devices and could be much higher than in 802.11n/ac.

## Spatial Reuse

802.11ax first introduced the concept of spatial reuse (SR) to increase capacity in a dense environment by increasing frequency reuse between BSS’s. 802.11be largely inherits the mechanisms specified for 802.11ax. We refer to the 802.11ax Coexistence Assurance document [7] for further discussion.

The important aspect of SR with respect to coexistence is that with 802.11be SR techniques, there may be more simultaneous transmissions on the air, which may increase the overall interference level.

## New OFDM Waveform Design

802.11be uses the same OFDM parameters as 802.11ax for transmission of the data field of the 802.11be PPDUs. Compared to 802.11n and 802.11ac, the tone spacing is four times smaller. The transmit spectrum requirements up to 160 MHz are identical to 802.11ax.

## 320 MHz operation

802.11be 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 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

## Preamble Puncturing

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

Unlike 802.11ax, a 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 provide protection for other users in parts of the spectrum that are not used by the EHT transmission.

## Operation in the 6 GHz Band

Operation in the 6 GHz follows the rules that have been defined in 802.11ax.

# 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] Draft P802.11be D0.4

[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] Draft P802.11ax D8.0

[5] 6 GHz Unlicensed R&O/FNPRM, [https://docs.fcc.gov/public/attachments/FCC−20−51A1.pdf](https://docs.fcc.gov/public/attachments/FCC%E2%88%9220%E2%88%9251A1.pdf)

[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