IEEE P802.11
Wireless LANs

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| **802.11bd Specification Framework Document** |
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Abstract

This document provides the framework from which the draft TGbd amendment will be developed. The document provides an outline of each the functional blocks that will be a part of the final amendment. The document is intended to reflect the working consensus of the group on the broad outline for the draft specification. As such it is expected to begin with minimal detail reflecting agreement on specific techniques and highlighting areas on which agreement is still required. It may also begin with an incomplete feature list with additional features added as they are justified. The document will evolve over time until it includes sufficient detail on all the functional blocks and their inter-dependencies so that work can begin on the draft amendment itself.

#  Revision history

|  |  |  |
| --- | --- | --- |
| Revision | Date | Changes |
| 0 | March 13, 2019 | Initial draft (approved by TG motion at the March 2019 meeting [1]) |
| 1 | April 9, 2019 | Added motioned text approved at the March 2019 meeting to Section 3. [1] |
| 2 | June 10, 2019 | Added motioned text approved at the May 2019 meeting to Section 3. [2] |
| 3  | September 5, 2019 | Added motioned text approved at the July 2019 meeting to Section 3 and updated Figure 3‑1 and Figure 3‑2 accordingly. [3] |
| 4 | October 7, 2019 | Added motioned text approved at the September 2019 meeting to Sections 3 and 4. [4] |
| 5 | November 19, 2019 | Added motion text approved at the November 2019 meeting to Section 3. [5] |
| 6 | January 24, 2020 | Added motion text approved at the January 2020 meeting to Section 3. [6] |
| 7 | September 14, 2020 | Added motion text approved during teleconference on Aug 4th, 2020. [7] |
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# Definitions

# Abbreviations and acronyms

AIFS arbitration interframe space

A-MPDU aggregate MAC protocol data unit

A-MSDU aggregate MAC service data unit

BPSK binary phase shift keying

BW bandwidth

DCM dual carrier modulation

EIFS extended interframe space

GI guard interval

IFFT inverse Fast Fourier Transform

IFS interframe space

LDPC low-density parity check

L-LTF non-HT Long Training field

L-SIG non-HT Signal field

L-STF non-HT Short Training field

LTF long training field

MAC medium access control

MCS modulation and coding scheme

MLME MAC sublayer management entity

MPDU MAC protocol data unit

NAV network allocation vector

NGV next generaion V2X

NGV-SIG NGV Signal field

NSS number of spatial streams

OCB outside the context of a BSS

OFDM orthogonal frequency division multiplexing

PHY physical layer

PPDU PHY protocol data unit

QAM quadrature amplitude modulation

RL-SIG repeated L-SIG

RNGV-SIG repeated NGV-SIG

RTT round trip time

SAP service access point

STA station

# Operation in 5.9GHz band

## Physical layer

This section describes the functional blocks in the physical layer.

11bd supports the 10MHz bandwidth PPDUs.

11bd supports the 20MHz bandwidth PPDUs.

[ [1] Motion #3]

11bd PHY shall define only one PPDU format.

[ [3] Motion #23]

11bd *10MHz BW* PPDU format includes L-STF, L-LTF, and L-SIG fields as shown in Figure 3‑1;

* L-STF means short training field of 11p.
* L-LTF means long training field of 11p.

L-SIG means signal field of 11p.

[ [1] Motion #2]



Figure 3‑1 11bd *10MHz* *BW* PPDU format

[ [4] Motion #49]

In 20MHz bandwidth, L-STF, L-LTF, and L-SIG for 10MHz PPDU are duplicated as shown in the figure below *(Figure 3‑2).*

[ [1] Motion #4]



Figure 3‑2 *11bd 20MHz BW PPDU format*

 [ [4] Motion #49]

The preamble of 11bd PPDU shall include repeated LSIG *(RL-SIG)* symbol after L-SIG.

[ [3] Motion #24]

RL-SIG is modulated same as L-SIG.

[ [4] Motion #54]

11bd PPDU includes an NGV-Signal field to indicate the transmission information.

[ [2] Motion #9]

NGV-SIG is located right after the RL-SIG in 11bd PPDU.

[ [3] Motion #21]

The preamble of 11bd PPDU shall include repeated NGV-SIG *(RNGV-SIG)* after NGV-SIG.

[ [4] Motion #47]

The RNGV-SIG is configured identically to the NGV-SIG.

[ [4] Motion #48]

The NGV-SIG symbol shall be BCC encoded at rate, R = 1/2, be interleaved, be mapped to a BPSK constellation.

[ [4] Motion #46]

The NGV-SIG field carries information required to interpret 11bd PPDU. The NGV-SIG field is composed of 24 data bits.

The contents for 24 data bits are TBD.

[ [4] Motion #46]

NGV-SIG field shall include the following bits with bit order TBD

• BW: 1 bit

• MCS: 4 bits

• Nss: 1 bit

• Midamble periodicity: 2 bits

• LDPC Extra symbol: 1 bit

• LTF format: 1 bit

• Tail bits: 6 bits.

[ [5] Motion #65]

NGV-SIG field shall use 4-bit CRC.

[ [5] Motion #67]

NGV SIG includes 2 PHY version bits and 2 Reserved bits.

[ [6] Motion #79]

The 24-bit NGV SIG content table is defined as below.

|  |  |  |  |
| --- | --- | --- | --- |
| **Bit** | **Field** | **Number of bits** | **Description** |
| B0-B1 | PHY version  | 2 | Set 0 for 11bd, other three options are reserved for future generations. |
| B2 | Bandwidth | 1 | Set 0 for 10MHz, set 1 for 20MHz. |
| B3-B6 | MCS | 4 | MCS table |
| B7 | Nss | 1 | Set 0 for 1 ss, and set 1 for 2ss. |
| B8-B9 | Midamble Periodicity | 2 | Set 0 for 4 symbols, set 1 for 8 symbols, set 2 for 16 symbol. Value 3 is reserved.  |
| B10 | LTF format | 1 | Set 0 for uncompressed LTF; set 1 for compressed LTF. |
| B11 | LDPC Extra OFDM Symbol | 1 | Set to 1 if the LDPC PPDU encoding process results in an extra OFDM symbol as described in 21.3.10.5.4 (LDPC coding). Set to 0 otherwise. |
| B12-B13 | Reserved | 2 | Reserved and set to 1. |
| B14-B17 | CRC | 4 | CRC calculated as in 19.3.9.4.4 (CRC calculation for HTSIG). |
| B18-B23 | Tail | 6 | Used to terminate the trellis of the convolutional decoder. Set to 0. |

[ [6] Motion #80]

11bd defines the following MCS table.

|  |  |  |
| --- | --- | --- |
| **MCS index** | **Modulation** | **Code rate** |
| 0 | BPSK | 1/2 |
| 1 | QPSK | 1/2 |
| 2 | QPSK | 3/4 |
| 3 | 16QAM | 1/2 |
| 4 | 16QAM | 3/4 |
| 5 | 64QAM | 2/3 |
| 6 | 64QAM | 3/4 |
| 7 | 64QAM | 5/6 |
| 8 | 256QAM | 3/4 |
| 9 | 256QAM | 5/6 |
| 10 | BPSK with DCM | 1/2 |

[ [6] Motion #81]

The preamble of 11bd PPDU shall include NGV-STF and NGV-LTF after repeated NGV-SIG.

The composition of NGV-STF and NGV-LTF is TBD.

[ [4] Motion #49]

The NGV-STF in 11bd 10MHz PPDU shall use 11ac 20MHz VHT-STF with 2x downclock.

The NGV-LTF in 11bd 10MHz PPDU shall use 11ac 20MHz VHT-LTF with 2x downclock.

[ [4] Motion #50]

The NGV-STF in 11bd 20MHz PPDU shall use 11ac 40MHz VHT-STF with 2x downclock.

The NGV-LTF in 11bd 20MHz PPDU shall use 11ac 40MHz VHT-LTF with 2x downclock.

[ [4] Motion #51]

NGV PPDU modulated with BPSK and DCM shall power boost L-STF and L-LTF by 3dB.

[ [5] Motion #63]

NGV PPDU modulated with BPSK shall power boost L-STF and L-LTF by 3dB.

[ [5] Motion #64]

L-STF and L-LTF power boost and repeated NGV-LTF only apply to 11bd transmission using 10MHz bandwidth, one spatial stream and BPSK modulation.

[ [6] Motion #77]

NGV-LTF-1x only applies to 11bd transmissions with one spatial stream.

[ [6] Motion #78]

11bd shall support 2x Compressed NGV-LTF (NGV-LTF-2x).

[ [4] Motion #33]

For the 10MHz transmission, the NGV-LTF-1x sequence on subcarriers [-28:28] is given by following sequence

 NGV-LTF-1x(-28:2:28) = [1     1      -1     1     -1    -1     1     1     1    -1     1     1     1     1  0   -1     1    -1     -1     -1    -1     -1      1     -1     -1     -1     1     1     -1]

[ [5] Motion #56]

For the 20MHz transmission, the NGV-LTF-1x sequence on subcarriers [-58:58] is given by following sequence

NGV-LTF-1x(-58:2:58) = [1      -1     1   -1    -1     1      1      1     -1      1     1     1      1     1    -1     1    -1    -1    -1    -1    -1     1    -1    -1    -1     1     1    -1     1  0    1    -1    -1     1     -1    1     1     -1     -1     -1     1     -1    -1     -1    -1     -1     1     -1      1     1     1      1     1     -1     1     1     1    -1     -1]

[ [5] Motion #57]

The same number of pilot tones are used in NGV-LTF-1x, NGV-LTF-2x and data field.

* In 10MHz, 4 pilot tones shall be inserted.
* In 20MHz, 6 pilot tones shall be inserted.

The pilot tones use the even tone indices defined for data field.

* In 10MHz, the tone indices are [±8, ±22].
* In 20MHz, the tone indices are [±54, ±26, ±12].

[ [5] Motion #58]

NGV-LTF-2x, NGV-LTF-1x and Data symbols shall define the same pilot location.

[ [5] Motion #70]

NGV-SIG field shall include 1 bit to indicate NGV-LTF format.

* The first option is 2x compressed LTF.
* The second option is non-compressed LTF.

[ [4] Motion #34]

11bd shall use two bits in NGV-SIG to signal the Midamble periodicity.

[ [4] Motion #40]

In an 11bd PPDU, the RATE field shall be set to the value representing 3 Mb/s in the 10 MHz channel spacing column of Table 17-6 (Contents of the SIGNAL field).

[ [3] Motion #20]

11bd PPDU design shall support Midamble(s) in Data field.

Midamble is composed by long training field, with design TBD.

Midamble periodicity is TBD.

[ [2] Motion #10]

The number of midamble periods is *denoted* $N\_{MA}$ *and is determined according to*

$N\_{MA}=\left⌊\left.(N\_{SYM}-1)/M\right⌋\right.$ ,

where $N\_{SYM}$ is the number of data symbols *and* $M$ *is the midamble periodicity*.

[ [4] Motion #30]

~~11bd PPDU shall support at least two values of midamble periodicity.~~

*~~The values of~~* ~~midamble periodicity~~ *~~are~~* ~~TBD.~~

~~[ [4] Motion #31]~~

Only three Midamble periodicity are defined in 11bd. The fourth option is Reserved.

[ [6] Motion #76]

One of the midamble periodicity values is 4.

[ [4] Motion #41]

One of the midamble periodicity values is 8.

[ [5]Motion #59]

One of the midamble periodicity values is 16.

[ [5]Motion #60]

11bd PPDU shall support Midamble periodicity indication in number of OFDM symbols in the Data field.

[ [4] Motion #32]

Midamble is the same format as NGV-LTF.

[ [4] Motion #33]

The Midamble and NGV-LTF format of 11bd 10MHz PPDU shall use Repeated LTF or Repeated compressed LTF for NGV-Data modulated with BPSK.

[ [4] Motion #39]

NGV-LTF and Midamble field shall use repeated NGV-LTF-2x when NGV Data is modulated using BPSK-1/2 with DCM.

[ [5]Motion #68]

PPDUs with midambles shall be randomized in order to suppress discrete spectrum components. The midambles symbols shall be multiplied by pseudo-random values plus/minus one. The data symbols immediately following any given midamble shall be multiplied by the same pseudo-random value as said midamble. In the case of MIMO PPDUs, the same pseudo-random values shall be applied to both symbols of the midamble. The pseudo-random values are defined in (17-25) of IEEE 802.11-2016.

[ [7] Slide 17 - Motion #1]

Repeated NGV-LTF-2x is constructed by repeating the IFFT output of NGV-LTF-2x and pre-append one cyclic prefix of duration 1.6us.

[ [5]Motion #69]

11bd devices shall support 256 QAM. The 256 QAM constellation mapping is the same as that defined in 21.3.10.9 (Constellation mapping).

[ [2] Motion #11]

11bd amendment shall support LDPC.

[ [1] Motion #5]

11bd devices shall support LDPC codes, with the same code structure and coding methods as defined in 19.3.11.7 (LDPC Codes).

[ [2] Motion #12]

LDPC is the only coding scheme for the data portion of 11bd PPDU.

[ [6] Motion #75]

10MHz 11bd Data symbol shall use 11ac 20MHz OFDM numerology.

[ [2] Motion #13]

11bd 20MHz PPDU Data symbol shall use 11ac 40MHz OFDM downclock by 2.

[ [4] Motion #42]

[ [4] Motion #52]

11bd shall support the same subcarrier spacing in both 10MHz PPDU and 20MHz PPDU.

[ [2] Motion #8]

11bd only supports single spatial stream PPDU when operating on OCB broadcast mode.

[ [2] Motion #15]

11bd supports two spatial streams for unicast transmissions as an optional feature.

[ [3] Motion #26]

BPSK DCM modulation is used to achieve lower sensitivity. For a BPSK DCM modulated OFDM symbol, the subcarriers in the second frequency segment is modulated by the rotated version of the signal modulated on the corresponding DCM subcarrier in the first frequency segment.



Where *N*SDis defined for DCM which is half of$ N\_{SD}^{DCM=0}$.

[ [3] Motion #18]

11bd shall support adaptive repetition of 11p PPDU when operating on OCB broadcast mode in 10MHz bandwidth.

The signaling of the adaptive repetition is TBD.

The time between repeated 11p PPDUs is TBD.

[ [3] Motion #19]

$TXTIME=40+T\_{RL-SIG}+T\_{NGV-SIG}+T\_{RNGV-SIG}$+ $T\_{NGV-STF}$+ $N\_{SYM}×T\_{SYM}$

 + $8×\left⌈\frac{N\_{NGV-LTF}×T\_{NGV-LTF} + N\_{MA}×N\_{NGV-LTF}×T\_{NGV-LTF}}{8}\right⌉$

where,

|  |  |
| --- | --- |
| $$T\_{RL-SIG}$$ | Repeated non-HT SIGNAL field duration |
| $$T\_{NGV-SIG}$$ | NGV-SIG field duration |
| $$T\_{RNGV-SIG}$$ | Repeated NGV-SIG field duration |
| $$T\_{NGV-STF}$$ | NGV-STF field duration |
| $$T\_{NGV-LTF}$$ | NGV-LTF field duration |
| $$T\_{SYM}$$ | OFDM symbol duration including GI |
| $$N\_{SYM}$$ | The number of OFDM symbols in the data field  |
| $$N\_{NGV-LTF}$$ | The number of OFDM symbols in the NGV-LTF field  |

[ [6] Motion #82]

$L\\_LENGTH=\frac{TXTIME-40}{8}×3-$3

Where L\_LENGTH is the value indicated by the LENGTH field of the L-SIG field and RL-SIG field.

[ [6] Motion #83]

$$N\_{MA,RX}=\left⌊\frac{\frac{\left(L\\_LEGNTH+3\right)×8}{3} - T\_{NGV-PREAMBLE} - T\_{SYM}}{N\_{NGV-LTF}∙T\_{NGV-LTF}+ M∙T\_{SYM}}\right⌋$$

$where T\_{NGV-PREAMBLE}$ =

 $T\_{RL-SIG}+T\_{NGV-SIG}+T\_{RNGV-SIG}$+ $T\_{NGV-STF}$+ $N\_{NGV-LTF}×T\_{NGV-LTF}$

[ [6] Motion #84]

$$N\_{SYM,RX}=\left⌊\left(\frac{\left(L\\_LENGTH+3\right)×8}{3}-T\_{NGV-PREAMBLE}-N\_{MA,RX}∙NNGV-LTF ×TNGV-LTF\right)/T\_{SYM}\right⌋$$

[ [6] Motion #85]

$RXTIME=\left⌈\frac{\left(L\\_LENGTH+3\right)}{3}\right⌉×8$ + 40

[ [6] Motion #86]

The function τk, BW is used to represent a rotation of the tones.

For a 10 MHz PPDU transmission,

τk, BW=1

For a 20 MHz PPDU transmission,



Where BW is channel bandwidth and *k* is subcarrier indices.

[ [6] Motion #87]

NGV adds a new spectrum mask definition for 20 MHz Class C2

Table 1—Spectrum mask data for 11bd 20 MHz channel

|  |  |
| --- | --- |
|  | **Permitted power spectral density, dBr** |
| +/-9.5 MHz offset (+/-f1) | +/-10 MHz offset (+/-f2) | +/-10.5MHz offset (+/-f3) | +/-15MHz offset (+/-f4) | +/-25MHz offset (+/-f5) |
| Class C2 | 0 | -26 | -32 | -40 | -50 |

[ [5] Motion #66]

## MAC layer

This section describes the functional blocks in the MAC layer.

The MAC service interface (MAC\_SAP and MLME\_SAP) shall be extended to provide higher layers with the ability to control NGV transmissions and receive status regarding NGV receptions and the radio environment when operating with dot11OCBActivated = TRUE.

[ [5] Motion #55]

An 11bd STA shall indicate the NGV capability in MAC level, when transmitting an 11p PPDU.

[ [1] Motion #7]

For each frame carried in an 11bd PPDU, one MPDU Delimiter shall be used to indicate the length of the frame in octets.

[ [4] Motion #27]

11bd enables both A-MSDU and A-MPDU operation to work for unicast OCB and not to exceed the constraints on A-MSDU in A-MPDU as defined in 802.11ac.

[ [4] Motion #36]

An 11bd 20MHz channel includes two contiguous 10MHz channels.

20MHz channel access shall use sensing and backoff procedure for both of 10MHz channels.

20MHz channel access shall use only one backoff counter.

The two contiguous 10MHz channels shall use the same receive sensitivity level.

[ [4] Motion #43]

20MHz channel access performs a backoff procedure based on the channel states of two contiguous 10MHz channels.

* The backoff counter decreases when the two contiguous 10MHz channels are idle
	+ Idle states are checked by TBD sensing methods (e.g., Packet detection, GI detection, energy detection)
* More details are TBD.

[ [4] Motion #44]

When channel busy is indicated in the secondary channel and the duration of channel use is not known (e.g., NAV, packet detection), channel state shall be determined to be idle for a TBD IFS (e.g., AIFS, EIFS) sensing period before it resumes the backoff procedure.”

[ [4] Motion #45]

Within a 20MHz channel, one 10MHz channel is OCB primary 10MHz channel, another 10MHz channel is OCB secondary 10MHz channel.

The OCB primary 10MHz channel is decided by upper layer.

[ [6] Motion #88]

20 MHz channel consists of two contiguous 10 MHz channel:

* In one 10 MHz channel (denoted as OCB primary channel), the channel sensing with PD and ED with NAV setting method shall be applied.
* When the OCB primary channel is sensed as channel busy, the backoff procedure on the OCB primary channel shall be same as the backoff procedure of 10 MHz transmission

[ [6] Motion #71]

When OCB secondary channel is sensed busy and the duration of channel busy is not known, after the channel state transitions from busy to idle, EIFS interval shall be used to detect if the channel remains idle before resuming the backoff procedure.

When OCB secondary channel is sensed busy and the duration of channel busy is known, after the channel state transitions from busy to idle, AIFS interval shall be used to detect if the channel remains idle before resuming the backoff procedure.

Note: STA is not required to decode the duration of channel busy on the OCB secondary channel.

[ [6] Motion #72]

The decision of whether the STA is allowed to use 10 MHz fallback mechanism, as specified in the baseline 802.11 specification, is indicated by the upper layer.

[ [6] Motion #73]

For 20 MHz operation, the minimum CCA sensitivity on the secondary 10 MHz channel shall be -85 dBm for NGV and legacy 802.11p PPDUs, and shall be -65 dBm for any other signal.

[ [6] Motion #74]

## Positioning

This section describes the functional blocks that support positioning in conjuction with V2X communications.

11bd supports round-trip-time (RTT) ranging for 10 MHz and 20 MHz bandwidth PPDUs.

[ [3] Motion #17]

## Interoperability, coexistence and backward compatibility

This section describes the functional blocks that support interoperability, coexistence and backward compability with deployed OCB devices.

An 11bd STA shall be capable of the following operations:

* To decode 11p PPDUs with TBD receive sensitivity threshold (TBD value is -85dBm or lower).
* To transmit PPDU format up on request from upper layer, the PPDU format can be either 11p PPDU or 11bd PPDU.

[ [1] Motion #6]

When an 11bd STA transmits an 11p group-addressed or unicast PPDU, the Duration/ID field of a frame in an 11p PPDU indicates that transmitter of the PPDU is an NGV capable STA.

[ [2] Motion #16]

Operation of 11bd device with 10MHz bandwidth is allowed in a 20MHz channel.

[ [2] Motion #14]

# Operation in 60GHz band

## MAC layer

This section describes the functional blocks in the MAC layer.

11bd supports enabling DMG operation when dot11OCBActivated is true.

[ [4] Motion #29]

# References:

[1] IEEE 802.11-19/0237r4 TGbd March 2019 meeting agenda

[2] IEEE 802.11-19/0514r4 Motion Booklet for IEEE 802.11 TGbd (May 2019)

[3] IEEE 802.11-19/0514r6 Motion Booklet for IEEE 802.11 TGbd (July 2019)

[4] IEEE 802.11-19/0514r10 Motion Booklet for IEEE 802.11 TGbd (September 2019)

[5] IEEE 802.11-19/0514r12 Motion Booklet for IEEE 802.11 TGbd (November 2019)

[6] IEEE 802.11-19/0514r14 Motion Booklet for IEEE 802.11 TGbd (January 2020)

[7] IEEE 802.11-20/1164r7 IEEE 802.11 TGbd Teleconference Agenda for Aug 2020