IEEE P802.11
Wireless LANs

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| CR for Mathematical description of signals Part 2 |
| Date: 2019-01-11 |
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Abstract

This contribution proposes comment resolutions for Section 32.2.7 of the TGba Draft D1.1. The CIDs resolved are: 157, 158, 194, 212, 258, 259, 260, 263, 318, 566, 665, 977, 1061

Revisions:

* Rev 0: Initial version of this document
* Rev 1: Corrected the resolution of CID 665 by removing a cross-reference to another CID.

Interpretation of a Motion to Adopt

A motion to approve this submission means that the editing instructions and any changed or added material are actioned in the TGba D1.1 Draft. This introduction is not part of the adopted material.

***Editing instructions formatted like this are intended to be copied into the TGba D1.1 Draft (i.e. they are instructions to the 802.11 editor on how to merge the text with the baseline documents).***

***TGba Editor: Editing instructions preceded by “TGba Editor” are instructions to the TGba editor to modify existing material in the TGba draft. As a result of adopting the changes, the TGba editor will execute the instructions rather than copy them to the TGba Draft.***

# Comments on clause 32.2.7

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| **CID** | **Page** | **Clause** | **Comment** | **Proposed Change** | **Resolution** |
| 157 | 78,64 | 32.2.7 | "the baseband signal can be obtained by taking the Inverse Discrete Fourier Transform (IDFT)" is an incomplete sentence. | change to "the baseband signal can be obtained by taking the Inverse Discrete Fourier Transform (IDFT) of a set of subcarrier coefficients" | **REJECT** The resolution to CID 212 eliminates the offending text |
| 158 |  | 32.2.7 | It may be better to have a mathematical expression for FDMA WUR PPDU signal. | Add an expression | **REJECT** The comment fails to identify changes in sufficient detail so that the specific wording of the changes that will satisfy the commenter can be determined. |
| 194 | 79,60 | 32.2.7 | Unlike Table 32-5 and 32-6 which specifies the cyclic shift value for each n, the Table 32-7 seems to give an example of cyclic shift values for the 1st 7 syn symbols. May want to clarify it | as in the comment | **REVISED**Update the title of Table 32-7 to*Table 32-7 The states of the LFSR, the values of the bits b2, b1, b0, the value of* n*, and the pseudo-random cyclic shift with cyclic shift index* n, *for the first seven MC-OOK symbols in the Sync field*Also, add the following text in 32.2.3.4, at the end of P78L2 clarifying when is the LFSR first updated“The state of the LFSR is first updated at the end of the first MC-OOK symbol in the Sync field.” |
| 212 | 78,62 | 32.2.7 | It is clear from the document that MC-OOK is the modulation used to generate WUR signals. There are examples of how MC-OOK might be constructed, but the modulation is never properly defined. I think this is a major flaw that needs to be fixed. | Replace the text "For the WUR Sync ON symbols and WUR Data MC-OOK ON symbols (SymLDROn and SymHDROn),the baseband signal can be obtained by taking the Inverse Discrete Fourier Transform (IDFT) as described below." with "For the WUR Sync ON symbols and WUR Data MC-OOK ON symbols (SymLDROn and SymHDROn),the baseband signal shall be constructed as equation (32-2)." | **REVISED**Replace the indicated text by“For the WUR Sync ON symbols and WUR Data MC-OOK ON symbols (SymLDROn and SymHDROn),the baseband signal is defined to be an inverse discrete Fourier transform as specified in Equation (32-3)." |
| 258 | 78,10 | 32.2.7 | BPSK-Mark was defined as repeated L-SIG. As in 11ax, use "RL-SIG" instead of "BPSK-Mark". | Change "BPSK-Mark" to "RL-SIG" in Figure 32-10. | **REJECT** RL-SIG is not simply a repetition of the L-SIG |
| 259 | 78,31 | 32.2.7 | BPSK-Mark was defined as repeated L-SIG. As in 11ax, use "RL-SIG" instead of "BPSK-Mark". | Change "r\_BPSK-Mark" to "r\_RL-SIG".Change "t\_BPSK-Mark" to "t\_RL-SIG". | **REJECT** RL-SIG is not simply a repetition of the L-SIG |
| 260 | 78,42 | 32.2.7 | BPSK-Mark was defined as repeated L-SIG. As in 11ax, use "RL-SIG" instead of "BPSK-Mark". | Change "t\_BPSK-Mark" to "t\_RL-SIG".Change "T\_BPSK-Mark" to "T\_RL-SIG". | **REJECT** RL-SIG is not simply a repetition of the L-SIG |
| 263 | 80,46 | 32.2.7 | The baseband signal equation for the WUR Sync and WUR Data in a FDMA transmission is also needed. | Present the the baseband signal equation for the WUR Sync and WUR Data in a FDMA transmission. | **REJECT** The comment fails to identify changes in sufficient detail so that the specific wording of the changes that will satisfy the commenter can be determined. |
| 318 | 79,31 | 32.2.7 | I think "a suggested value" should be replaced with "a recommended value" or "an example of the value" | as in comment | **REVISED** Change "a suggested value is specified" to "example values are given" in page 83 of D1.1. |
| 566 | 77,64 | 32.2.7 | typo | replace "derived" by "obtained" | **ACCEPT** |
| 665 | 78,63 | 32.2.7 | The text reads: "For the WUR Sync ON symbols and WUR Data MC-OOK ON symbols (SymLDROn and SymHDROn), the baseband signal can be obtained". This text ought to be normative. As described in 11-09/1034 the usage of the verb "can" is non-normative and its use should be considered carefully. If this text is not normative, then the spec would be incomplete. The normative text in Section 32.2.9.2, page 84, line 11, states that "The encoded binary data shall be modulated using MC-OOK", but MC-OOK is undefined in the current version of this draft. | Change the text to: "For the WUR Sync ON symbols and WUR Data MC-OOK ON symbols (SymLDROn and SymHDROn), the baseband signal shall be as specified in Equation (32-2) " | **REVISED**Replace the indicated text by“For the WUR Sync ON symbols and WUR Data MC-OOK ON symbols (SymLDROn and SymHDROn),the baseband signal is defined to be an inverse discrete Fourier transform as specified in Equation (32-3)." |
| 977 | 80,05 | 32.2.7 | In Tables 32-5 and 32-6 we use negative values for cyclic shifts while in Annex AB we use positive values for cyclic shift values. Maybe we should harmonize on one approach. Also, it is possible the total CS to exceed the symbol duration when we combine both the random CS and the per-antenna CS. That may lead to some confusion. The mathematics is okay in 32-2 due to the nature of the exponential function, but this still may cause confusion. | Consider harmonizing the polarity of the CS values for the random CS and the per-antenna CS to either all positive or all negative values, and possibly add text to avoid confusion of the total CS exceeds the duration of the symbol (not counting the GI) | **REVISED**Update Annex AB to have negative values |
| 1061 | 79,48 | 32.2.7 | The Eq. (32-2) is provided for single 20 MHz WUR channel. The corresponding equation for FDMA case is missing. | As shown in the comment. | **REJECT** The comment fails to identify changes in sufficient detail so that the specific wording of the changes that will satisfy the commenter can be determined. |

**Discussion:** *None.*

**Propose:** Accepted for CID 566, revised for CID 194, 212, 318, 665, 977 per discussion and editing instructions in 11-19/0066r1.

***TGba editor: Change 32.2.3.4 Symbol Randomizer as follows: (Track change on)***

* Symbol Randomizer

The symbol randomizer is used to remove any spectral lines in the power spectral density.

The Symbol Randomizer, shown in Figure 32-9 (Symbol Randomizer), uses a linear feedback shift register (LFSR) with a generator polynomial  to generate a sequence of pseudo random bits. At the beginning of each PPDU, the LFSR is loaded with all ones.

One of the bits on the LFSR is converted to an integer *m*, with a value of either plus or minus one. A logical zero bit is converted to plus one and a logical one bit is converted to minus one. The input waveform is then multiplied by either plus or minus one, based on the logical bit.

Three of the bits from the LFSR are converted to an integer value between zero and seven, indicated by *n* in Figure 32-9 (Symbol Randomizer). In Figure 32-9 (Symbol Randomizer), b0 is the least significant bit (LSB) of the integer *n*, while b2 is the most significant bit of the integer *n*. This integer is used to lookup a cyclic shift value, from a table of cyclic shift values. A cyclic shift, corresponding to that value, is then applied to the waveform.

Then the per-antenna cyclic shift is applied to the waveform. Example values of such cyclic shift diversity are provided in Annex AB.

The symbol randomizer is used for both the WUR-Sync field and the WUR-Data field. The LFSR is updated every *TSync*

during the WUR-Sync field and updated every *TSym* during the WUR-Data field. The state of the LFSR is first updated at the end of the first MC-OOK symbol in the Sync field. (#194)

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| * Symbol Randomizer
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***TGba editor: Change 32.2.7 Mathematical description of signals as follows: (Track change on)***

* Mathematical description of signals

The transmitted signal is described in complex baseband signal notation. The actual transmitted signal on transmit chain , , is related to the complex baseband signal by the relation shown in Equation (32-1).

*

where

represents the real part of a complex variable

 is the center frequency

 is the baseband WUR signal on transmit chain

The transmitted RF signal is obtained (#566) by up-converting the complex baseband signal, which consists of
several fields. The timing boundaries for the various fields are shown in Figure 32-10 (Timing boundaries for the WUR PPDU Fields) where *NWUR-Sync* is the number of WUR-Sync symbols and is defined in Table 32-4 (Frequently used parameters).

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| * Timing boundaries for the WUR PPDU Fields
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The time offset, *tField*, determines the starting time of the corresponding field relative to the start of L-STF
(*t* = 0).

The baseband signal is constructed by the concatenation of several fields as shown in Figure 32-10 (Timing boundaries for the WUR PPDU Fields). It shall be as shown in Equation (32-2):(#664, #217)

*

The timing offset values for various fields are given below:

*tL-LTF* = *TL-STF*

*tL-SIG* = *tL-LTF* + *TL-LTF*

*tBSPK-Mark* = *tL-SIG* + *TL-SIG*

*tWUR-Sync* = *tBSPK-Mark* + *TBSPK-Mark*

*tData* = *tWUR-Sync* + *TWUR-Sync*

where *TField* is the duration of the field, *TWUR-Sync* is the duration of WUR-Sync field, *TWUR-Sync*=*TWUR-sync-LDR* if low data rate is used to transmit the WUR-Data field of a WUR PPDU, and *TWUR-Sync*=*TWUR-sync-HDR* if high data rate is used to transmit the WUR-Data field of a WUR PPDU. The duration of different fields of the WUR PPDU are provided in Table 32-3 (Timing-related constants(#565)).

For the legacy preamble fields (L-STF, L-LTF and L-SIG), the baseband signal is constructed as described in 21.3.7.4 (Transmitted signal). For the BPSK-Mark field, the baseband signal is constructed as described in 32.2.8.2 (Non-WUR portion of WUR PHY preamble).

For the WUR Sync ON symbols and WUR Data MC-OOK ON symbols (SymLDROn and SymHDROn), the baseband signal is defined to be an inverse discrete Fourier transform as specified in Equation (32-3) (#212)(#665).

*

where

 is the scaling factor to compensate for 50% duty cycle from On-Off Keying.(#1057)

 is the number of transmit chains as defined in Table 32-4 (Frequently used parameters).

 is a windowing function used to control spectral leakage. Refer to 17.3.2.5 (Mathematical conventions in the signal descriptions) for a discussion of windowing functions.(#1058)

The integer *m* is described in 32.2.3.4 (Symbol Randomizer).(#1210)

 is the subcarrier frequency spacing and is given in Table 32-3 (Timing-related constants(#565)).

 is the length of cyclic prefix. For 4 µs symbol (SymLDROn),  is equal to 0.8 µs, and for 2

µs symbol (SymHDROn and WUR Sync ON),  is equal to 0.4 µs.

 is the cyclic shift applied to the signal from transmit chain , and example values are given (#318) in Annex AB.

 is the pseudo-random cyclic shift with cyclic shift index *n* described in 32.2.3.4 (Symbol Randomizer). Its values are specified in Table 32-5 (Values of pseudo-random cyclic shift with cyclic shift index n for the WUR-Sync field and HDR WUR-Data field) and Table 32-6 (Values of pseudo-random cyclic shift with cyclic shift index n for the LDR WUR-Data field).(#1211)

, are the subcarrier coefficients, and  equals S-6,6(*k*) if  and 0 otherwise. S-6,6 is an implementation dependent sequence. Example sequences are described in Table AB-1 (Example Values for the Sequence S-6,6 used for the Construction of the 2 µs MC-OOK On symbol) and Table AB-2 (Example Values for the Sequence S-6,6 used for the Construction of the 4 µs MC-OOK On symbol).(#317, #163, #227, #261, #666, #1059)

 is a tone scaling factor. The value of this factor is 12 for LDR and 6 for HDR, respectively.(#228, #191, #262, #667, #1060)

NOTE—The expression in equation (32-3) is provided for a single 20 MHz WUR channel.

Table 32-5 (Values of pseudo-random cyclic shift with cyclic shift index n for the WUR-Sync field and HDR WUR-Data field) provides, for each value of the index *n*, the cyclic shift values, , for the WUR-Sync field and the HDR WUR-Data field.

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| * Values of pseudo-random cyclic shift with cyclic shift index n for the WUR-Sync field and HDR WUR-Data field
 |
| *n* |  (ns) |
| 0 | 0 |
| 1 | -200 |
| 2 | -400 |
| 3 | -600 |
| 4 | -800 |
| 5 | -1000 |
| 6 | -1200 |
| 7 | -1400 |

Table 32-6 (Values of pseudo-random cyclic shift with cyclic shift index n for the LDR WUR-Data field) provides, for each value of the index *n*, the cyclic shift values, , for the LDR WUR-Data field.

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| * Values of pseudo-random cyclic shift with cyclic shift index n for the LDR WUR-Data field
 |
| *n* |  (ns) |
| 0 | 0 |
| 1 | -400 |
| 2 | -800 |
| 3 | -1200 |
| 4 | -1600 |
| 5 | -2000 |
| 6 | -2400 |
| 7 | -2800 |

Table 32-7 (The values of the LFSR, bits b2, b1, b0, value of n, and pseudo-random cyclic shift with cyclic shift index n for the WUR-Sync field) provides the values of the LFSR, the three bits (b2, b1, b0), the index value *n*, and the time delay value for  for the first seven states of the LFSR.

|  |
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| * *The states of the LFSR, the values of the bits b2, b1, b0, the value of* n*, and the* pseudo-random cyclic shift with cyclic shift index n, *for the for the first seven MC-OOK symbols in the WUR-Sync field (#194)*
 |
| Time Step | LFSR X7...X1 | b2 b1 b0 | Index *n* |  (ns) |
| 1 | 1 1 1 1 1 1 1 | 1 1 1 | 7 | -1400 |
| 2 | 1 1 1 1 1 1 0 | 1 1 0 | 6 | -1200 |
| 3 | 1 1 1 1 1 0 0 | 1 0 0 | 4 | -800 |
| 4 | 1 1 1 1 0 0 0 | 0 0 0 | 0 | 0 |
| 5 | 1 1 1 0 0 0 0 | 0 0 0 | 0 | 0 |
| 6 | 1 1 0 0 0 0 1 | 0 0 1 | 1 | -200 |
| 7 | 1 0 0 0 0 1 1 | 0 1 1 | 3 | -600 |

***TGba editor: Change Annex AB as follows: (Track change on)***

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**Examples of WUR MC-OOK Symbol Design and CSD Design**

Subclauses 32.2.3.1 (WUR PPDU waveform generation for WUR-Sync field and high rate WUR-Data field), 32.2.3.2 (WUR PPDU waveform generation for low rate WUR-Data field), and 32.2.3.3 (WUR PPDU WUR-Data field waveform generation for the FDMA transmission) provides a description of how the MC-OOK 2 µs and 4 µs On and Off symbols can be constructed but does not provide the actual frequency domain sequences for those symbols. This annex provides example sequences for the construction of these symbols.

Table AB-1 (Example Values for the Sequence S-6,6 used for the Construction of the 2 µs MC-OOK On symbol) provides example sequences for the construction of the 2 µs MC-OOK On symbol.

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| * Example Values for the Sequence *S-6,6* used for the Construction of the 2 µs MC-OOK On symbol
 |
| Index | Sequence S-6,6 (#160, #1062) |
| Example 1 |  |
| Example 2 |  |
| Example 3 |  |
| NOTE - For Example 2, the scaling factor has been chosen so that the MC-OOK On symbol is normalized to have the same power as the other examples.(#160, #1062) |

Example 1 in Table AB-1 (Example Values for the Sequence S-6,6 used for the Construction of the 2 µs MC-OOK On symbol) has been evaluated under a number of channel conditions and has shown consistent good performance in both multipath fading and additive white Gaussian noise channels. This sequence also has the lowest PAPR among the BPSK MC-OOK On symbols for a single channel transmission.

Example 2 in Table AB-1 (Example Values for the Sequence S-6,6 used for the Construction of the 2 µs MC-OOK On symbol) has been designed to provide good performance in commonly found propagation conditions, including the additive white Gaussian noise channel. This MC-OOK On symbol has nearly constant envelope and power distributed over the full bandwidth. Therefore, it can be transmitted with an output power higher than during the legacy preamble.

Example 3 in Table AB-1 (Example Values for the Sequence S-6,6 used for the Construction of the 2 µs MC-OOK On symbol) has been found to provide good performance through exhaustive search among the OFDM symbols with BPSK modulation. This sequence is optimized for good tradeoff between multipath fading channel performance and PAPR.

Table AB-2 (Example Values for the Sequence S-6,6 used for the Construction of the 4 µs MC-OOK On symbol) provides example sequences for the construction of the 4 µs MC-OOK On symbol.

|  |
| --- |
| * Example Values for the Sequence *S-6,6* used for the Construction of the 4 µs MC-OOK On symbol
 |
|  Index | Sequence S-6,6(#160, #215,#278, #1064) |
| Example 1 |  |
| Example 2 |  |
| Example 3 |  |
| NOTE - For Example 2, the scaling factor has been chosen so that the MC-OOK On symbol is normalized to have the same power as the other examples.(#160, #1063) |

Example 1 in Table AB-2 (Example Values for the Sequence S-6,6 used for the Construction of the 4 µs MC-OOK On symbol) has been evaluated under a number of channel conditions and has shown consistent good performance in both multipath fading and additive white Gaussian noise channels. This sequence also has the lowest PAPR among the BPSK MC-OOK On symbols for a single channel transmission.

Example 2 in Table AB-2 (Example Values for the Sequence S-6,6 used for the Construction of the 4 µs MC-OOK On symbol) has been designed to provide good performance in commonly found propagation conditions, including the additive white Gaussian noise channel. This MC-OOK On symbol has nearly constant envelope and power distributed over the full bandwidth. Therefore, it can be transmitted with an output power higher than during the legacy preamble.

Example 3 in Table AB-2 (Example Values for the Sequence S-6,6 used for the Construction of the 4 µs MC-OOK On symbol) has been found to provide good performance through exhaustive search among the OFDM symbols with BPSK modulation. This sequence is optimized for good tradeoff between multipath fading channel performance and PAPR.

For the WUR-Sync field and the HDR WUR-Data field, which are both constructed from 2 µs MC-OOK symbols, Table AB-3 (Recommended CSD values for the WUR-Sync field and HDR WUR-Data field) provides recommended CSD values for up to eight transmit antennas, for each of the three recommended MC-OOK symbols from Table AB-1 (Example Values for the Sequence S-6,6 used for the Construction of the 2 µs MC-OOK On symbol).

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| * Recommended CSD values for the WUR-Sync field and HDR WUR-Data field (#977)
 |
| Example Sequence | Number of Transmit Antennas | CSD Values (ns) |
| Example 1 | 1 | [0] |
| 2 | [0, -600] |
| 3 | [0, -600, -1100] |
| 4 | [0, -600, -1100, -1350] |
| 5 | [0, -600, -1100, -1350, -350] |
| 6 | [0, -600, -1100, -1350, -350, -850] |
| 7 | [0, -600, -1100, -1350, -350, -850, -600] |
| 8 | [0, -600, -1100, -1350, -350, -850, -600, -1350] |
| Example 2 | 1 | [0] |
| 2 | [0, -100] |
| 3 | [0, -850, -100] |
| 4 | [0, -1100, -600, -100] |
| 5 | [0, -1200, -850, -450, -100] |
| 6 | [0, -1300, -1000, -700, -400, -100] |
| 7 | [0, -1350, -1100, -850, -600, -350, -100] |
| 8 | [0, -1400, -1150, -950, -750, -550, -300, -100] |
| Example 3 | 1 | [0] |
| 2 | [0, -100] |
| 3 | [0, -850, -100] |
| 4 | [0, -1100, -600, -100] |
| 5 | [0, -1200, -850, -450, -100] |
| 6 | [0, -1300, -1000, -700, -400, -100] |
| 7 | [0, -1350, -1100, -850, -600, -350, -100] |
| 8 | [0, -1400, -1150, -950, -750, -550, -300, -100] |

For the LDR WUR-Data field, which is constructed from 4 µs MC-OOK symbols, Table AB-4 (Recommended CSD values for the LDR WUR-Data field) provides recommended CSD values for up to eight transmit antennas, for each of the three recommended MC-OOK symbols from Table AB-2 (Example Values for the Sequence S-6,6 used for the Construction of the 4 µs MC-OOK On symbol).

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| * Recommended CSD values for the LDR WUR-Data field(#977)
 |
| Example Sequence | Number of Transmit Antennas | CSD Values (ns) |
| Example 1 | 1 | [0] |
| 2 | [0, -1200] |
| 3 | [0, -1200, -2200] |
| 4 | [0, -1200, -2200, -2700] |
| 5 | [0, -1200, -2200, -2700, -700] |
| 6 | [0, -1200, -2200, -2700, -700, -1700] |
| 7 | [0, -1200, -2200, -2700, -700, -1700, -1200] |
| 8 | [0, -1200, -2200, -2700, -700, -1700, -1200, -2700] |
| Example 2 | 1 | [0] |
| 2 | [0, -200] |
| 3 | [0, -1700, -200] |
| 4 | [0, -2200, -1200, -200] |
| 5 | [0, -2450, -1700, -950, -200] |
| 6 | [0, -2600, -2000, -1400, -800, -200] |
| 7 | [0, -2700, -2200, -1700, -1200, -700, -200] |
| 8 | [0, -2750, -2350, -1900, -1500, -1050, -650, -200] |
| Example 3 | 1 | [0] |
| 2 | [0, -200] |
| 3 | [0, -1700, -200] |
| 4 | [0, -2200, -1200, -200] |
| 5 | [0, -2450, -1700, -950, -200] |
| 6 | [0, -2600, -2000, -1400, -800, -200] |
| 7 | [0, -2700, -2200, -1700, -1200, -700, -200] |
| 8 | [0, -2750, -2350, -1900, -1500, -1050, -650, -200] |