### **IEEE P802.11Wireless LANs**

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| Comment Resolutions on MC-OOK On Symbols |
| Date: 2019-09-16 |
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**Abstract**

The document provides comment resolutions for CIDs: 3064, 3304, 3305 and 3383.

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| **CID** | **Clause** | **Page/Line** | **Comment** | **Proposed Change** | **Resolution** |
| 3064 | 30.3.4.1 | 139/139 | There is no requirement on tendency ON waveforms (in SYNC, HDR or LDR ON periods) to cause false preamble detections in 802.11a/n/g/ac/ax receivers. For example, Low Data Rate waveform Example 1 in Annex AC has a high 800ns autocorrelation peak. Autocorrelation is the prevalent method to detect OFDM waveforms. | Require that ON waveforms have autocorrelation metric of 0.5 or less. | **Revised**TGba Editor makes changes as shown in IEEE 802.11-19/1171r0 |
| 3304 | Annex AC | 180/18 | Recommended sequences for the 4us MC-OOK On Symbol are provided in Table AC-2. Recently it has been discovered that STAs operating in non-WUR mode will frequently falsely detect the LDR Data Field, constructed with any of these recommended sequences, as an L-STF causing the STA to think it has detected a non-WUR PPDU. This can have a negative impact on the STA operation. | I will prepare a presentation describing this issue in more detail and provide a recommended text change. | **Revised**TGba Editor makes changes as shown in IEEE 802.11-19/1171r0 |
| 3305 | Annex AC | 179/33 | Recommended sequences for the 4us MC-OOK On Symbol are provided in Table AC-2. Recently it has been discovered that STAs operating in non-WUR mode will frequently falsely detect the LDR Data Field, constructed with any of these recommended sequences, as an L-STF causing the STA to think it has detected a non-WUR PPDU. This can have a negative impact on the STA operation. | I will prepare a presentation describing this issue in more detail and provide a recommended text change. | **Revised**TGba Editor makes changes as shown in IEEE 802.11-19/1171r0 |
| 3383 | Annex AC | 179/15 | Receivers may false detect these WUR MC-OOK symbols as L-STF. | Update the WUR symbols to reduce false detection as L-STF. | **Revised**TGba Editor makes changes as shown in IEEE 802.11-19/1171r0 |

**Discussion**

In [1] we show that the narrowband portion of the WUR PPDU may falsely trigger the L-STF detector of STAs not operating in WUR mode. This was confirmed independently in [2].

We showed [1] that the MC-OOK On Symbols must be chosen so that the autocorrelation metric is sufficiently low to avoid this problem. We show that Examples 1 and 2 in Table AC-1, for 2 µs On Symbols, have low autocorrelation metric values while Example 3 does not. We also show that all three examples in Table AC, for 4 µs On Symbols, have high autocorrelation metric values. These high autocorrelation metric values cause high false alarm rates in the L-STF detector simulations.

Our proposal is to add a new transmitter specification based on the correlation metric to avoid false L-STF detection in a non-WUR receiver, due to an 802.11ba PPDU. We also propose to change some of the example MC-OOK symbols in Annex AC.

1. Steve Shellhammer, et. al., “False L-STF Detection Issue,” IEEE 802.11-19/1120r0, July 2019
2. Miguel Lopez and Leif Wilhelmsson, “Study of False L-STF Detections Triggered by MC-OOK,” IEEE 802.11-19/1178r0, July 2019

**Proposed Resolution**

TGba Editor make the following changes to Draft 3.1,

* WUR Basic PPDU waveform generation for WUR-Sync field and high data rate WUR-Data field

For the WUR-Data field, the sequence generation block generates the WUR encoded bits. For the WUR-Sync field, the sequence generation block outputs the WUR-Sync sequence.

For a single 20 MHz WUR channel, the 2 µs duration MC-OOK On symbol should be constructed by the On-WG using center 13 subcarriers of a 64-point IDFT, sampling at 20 MHz as follows:

* The six subcarriers with subcarrier indices *k* = (-6, -4, -2, 2, 4, 6) are used with non-zero input. Other subcarriers are null.
* The non-zero subcarriers are selected from any of the following constellations: BPSK, QPSK, 16-QAM, 64-QAM, and 256-QAM.
* The first 32 values of the 64-point IDFT output are selected.
* Those 32 values are processed by the Symbol Randomizer as described in 30.3.4.4 (Symbol Randomizer and Per-transmit chain Cyclic Shift).
* The last 8 samples of those 32 samples are prepended to the 32 samples generating 40 samples, representing the 2 µs duration MC-OOK On symbol. This step corresponds to the GI Insertion in Figure 30-6 (An example of an On-WG for the WUR-Sync and high data rate WUR-Data fields).

For a single 20 MHz WUR channel, the 2 µs duration MC-OOK Off symbol should be constructed by the Off-Waveform Generator (Off-WG) as zero for 2 µs.

With the 2 µs duration MC-OOK On and Off symbols shall meet the Correlation Test in Subclause 30.2.12.15

* WUR Basic PPDU waveform generation for low data rate WUR-Data field

For a single 20 MHz WUR channel the 4 µs duration MC-OOK On symbol should be constructed by the On-WG using center 13 subcarriers of a 64-point IDFT, sampling at 20 MHz as follows:

* The 12 subcarriers with subcarrier indices *k* = (-6, -5, … -1, 1, 2, … 6) are used with non-zero input. Other subcarriers are null.
* The non-zero subcarriers are selected from any of the following constellations: BPSK, QPSK, 16-QAM, 64-QAM, and 256-QAM.
* The 64 values from the 64-point IDFT are processed by the Symbol Randomizer as described in 30.3.4.4 (Symbol Randomizer and Per-transmit chain Cyclic Shift).
* The last 16 values of the 64-point IDFT output are prepended to the 64 samples generating 80 samples, representing the 4 µs duration MC-OOK On symbol. This step corresponds to the GI Insertion in Figure 30-7 (An example of an On-WG for the low data rate WUR-Data fields).

For a single 20 MHz WUR channel the 4 µs duration MC-OOK Off symbol should be constructed by the Off-Waveform Generator (Off-WG) as zero for 4 µs.

With the 2 µs duration MC-OOK On and Off symbols shall meet the Correlation Test in Subclause 30.2.12.15

TGba Editor, add a new section after subclause 30.3.12.4

**30.3.12.5 Correlation Test on MC-OOK Symbols**

We define an autocorrelation metric indicative of that used for L-STF detection in non-WUR receivers. The metric is given in Equation (30-XYZ),

 $C\left(n\right)= \left|\left(\frac{6}{5}\right)\frac{\sum\_{k=0}^{79}x\left(n+k\right)x^{\*}(n+k+16)}{\sum\_{k=0}^{95}\left|x\left(n+k\right)\right|^{2}}\right|$ (30-XYZ)

This metric is calculated over the WUR PPDU at a sampling rate of 20 MHz using the 2 µs and 4 µs MC-OOK symbols. The PPDU shall use the LDR with a 6-byte data field of random data. The maximum value of the correlation shall be less than 0.35.

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Examples of WUR MC-OOK Symbol Design and CSD Design

Subclauses 30.3.4.1 (WUR Basic PPDU waveform generation for WUR-Sync field and high data rate WUR-Data field), 30.3.4.2 (WUR Basic PPDU waveform generation for low data rate WUR-Data field), and 30.3.4.3 (WUR FDMA PPDU WUR-Data field waveform generation) provides a description of how the 2 µs duration MC-OOK and 4 µs duration MC-OOK 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 AC-1 (Example Values for the Sequence SHDR used for the Construction of the 2 µs duration MC-OOK On symbol) provides example sequences for the construction of the 2 µs duration MC-OOK On symbol.

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| * Example Values for the Sequence *SHDR* used for the Construction of the 2 µs duration MC-OOK On symbol
 |
| Index | Sequence *SHDR* |
| Example 1 |  |
| Example 2 |  |
|  |  |
| 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. |

Example 1 in Table AC-1 (Example Values for the Sequence SHDR used for the Construction of the 2 µs duration 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. This sequence has been shown to have low autocorrelation metric values to minimize false L-STF detection in STAs not operating in WUR mode.

Example 2 in Table AC-1 (Example Values for the Sequence SHDR used for the Construction of the 2 µs duration 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 L-STF, L-LTF and L-SIG. This sequence has been shown to have low autocorrelation metric values to minimize false L-STF detection in STAs not operating in WUR mode. (#2068, #2495)

Table AC-2 (Example Values for the Sequence SLDR used for the Construction of the 4 µs duration MC-OOK On symbol) provides example sequences for the construction of the 4 µs duration MC-OOK On symbol.

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| * Example Values for the Sequence *SLDR* used for the Construction of the 4 µs duration MC-OOK On symbol
 |
|  Index | Sequence *SLDR* |
| Example 1 | {-1, 1, 1, 1, -1, 1, 0, -1, -1, -1, 1, -1, -1} |
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Example 1 in Table AC-2 (Example Values for the Sequence SLDR used for the Construction of the 4 µs duration 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 has been shown to have low autocorrelation metric values to minimize false L-STF detection in STAs not operating in WUR mode.

For the WUR-Sync field and the HDR WUR-Data field, which are both constructed from 2 µs duration MC-OOK symbols, Table AC-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 AC-1 (Example Values for the Sequence SHDR used for the Construction of the 2 µs duration MC-OOK On symbol).

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| * Recommended CSD values for the WUR-Sync field and HDR WUR-Data field
 |
| Example Sequence | Number of Transmit Chains | 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] |
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For the LDR WUR-Data field, which is constructed from 4 µs duration MC-OOK symbols, Table AC-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 AC-2 (Example Values for the Sequence SLDR used for the Construction of the 4 µs duration MC-OOK On symbol).

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| * Recommended CSD values for the LDR WUR-Data field
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| Example Sequence | Number of Transmit Chains | 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] |
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(#3064, 3304, 3305 and 3383)