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Wireless LANs

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| PDT PHY Overview of the PPDU encoding process |
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# Revision information

The following is a summary of the important changes that occurred within each revision of this document:

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| **Revision** | **Major changes** |
| 0 | Initial revision |
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# Introduction

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 TGbn Draft. The abstract, revision information, introduction, explanation of the proposed changes, and references sections are not part of the adopted material.

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

# Text to be adopted begins here:

***TGbn editor: Please add the following subclauses for Overview of the PPDU encoding process to the 802.11bn draft D0.1:***

# 38.3.9 Overview of the PPDU encoding process

## 38.3.9.1 General

This subclause provides an overview of the UHR PPDU encoding process. A UHR ELR PPDU shall comply with transmit requirements as described in 38.3.19 (Transmit requirements for a UHR ELR PPDU). A UHR TB PPDU shall comply with the transmit requirements as described in 38.3.18 (Transmit requirements for PPDUs sent in response to a triggering frame).

## 38.3.9.2 Construction of L-STF

Construct the L-STF field as defined in 38.3.14.3 (L-STF) with the following highlights:

1. Determine the channel bandwidth from the TXVECTOR parameter CH\_BANDWIDTH.
2. Sequence generation: Generate the L-STF sequence over the channel bandwidth as described in 38.3.14.3 (L-STF). Apply a 3 dB power boost if transmitting a UHR ELR PPDU as described in 38.3.14.3 (L-STF).
3. Phase rotation: Apply appropriate phase rotation for each occupied 20 MHz subchannel as described in 38.3.13 (Mathematical description of signals) and 38.3.13.4 (Transmitted signal).
4. IDFT: Compute the inverse discrete Fourier transform.
5. CSD per chain: Apply CSD per chain for each transmit chain as described in 38.3.14.2.1 (Cyclic shift for pre-UHR modulated fields).
6. Insert GI and apply windowing: Prepend a GI ($T\_{GI,Pre-UHR}$) and apply windowing as described in 38.3.13 (Mathematical description of signals).
7. Analog and RF: Upconvert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 38.3.13 (Mathematical description of signals) and 38.3.14 (UHR preamble) for details.

## 38.3.9.3 Construction of L-LTF

Construct the L-LTF field as defined in 38.3.14.4 (L-LTF) with the following highlights:

1. Determine the channel bandwidth from the TXVECTOR parameter CH\_BANDWIDTH.
2. Sequence generation: Generate the L-LTF sequence over the channel bandwidth as described in 38.3.14.4 (L-LTF). Apply a 3 dB power boost if transmitting a UHR ELR PPDU as described in 38.3.14.4 (L-LTF).
3. Phase rotation: Apply appropriate phase rotation for each occupied 20 MHz subchannel as described in 38.3.13 (Mathematical description of signals) and 38.3.13.4 (Transmitted signal).
4. IDFT: Compute the inverse discrete Fourier transform.
5. CSD per chain: Apply CSD per chain for each transmit chain as described in 38.3.14.2.1 (Cyclic shift for pre-UHR modulated fields).
6. Insert GI and apply windowing: Prepend a GI ($T\_{GI,L-LTF}$) and apply windowing as described in 38.3.13 (Mathematical description of signals).
7. Analog and RF: Upconvert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the carrier frequency of the desired channel and transmit. Refer to 38.3.13 (Mathematical description of signals) and 38.3.14 (UHR preamble) for details.

## 38.3.9.4 Construction of L-SIG

Construct the L-SIG field as defined in 38.3.14.5 (L-SIG) with the following highlights:

1. Set the RATE subfield in the L-SIG field to 6 Mb/s. Set the LENGTH, Parity, and Tail fields in the L-SIG field as described in 38.3.14.5 (L-SIG).
2. BCC encoder: Encode the L-SIG field by a convolutional encoder at the rate of $R=1/2 $as described in 38.3.15.1.2 (BCC coding).
3. BCC interleaver: Interleave as described in 17.3.5.7 (Data interleavers).
4. Constellation Mapper: BPSK modulate as described in 36.3.13.7 (Constellation mapping).
5. Pilot insertion: Insert pilots as described in 38.3.14.5 (L-SIG).
6. Extra subcarrier insertion: Four extra subcarriers are inserted at $k\in \left\{-28, -27,27,28\right\}$ for channel estimation purpose and the values on these four extra subcarriers are $\left\{-1,-1,-1,1\right\}$, respectively.
7. Duplication and phase rotation: Duplicate the L-SIG field over each occupied 20 MHz subchannel of the channel bandwidth. Apply appropriate phase rotation for each occupied 20 MHz subchannel as described in 38.3.13 (Mathematical description of signals) and 38.3.13.4 (Transmitted signal).
8. IDFT: Compute the inverse discrete Fourier transform.
9. CSD per chain: Apply CSD per chain for each transmit chain as described in 38.3.14.2.1 (Cyclic shift for pre-UHR modulated fields).
10. Insert GI and apply windowing: Prepend a GI $\left(T\_{GI,Pre-UHR}\right)$ and apply windowing as described in 38.3.13 (Mathematical description of signals).
11. Analog and RF: Upconvert the resulting complex baseband waveform associated with each transmit chain. Refer to 38.3.13 (Mathematical description of signals) and 38.3.14 (UHR preamble) for details.

## 38.3.9.5 Construction of RL-SIG

Construct the RL-SIG field as defined in 38.3.14.6 (RL-SIG) with the following highlights:

1. Set the RATE subfield in the RL-SIG field to 6 Mb/s. Set the LENGTH, Parity, and Tail fields in the RL-SIG field as described in 38.3.14.6 (RL-SIG).
2. BCC encoder: Encode the RL-SIG field by a convolutional encoder at the rate of $R=1/2$ as described in 38.3.15.1.2 (BCC coding).
3. BCC interleaver: Interleave as described in 17.3.5.7 (Data interleavers).
4. Constellation Mapper: BPSK modulate as described in 36.3.13.7 (Constellation mapping).
5. Pilot insertion: Insert pilots as described in 38.3.14.6 (RL-SIG).
6. Extra subcarrier insertion: Four extra subcarriers are inserted at $k\in \left\{-28, -27,27,28\right\}$ for the purpose of channel estimation and the values on these four extra subcarriers are $\left\{-1,-1,-1,1\right\}$, respectively.
7. Duplication and phase rotation: Duplicate the RL-SIG field over each occupied 20 MHz subchannel of the channel bandwidth. Apply appropriate phase rotation for each occupied 20 MHz subchannel as described in 38.3.13 (Mathematical description of signals) and 38.3.13.4 (Transmitted signal).
8. IDFT: Compute the inverse discrete Fourier transform.
9. CSD per chain: Apply CSD per chain for each transmit chain as described in 38.3.14.2.1 (Cyclic shift for pre-UHR modulated fields).
10. Insert GI and apply windowing: Prepend a GI $\left(T\_{GI,Pre-UHR}\right)$ and apply windowing as described in 38.3.13 (Mathematical description of signals).
11. Analog and RF: Upconvert the resulting complex baseband waveform associated with each transmit chain. Refer to 38.3.13 (Mathematical description of signals) and 38.3.14 (UHR preamble) for details.

## 38.3.9.6 Construction of U-SIG

Construct the U-SIG field as defined in 38.3.14.7 (U-SIG) with the following highlights:

Steps a) to f) apply for each frequency subblock:

1. Obtain the U-SIG field values from the TXVECTOR. Set the values of the Disregard and Validate fields as defined in Table 38-xx (U-SIG field of an UHR MU PPDU) in case of UHR MU PPDU. Append the calculated CRC and then append the $N\_{tail}$ tail bits as described in 38.3.14.7 (U-SIG). This results in 52 uncoded bits.

NOTE 1—The values of the Disregard and Validate fields in an UHR TB PPDU is specified in the TXVECTOR.

1. BCC encoder: Encode the data by a convolutional encoder at the rate of as described in 17.3.5.6 (Convolutional encoder).
2. BCC interleaver: Interleave as described in 27.3.12.8 (BCC interleavers) for HE-SIG-A/HE-SIG-B.
3. Constellation mapper: BPSK modulate the first 52 interleaved bits as described in 17.3.5.8 (Subcarrier modulation mapping) to form the first OFDM symbol of U-SIG field. BPSK modulate the second 52 interleaved bits to form the second OFDM symbol of U-SIG field.
4. Pilot insertion: Insert pilots as described in 38.3.14.9.7 (Encoding and modulation).
5. Duplicate: Duplicate the U-SIG OFDM symbols over each occupied 20 MHz subchannel of the frequency subblock.

NOTE 2—20, 40, and 80 MHz UHR PPDUs have one 20, 40, and 80 MHz frequency subblock, respectively. 160 and 320 MHz UHR PPDUs have two and four 80 MHz frequency subblocks, respectively.

NOTE 3—U-SIG field content might vary between 80 MHz frequency subblocks in a 160 or 320 MHz UHR MU PPDU with the PPDU Type And Compression Mode field equal to 0 and the UL/DL field equal to 0 in the U-SIG field (DL OFDMA). For all other cases, U-SIG field content is the same for all frequency subblocks. See 38.3.14.7 (U-SIG).

1. Phase rotation: Apply the appropriate phase rotation for each occupied 20 MHz subchannel as described in 38.3.13 (Mathematical description of signals) and 36.3.13.4 (Transmitted signal).
2. IDFT: Compute the inverse discrete Fourier transform.
3. CSD per chain: Apply CSD per chain for each transmit chain as described in 38.3.14.2.1 (Cyclic shift for pre-UHR modulated fields).
4. Insert GI and apply windowing: Prepend a GI $\left(T\_{GI,Pre-UHR}\right)$ and apply windowing as described in 38.3.13 (Mathematical description of signals).
5. Analog and RF: Upconvert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 38.3.13 (Mathematical description of signals) and 38.3.14 (UHR preamble) for details.

## 38.3.9.7 Construction of UHR ELR-MARK

The ELR-MARK field consists of two OFDM symbols. Construct the ELR-MARK field as defined in 38.3.14.8 (ELR-MARK field) with the following highlights:

1. Determine the BSS color from the TXVECTOR parameter BSS\_COLOR.
2. Sequence generation: Generate the ELR-MARK sequence corresponding to the chosen BSS color as described in 38.3.14.8 (ELR-MARK field). Assign the first 48 elements of the sequence to the first OFDM symbol of the ELR-MARK field, and the remaining 48 elements of the sequence to the second OFDM symbol of the ELR-MARK field.

Steps below apply for each OFDM symbol of the ELR-MARK field:

1. Constellation mapper: QBPSK modulate the 48 elements and map them onto the 48 data tones of the OFDM symbol as described in 38.3.14.8 (ELR-MARK field).
2. Pilot insertion: Insert pilots as described in 38.3.14.8 (ELR-MARK field).
3. IDFT: Compute the inverse discrete Fourier transform.
4. CSD per chain: Apply CSD per chain for each transmit chain as described in 38.3.14.2.1 (Cyclic shift for pre-UHR modulated fields).
5. Insert GI and apply windowing: Prepend a GI ($T\_{GI,Pre-UHR}$) and apply windowing as described in 38.3.13 (Mathematical description of signals).
6. Analog and RF: Upconvert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the carrier frequency of the desired channel and transmit. Refer to 38.3.13 (Mathematical description of signals) and 38.3.14 (UHR preamble) for details.

## 38.3.9.8 Construction of UHR-SIG

For an UHR MU PPDU, construct the UHR-SIG field as defined in 38.3.14.9 (UHR-SIG) with the following highlights:

1. Obtain the UHR-SIG subfield values from the TXVECTOR. Add the Disregard fields. For each encoding block, append the calculated CRC and then append the tail bits as shown in 38.3.14.9 (UHR-SIG). Append padding bits if needed.
2. BCC encoder: Encode each code block by a convolutional encoder as described in 27.3.12.5.1 (BCC coding and puncturing).
3. BCC interleaver: Interleave as described in 27.3.12.8 (BCC interleavers) for HE-SIG-A/HE-SIG-B.
4. Constellation mapper: Obtain MCS\_UHR\_SIG from the TXVECTOR and use it to modulate the interleaved bits as described in 38.3.15.4 (Constellation mapping) to form the UHR-SIG OFDM symbols.
5. Pilot insertion: Insert pilots as described in 38.3.14.9.7 (Encoding and modulation).
6. Duplicate and phase rotation: Duplicate UHR-SIG OFDM symbols as described in 38.3.14.9.7 (Encoding and modulation). Apply the appropriate phase rotation for each occupied 20 MHz subchannel as described in 38.3.13 (Mathematical description of signals) and 38.3.13.4 (Transmitted signal).
7. IDFT: Compute the inverse Fourier transform.
8. CSD per chain: Apply CSD per chain for each transmit chain as described in 38.3.14.2.1 (Cyclic shift for pre-UHR modulated fields).
9. Insert GI and apply windowing: Prepend a GI ($T\_{GI,Pre-UHR}$) and apply windowing as described in 38.3.13 (Mathematical description of signals).
10. Analog and RF: Upconvert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 38.3.13 (Mathematical description of signals) and 38.3.14 (UHR preamble) for details.

## 38.3.9.9 Construction of UHR-STF

Construct the UHR-STF field as defined in 38.3.14.10 (UHR-STF) with the following highlights:

1. Sequence generation: Generate the UHR-STF in the frequency domain over the bandwidth indicated by the TXVECTOR parameter CH\_BANDWIDTH as described in 38.3.14.10 (UHR-STF). Apply a 3 dB power boost if transmitting a UHR ELR PPDU as described in 38.3.14.10.4 (UHR-STF for ELR PPDU).
2. CSD: Apply CSD for each spatial stream as described in 38.3.14.2.2 (Cyclic shift for UHR modulated fields).
3. Spatial mapping: Apply the Q matrix as described in 38.3.14.10 (UHR-STF).
4. IDFT: Compute the inverse discrete Fourier transform.
5. Insert GI and apply windowing: Prepend a GI of 0.8 μs for UHR MU PPDU and UHR ELR PPDU, and 1.6us for UHR TB PPDU, respectively. Apply windowing as described in 38.3.13 (Mathematical description of signals).
6. Analog and RF: Upconvert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 38.3.13 (Mathematical description of signals) and 38.3.14 (UHR preamble) for details.

## 38.3.9.10 Construction of UHR-LTF

Construct the UHR-LTF field as defined in 38.3.14.11 (UHR-LTF) with the following highlights:

1. Sequence generation: Generate the UHR-LTF sequence in frequency domain over the bandwidth indicated by CH\_BANDWIDTH as described in 38.3.14.11 (UHR-LTF). For a UHR ELR PPDU, 2x UHR-LTF is used. Apply a 3 dB power boost if transmitting a UHR ELR PPDU as described in 38.3.14.11 (UHR-LTF).
2. $A\_{UHR-LTF}$ matrix mapping: Apply the $P\_{UHR-LTF}$ matrix to the data tones of the UHR-LTF sequence and apply the $R\_{UHR-LTF}$ matrix to pilot subcarriers of the UHR-LTF sequence except for a UL MU-MIMO transmission using 1×UHR-LTF as described in 38.3.14.11 (UHR-LTF).
3. CSD: Apply CSD for each spatial stream as described in 38.3.14.2.2 (Cyclic shift for UHR modulated fields).
4. Spatial mapping: Apply the *Q* matrix as described in 38.3.14.11 (UHR-LTF).
5. IDFT: Compute the inverse discrete Fourier transform.
6. Insert GI and apply windowing: Prepend a GI indicated by the TXVECTOR parameter GI\_TYPE and apply windowing as described in 38.3.13 (Mathematical description of signals).
7. Analog and RF: Upconvert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 38.3.13 (Mathematical description of signals) and 38.3.14 (UHR preamble) for details.

## 38.3.9.11 Construction of ELR-SIG

The ELR-SIG field consists of two subfields, ELR-SIG-1 and ELR-SIG-2, as defined in 38.3.14.12 (ELR-SIG). Construct the ELR-SIG field as defined in 38.3.14.12 (ELR-SIG) with the following highlights:

1. Obtain the ELR-SIG field values from the TXVECTOR.

Steps below apply to each subfield of the ELR-SIG field:

1. Append the calculated 4 CRC bits and then append the 6 tail bits as described in 38.3.14.12 (ELR-SIG). This results in 24 uncoded bits.
2. BCC encoder: Encode the data by a convolutional encoder at the rate of $R=1/2$ as described in 17.3.5.6 (Convolutional encoder).
3. BCC interleaver: Interleave as described in 27.3.12.8 (BCC interleavers) for 52-tone RRU.
4. Constellation mapper: BPSK modulate the 48 interleaved bits and map them onto the 52-tone RRU 1 of a UHR ELR PPDU as described in 38.3.14.12 (ELR-SIG).
5. Pilot insertion: Insert pilots as described in 38.3.15.7 (Pilot subcarriers) for UHR ELR PPDU.
6. Frequency domain duplication: For a UHR ELR PPDU, steps d)-f) are done for the 52-tone RRU 1, and then the 52-tone RRU 1 is duplicated to the 52-tone RRU 2, 52-tone RRU 3 and 52-tone RRU 4 as described in 38.3.14.12 (ELR-SIG). Apply PAPR reduction mask on data tones, as described in 38.3.14.12 (ELR-SIG).
7. CSD: Apply CSD for each spatial stream as described in 38.3.14.2.2 (Cyclic shift for UHR modulated fields).
8. Spatial mapping: Apply the *Q* matrix as described in 38.3.15.8 (OFDM modulation).
9. IDFT: Compute the inverse discrete Fourier transform.
10. Insert GI and apply windowing: Prepend a GI of 1.6 μs and apply windowing as described in 38.3.13 (Mathematical description of signals).
11. Analog and RF: Upconvert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 38.3.13 (Mathematical description of signals) and 38.3.14 (UHR preamble) for details.

## 38.3.9.12 Construction of Data field in a UHR PPDU

## 38.3.9.12.1 non-ELR PPDU

Construct the UHR non-ELR-Data field as defined in 38.3.15 (Data field) with the following highlights:

For each user,

1. Construct the SERVICE field as described in 38.x (SERVICE field) and append the PSDU to the SERVICE field.
2. Pre-FEC padding: Append the pre-FEC padding bits as described in 38.3.15 (Data field). If the user is using BCC, then add tail bits.
3. Scrambler: Scramble the pre-FEC padded data as described in 38.x (UHR PHY DATA scrambler and descrambler).
4. Encoder: If the user is using BCC, then BCC encode as described in 38.3.15.1.2 (BCC coding). If the user is using LDPC, then LDPC encode as described in 38.x (LDPC coding).
5. Post-FEC padding: Append the post-FEC padded bits as described in 38.3.15 (Data field) and the PE field as described in 38.3.16 (Packet extension).
6. Stream parser: Rearrange the output of encoder into blocks as described in 38.3.15.2 (Stream parser).
7. Segment parser: In a 2×996-tone RU, 4×996-tone RU, 996+484-tone MRU, 996+484+242-tone MRU, 2×996+484-tone MRU, 3×996-tone MRU, or 3×996+484-tone MRU using UHR-MCS 0 to 13 or 15, divide each spatial stream output from the stream parser into multiple frequency subblocks as described in 38.3.15.3 (Segment parser). This block is bypassed for RU(s) or MRU(s) of other sizes when using UHR-MCS 0 to 13 or 15. In a 320 MHz UHR MU PPDU using UHR-MCS 14, the output of the stream parser is divided into two 80 MHz frequency subblocks as described in 38.3.15.3 (Segment parser). Segment parser is bypassed in an 80 MHz or 160 MHz UHR MU PPDU using UHR-MCS 14.
8. BCC interleaver: If the user is using BCC, interleave as described in 38.3.15.3 (BCC interleavers). This block is bypassed if the user is using LDPC.
9. Constellation mapper: Map to BPSK, BPSK-DCM, QPSK, 16-QAM, 64-QAM, 256-QAM, 1024- QAM, or 4096-QAM constellation points as described in 38.x (Constellation mapping).
10. LDPC tone mapper: If the user is using LDPC, the LDPC tone mapping is performed on all LDPC encoded streams as described in 38.x (LDPC tone mapper). This block is bypassed if the user is using BCC.
11. Segment deparser: In a 2×996-tone RU, 4×996-tone RU, 996+484-tone MRU, 996+484+242-tone MRU, 2×996+484-tone MRU, 3×996-tone MRU, or 3×996+484-tone MRU using UHR-MCS 0 to 13 or 15, merge the multiple 80 MHz frequency subblocks into one frequency segment as described in 38.x (Segment deparser). This block is bypassed for RU(s) or MRU(s) of other sizes when using UHR-MCS 0 to 13 or 15. In a 320 MHz UHR MU PPDU using UHR-MCS 14, merge the two 80 MHz frequency subblocks into one frequency segment as described in 38.x (Segment deparser). Segment deparser is bypassed in an 80 MHz or 160 MHz UHR MU PPDU using UHR-MCS 14.
12. Frequency domain duplication: For an UHR SU transmission using UHR-MCS 14, perform frequency domain duplication as described in 36.3.13.10 (Frequency domain duplication).
13. Pilot insertion: Insert pilots following the steps described in 38.x (Pilot subcarriers).
14. CSD: Apply CSD for each spatial stream as described in 38.3.14.2.2 (Cyclic shift for UHR modulated fields).

After steps a) to n) performed for all users in the PPDU,

1. Spatial mapping: Apply the *Q* matrix as described in 38.3.15.8 (OFDM modulation). Signal from all users in each RU is combined in this block.
2. IDFT: Compute the inverse discrete Fourier transform.
3. Insert GI and apply windowing: Prepend a GI determined by the TXVECTOR parameter GI\_TYPE and apply windowing as described in 38.3.13 (Mathematical description of signals).
4. Analog and RF: Upconvert the resulting complex baseband waveform with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 38.3.13 (Mathematical description of signals) for details.

### 38.3.9.12.2 ELR PPDU

Construct the UHR ELR-Data field as defined in 38.3.15 (Data field) with the following highlights:

1. Construct the SERVICE field as described in 38.x (SERVICE field) and append the PSDU to the SERVICE field.
2. Pre-FEC padding: Append the pre-FEC padding bits as described in 38.3.15 (Data field). If the user is using BCC, then add tail bits.
3. Scrambler: Scramble the pre-FEC padded data as described in 38.x (UHR PHY DATA scrambler and descrambler).
4. Encoder: If the user is using BCC, then BCC encode as described in 38.3.15.1.2 (BCC coding). If the user is using LDPC, then LDPC encode as described in 38.x (LDPC coding).
5. BCC interleaver: If the user is using BCC, interleave as described in 27.3.12.8 (BCC interleavers) for 52-tone RRU. This block is bypassed if the user is using LDPC.
6. Constellation mapper: Map to BPSK or QPSK constellation points as described in 38.x (Constellation mapping). These constellation points are then mapped onto the 52-tone RRU 1 of a UHR ELR PPDU as described in 38.x (Data field).
7. LDPC tone mapper: If the user is using LDPC, the LDPC tone mapping is performed on all LDPC encoded streams on the 52-tone RRU 1 of the UHR ELR PPDU with $D\_{TM}$ corresponding to 52-tone RRU with no DCM as described in 38.x (LDPC tone mapper). This block is bypassed if the user is using BCC.
8. Frequency domain duplication: For a UHR ELR PPDU, steps e) to g) are done for the 52-tone RRU 1, and then the 52-tone RRU 1 is duplicated to the 52-tone RRU 2, 52-tone RU 3 and 52-tone RRU 4 as described in 38.3.15.6 (Frequency domain doplication). Apply PAPR reduction mask on data tones, as described in 38.3.15.6 (Frequency domain doplication).
9. Pilot insertion: Insert pilots as described in 38.3.15.7 (Pilot subcarriers) for UHR ELR PPDU.
10. CSD: Apply CSD for each spatial stream as described in 38.3.14.2.2 (Cyclic shift for UHR modulated fields).
11. Spatial mapping: Apply the *Q* matrix as described in 38.3.15.8 (OFDM modulation).
12. IDFT: Compute the inverse discrete Fourier transform.
13. Insert GI and apply windowing: Prepend a GI of 1.6 μs and apply windowing as described in 38.3.13 (Mathematical description of signals).
14. Analog and RF: Upconvert the resulting complex baseband waveform with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 38.3.13 (Mathematical description of signals) for details.

# Text to be adopted ends here.

**References:**

1. 11-24-0171r21: 11-24-0171-21-00bn-tgbn-motions-list-part-1, Alfred Asterjadhi (Qualcomm Inc.)