IEEE P802.11
Wireless LANs

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| D1.0 Comment Resolution –Clause 22.3.4 |
| Date: Sep. 19 2011 |
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Abstract

This document provides resolutions for CIDs 2985, 2215, 2375, 2384, 2376, 2377, 2216, 2217, 2378, 2692, 3678, 2383, 2386, 2387, 2389.

**Comments on pilot insertion**

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| **CID** | **Page** | **Clause** | **Comment** | **Proposed Change** | **Resolution** |
| 2985 | 119.44 | 22.3.4 | The operation of pilot insertion is described in a mess. In 22.3.4.3 and 22.3.4.4, the operation of pilot insertion is included in IDFT. In 22.3.4.6, the meaning of pilot insertion is extended to "pilot insertion + phase rotation." In 22.3.4.7, pilot insertion is combined with P\_VHTLTF matrix mapping. In 22.3.4.8.1, the operation of pilot insertion is included in CSD. In 22.3.4.8.2, there is no operation of pilot insertion. | Suggest to describe pilot insertion as an individual operation in the mentioned subclauses. | AGREE in PRINCIPLE. See in 11/1282r0 |
| 2216 | 125.12 | 22.3.4.4 | Insertion of pilots is treated as part of IDFT. Note that throughout the subsections of 22.3.4, pilot insertion is treated in different ways. In 22.3.4.7 is is listed as a separate step. In 22.3.4.8.1 it is treated under CSD, in 22.3.4.8.2 it is not mentioned at all. | Find a consistent way to describe the insertion of pilots. | AGREE in PRINCIPLE. See in 11/1282r0 |
| 2386 | 127.63 | 22.3.4.8.2 | LDPC does not need pilots - great stuff | Maybe worth double-checking, and adding pilots if required? | COUNTER. See in 11/1282r0 |
| 2389 | 128.23 | 22.3.4.9.2 | The pilot insertion is more complicated for MU than is stated | Need to back up one step and refer to per-user sequential pilot insertion. Ditto LDPC in 22.3.4.9.3 | DISGREE. See in 11/1282r0 |

<Discussion>

It seems better to describe the pilot insertion in this clause in a consistent way by describing it as an individual operation as commenters pointed out.

Regardless of codec type between BCC and LDPC, the pilot insertion is always used for phase tracking et al. As seen in clause 22.3.10.9.2 (LDPC tone mapping), even in the use of LDPC tone mapping, it is only applied to *NSD* subcarrier, in which pilot subcarrier are not included. FYI, *NST = NSD + NSP* in Table 22-4.

As seen in clause 22.3.10.10 (Pilot Subcarriers) and Table 22-82 (transmission in VHT format), pilot values are not a function of each user.

**Comments on guard interval**

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| **CID** | **Page** | **Clause** | **Comment** | **Proposed Change** | **Resolution** |
| 2215 | 124.22 | 22.3.4.2 | There is no 800 ns GI for L-STF or L-LTF |  | DISAGREE See in 11/1282r2 |
| 2376 | 124.50 | 22.3.4.2 | The magic number 800 ns is used throughout clause 22. Replace throughout by "LONG GI" as per TX/RXVECTOR or "T\_GI" as per table 22-4. Relabel T\_GI in Table 22-4 "guard interval duration" to "long guard interval duration" Also, regular GI (P198L36) => LONG\_GI/T\_GI | As in comment | AGREE in PRINCIPLE. See in 11/1282r0 |
| 2217 | 125.39 | 22.3.4.5 | There should be no GI insertion for VHT-STF |  | DISGREE. See in 11/1282r2 |
| 2387 | 128.04 | 22.3.4.8.2 | The magic number 400 ns is used here, and 22.3.4.9.4; search for 400 elsewhere (e.g. 22.5). Replace by "SHORT GI" as per TX/RXVECTOR or "T\_SGI" as per table 22-4.  | As in comment | AGREE in PRINCIPLE. See in 11/1282r0 |

<Discussion>

Accurately speaking, Guard interval is not defined for L-STF and VHT-STF as seen in Eq. (22-16) and Eq. (22-28), respectively. Guard interval is defined as TGI2 (1.6us) for L-LTF because clause 20 explains the guard interval insertion as one-shot prepending for the entire 8us-long L-LTF. Guard interval is defined as TGI for VHT-LTF because its waveform is described per each 4us-long symbol.

Even though *T\_GI* is not introduced in the corresponding equation of L-STF and VHT-STF, prepending of guard interval is actually done for L-STF and VHT-STF as well to get totally 8us L-STF and 4us VHTSTF. . The only reason not to include *T\_GI* in those equations is that the equation will be the same thing regardless of whether *T\_GI* is inserted or not in it due to the STF periodic characteristics. Slightly different from the equation things, this clause 22.3.4 talks about encoding process description. So, guard interval is needed to be included in this clause not to give any ambiguity. FYI, STF is created from frequency domain, i.e. IDFT is applied (it is 64 point IDFT), therefore it actually needs inserting GI to get totally 8us L-STF and 4us VHTSTF.

Instead of 800ns or 400ns, I introduced LONG\_GI or SHORT\_GI already defined in clause 22.2.2 (TXVECTOR/RXVECTOR) rather than *T\_GI* or *T\_SGI* because Table 22-4 comes later in the draft.

Comments on subband things

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| **CID** | **Page** | **Clause** | **Comment** | **Proposed Change** | **Resolution** |
| 2384 | 124.46 | 22.3.4.2 | "appropriate phase rotation for each 20 MHz sub-band" is vague | Add reference as per 22.3.4.2; here and in each other subclause in 22.3.4; also 22.3.4.9.4 | AGREE. See in 11/1282r0 |
| 2383 | 126.33 | 22.3.4.7 | a 20 MHz subchannel is sometimes called a sub-band or subband, but say 5.15-5.25 GHz is more naturally a subband of the 5 GHz band | Replace sub-band or subband by "20 MHz subchannel", throughout clause 22 when applying to 20 MHz. Sometimes subband refers to the 80 MHz within a 160 or 80+80 MHz transmission - likely "80 MHz subchannel" would be suitable there also (or just primary80/secondary80) | AGREE in PRINCIPLE. See in 11/1282r0 |

<Discussion>

Introduced 20MHz subchannel in this clause 22 as commenter suggested. But, for 80MHz subband, it seems better to introduce the term “frequency segment”.

**Comments on text change**

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| **CID** | **Page** | **Clause** | **Comment** | **Proposed Change** | **Resolution** |
| 2375 | 124.26 | 22.3.4.2 | "each transmit chain" | "each transmit chain and frequency segment"; here and in each subclause in 22.3.4, but this also arises elsewhere e.g. 22.3.4.9.4, 23.3.10.11.1 (search for "transmit chain") | AGREE in PRINCIPLE. See in 11/1282r0 |
| 2377 | 124.65 | 22.3.4.2 | "add the reserved bits and Ntail bits. … Calculate the CRC and append it" - presumably after the tail bits. | Rewrite: add the reserved bits, append the calculated CRC, then append the Ntail tail bits | AGREE in PRINCIPLE. See in 11/1282r0 |
| 2378 | 125.50 | 22.3.4.6 | "exactly the STSs … PSDU". Arguably for MU there are an array of PSDUs | "all the STSs used for transmission of all the PSDUs" | AGREE. See in 11/1282r0 |

<Discussion>

It is correct that CSD is applied to each transmit chain (or space-time stream) and frequency segment.

As for upconverting in analog and RF, I did not introduce “each frequency segment” because it depends on implementation to do upconversion its waveform per each segment or per entire 160MHz when we transmit contiguous/non-contiguous 80+80 MHz PPDU.

**Comments on references**

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| **CID** | **Page** | **Clause** | **Comment** | **Proposed Change** | **Resolution** |
| 2692 | 126.30 | 22.3.4.7 | Incorrect reference. | Change 22.3.8.1.1 to 22.3.8.2.2 | AGREE. See in 11/1282r0 |
| 3678 | 126.30 | 22.3.4.7 | Apply CSD for each space-time stream as described in 22.3.8.1.1, should refer to 22.3.8.2.2 | Change reference to 22.3.8.2.2. | AGREE. See in 11/1282r0 |

**TGac editor: modify clause 22.3.4 based on Draft 1.1, as follows**

FYI, I changed clause 17 into clause 18, which is currenly for 11mb D10.0

* Overview of the PPDU encoding process
* General

This subclause provides an overview of the VHT PPDU encoding process.

* Construction of L-STF

Construct the L-STF fields(#314) as defined in Clause 18 with the following extensions and highlights:(#311)

* (#312)Determine the CH\_BANDWIDTH from the TXVECTOR(Ed).
* Sequence generation: Generate(#314) the L-STF sequences as described in 18.3.3 (PLCP preamble (SYNC))(Ed).
* Duplication and phase rotation: Duplicate the L-STF over each 20 MHz of the CH\_BANDWIDTH. Apply appropriate phase rotation for each 20 MHz subchannel as described in 22.3.7 (Mathematical description of signals)
* IDFT: Compute the inverse discrete Fourier transform(#315) (#2374).
* CSD: Apply CSD for each transmit chain and frequency segment as described in 22.3.8.1.1 (Cyclic shift definition).
* Insert GI and apply windowing(#893): Prepend a GI (LONG\_GI) and apply windowing as described 18.3.2.5 (Mathematical conventions in the signal descriptions) (#2057).
* Analog and RF: Up-convert 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 22.3.7 (Mathematical description of signals) and 22.3.8 (VHT preamble) for details.
* Construction of L-LTF

Construct the L-LTF fields(#314) as defined in Clause 18 with the following extensions and highlights:(#311)

* (#312)Determine the CH\_BANDWIDTH from the TXVECTOR(Ed).
* Sequence generation: Generate(#314) the L-LTF sequences as described in 18.3.3 (PLCP preamble (SYNC))(Ed).
* Duplication and phase rotation: Duplicate the L-LTF over each 20 MHz of the CH\_BANDWIDTH. Apply appropriate phase rotation for each 20 MHz subchannel as described in 22.3.7 (Mathematical description of signals)
* IDFT: Compute the inverse discrete Fourier transform(#315) (#2374).
* CSD: Apply CSD for each transmit chain and frequency segment as described in 22.3.8.1.1 (Cyclic shift definition).
* Insert GI and apply windowing(#893): Prepend a GI (2xLONG\_GI) and apply windowing as described 18.3.2.5 (Mathematical conventions in the signal descriptions) (#2057).
* Analog and RF: Up-convert 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 22.3.7 (Mathematical description of signals) and 22.3.8 (VHT preamble) for details.
* Construction of L-SIG(#980)

Construct the L-SIG field(#314) as the SIGNAL field defined by Clause 18 with the following extensions and highlights:(#316)

* (#312)For a(#317) VHT PPDU, set the RATE subfield in the SIGNAL field to 6 Mbps. Set the Length, Parity and Tail bits in the SIGNAL field as described in 22.3.8.1.4 (L-SIG definition)(#78)(#320). Add calculated one bit parity and (#421) tail bits into the L-SIG(#318) symbol.
* FEC Encoder: Encode the L-SIG(#318) symbol of the PLCP header by a convolution encoder (#2980) at the rate of R=1/2 as described in 18.3.5.6 (Convolutional encoder)(Ed).
* BCC Interleaver: Interleave as described in 18.3.5.7 (Data interleaving)(Ed).
* Constellation Mapper: BPSK modulate as(#321) described in 18.3.5.8 (Subcarrier modulation mapping)(Ed).
* Pilot insertion: Insert pilots as described in 18.3.5.10 (OFDM modulation).
* Duplication and phase rotation: Duplicate the L-SIG field over each 20 MHz of the CH\_BANDWIDTH. Apply appropriate phase rotation for each 20MHz subchannel as described in 22.3.7 (Mathematical description of signals).
* IDFT: (#314)Compute the inverse discrete Fourier transform(#315) (#2374).
* CSD: Apply CSD for each transmit chain and frequency segment as described in 22.3.8.1.1 (Cyclic shift definition).
* Insert GI and apply windowing(#893): Prepend a GI (LONG\_GI) and apply windowing as described in 18.3.2.5 (Mathematical conventions in the signal descriptions)(Ed).
* Analog and RF: Up-convert 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 22.3.7 (Mathematical description of signals) and 22.3.8 (VHT preamble) for details.
* Construction of VHT-SIG-A

The VHT-SIG-A field(#314) consists of two symbols, VHT-SIG-A1 and VHT-SIG-A2, as defined in 22.3.2 (VHT PPDU format)(#319).

* (#312)Obtain the CH\_BANDWIDTH, STBC, GROUP\_ID, PARTIAL\_AID (SU only), NUM\_STS, GI\_TYPE, FEC\_CODING, MCS (SU only), BEAMFORMED (SU only)(#594), NUM\_USERS from the TXVECTOR(#595). Add the reserved bits, append the calculated CRC, then append the *Ntail* tail bits as shown in 22.3.8.2.3 (VHT SIG-A definition). Partition the VHT-SIG-A bits such that the first 24 uncoded bits are assigned to(#323) the VHT-SIG-A1 symbol, and the second 24 uncoded bits are assigned to(#323) the VHT-SIG-A2 symbol.
* FEC Encoder: Encode the data by a convolution coder at the rate of R=1/2 as described in 18.3.5.6 (Convolutional encoder)(Ed).
* BCC Interleaver: Interleave as described in 18.3.5.7 (Data interleaving)(Ed).
* Constellation Mapper: BPSK modulate VHT-SIG-A1 as described in 18.3.5.8 (Subcarrier modulation mapping)(Ed). Rotate VHT-SIG-A2 by 90° counter-clockwise(#324) relative to VHT-SIG-A1.(#313)
* Pilot insertion: Insert pilots for both the symbols as described in 18.3.5.10 (OFDM modulation).
* Duplication and phase rotation: Duplicate VHT-SIG-A1 and VHT-SIG-A2 over each 20MHz of the CH\_BANDWIDTH. Apply the appropriate phase rotation for each 20 MHz subchannel as described in 22.3.7 (Mathematical description of signals).
* IDFT: Compute the inverse discrete Fourier transform(#315) (#2374).
* CSD: Apply CSD for each transmit chain and frequency segment as described in 22.3.8.1.1 (Cyclic shift definition)(#872).
* Insert GI and apply windowing(#893): Prepend a GI (LONG\_GI) and apply windowing as described in 18.3.2.5 (Mathematical conventions in the signal descriptions)(Ed).
* Analog and RF: Up-convert 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 22.3.7 (Mathematical description of signals) and 22.3.8 (VHT preamble) for details.
* Construction of VHT-STF

Construct the VHT-STF field(#314) as described in(Ed) 22.3.8.2.4 (VHT-STF definition).

* Sequence generation: Generate the VHT-STF in the frequency-domain over the(#325) bandwidth indicated by CH\_BANDWIDTH as described in 22.3.8.2.4 (VHT-STF definition).
* Phase rotation: Apply appropriate phase rotation for each 20 MHz sub-band(#326) as described in 22.3.7 (Mathematical description of signals).
* CSD: Apply CSD for each space-time stream (#2385) (#873 and frequency segment as described in 22.3.8.2.2 (Cyclic shift definition).
* Spatial mapping: Apply the *Q* matrix as described in 22.3.10.11.1 (Transmission in VHT format).(#889)
* IDFT: Compute the inverse discrete Fourier transform (#2374).(#326)
* Insert GI and applywindowing(#893): Prepend a GI (LONG\_GI) and apply windowing as described in 18.3.2.5 (Mathematical conventions in the signal descriptions)(Ed).
* Analog and RF: Up-convert 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 22.3.7 (Mathematical description of signals) and 22.3.8 (VHT preamble) for details.
* Construction of VHT-LTF

The VHT-LTF field(#314) allows (#2368) the receiver to estimate the MIMO channel. The transmitter provides training for all the space-time streams used for transmission of all the PSDUs.

* Sequence generation: Generate the VHT-LTF sequence in the frequency-domain over the bandwidth indicated by CH\_BANDWIDTH as described in 22.3.8.2.5 (VHT-LTF definition)(#327).
* Phase rotation: Apply appropriate phase rotation for each 20MHz subchannel as described in 22.3.7 (Mathematical description of signals).
* *AVHTLTF* matrix mapping: Apply the *PVHTLTF* matrix to the VHT-LTF sequence and apply the *RVHTLTF* matrix to the pilot tones as described in 22.3.8.2.5 (VHT-LTF definition).(#328)
* CSD: Apply CSD for each space-time stream(#874) and frequency segment as described in 22.3.8.2.2 (Cyclic shift definition).
* Spatial mapping: Apply the *Q* matrix as described in 22.3.10.11.1 (Transmission in VHT format)(#329).
* IDFT: Compute the inverse discrete Fourier transform(#315) (#2374).
* Insert GI and apply windowing(#893): Prepend a GI (LONG\_GI) and apply windowing as described in 18.3.2.5 (Mathematical conventions in the signal descriptions)(Ed).
* Analog and RF: Up-convert 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 22.3.7 (Mathematical description of signals) and 22.3.8 (VHT preamble) for details.
* Construction of VHT-SIG-B

The VHT-SIG-B field(#314) is constructed per-user(#1225) as follows:

* (#312)Obtain the MCS (for MU only) and(#330) LENGTH(#1350) from the TXVECTOR (#2379).
* VHT-SIG-B bits: For a VHT PPDU, set the MCS (for MU only) and VHT-SIG-B(#414) Length field as described in 22.3.8.2.6 (VHT-SIG-B definition)(#319). Add the reserved bits (for SU only) and (#421) *Ntail* bits of (#2381) tail. For an NDP (#2380) #42 set VHT-SIG-B to the fixed bit pattern for the bandwidth used as described in 22.3.8.2.6 (VHT-SIG-B definition)(#313).
* VHT-SIG-B Bit Repetition: Repeat the VHT-SIG-B bits over the(#332) bandwidth indicated by CH\_BANDWIDTH.(#313)
* BCC Encoder: Encode the VHT-SIG-B field(#314) using BCC at rate R=1/2 as described in 18.3.5.6 (Convolutional encoder)(#313).
* BCC Interleaver: Interleave as described in 22.3.10.8 (BCC interleaver).
* Constellation Mapper: Map to a BPSK constellation as defined in 18.3.5.8 (Subcarrier modulation mapping) (#2382).
* Pilot insertion: Insert pilots following the steps described in 22.3.10.10 (Pilot subcarrier). (#313)(Ed).(#875)
* *PVHTLTF* matrix mapping: Apply the mapping of the 1st column of the *PVHTLTF* matrix(#313) to the data subcarriers as described in 22.3.8.2.6 (VHT-SIG-B definition). The total number of data and pilot subcarriers is the same as in the Data field(Ed).(#875)
* CSD: Apply CSD for each space-time stream(#876) and frequency segment as described in 22.3.8.2.2 (Cyclic shift definition)(#835).
* Spatial Mapping: Apply the *Q* matrix as described in 22.3.10.11.1 (Transmission in VHT format).
* Phase rotation: Apply the appropriate phase rotations for each 20 MHz subchannel as described in 22.3.7 (Mathematical description of signals).
* IDFT: Compute the inverse discrete Fourier transform(#315) (#2374).
* Insert GI and apply windowing(#893): Prepend a GI (LONG\_GI) and apply windowing as described in 18.3.2.5 (Mathematical conventions in the signal descriptions)(Ed).
* Analog and RF: Up-convert 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 22.3.7 (Mathematical description of signals) and 22.3.8 (VHT preamble) for details.
* Construction of the Data field in an SU packet
* Using BCC

The construction of the Data field in a VHT SU packet with BCC encoding proceeds as follows:

* (#312)Insert(#313) the CRC calculated for VHT-SIG-B in the SERVICE field as described in 22.3.10.2 (SERVICE field) and append the PSDU to the SERVICE field.(#334)
* PHY Padding: Append(#313) the PHY pad bits and (#897)tail bits to the PSDU.
* Scrambler: Scramble the PHY padded data(#596).
* Encoder Parser: Divide(#313) the scrambled bits between the encoders by sending bits to different encoders in a round robin manner. The number of encoders is determined by rate-dependent parameters described in 22.5 (Parameters for VHT MCSs).
* BCC Encoder: BCC encode as described in 22.3.10.5.1 (Binary convolutional coding)(#837).
* Stream Parser: Rearrange(#313) the output of the BCC encoders into blocks as described in 22.3.10.6 (Stream parser).
* Segment Parser (if needed): For a contiguous 160 MHz or non-contiguous 80+80 MHz transmission, divide(#313) the output bits of each stream parser into two frequency segments as described in 22.3.10.7 (Segment parser)(#319). For a contiguous 160 MHz transmission, map(#313) each segment to the upper and the lower part of one IDFT(#337). For a non-contiguous 80+80 MHz transmission, map(#313) each segment to the separate IDFT. This block is bypassed for (#3286) 20 MHz, 40 MHz and 80 MHz VHT PPDU transmissions.
* BCC Interleaver: Interleave as described in 22.3.10.8 (BCC interleaver).
* Constellation Mapper: Map to BPSK, QPSK, 16-QAM, 64-QAM or 256-QAM constellation points(#338) as described in 22.3.10.9 (Constellation mapping).
* Segment Deparser: For a contiguous 160 MHz transmission, merge the two frequency subblocks into one frequency segment as described in 22.3.11.9.3 (Segment deparser)(#306).
* STBC: Apply STBC as described in 22.3.10.9.4 (Space-time block coding).
* Pilot insertion: Insert pilots following the steps described in 22.3.10.10 (Pilot subcarrier).
* CSD: Apply CSD for each space-time stream(#877) and frequency segment as described in 22.3.8.2.2 (Cyclic shift definition).
* Spatial Mapping: Apply(#313) the *Q* matrix as described in 22.3.10.11.1 (Transmission in VHT format).
* Phase rotation: Apply the appropriate phase rotation for each 20MHz subchannel as described in 22.3.7 (Mathematical description of signals).
* IDFT: Compute the inverse discrete Fourier transform(#315) (#2374).
* Insert GI and apply windowing(#893): Prepend a GI (SHORT\_GI or LONG\_GI) and apply windowing as described in 18.3.2.5 (Mathematical conventions in the signal descriptions)(Ed).
* Analog and RF: Up-convert 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 22.3.7 (Mathematical description of signals) and 22.3.8 (VHT preamble) for details.
* Using LDPC

The construction of the Data field in a VHT SU packet with LDPC encoding proceeds as follows:

* (#312)Insert(#313) the CRC calculated for VHT-SIG-B in the SERVICE field as described in 22.3.10.2 (SERVICE field) and append the PSDU to the SERVICE field.(#334)
* PHY Padding: Append(#313) the PHY pad bits to the PSDU. There are no tail bits.
* Scrambler: Scramble the PHY padded data(#598).
* LDPC Encoder: The scrambled bits are encoded using the LDPC code with the LENGTH in the TXVECTOR(#335) as described in 22.3.10.5.2 (LDPC coding).
* Stream Parser: The output of the LDPC encoder is rearranged into blocks as described in 22.3.10.6 (Stream parser).
* Segment Parser (if needed): For a contiguous 160 MHz or non-contiguous 80+80 MHz transmission, divide(#313) the output bits of each stream parser into two frequency segments as described in 22.3.10.7 (Segment parser). For a contiguous 160 MHz transmission, map(#313) each segment to the upper and the lower part of one IDFT, respectively. For a non-contiguous 80+80 MHz transmission, map(#313) each segment to the separate IDFT. This block is bypassed for (#3286) 20 MHz, 40 MHz and 80 MHz VHT PPDU transmissions.
* Constellation Mapper: Map to BPSK, QPSK, 16-QAM, 64-QAM or 256-QAM constellation points(#338) as described in 22.3.10.9 (Constellation mapping).
* LDPC Tone Mapper: The LDPC tone mapping shall be performed on all LDPC coded streams as described in 22.3.10.9.2 (LDPC tone mapping).
* Segment Deparser: For a contiguous 160 MHz transmission, merge the two frequency subblocks into one frequency segment as described in 22.3.11.9.3 (Segment deparser).(#306)
* STBC: Apply(#313) STBC as described in 22.3.10.9.4 (Space-time block coding).

Pilot insertion: Insert pilots following the steps described in 22.3.10.10 (Pilot subcarrier).

* CSD: Apply CSD for each space-time stream(#878) and frequency segment as described in 22.3.8.2.2 (Cyclic shift definition).
* Spatial Mapping: Apply the *Q* matrix as described in 22.3.10.11.1 (Transmission in VHT format).
* Phase rotation: Apply the appropriate phase rotations for each 20 MHz subchannel as described in 22.3.7 (Mathematical description of signals).
* IDFT: Compute the inverse discrete Fourier transform(#315) (#2374).
* Insert GI and apply windowing(#893): Prepend a GI (SHORT\_GI or LONG\_GI) and apply windowing as described in 18.3.2.5 (Mathematical conventions in the signal descriptions)(Ed).
* Analog and RF: Up-convert 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 22.3.7 (Mathematical description of signals) and 22.3.8 (VHT preamble) for details.
* Construction of the Data field in an MU packet
* General

For (#3286) an MU transmission, the PPDU encoding process is performed on a per-user basis and all user(Ed) data is combined(#339) in the spatial mapping.

* Using BCC

A Data field with BCC encoding is constructed using the process described in 22.3.4.8.1 (Using BCC) before the spatial mapping block and repeated for each user that uses BCC encoding.(#340)(Ed)

* Using LDPC

A Data field with LDPC encoding is constructed using the process described in 22.3.4.8.2 (Using LDPC) before the spatial mapping block and repeated for each user that uses LDPC encoding.(#340)(Ed)

* Combining to form MU packet

The per-user data is combined as follows:

* Spatial Mapping: The *Q* matrix is applied as described in 22.3.10.11.1 (Transmission in VHT format). The combining of all user data is done in this block(Ed).
* Phase rotation: Apply appropriate phase rotation for each 20 MHz subchannel as described in 22.3.7 (Mathematical description of signals).
* IDFT: Compute the inverse discrete Fourier transform(#315) (#2374).
* Insert GI and apply windowing(#893): Prepend a GI (SHORT\_GI or LONG\_GI) and apply windowing as described in 18.3.2.5 (Mathematical conventions in the signal descriptions)(Ed).
* Analog and RF: Up-convert 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 22.3.7 (Mathematical description of signals) and 22.3.8 (VHT preamble) for details.

**TGac editor: modify the Draft 1.1 text from P166L23, as follows**

In a 40 and 80 MHz transmission, the VHT-STF field is constructed from the 20 MHz version by frequency shifting a duplicate of it to each 20 MHz subchannel and applying appropriate phase rotations per 20 MHz subchannel.

**TGac editor: modify the Draft 1.1 text from P191L60, as follows**

For a 160 MHz transmission, the 80 MHz pilot mapping is replicated in the two 80 MHz subchannel of the 160 MHz transmission.