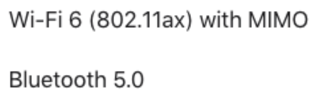
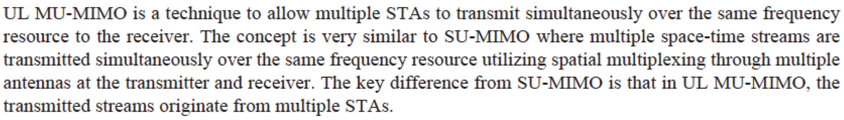
U.S. Patent No. 10,715,235 (“’235 Patent”)

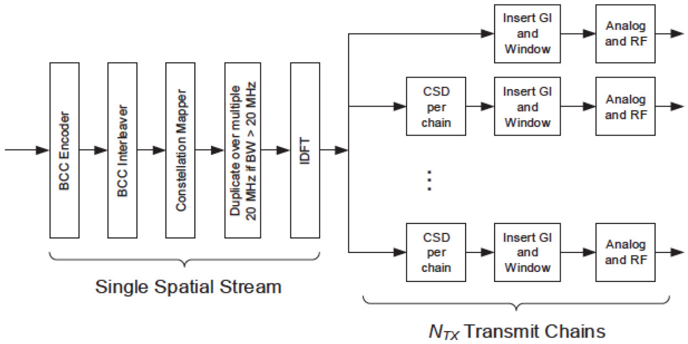
Accused Products

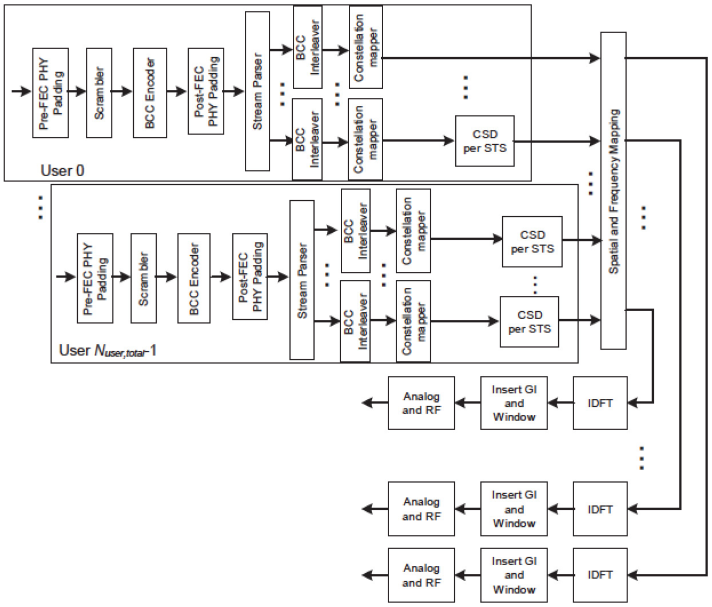
Apple products utilizing the IEEE 802.11ac wave 2 standard alone, or the 802.11ac wave 2 standard and/or the 802.11ax or “Wi-Fi 6” standard supporting MIMO and/or MU-MIMO technologies, including without limitation the iPhone 12 Pro Max, iPhone 12 Pro, iPhone 12, iPhone 12 mini, iPhone SE (2nd Generation), iPhone 11 Pro Max, iPhone 11 Pro, iPhone 11, , iPhone XS, XR, iPhone X, iPhone 8 Plus, iPhone 8, iPhone 7 Plus, iPhone 7, iPhone 6s Plus, iPhone 6s; iPad Pro 12.9-in (5th generation), iPad Pro 12.9-in (4th generation), iPad Pro 12.9-in (3rd generation), iPad Pro 12.9-in (2nd generation), iPad Pro 12.9-in (1st generation), iPad Pro 11-in (2nd generation), iPad Pro 11-in (3rd generation), iPad Pro 11-in (1st generation), iPad Air (4th generation), iPad (8th generation), iPad mini (5th generation), iPad Pro 10.5-in, iPad Pro 9.7-in, iPad Air (3rd generation), iPad Air 2, iPad Air (1st generation), iPad (7th generation), iPad (6th generation), iPad (5th generation), iPad mini 4, iPad mini 3, iPad mini 2; MacBook Air (M1, 2020), MacBook Pro 13-in (M1, 2020), iMac 24-in (M1, Two ports, 2021), iMac 24-in (M1, Four ports, 2021), Mac mini (M1, 2020); MacBook Pro 16-in, MacBook Air (Retina, 2020), MacBook Air (2017), MacBook Pro 13-in (Two Thunderbolt 2020), MacBook Pro 13-in (Four Thunderbolt 2020), MacBook Pro 13-in (Two Thunderbolt 2016), iMac 21.5-in, iMac 21.5-in (4K Retina), iMac 27-in (5K Retina), iMac Pro, Mac mini (2018), Mac Pro (“Accused Products”) infringe at least Claims 1, 2, 4, 8, 9, 11, 12, 15, and 16 of the ’235 Patent. The infringement chart below is based on the Apple iPhone 12 (“iPhone 12”) supporting MIMO and/or MU-MIMO utilizing the 802.11ac wave 2 and/or 802.11ax standard, which is exemplary of the infringement of the ‘235 Patent.

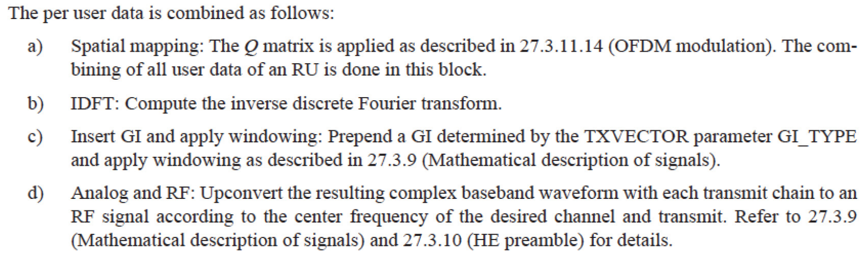
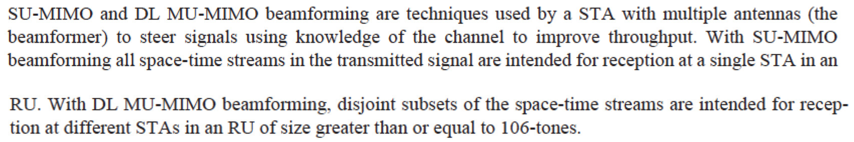
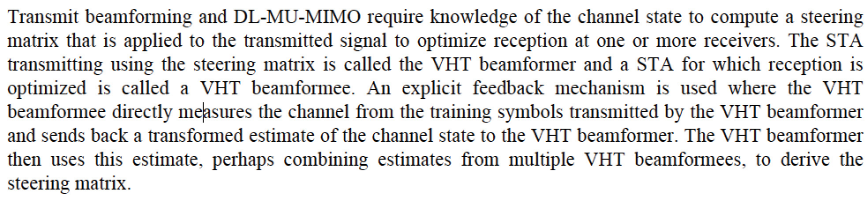
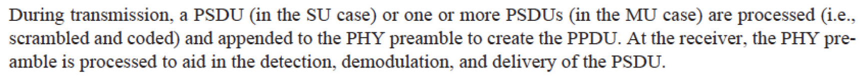
Claim 1

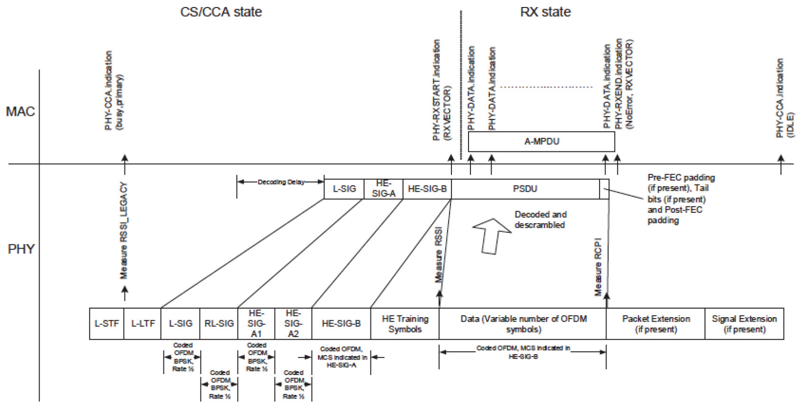
Claim 1	iPhone 12
[1pre]. A receiver for use in a wireless communications system, the receiver comprising:	To the extent the preamble is limiting, the iPhone 12 includes a receiver for use in a wireless communications system. For example, the iPhone 12 supports MU-MIMO technology.  Wi-Fi 6 (802.11ax) with MIMO Bluetooth 5.0 *See* iPhone 12 available at https://www.apple.com/iPhone/compare/?modelList=iPhoneXSmax,iPhone12,iPhone12mini

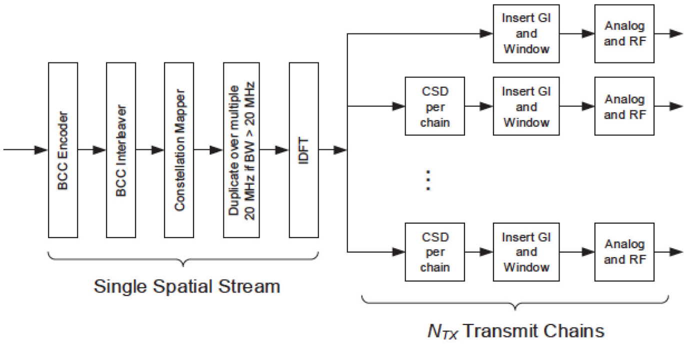
Claim 1	iPhone 12
	Each Accused Product operates as a communicating device or station in a Wi-Fi network. Each Accused Product that supports or utilizes Wi-Fi 6 infringes in substantially the same manner as the iPhone 12 according to the exemplary descriptions of Wi-Fi 6 / 802.11ax functionality cited below. Each Accused Product that supports or utilizes MIMO / MU-MIMO technologies pursuant to IEEE 802.11ac wave 2 infringes in substantially the same manner as the iPhone 12 according to the exemplary descriptions of 802.11ac wave 2 functionality cited below.
[1a] an antenna, wherein the antenna comprises a first antenna element and a second antenna element;	The iPhone 12 includes an antenna, wherein the antenna comprises a first antenna element and a second antenna element. For example, iPhone 12 transmits MU-MIMO signal through multiple antennas.  UL MU-MIMO is a technique to allow multiple STAs to transmit simultaneously over the same frequency resource to the receiver. The concept is very similar to SU-MIMO where multiple space-time streams are transmitted simultaneously over the same frequency resource utilizing spatial multiplexing through multiple antennas at the transmitter and receiver. The key difference from SU-MIMO is that in UL MU-MIMO, the transmitted streams originate from multiple STAs. *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.3.2.1. *See*, *e.g.*, IEEE 802.11ax Standard, at Sections 26.5, 26.5.1, 26.5.2, 26.5.3, 27.1.1, 27.3.1, 27.3.2.5, 27.3.2.6, 27.3.5, 27.3.6.11.4, 27.3.10.7, 27.3.10.8, 27.3.10.9, 27.3.15, including Tables 27-19, 27-20, 27-21, 27-24, 27-25, 27-26, 27-27, 27-28, 27-29, Figures 27-19, 27-20, and other transmitter block diagrams for MU-MIMO transmission. *See, e.g.,* 802.11ac Standard Clause 22.3, 22.3.1, 22.3.2, 22.3.3, 22.3.4, 22.3.4.1, 22.3.4.2, 22.3.4.3, 22.3.4.4, 22.3.4.5, 22.3.4.6, 22.3.4.7, 22.3.4.8, 22.3.4.9, 22.3.4.10, 22.3.5, including Tables, Figures 22-1, 22-2, 22-3, 22-4, 22-5, 22-6, 22-7, 22-8, 22-9, 22-10, 22-11, 22-12, 22-13, 22-14, 22-15, 22-16, and other transmitter block diagrams for MIMO transmission.
[1b] a transceiver operatively coupled to the antenna and configured to transmit and receive electromagnetic signals using the antenna; and	The iPhone 12 includes a transceiver operatively coupled to the antenna and configured to transmit and receive electromagnetic signals using the antenna.

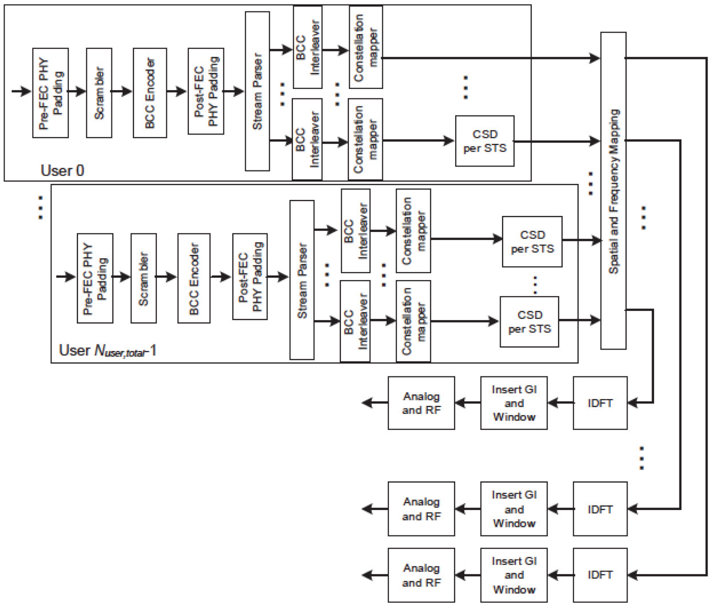
Claim 1	iPhone 12
	For example, the iPhone 12 includes a transmitter that is connected to the array of antennas and is configured to transmit and receive RF signals using the transmit and receive chains.  *See*, *e.g.*, Figure 27-13 IEEE 802.11ax Standard, Section 27.3.5

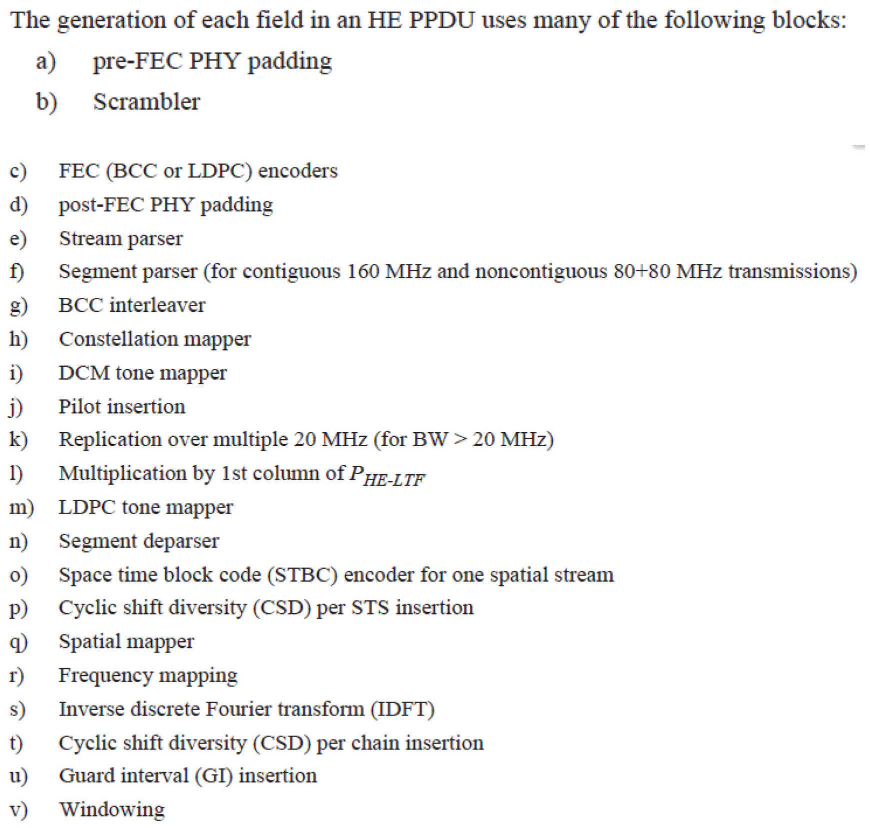
Claim 1	iPhone 12
	 **Figure 27-19—Transmitter block diagram for the Data field of an HE DL MU-MIMO transmission in a 106-, 242-, 484- or 996-tone RU with BCC encoding** *See*, *e.g.*, Figure 27-19 IEEE 802.11ax Standard, Section 27.3.5

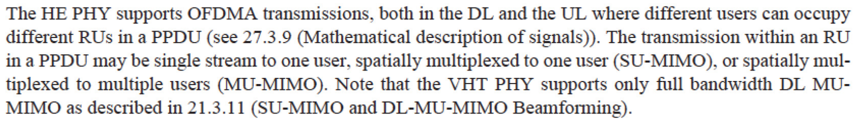
Claim 1	iPhone 12
	 The per user data is combined as follows: a) Spatial mapping: The Q matrix is applied as described in 27.3.11.14 (OFDM modulation). The combining of all user data of an RU is done in this block. b) IDFT: Compute the inverse discrete Fourier transform. c) Insert GI and apply windowing: Prepend a GI determined by the TXVECTOR parameter GI_TYPE and apply windowing as described in 27.3.9 (Mathematical description of signals). d) 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 27.3.9 (Mathematical description of signals) and 27.3.10 (HE preamble) for details. *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.6.11.4  SU-MIMO and DL MU-MIMO beamforming are techniques used by a STA with multiple antennas (the beamformer) to steer signals using knowledge of the channel to improve throughput. With SU-MIMO beamforming all space-time streams in the transmitted signal are intended for reception at a single STA in an RU. With DL MU-MIMO beamforming, disjoint subsets of the space-time streams are intended for reception at different STAs in an RU of size greater than or equal to 106-tones. *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.15.1  Transmit beamforming and DL-MU-MIMO require knowledge of the channel state to compute a steering matrix that is applied to the transmitted signal to optimize reception at one or more receivers. The STA transmitting using the steering matrix is called the VHT beamformer and a STA for which reception is optimized is called a VHT beamformee. An explicit feedback mechanism is used where the VHT beamformee directly measures the channel from the training symbols transmitted by the VHT beamformer and sends back a transformed estimate of the channel state to the VHT beamformer. The VHT beamformer then uses this estimate, perhaps combining estimates from multiple VHT beamformees, to derive the steering matrix. *See*, *e.g.*, IEEE 802.11ac Standard Clause 9.31.5.1  During transmission, a PSDU (in the SU case) or one or more PSDUs (in the MU case) are processed (i.e., scrambled and coded) and appended to the PHY preamble to create the PPDU. At the receiver, the PHY preamble is processed to aid in the detection, demodulation, and delivery of the PSDU. *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.1

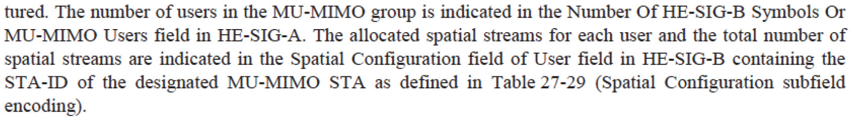
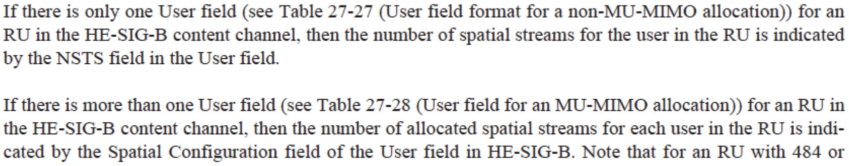
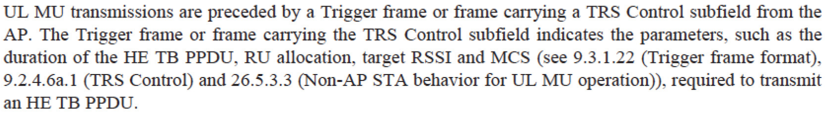
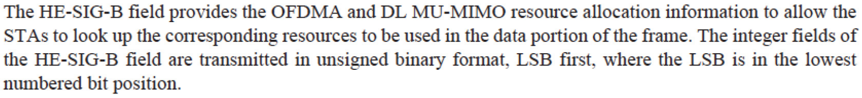
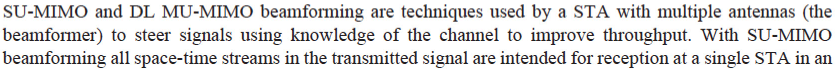
Claim 1	iPhone 12
	 **Figure 27-61—PHY receive procedure for an HE MU PPDU** *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.21. *See, e.g.,* 802.11ac Standard Clause 22.3, 22.3.1, 22.3.2, 22.3.3, 22.3.4, 22.3.4.1, 22.3.4.2, 22.3.4.3, 22.3.4.4, 22.3.4.5, 22.3.4.6, 22.3.4.7, 22.3.4.8, 22.3.4.9, 22.3.4.10, 22.3.5, including Tables, Figures 22-1, 22-2, 22-3, 22-4, 22-5, 22-6, 22-7, 22-8, 22-9, 22-10, 22-11, 22-12, 22-13, 22-14, 22-15, 22-16, and other transmitter block diagrams for MIMO transmission.
[1c] a processor operatively coupled to the transceiver, the processor configured to:	The iPhone 12 includes a processor operatively coupled to the transceiver. For example, iPhone 12 includes a digital signal processor.

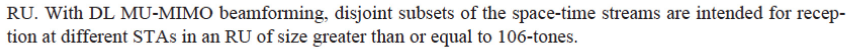
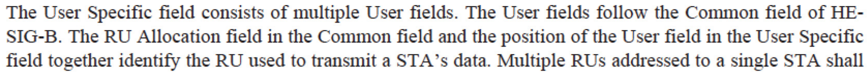
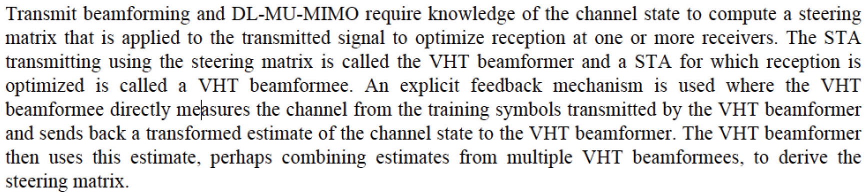
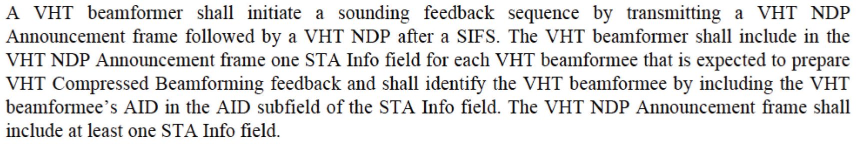
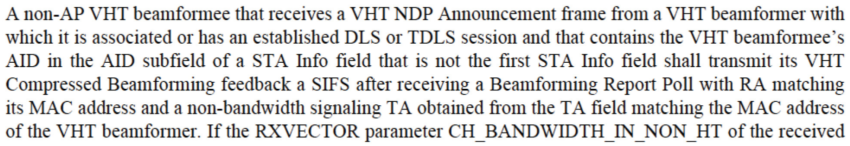
Claim 1	iPhone 12
	 *See*, *e.g.*, Figure 27-13 IEEE 802.11ax Standard, Section 27.3.5

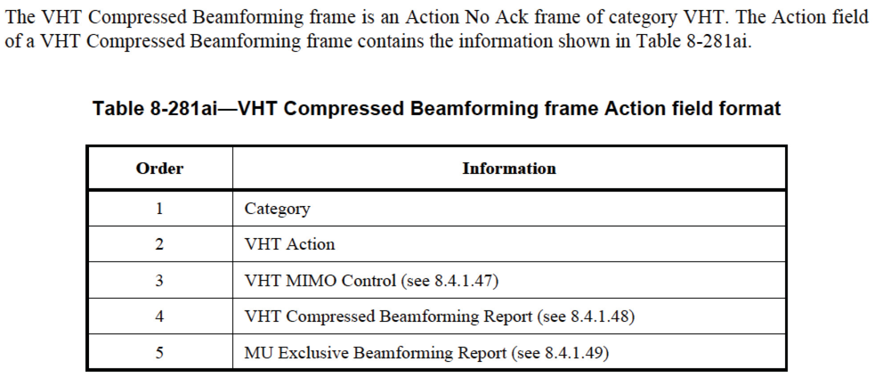
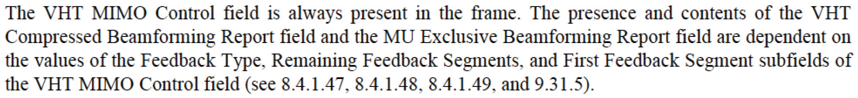
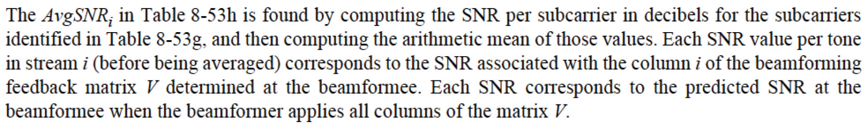
Claim 1	iPhone 12
	 **Figure 27-19—Transmitter block diagram for the Data field of an HE DL MU-MIMO transmission in a 106-, 242-, 484- or 996-tone RU with BCC encoding** *See*, *e.g.*, Figure 27-19 IEEE 802.11ax Standard, Section 27.3.5

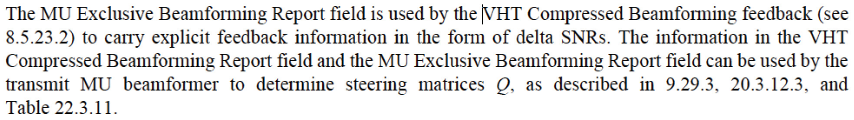
Claim 1	iPhone 12
	 The generation of each field in an HE PPDU uses many of the following blocks: a) pre-FEC PHY padding b) Scrambler c) FEC (BCC or LDPC) encoders d) post-FEC PHY padding e) Stream parser f) Segment parser (for contiguous 160 MHz and noncontiguous 80+80 MHz transmissions) g) BCC interleaver h) Constellation mapper i) DCM tone mapper j) Pilot insertion k) Replication over multiple 20 MHz (for BW > 20 MHz) l) Multiplication by 1st column of $P_{HE\text{-}LTF}$ m) LDPC tone mapper n) Segment deparser o) Space time block code (STBC) encoder for one spatial stream p) Cyclic shift diversity (CSD) per STS insertion q) Spatial mapper r) Frequency mapping s) Inverse discrete Fourier transform (IDFT) t) Cyclic shift diversity (CSD) per chain insertion u) Guard interval (GI) insertion v) Windowing *See*, *e.g.*, Figure 27-19 IEEE 802.11ax Standard, Section 27.3.5.

Claim 1	iPhone 12
	See, e.g., 802.11ac Standard Clause 22.3, 22.3.1, 22.3.2, 22.3.3, 22.3.4, 22.3.4.1, 22.3.4.2, 22.3.4.3, 22.3.4.4, 22.3.4.5, 22.3.4.6, 22.3.4.7, 22.3.4.8, 22.3.4.9, 22.3.4.10, 22.3.5, including Tables, Figures 22-1, 22-2, 22-3, 22-4, 22-5, 22-6, 22-7, 22-8, 22-9, 22-10, 22-11, 22-12, 22-13, 22-14, 22-15, 22-16, and other transmitter block diagrams for MIMO transmission.
[1d] receive a first signal transmission from a remote station via the first antenna element and a second signal transmission from the remote station via the second antenna element simultaneously;	The processor in iPhone 12 receives a first signal transmission from a remote station via the first antenna element and a second signal transmission from the remote station via the second antenna element simultaneously. For example, the iPhone 12 receives a first signal transmission from a remote station, such as a Wi-Fi Access Point, via a first antenna element of an antenna and a second signal transmission from the remote station via a second antenna element of the antenna simultaneously. For example, the iPhone 12 receives a first signal transmission from a remote station, such as a Wi-Fi Access Point, via a first antenna element of an antenna and a second signal transmission from the remote station via a second antenna element of the antenna simultaneously, such as when the iPhone 12 receives first and second signals with its first and second antenna elements that contain training fields of a null data packet used for MU-MIMO sounding and channel estimation procedures.  The HE PHY supports OFDMA transmissions, both in the DL and the UL where different users can occupy different RUs in a PPDU (see 27.3.9 (Mathematical description of signals)). The transmission within an RU in a PPDU may be single stream to one user, spatially multiplexed to one user (SU-MIMO), or spatially multiplexed to multiple users (MU-MIMO). Note that the VHT PHY supports only full bandwidth DL MU-MIMO as described in 21.3.11 (SU-MIMO and DL-MU-MIMO Beamforming). *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.1.1

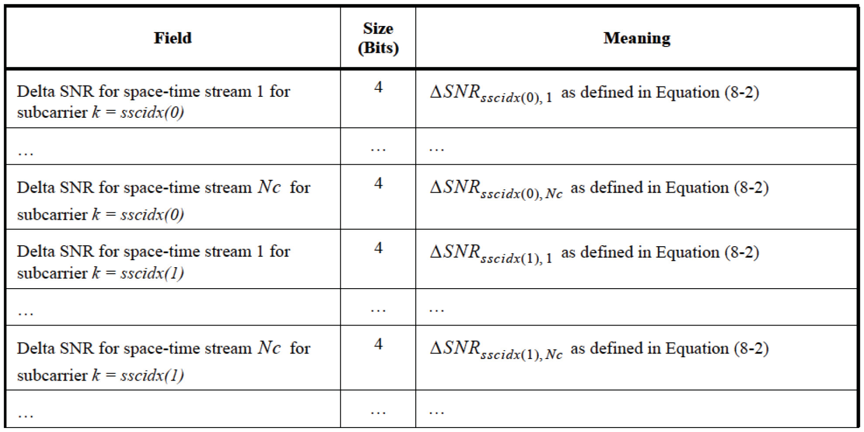
Claim 1	iPhone 12
	 tured. The number of users in the MU-MIMO group is indicated in the Number Of HE-SIG-B Symbols Or MU-MIMO Users field in HE-SIG-A. The allocated spatial streams for each user and the total number of spatial streams are indicated in the Spatial Configuration field of User field in HE-SIG-B containing the STA-ID of the designated MU-MIMO STA as defined in Table 27-29 (Spatial Configuration subfield encoding). *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.2.5  If there is only one User field (see Table 27-27 (User field format for a non-MU-MIMO allocation)) for an RU in the HE-SIG-B content channel, then the number of spatial streams for the user in the RU is indicated by the NSTS field in the User field. If there is more than one User field (see Table 27-28 (User field for an MU-MIMO allocation)) for an RU in the HE-SIG-B content channel, then the number of allocated spatial streams for each user in the RU is indicated by the Spatial Configuration field of the User field in HE-SIG-B. Note that for an RU with 484 or *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.2.5  UL MU transmissions are preceded by a Trigger frame or frame carrying a TRS Control subfield from the AP. The Trigger frame or frame carrying the TRS Control subfield indicates the parameters, such as the duration of the HE TB PPDU, RU allocation, target RSSI and MCS (see 9.3.1.22 (Trigger frame format), 9.2.4.6a.1 (TRS Control) and 26.5.3.3 (Non-AP STA behavior for UL MU operation)), required to transmit an HE TB PPDU. *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.2.6  The HE-SIG-B field provides the OFDMA and DL MU-MIMO resource allocation information to allow the STAs to look up the corresponding resources to be used in the data portion of the frame. The integer fields of the HE-SIG-B field are transmitted in unsigned binary format, LSB first, where the LSB is in the lowest numbered bit position. *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.10.8  SU-MIMO and DL MU-MIMO beamforming are techniques used by a STA with multiple antennas (the beamformer) to steer signals using knowledge of the channel to improve throughput. With SU-MIMO beamforming all space-time streams in the transmitted signal are intended for reception at a single STA in an

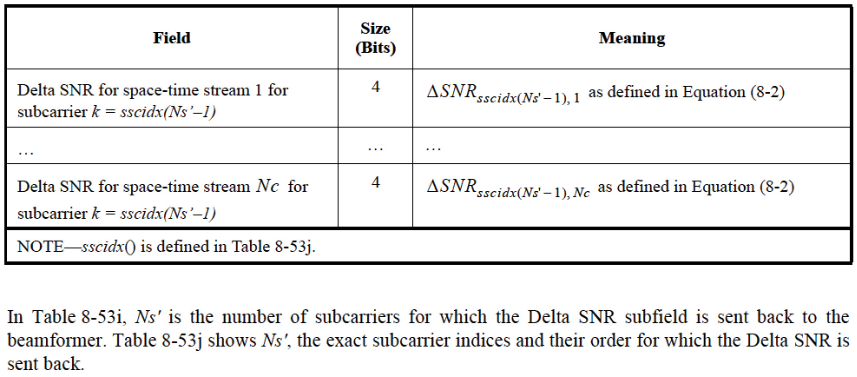
Claim 1	iPhone 12
	 RU. With DL MU-MIMO beamforming, disjoint subsets of the space-time streams are intended for reception at different STAs in an RU of size greater than or equal to 106-tones. *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.15.1  The User Specific field consists of multiple User fields. The User fields follow the Common field of HE-SIG-B. The RU Allocation field in the Common field and the position of the User field in the User Specific field together identify the RU used to transmit a STA's data. Multiple RUs addressed to a single STA shall *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.10.8.5  Transmit beamforming and DL-MU-MIMO require knowledge of the channel state to compute a steering matrix that is applied to the transmitted signal to optimize reception at one or more receivers. The STA transmitting using the steering matrix is called the VHT beamformer and a STA for which reception is optimized is called a VHT beamformee. An explicit feedback mechanism is used where the VHT beamformee directly measures the channel from the training symbols transmitted by the VHT beamformer and sends back a transformed estimate of the channel state to the VHT beamformer. The VHT beamformer then uses this estimate, perhaps combining estimates from multiple VHT beamformees, to derive the steering matrix. *See*, *e.g.*, IEEE 802.11ac Standard Clause 9.31.5.1  A VHT beamformer shall initiate a sounding feedback sequence by transmitting a VHT NDP Announcement frame followed by a VHT NDP after a SIFS. The VHT beamformer shall include in the VHT NDP Announcement frame one STA Info field for each VHT beamformee that is expected to prepare VHT Compressed Beamforming feedback and shall identify the VHT beamformee by including the VHT beamformee's AID in the AID subfield of the STA Info field. The VHT NDP Announcement frame shall include at least one STA Info field. *See*, *e.g.*, IEEE 802.11ac Standard Clause 9.31.5.2  A non-AP VHT beamformee that receives a VHT NDP Announcement frame from a VHT beamformer with which it is associated or has an established DLS or TDLS session and that contains the VHT beamformee's AID in the AID subfield of a STA Info field that is not the first STA Info field shall transmit its VHT Compressed Beamforming feedback a SIFS after receiving a Beamforming Report Poll with RA matching its MAC address and a non-bandwidth signaling TA obtained from the TA field matching the MAC address of the VHT beamformer. If the RXVECTOR parameter CH_BANDWIDTH_IN_NON_HT of the received *See*, *e.g.*, IEEE 802.11ac Standard Clause 9.31.5.2

<table>
<tr><th>Claim 1</th><th>iPhone 12</th></tr>
<tr><td></td><td>

The VHT Compressed Beamforming frame is an Action No Ack frame of category VHT. The Action field of a VHT Compressed Beamforming frame contains the information shown in Table 8-281ai.
Table 8-281ai—VHT Compressed Beamforming frame Action field format
<table>
<tr><th>Order</th><th>Information</th></tr>
<tr><td>1</td><td>Category</td></tr>
<tr><td>2</td><td>VHT Action</td></tr>
<tr><td>3</td><td>VHT MIMO Control (see 8.4.1.47)</td></tr>
<tr><td>4</td><td>VHT Compressed Beamforming Report (see 8.4.1.48)</td></tr>
<tr><td>5</td><td>MU Exclusive Beamforming Report (see 8.4.1.49)</td></tr>
</table>
<i>See</i>, <i>e.g.</i>, IEEE 802.11ac Standard Clause 8.5.23.2

The VHT MIMO Control field is always present in the frame. The presence and contents of the VHT Compressed Beamforming Report field and the MU Exclusive Beamforming Report field are dependent on the values of the Feedback Type, Remaining Feedback Segments, and First Feedback Segment subfields of the VHT MIMO Control field (see 8.4.1.47, 8.4.1.48, 8.4.1.49, and 9.31.5).
<i>See</i>, <i>e.g.</i>, IEEE 802.11ac Standard Clause 8.5.23.2
<i>See</i> Tables 8-53(d)-(h) in IEEE 802.11ac Standard Clause 8.4.1.48

The $AvgSNR_i$ in Table 8-53h is found by computing the SNR per subcarrier in decibels for the subcarriers identified in Table 8-53g, and then computing the arithmetic mean of those values. Each SNR value per tone in stream i (before being averaged) corresponds to the SNR associated with the column i of the beamforming feedback matrix V determined at the beamformee. Each SNR corresponds to the predicted SNR at the beamformee when the beamformer applies all columns of the matrix V.
<i>See</i>, <i>e.g.</i>, IEEE 802.11ac Standard Clause 8.4.1.48
</td></tr>
</table>

<table>
<tr><th>Claim 1</th><th>iPhone 12</th></tr>
<tr><td></td><td>

The MU Exclusive Beamforming Report field is used by the VHT Compressed Beamforming feedback (see 8.5.23.2) to carry explicit feedback information in the form of delta SNRs. The information in the VHT Compressed Beamforming Report field and the MU Exclusive Beamforming Report field can be used by the transmit MU beamformer to determine steering matrices Q, as described in 9.29.3, 20.3.12.3, and Table 22.3.11.

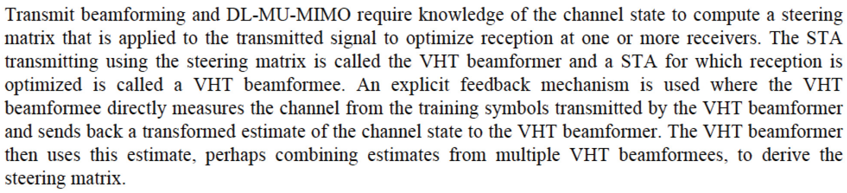
<i>See</i>, <i>e.g.</i>, IEEE 802.11ac Standard Clause 8.4.1.49


<table>
<tr><th>Field</th><th>Size (Bits)</th><th>Meaning</th></tr>
<tr><td>Delta SNR for space-time stream 1 for subcarrier $k = sscidx(0)$</td><td>4</td><td>$\Delta SNR_{sscidx(0),1}$ as defined in Equation (8-2)</td></tr>
<tr><td>…</td><td>…</td><td>…</td></tr>
<tr><td>Delta SNR for space-time stream Nc for subcarrier $k = sscidx(0)$</td><td>4</td><td>$\Delta SNR_{sscidx(0),Nc}$ as defined in Equation (8-2)</td></tr>
<tr><td>Delta SNR for space-time stream 1 for subcarrier $k = sscidx(1)$</td><td>4</td><td>$\Delta SNR_{sscidx(1),1}$ as defined in Equation (8-2)</td></tr>
<tr><td>…</td><td>…</td><td>…</td></tr>
<tr><td>Delta SNR for space-time stream Nc for subcarrier $k = sscidx(1)$</td><td>4</td><td>$\Delta SNR_{sscidx(1),Nc}$ as defined in Equation (8-2)</td></tr>
<tr><td>…</td><td>…</td><td>…</td></tr>
</table>
</td></tr>
</table>

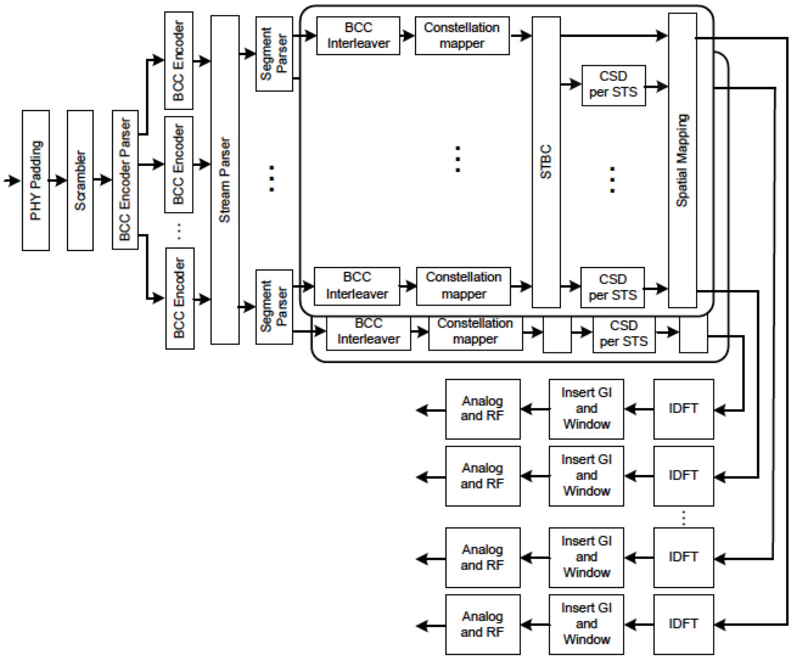
<table>
<tr><th>Claim 1</th><th>iPhone 12</th></tr>
<tr><td></td><td>

<table>
<tr><th>Field</th><th>Size (Bits)</th><th>Meaning</th></tr>
<tr><td>Delta SNR for space-time stream 1 for subcarrier <i>k</i> = <i>sscidx(Ns'–1)</i></td><td>4</td><td>$\Delta SNR_{sscidx(Ns'-1),1}$ as defined in Equation (8-2)</td></tr>
<tr><td>…</td><td>…</td><td>…</td></tr>
<tr><td>Delta SNR for space-time stream Nc for subcarrier <i>k</i> = <i>sscidx(Ns'–1)</i></td><td>4</td><td>$\Delta SNR_{sscidx(Ns'-1),Nc}$ as defined in Equation (8-2)</td></tr>
<tr><td colspan="3">NOTE—<i>sscidx</i>() is defined in Table 8-53j.</td></tr>
</table>

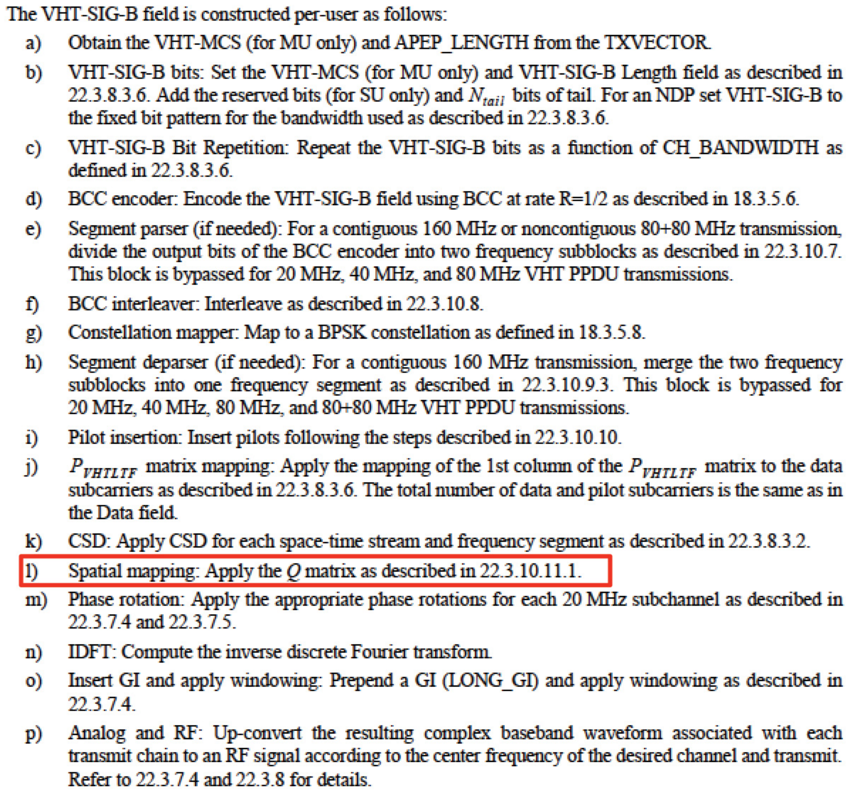
In Table 8-53i, Ns' is the number of subcarriers for which the Delta SNR subfield is sent back to the beamformer. Table 8-53j shows Ns', the exact subcarrier indices and their order for which the Delta SNR is sent back.

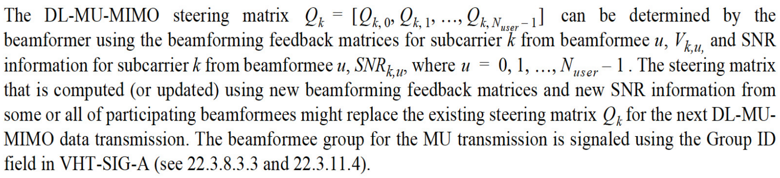
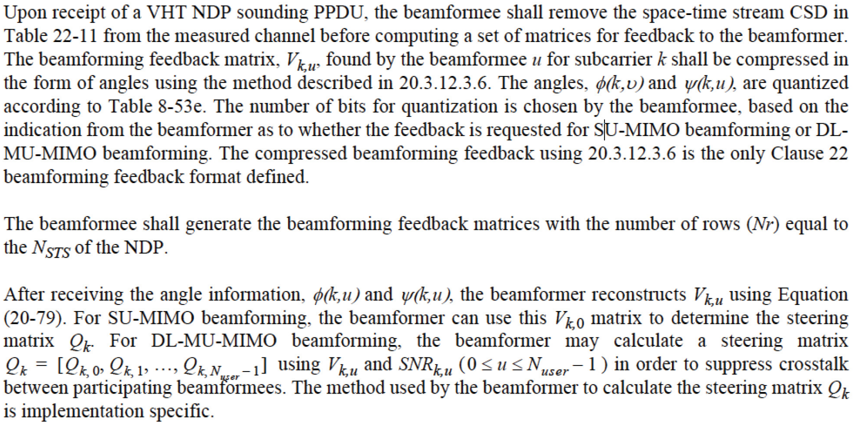
<i>See</i>, <i>e.g.</i>, Table 8-53i IEEE 802.11ac Standard Clause 8.4.1.48

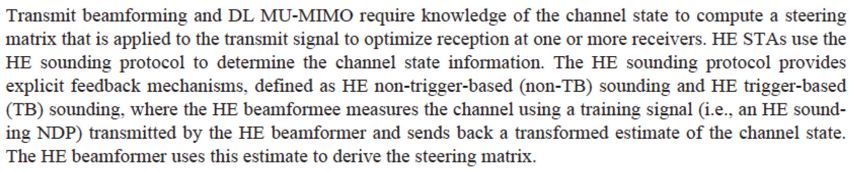
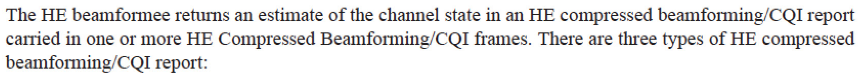
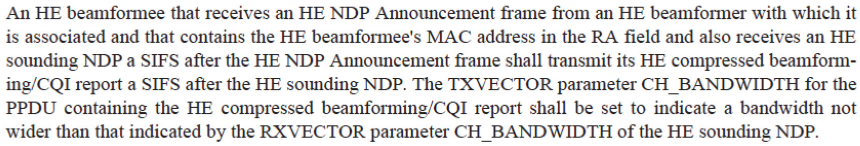
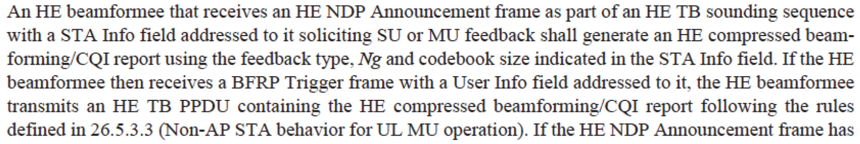
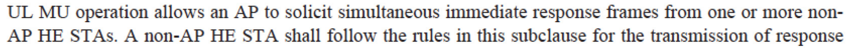

Transmit beamforming and DL-MU-MIMO require knowledge of the channel state to compute a steering matrix that is applied to the transmitted signal to optimize reception at one or more receivers. The STA transmitting using the steering matrix is called the VHT beamformer and a STA for which reception is optimized is called a VHT beamformee. An explicit feedback mechanism is used where the VHT beamformee directly measures the channel from the training symbols transmitted by the VHT beamformer and sends back a transformed estimate of the channel state to the VHT beamformer. The VHT beamformer then uses this estimate, perhaps combining estimates from multiple VHT beamformees, to derive the steering matrix.

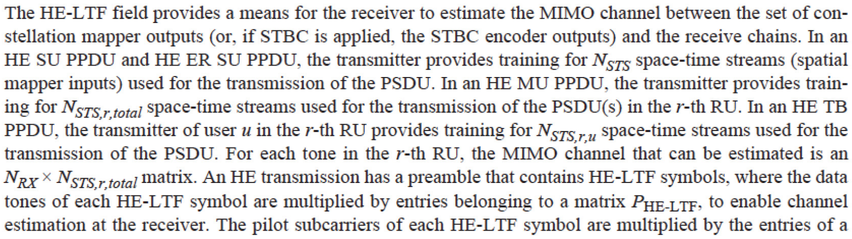
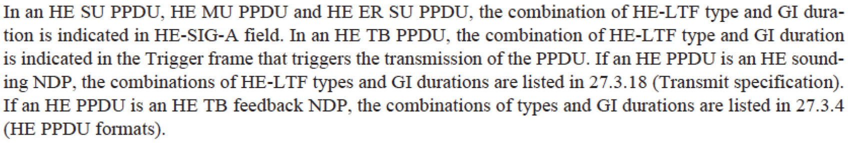
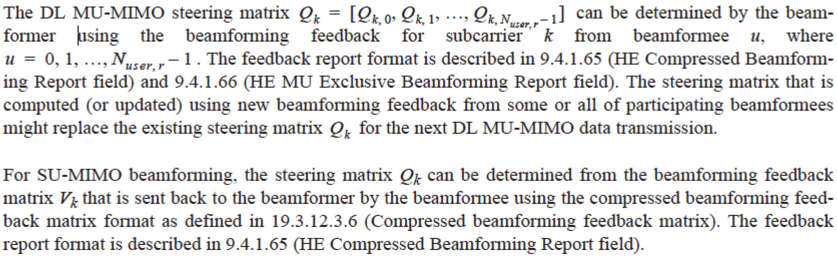
<i>See</i>, <i>e.g.</i>, IEEE 802.11ac Standard Clause 9.31.5.1
</td></tr>
</table>

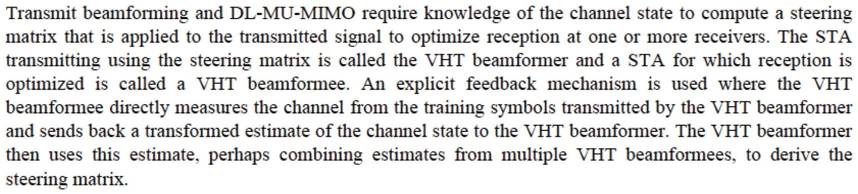
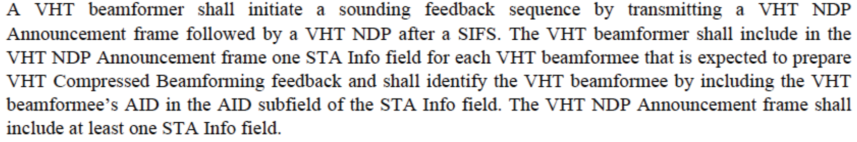
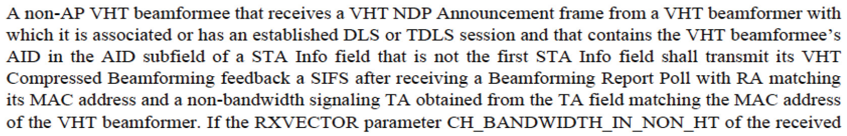
Claim 1	iPhone 12
	 *See*, *e.g.*, IEEE 802.11ac Standard Clause 22.3.4.6(d)

Claim 1	iPhone 12
	 The VHT-SIG-B field is constructed per-user as follows: a) Obtain the VHT-MCS (for MU only) and APEP_LENGTH from the TXVECTOR. b) VHT-SIG-B bits: Set the VHT-MCS (for MU only) and VHT-SIG-B Length field as described in 22.3.8.3.6. Add the reserved bits (for SU only) and N_{tail} bits of tail. For an NDP set VHT-SIG-B to the fixed bit pattern for the bandwidth used as described in 22.3.8.3.6. c) VHT-SIG-B Bit Repetition: Repeat the VHT-SIG-B bits as a function of CH_BANDWIDTH as defined in 22.3.8.3.6. d) BCC encoder: Encode the VHT-SIG-B field using BCC at rate R=1/2 as described in 18.3.5.6. e) Segment parser (if needed): For a contiguous 160 MHz or noncontiguous 80+80 MHz transmission, divide the output bits of the BCC encoder into two frequency subblocks as described in 22.3.10.7. This block is bypassed for 20 MHz, 40 MHz, and 80 MHz VHT PPDU transmissions. f) BCC interleaver: Interleave as described in 22.3.10.8. g) Constellation mapper: Map to a BPSK constellation as defined in 18.3.5.8. h) Segment deparser (if needed): For a contiguous 160 MHz transmission, merge the two frequency subblocks into one frequency segment as described in 22.3.10.9.3. This block is bypassed for 20 MHz, 40 MHz, 80 MHz, and 80+80 MHz VHT PPDU transmissions. i) Pilot insertion: Insert pilots following the steps described in 22.3.10.10. j) P_{VHTLTF} matrix mapping: Apply the mapping of the 1st column of the P_{VHTLTF} matrix to the data subcarriers as described in 22.3.8.3.6. The total number of data and pilot subcarriers is the same as in the Data field. k) CSD: Apply CSD for each space-time stream and frequency segment as described in 22.3.8.3.2. l) Spatial mapping: Apply the Q matrix as described in 22.3.10.11.1. m) Phase rotation: Apply the appropriate phase rotations for each 20 MHz subchannel as described in 22.3.7.4 and 22.3.7.5. n) IDFT: Compute the inverse discrete Fourier transform. o) Insert GI and apply windowing: Prepend a GI (LONG_GI) and apply windowing as described in 22.3.7.4. p) 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 22.3.7.4 and 22.3.8 for details. *See*, *e.g.*, IEEE 802.11ac Standard Clauses 22.3.4.8(l) and 22.3.4.9.1(m), 22.3.4.9.2(m), 22.3.4.10.4(a).

Claim 1	iPhone 12
	 The DL-MU-MIMO steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user}-1}]$ can be determined by the beamformer using the beamforming feedback matrices for subcarrier k from beamformee u, $V_{k,u,}$ and SNR information for subcarrier k from beamformee u, $SNR_{k,u}$, where $u = 0, 1, \ldots, N_{user} - 1$. The steering matrix that is computed (or updated) using new beamforming feedback matrices and new SNR information from some or all of participating beamformees might replace the existing steering matrix Q_k for the next DL-MU-MIMO data transmission. The beamformee group for the MU transmission is signaled using the Group ID field in VHT-SIG-A (see 22.3.8.3.3 and 22.3.11.4). *See*, *e.g.*, IEEE 802.11ac Standard Clause 22.3.11.1  Upon receipt of a VHT NDP sounding PPDU, the beamformee shall remove the space-time stream CSD in Table 22-11 from the measured channel before computing a set of matrices for feedback to the beamformer. The beamforming feedback matrix, $V_{k,u}$, found by the beamformee u for subcarrier k shall be compressed in the form of angles using the method described in 20.3.12.3.6. The angles, $\phi(k,\upsilon)$ and $\psi(k,u)$, are quantized according to Table 8-53e. The number of bits for quantization is chosen by the beamformee, based on the indication from the beamformer as to whether the feedback is requested for SU-MIMO beamforming or DL-MU-MIMO beamforming. The compressed beamforming feedback using 20.3.12.3.6 is the only Clause 22 beamforming feedback format defined. The beamformee shall generate the beamforming feedback matrices with the number of rows (Nr) equal to the N_{STS} of the NDP. After receiving the angle information, $\phi(k,u)$ and $\psi(k,u)$, the beamformer reconstructs $V_{k,u}$ using Equation (20-79). For SU-MIMO beamforming, the beamformer can use this $V_{k,0}$ matrix to determine the steering matrix Q_k. For DL-MU-MIMO beamforming, the beamformer may calculate a steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user}-1}]$ using $V_{k,u}$ and $SNR_{k,u}$ $(0 \le u \le N_{user} - 1)$ in order to suppress crosstalk between participating beamformees. The method used by the beamformer to calculate the steering matrix Q_k is implementation specific. *See*, *e.g.*, IEEE 802.11ac Standard Clause 22.3.11.2
[1e] determine first signal information for the first signal transmission;	The processor in the iPhone 12 determines first signal information for the first signal transmission. For example, the iPhone 12 determines the first signal information for the first signal transmission, by determining symbols corresponding to e.g. a first space-time stream using e.g. the training fields of a null data packet for MU-MIMO sounding and channel

Claim 1	iPhone 12
	estimation, which allows for determining, e.g., an estimate of the channel state, e.g., a transformed estimate of the channel state to be transmitted in a compressed beamforming report, e.g., the parameters in the beamforming feedback matrix.  Transmit beamforming and DL MU-MIMO require knowledge of the channel state to compute a steering matrix that is applied to the transmit signal to optimize reception at one or more receivers. HE STAs use the HE sounding protocol to determine the channel state information. The HE sounding protocol provides explicit feedback mechanisms, defined as HE non-trigger-based (non-TB) sounding and HE trigger-based (TB) sounding, where the HE beamformee measures the channel using a training signal (i.e., an HE sounding NDP) transmitted by the HE beamformer and sends back a transformed estimate of the channel state. The HE beamformer uses this estimate to derive the steering matrix.  The HE beamformee returns an estimate of the channel state in an HE compressed beamforming/CQI report carried in one or more HE Compressed Beamforming/CQI frames. There are three types of HE compressed beamforming/CQI report: *See*, *e.g.*, IEEE 802.11ax Standard, Section 26.7.1  An HE beamformee that receives an HE NDP Announcement frame from an HE beamformer with which it is associated and that contains the HE beamformee's MAC address in the RA field and also receives an HE sounding NDP a SIFS after the HE NDP Announcement frame shall transmit its HE compressed beamforming/CQI report a SIFS after the HE sounding NDP. The TXVECTOR parameter CH_BANDWIDTH for the PPDU containing the HE compressed beamforming/CQI report shall be set to indicate a bandwidth not wider than that indicated by the RXVECTOR parameter CH_BANDWIDTH of the HE sounding NDP. *See*, *e.g.*, IEEE 802.11ax Standard, Section 26.7.3  An HE beamformee that receives an HE NDP Announcement frame as part of an HE TB sounding sequence with a STA Info field addressed to it soliciting SU or MU feedback shall generate an HE compressed beamforming/CQI report using the feedback type, *Ng* and codebook size indicated in the STA Info field. If the HE beamformee then receives a BFRP Trigger frame with a User Info field addressed to it, the HE beamformee transmits an HE TB PPDU containing the HE compressed beamforming/CQI report following the rules defined in 26.5.3.3 (Non-AP STA behavior for UL MU operation). If the HE NDP Announcement frame has *See*, *e.g.*, IEEE 802.11ax Standard, Section 26.7.3  UL MU operation allows an AP to solicit simultaneous immediate response frames from one or more non-AP HE STAs. A non-AP HE STA shall follow the rules in this subclause for the transmission of response *See*, *e.g.*, IEEE 802.11ax Standard, Section 26.5.3

Claim 1	iPhone 12
	 The HE-LTF field provides a means for the receiver to estimate the MIMO channel between the set of constellation mapper outputs (or, if STBC is applied, the STBC encoder outputs) and the receive chains. In an HE SU PPDU and HE ER SU PPDU, the transmitter provides training for N_{STS} space-time streams (spatial mapper inputs) used for the transmission of the PSDU. In an HE MU PPDU, the transmitter provides training for $N_{STS,r,total}$ space-time streams used for the transmission of the PSDU(s) in the r-th RU. In an HE TB PPDU, the transmitter of user u in the r-th RU provides training for $N_{STS,r,u}$ space-time streams used for the transmission of the PSDU. For each tone in the r-th RU, the MIMO channel that can be estimated is an $N_{RX} \times N_{STS,r,total}$ matrix. An HE transmission has a preamble that contains HE-LTF symbols, where the data tones of each HE-LTF symbol are multiplied by entries belonging to a matrix $P_{\text{HE-LTF}}$, to enable channel estimation at the receiver. The pilot subcarriers of each HE-LTF symbol are multiplied by the entries of a *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.10.10  In an HE SU PPDU, HE MU PPDU and HE ER SU PPDU, the combination of HE-LTF type and GI duration is indicated in HE-SIG-A field. In an HE TB PPDU, the combination of HE-LTF type and GI duration is indicated in the Trigger frame that triggers the transmission of the PPDU. If an HE PPDU is an HE sounding NDP, the combinations of HE-LTF types and GI durations are listed in 27.3.18 (Transmit specification). If an HE PPDU is an HE TB feedback NDP, the combinations of types and GI durations are listed in 27.3.4 (HE PPDU formats). *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.10.10  The DL MU-MIMO steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user,r}-1}]$ can be determined by the beamformer using the beamforming feedback for subcarrier k from beamformee u, where $u = 0, 1, \ldots, N_{user,r}-1$. The feedback report format is described in 9.4.1.65 (HE Compressed Beamforming Report field) and 9.4.1.66 (HE MU Exclusive Beamforming Report field). The steering matrix that is computed (or updated) using new beamforming feedback from some or all of participating beamformees might replace the existing steering matrix Q_k for the next DL MU-MIMO data transmission. For SU-MIMO beamforming, the steering matrix Q_k can be determined from the beamforming feedback matrix V_k that is sent back to the beamformer by the beamformee using the compressed beamforming feedback matrix format as defined in 19.3.12.3.6 (Compressed beamforming feedback matrix). The feedback report format is described in 9.4.1.65 (HE Compressed Beamforming Report field). *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.15.1

Claim 1	iPhone 12
	 Transmit beamforming and DL-MU-MIMO require knowledge of the channel state to compute a steering matrix that is applied to the transmitted signal to optimize reception at one or more receivers. The STA transmitting using the steering matrix is called the VHT beamformer and a STA for which reception is optimized is called a VHT beamformee. An explicit feedback mechanism is used where the VHT beamformee directly measures the channel from the training symbols transmitted by the VHT beamformer and sends back a transformed estimate of the channel state to the VHT beamformer. The VHT beamformer then uses this estimate, perhaps combining estimates from multiple VHT beamformees, to derive the steering matrix. *See*, *e.g.*, IEEE 802.11ac Standard Clause 9.31.5.1  A VHT beamformer shall initiate a sounding feedback sequence by transmitting a VHT NDP Announcement frame followed by a VHT NDP after a SIFS. The VHT beamformer shall include in the VHT NDP Announcement frame one STA Info field for each VHT beamformee that is expected to prepare VHT Compressed Beamforming feedback and shall identify the VHT beamformee by including the VHT beamformee's AID in the AID subfield of the STA Info field. The VHT NDP Announcement frame shall include at least one STA Info field. *See*, *e.g.*, IEEE 802.11ac Standard Clause 9.31.5.2  A non-AP VHT beamformee that receives a VHT NDP Announcement frame from a VHT beamformer with which it is associated or has an established DLS or TDLS session and that contains the VHT beamformee's AID in the AID subfield of a STA Info field that is not the first STA Info field shall transmit its VHT Compressed Beamforming feedback a SIFS after receiving a Beamforming Report Poll with RA matching its MAC address and a non-bandwidth signaling TA obtained from the TA field matching the MAC address of the VHT beamformer. If the RXVECTOR parameter CH_BANDWIDTH_IN_NON_HT of the received *See*, *e.g.*, IEEE 802.11ac Standard Clause 9.31.5.2

<table>
<tr><th>Claim 1</th><th>iPhone 12</th></tr>
<tr><td></td><td>

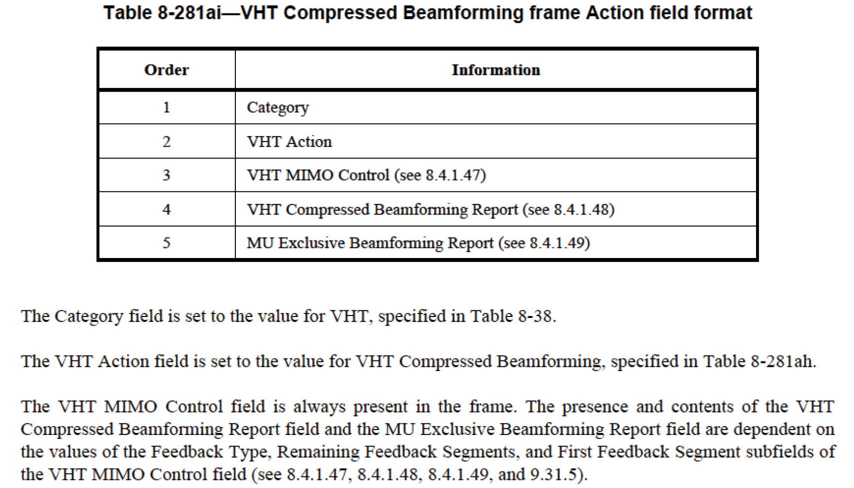
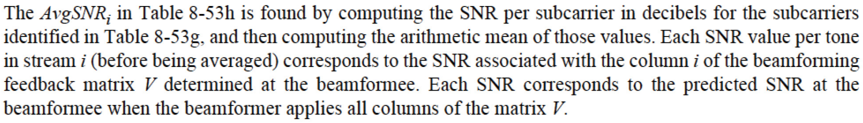



Table 8-281ai—VHT Compressed Beamforming frame Action field format
<table>
<tr><th>Order</th><th>Information</th></tr>
<tr><td>1</td><td>Category</td></tr>
<tr><td>2</td><td>VHT Action</td></tr>
<tr><td>3</td><td>VHT MIMO Control (see 8.4.1.47)</td></tr>
<tr><td>4</td><td>VHT Compressed Beamforming Report (see 8.4.1.48)</td></tr>
<tr><td>5</td><td>MU Exclusive Beamforming Report (see 8.4.1.49)</td></tr>
</table>
The Category field is set to the value for VHT, specified in Table 8-38.

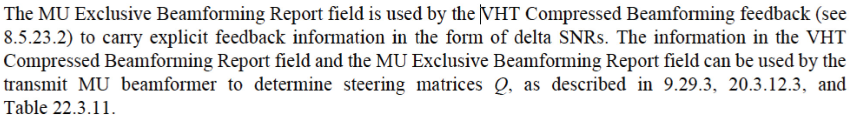
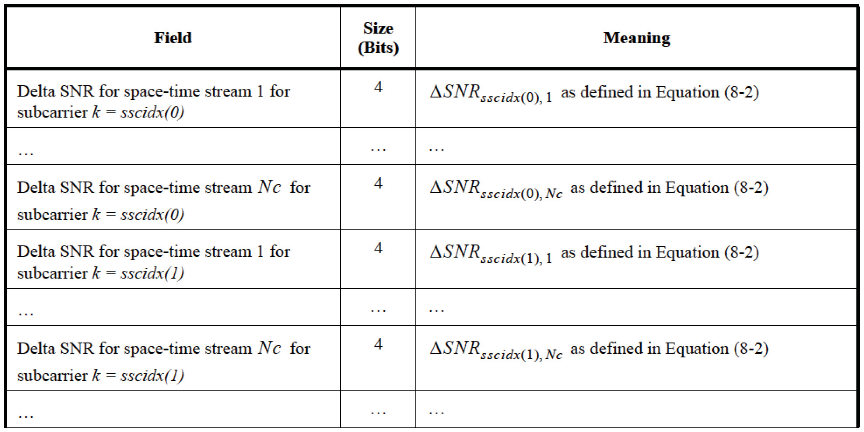
The VHT Action field is set to the value for VHT Compressed Beamforming, specified in Table 8-281ah.

The VHT MIMO Control field is always present in the frame. The presence and contents of the VHT Compressed Beamforming Report field and the MU Exclusive Beamforming Report field are dependent on the values of the Feedback Type, Remaining Feedback Segments, and First Feedback Segment subfields of the VHT MIMO Control field (see 8.4.1.47, 8.4.1.48, 8.4.1.49, and 9.31.5).

See, *e.g.*, IEEE 802.11ac Standard Clause 8.5.23.2
See Tables 8-53(d)-(h) in IEEE 802.11ac Standard Clause 8.4.1.48


The $AvgSNR_i$ in Table 8-53h is found by computing the SNR per subcarrier in decibels for the subcarriers identified in Table 8-53g, and then computing the arithmetic mean of those values. Each SNR value per tone in stream i (before being averaged) corresponds to the SNR associated with the column i of the beamforming feedback matrix V determined at the beamformee. Each SNR corresponds to the predicted SNR at the beamformee when the beamformer applies all columns of the matrix V.

See, *e.g.*, IEEE 802.11ac Standard Clause 8.4.1.48
</td></tr>
</table>

<table>
<tr><th>Claim 1</th><th>iPhone 12</th></tr>
<tr><td></td><td>

<p>The MU Exclusive Beamforming Report field is used by the VHT Compressed Beamforming feedback (see 8.5.23.2) to carry explicit feedback information in the form of delta SNRs. The information in the VHT Compressed Beamforming Report field and the MU Exclusive Beamforming Report field can be used by the transmit MU beamformer to determine steering matrices <i>Q</i>, as described in 9.29.3, 20.3.12.3, and Table 22.3.11.</p>
<p><i>See</i>, <i>e.g.</i>, IEEE 802.11ac Standard Clause 8.4.1.49</p>

<table>
<tr><th>Field</th><th>Size (Bits)</th><th>Meaning</th></tr>
<tr><td>Delta SNR for space-time stream 1 for subcarrier $k = sscidx(0)$</td><td>4</td><td>$\Delta SNR_{sscidx(0),1}$ as defined in Equation (8-2)</td></tr>
<tr><td>…</td><td>…</td><td>…</td></tr>
<tr><td>Delta SNR for space-time stream Nc for subcarrier $k = sscidx(0)$</td><td>4</td><td>$\Delta SNR_{sscidx(0),Nc}$ as defined in Equation (8-2)</td></tr>
<tr><td>Delta SNR for space-time stream 1 for subcarrier $k = sscidx(1)$</td><td>4</td><td>$\Delta SNR_{sscidx(1),1}$ as defined in Equation (8-2)</td></tr>
<tr><td>…</td><td>…</td><td>…</td></tr>
<tr><td>Delta SNR for space-time stream Nc for subcarrier $k = sscidx(1)$</td><td>4</td><td>$\Delta SNR_{sscidx(1),Nc}$ as defined in Equation (8-2)</td></tr>
<tr><td>…</td><td>…</td><td>…</td></tr>
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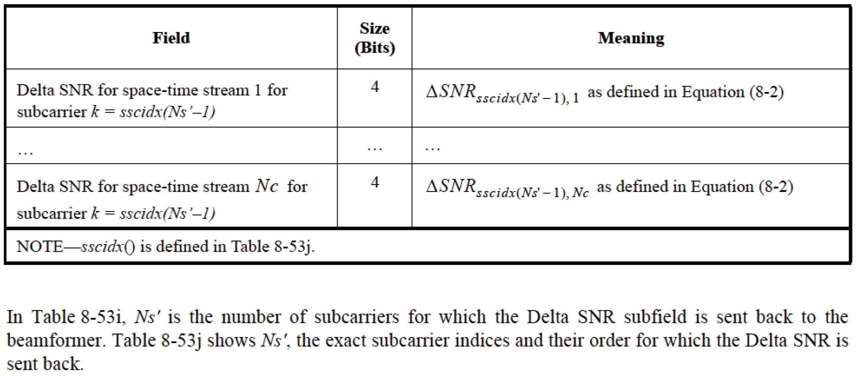
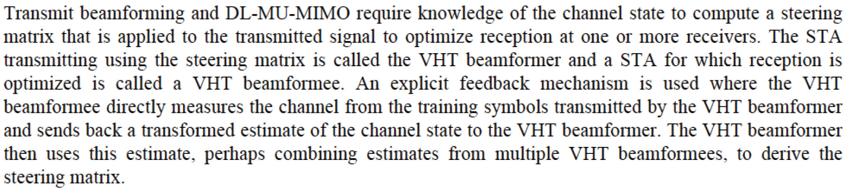
<table>
<tr><th>Claim 1</th><th>iPhone 12</th></tr>
<tr><td></td><td>



<table>
<tr><th>Field</th><th>Size (Bits)</th><th>Meaning</th></tr>
<tr><td>Delta SNR for space-time stream 1 for subcarrier $k = sscidx(Ns'-1)$</td><td>4</td><td>$\Delta SNR_{sscidx(Ns'-1),1}$ as defined in Equation (8-2)</td></tr>
<tr><td>…</td><td>…</td><td>…</td></tr>
<tr><td>Delta SNR for space-time stream Nc for subcarrier $k = sscidx(Ns'-1)$</td><td>4</td><td>$\Delta SNR_{sscidx(Ns'-1),Nc}$ as defined in Equation (8-2)</td></tr>
<tr><td colspan="3">NOTE—<i>sscidx</i>() is defined in Table 8-53j.</td></tr>
</table>

In Table 8-53i, Ns' is the number of subcarriers for which the Delta SNR subfield is sent back to the beamformer. Table 8-53j shows Ns', the exact subcarrier indices and their order for which the Delta SNR is sent back.

<i>See</i>, <i>e.g.</i>, Table 8-53i IEEE 802.11ac Standard Clause 8.4.1.48



Transmit beamforming and DL-MU-MIMO require knowledge of the channel state to compute a steering matrix that is applied to the transmitted signal to optimize reception at one or more receivers. The STA transmitting using the steering matrix is called the VHT beamformer and a STA for which reception is optimized is called a VHT beamformee. An explicit feedback mechanism is used where the VHT beamformee directly measures the channel from the training symbols transmitted by the VHT beamformer and sends back a transformed estimate of the channel state to the VHT beamformer. The VHT beamformer then uses this estimate, perhaps combining estimates from multiple VHT beamformees, to derive the steering matrix.

<i>See</i>, <i>e.g.</i>, IEEE 802.11ac Standard Clause 9.31.5.1

</td></tr>
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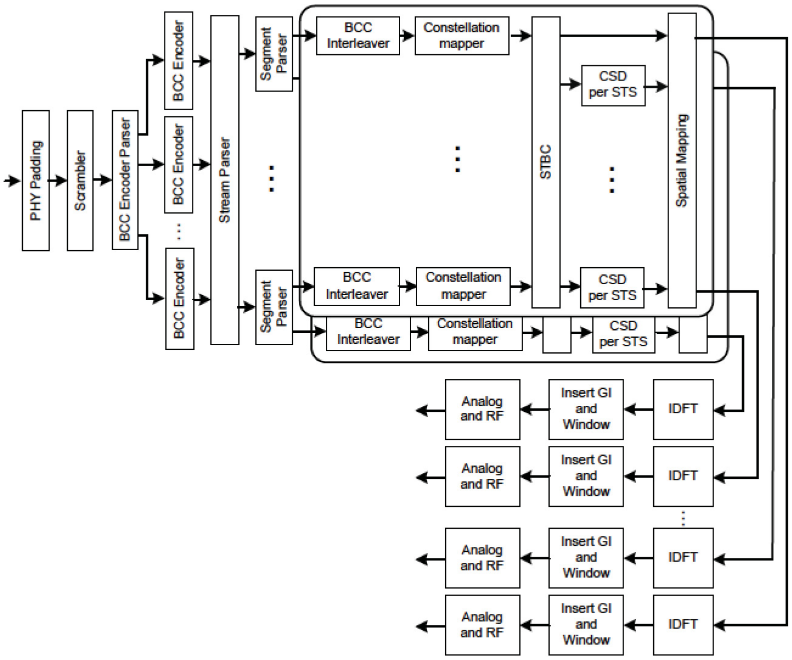
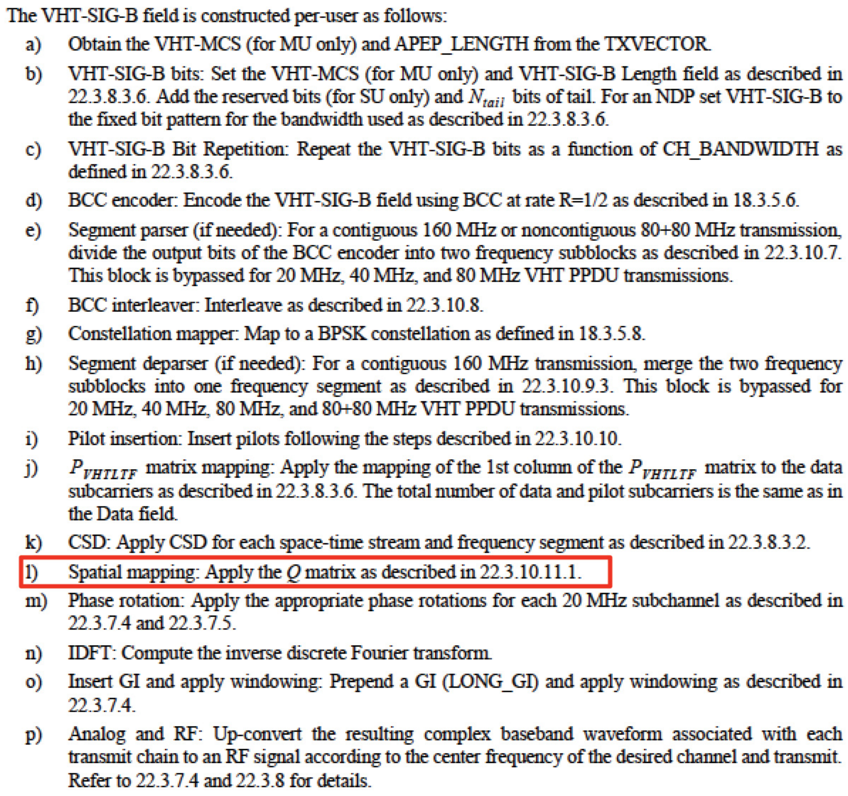
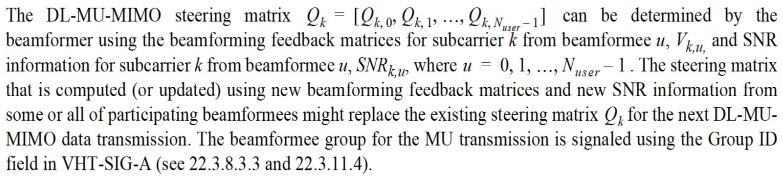
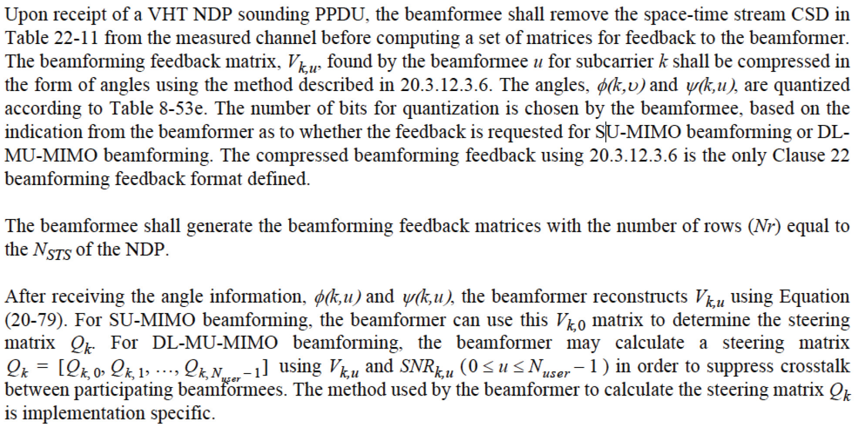
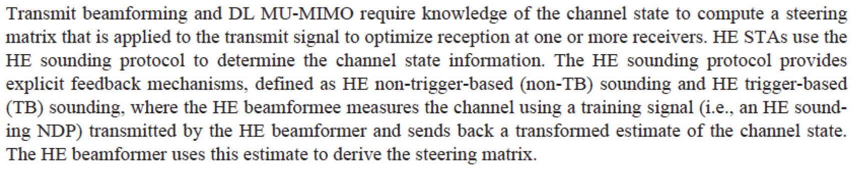
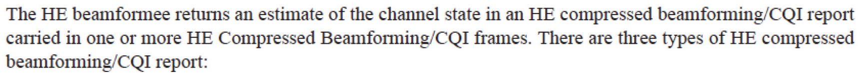
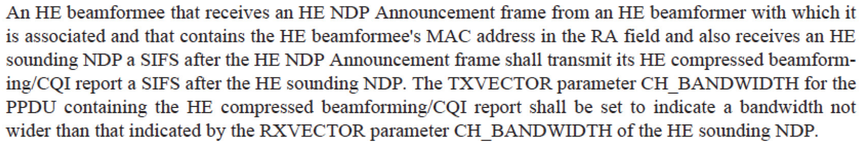
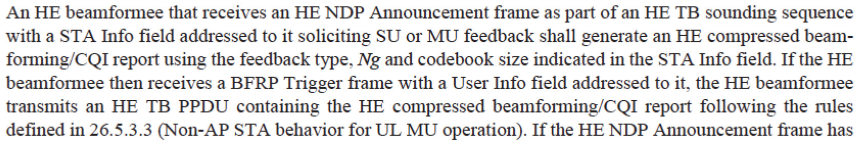
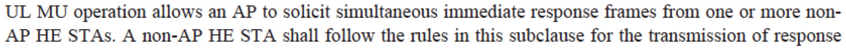
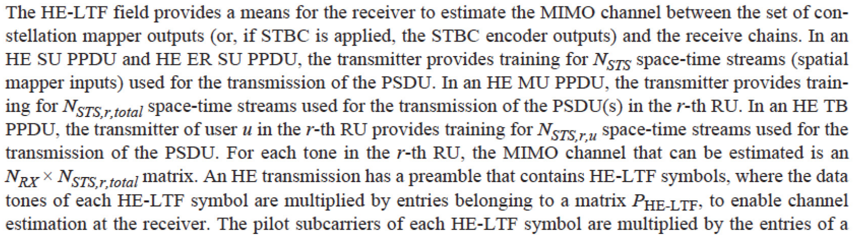
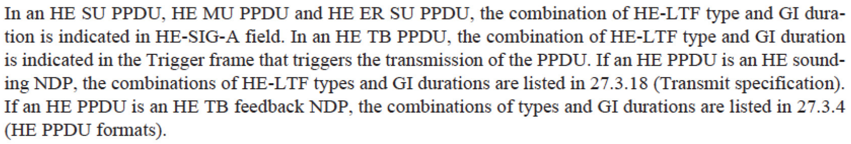
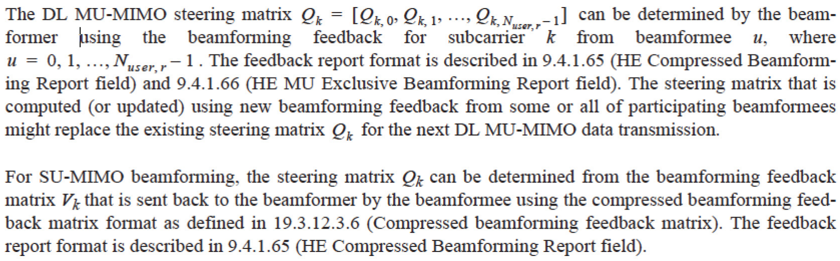
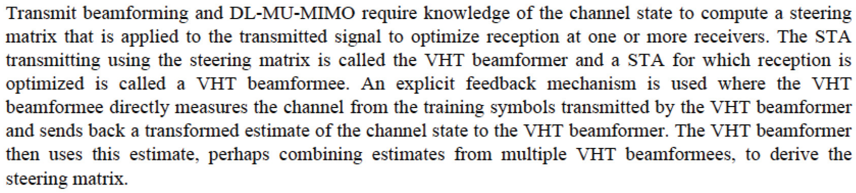
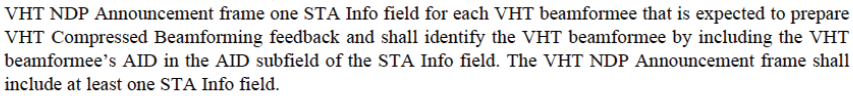
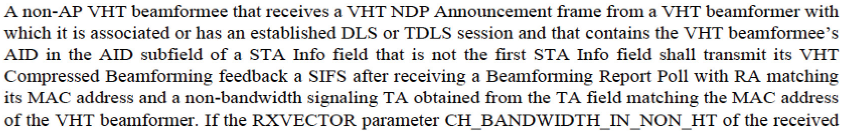
Claim 1	iPhone 12
	 *See*, *e.g.*, IEEE 802.11ac Standard Clause 22.3.4.6(d)

Claim 1	iPhone 12
	 The VHT-SIG-B field is constructed per-user as follows: a) Obtain the VHT-MCS (for MU only) and APEP_LENGTH from the TXVECTOR. b) VHT-SIG-B bits: Set the VHT-MCS (for MU only) and VHT-SIG-B Length field as described in 22.3.8.3.6. Add the reserved bits (for SU only) and N_{tail} bits of tail. For an NDP set VHT-SIG-B to the fixed bit pattern for the bandwidth used as described in 22.3.8.3.6. c) VHT-SIG-B Bit Repetition: Repeat the VHT-SIG-B bits as a function of CH_BANDWIDTH as defined in 22.3.8.3.6. d) BCC encoder: Encode the VHT-SIG-B field using BCC at rate R=1/2 as described in 18.3.5.6. e) Segment parser (if needed): For a contiguous 160 MHz or noncontiguous 80+80 MHz transmission, divide the output bits of the BCC encoder into two frequency subblocks as described in 22.3.10.7. This block is bypassed for 20 MHz, 40 MHz, and 80 MHz VHT PPDU transmissions. f) BCC interleaver: Interleave as described in 22.3.10.8. g) Constellation mapper: Map to a BPSK constellation as defined in 18.3.5.8. h) Segment deparser (if needed): For a contiguous 160 MHz transmission, merge the two frequency subblocks into one frequency segment as described in 22.3.10.9.3. This block is bypassed for 20 MHz, 40 MHz, 80 MHz, and 80+80 MHz VHT PPDU transmissions. i) Pilot insertion: Insert pilots following the steps described in 22.3.10.10. j) P_{VHTLTF} matrix mapping: Apply the mapping of the 1st column of the P_{VHTLTF} matrix to the data subcarriers as described in 22.3.8.3.6. The total number of data and pilot subcarriers is the same as in the Data field. k) CSD: Apply CSD for each space-time stream and frequency segment as described in 22.3.8.3.2. l) Spatial mapping: Apply the Q matrix as described in 22.3.10.11.1. m) Phase rotation: Apply the appropriate phase rotations for each 20 MHz subchannel as described in 22.3.7.4 and 22.3.7.5. n) IDFT: Compute the inverse discrete Fourier transform. o) Insert GI and apply windowing: Prepend a GI (LONG_GI) and apply windowing as described in 22.3.7.4. p) 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 22.3.7.4 and 22.3.8 for details. *See*, *e.g.*, IEEE 802.11ac Standard Clauses 22.3.4.8(l) and 22.3.4.9.1(m), 22.3.4.9.2(m), 22.3.4.10.4(a).

Claim 1	iPhone 12
	 The DL-MU-MIMO steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user}-1}]$ can be determined by the beamformer using the beamforming feedback matrices for subcarrier k from beamformee u, $V_{k,u,}$ and SNR information for subcarrier k from beamformee u, $SNR_{k,u}$, where $u = 0, 1, \ldots, N_{user} - 1$. The steering matrix that is computed (or updated) using new beamforming feedback matrices and new SNR information from some or all of participating beamformees might replace the existing steering matrix Q_k for the next DL-MU-MIMO data transmission. The beamformee group for the MU transmission is signaled using the Group ID field in VHT-SIG-A (see 22.3.8.3.3 and 22.3.11.4). *See*, *e.g.*, IEEE 802.11ac Standard Clause 22.3.11.1  Upon receipt of a VHT NDP sounding PPDU, the beamformee shall remove the space-time stream CSD in Table 22-11 from the measured channel before computing a set of matrices for feedback to the beamformer. The beamforming feedback matrix, $V_{k,u}$, found by the beamformee u for subcarrier k shall be compressed in the form of angles using the method described in 20.3.12.3.6. The angles, $\phi(k,\upsilon)$ and $\psi(k,u)$, are quantized according to Table 8-53e. The number of bits for quantization is chosen by the beamformee, based on the indication from the beamformer as to whether the feedback is requested for SU-MIMO beamforming or DL-MU-MIMO beamforming. The compressed beamforming feedback using 20.3.12.3.6 is the only Clause 22 beamforming feedback format defined. The beamformee shall generate the beamforming feedback matrices with the number of rows (Nr) equal to the N_{STS} of the NDP. After receiving the angle information, $\phi(k,u)$ and $\psi(k,u)$, the beamformer reconstructs $V_{k,u}$ using Equation (20-79). For SU-MIMO beamforming, the beamformer can use this $V_{k,0}$ matrix to determine the steering matrix Q_k. For DL-MU-MIMO beamforming, the beamformer may calculate a steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user}-1}]$ using $V_{k,u}$ and $SNR_{k,u}$ $(0 \leq u \leq N_{user} - 1)$ in order to suppress crosstalk between participating beamformees. The method used by the beamformer to calculate the steering matrix Q_k is implementation specific. *See*, *e.g.*, IEEE 802.11ac Standard Clause 22.3.11.2
[1f] determine second signal information for the second signal transmission, wherein the second signal information is different than the first signal information;	The processor in the iPhone 12 determines second signal information for the second signal transmission, wherein the second signal information is different than the first signal information.

Claim 1	iPhone 12
	For example, the iPhone 12 determines the second signal information for the second signal transmission, by determining symbols corresponding to e.g. a second space-time stream using e.g. the training fields of a null data packet for MU-MIMO sounding and channel estimation, which allows for determining , e.g., an estimate of the channel state, e.g., a transformed estimate of the channel state to be transmitted in a compressed beamforming report, e.g., the parameters in the beamforming feedback matrix.  Transmit beamforming and DL MU-MIMO require knowledge of the channel state to compute a steering matrix that is applied to the transmit signal to optimize reception at one or more receivers. HE STAs use the HE sounding protocol to determine the channel state information. The HE sounding protocol provides explicit feedback mechanisms, defined as HE non-trigger-based (non-TB) sounding and HE trigger-based (TB) sounding, where the HE beamformee measures the channel using a training signal (i.e., an HE sounding NDP) transmitted by the HE beamformer and sends back a transformed estimate of the channel state. The HE beamformer uses this estimate to derive the steering matrix.  The HE beamformee returns an estimate of the channel state in an HE compressed beamforming/CQI report carried in one or more HE Compressed Beamforming/CQI frames. There are three types of HE compressed beamforming/CQI report: *See*, *e.g.*, IEEE 802.11ax Standard, Section 26.7.1  An HE beamformee that receives an HE NDP Announcement frame from an HE beamformer with which it is associated and that contains the HE beamformee's MAC address in the RA field and also receives an HE sounding NDP a SIFS after the HE NDP Announcement frame shall transmit its HE compressed beamforming/CQI report a SIFS after the HE sounding NDP. The TXVECTOR parameter CH_BANDWIDTH for the PPDU containing the HE compressed beamforming/CQI report shall be set to indicate a bandwidth not wider than that indicated by the RXVECTOR parameter CH_BANDWIDTH of the HE sounding NDP. *See*, *e.g.*, IEEE 802.11ax Standard, Section 26.7.3  An HE beamformee that receives an HE NDP Announcement frame as part of an HE TB sounding sequence with a STA Info field addressed to it soliciting SU or MU feedback shall generate an HE compressed beamforming/CQI report using the feedback type, *Ng* and codebook size indicated in the STA Info field. If the HE beamformee then receives a BFRP Trigger frame with a User Info field addressed to it, the HE beamformee transmits an HE TB PPDU containing the HE compressed beamforming/CQI report following the rules defined in 26.5.3.3 (Non-AP STA behavior for UL MU operation). If the HE NDP Announcement frame has *See*, *e.g.*, IEEE 802.11ax Standard, Section 26.7.3  UL MU operation allows an AP to solicit simultaneous immediate response frames from one or more non-AP HE STAs. A non-AP HE STA shall follow the rules in this subclause for the transmission of response

Claim 1	iPhone 12
	See, *e.g.*, IEEE 802.11ax Standard, Section 26.5.3  The HE-LTF field provides a means for the receiver to estimate the MIMO channel between the set of constellation mapper outputs (or, if STBC is applied, the STBC encoder outputs) and the receive chains. In an HE SU PPDU and HE ER SU PPDU, the transmitter provides training for N_{STS} space-time streams (spatial mapper inputs) used for the transmission of the PSDU. In an HE MU PPDU, the transmitter provides training for $N_{STS,r,total}$ space-time streams used for the transmission of the PSDU(s) in the r-th RU. In an HE TB PPDU, the transmitter of user u in the r-th RU provides training for $N_{STS,r,u}$ space-time streams used for the transmission of the PSDU. For each tone in the r-th RU, the MIMO channel that can be estimated is an $N_{RX} \times N_{STS,r,total}$ matrix. An HE transmission has a preamble that contains HE-LTF symbols, where the data tones of each HE-LTF symbol are multiplied by entries belonging to a matrix $P_{\text{HE-LTF}}$, to enable channel estimation at the receiver. The pilot subcarriers of each HE-LTF symbol are multiplied by the entries of a *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.10.10  In an HE SU PPDU, HE MU PPDU and HE ER SU PPDU, the combination of HE-LTF type and GI duration is indicated in HE-SIG-A field. In an HE TB PPDU, the combination of HE-LTF type and GI duration is indicated in the Trigger frame that triggers the transmission of the PPDU. If an HE PPDU is an HE sounding NDP, the combinations of HE-LTF types and GI durations are listed in 27.3.18 (Transmit specification). If an HE PPDU is an HE TB feedback NDP, the combinations of types and GI durations are listed in 27.3.4 (HE PPDU formats). *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.10.10  The DL MU-MIMO steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user,r}-1}]$ can be determined by the beamformer using the beamforming feedback for subcarrier k from beamformee u, where $u = 0, 1, \ldots, N_{user,r} - 1$. The feedback report format is described in 9.4.1.65 (HE Compressed Beamforming Report field) and 9.4.1.66 (HE MU Exclusive Beamforming Report field). The steering matrix that is computed (or updated) using new beamforming feedback from some or all of participating beamformees might replace the existing steering matrix Q_k for the next DL MU-MIMO data transmission. For SU-MIMO beamforming, the steering matrix Q_k can be determined from the beamforming feedback matrix V_k that is sent back to the beamformer by the beamformee using the compressed beamforming feedback matrix format as defined in 19.3.12.3.6 (Compressed beamforming feedback matrix). The feedback report format is described in 9.4.1.65 (HE Compressed Beamforming Report field). *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.15.1

Claim 1	iPhone 12
	 Transmit beamforming and DL-MU-MIMO require knowledge of the channel state to compute a steering matrix that is applied to the transmitted signal to optimize reception at one or more receivers. The STA transmitting using the steering matrix is called the VHT beamformer and a STA for which reception is optimized is called a VHT beamformee. An explicit feedback mechanism is used where the VHT beamformee directly measures the channel from the training symbols transmitted by the VHT beamformer and sends back a transformed estimate of the channel state to the VHT beamformer. The VHT beamformer then uses this estimate, perhaps combining estimates from multiple VHT beamformees, to derive the steering matrix. *See*, *e.g.*, IEEE 802.11ac Standard Clause 9.31.5.1  A VHT beamformer shall initiate a sounding feedback sequence by transmitting a VHT NDP Announcement frame followed by a VHT NDP after a SIFS. The VHT beamformer shall include in the VHT NDP Announcement frame one STA Info field for each VHT beamformee that is expected to prepare VHT Compressed Beamforming feedback and shall identify the VHT beamformee by including the VHT beamformee's AID in the AID subfield of the STA Info field. The VHT NDP Announcement frame shall include at least one STA Info field. *See*, *e.g.*, IEEE 802.11ac Standard Clause 9.31.5.2  A non-AP VHT beamformee that receives a VHT NDP Announcement frame from a VHT beamformer with which it is associated or has an established DLS or TDLS session and that contains the VHT beamformee's AID in the AID subfield of a STA Info field that is not the first STA Info field shall transmit its VHT Compressed Beamforming feedback a SIFS after receiving a Beamforming Report Poll with RA matching its MAC address and a non-bandwidth signaling TA obtained from the TA field matching the MAC address of the VHT beamformer. If the RXVECTOR parameter CH_BANDWIDTH_IN_NON_HT of the received *See*, *e.g.*, IEEE 802.11ac Standard Clause 9.31.5.2

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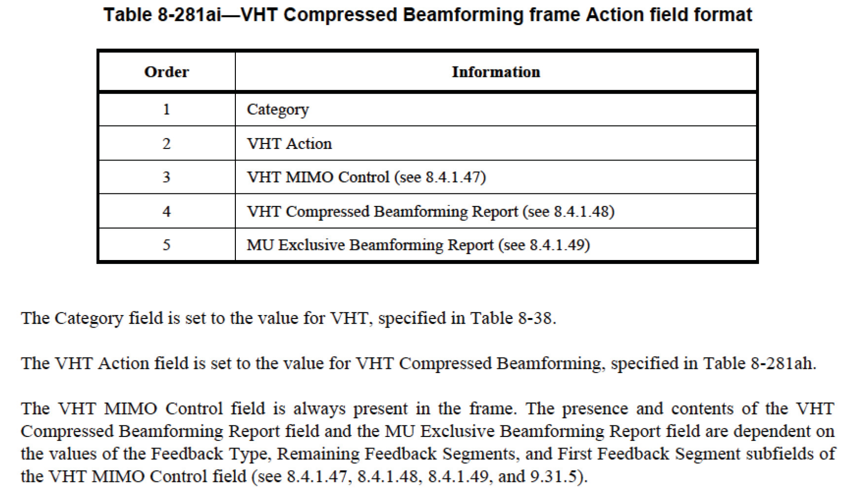
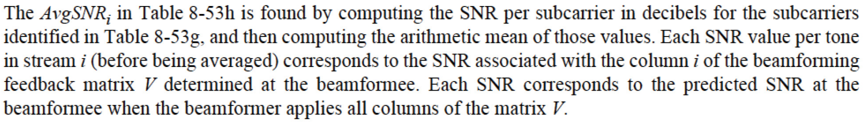


Table 8-281ai—VHT Compressed Beamforming frame Action field format
<table>
<tr><th>Order</th><th>Information</th></tr>
<tr><td>1</td><td>Category</td></tr>
<tr><td>2</td><td>VHT Action</td></tr>
<tr><td>3</td><td>VHT MIMO Control (see 8.4.1.47)</td></tr>
<tr><td>4</td><td>VHT Compressed Beamforming Report (see 8.4.1.48)</td></tr>
<tr><td>5</td><td>MU Exclusive Beamforming Report (see 8.4.1.49)</td></tr>
</table>
<p>The Category field is set to the value for VHT, specified in Table 8-38.</p>
<p>The VHT Action field is set to the value for VHT Compressed Beamforming, specified in Table 8-281ah.</p>
<p>The VHT MIMO Control field is always present in the frame. The presence and contents of the VHT Compressed Beamforming Report field and the MU Exclusive Beamforming Report field are dependent on the values of the Feedback Type, Remaining Feedback Segments, and First Feedback Segment subfields of the VHT MIMO Control field (see 8.4.1.47, 8.4.1.48, 8.4.1.49, and 9.31.5).</p>
<p><i>See</i>, <i>e.g.</i>, IEEE 802.11ac Standard Clause 8.5.23.2
<i>See</i> Tables 8-53(d)-(h) in IEEE 802.11ac Standard Clause 8.4.1.48</p>

<p>The $AvgSNR_i$ in Table 8-53h is found by computing the SNR per subcarrier in decibels for the subcarriers identified in Table 8-53g, and then computing the arithmetic mean of those values. Each SNR value per tone in stream i (before being averaged) corresponds to the SNR associated with the column i of the beamforming feedback matrix V determined at the beamformee. Each SNR corresponds to the predicted SNR at the beamformee when the beamformer applies all columns of the matrix V.</p>
<p><i>See</i>, <i>e.g.</i>, IEEE 802.11ac Standard Clause 8.4.1.48</p>
</td></tr>
</table>

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<tr><th>Claim 1</th><th>iPhone 12</th></tr>
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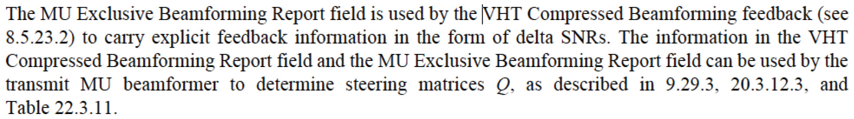
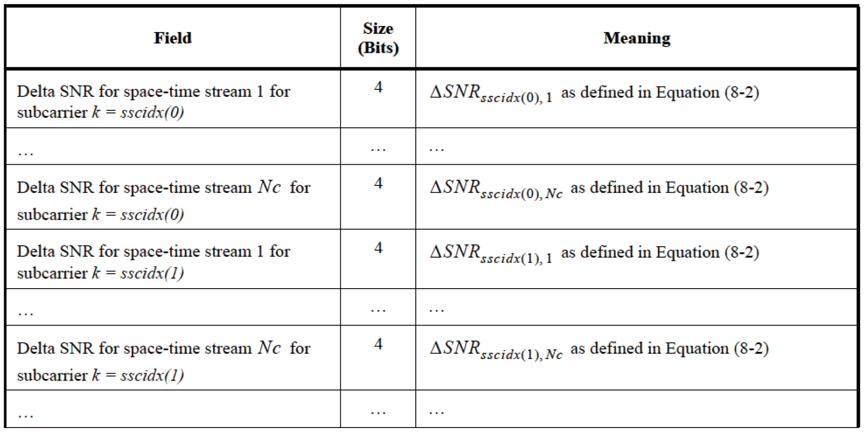


The MU Exclusive Beamforming Report field is used by the VHT Compressed Beamforming feedback (see 8.5.23.2) to carry explicit feedback information in the form of delta SNRs. The information in the VHT Compressed Beamforming Report field and the MU Exclusive Beamforming Report field can be used by the transmit MU beamformer to determine steering matrices Q, as described in 9.29.3, 20.3.12.3, and Table 22.3.11.

See, *e.g.*, IEEE 802.11ac Standard Clause 8.4.1.49



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<tr><th>Field</th><th>Size (Bits)</th><th>Meaning</th></tr>
<tr><td>Delta SNR for space-time stream 1 for subcarrier $k = sscidx(0)$</td><td>4</td><td>$\Delta SNR_{sscidx(0),1}$ as defined in Equation (8-2)</td></tr>
<tr><td>…</td><td>…</td><td>…</td></tr>
<tr><td>Delta SNR for space-time stream Nc for subcarrier $k = sscidx(0)$</td><td>4</td><td>$\Delta SNR_{sscidx(0),Nc}$ as defined in Equation (8-2)</td></tr>
<tr><td>Delta SNR for space-time stream 1 for subcarrier $k = sscidx(1)$</td><td>4</td><td>$\Delta SNR_{sscidx(1),1}$ as defined in Equation (8-2)</td></tr>
<tr><td>…</td><td>…</td><td>…</td></tr>
<tr><td>Delta SNR for space-time stream Nc for subcarrier $k = sscidx(1)$</td><td>4</td><td>$\Delta SNR_{sscidx(1),Nc}$ as defined in Equation (8-2)</td></tr>
<tr><td>…</td><td>…</td><td>…</td></tr>
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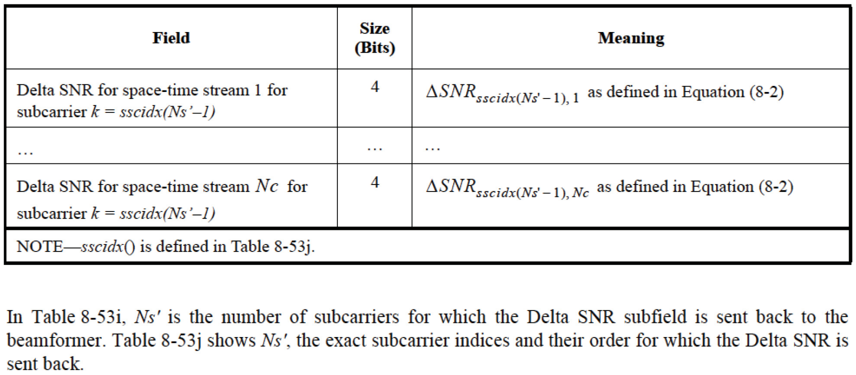
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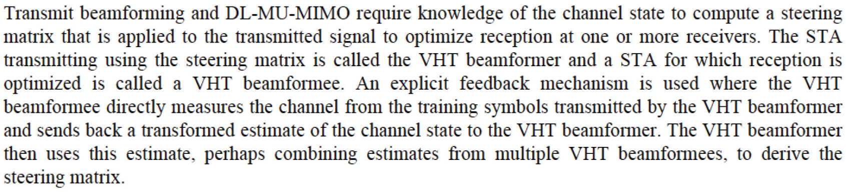
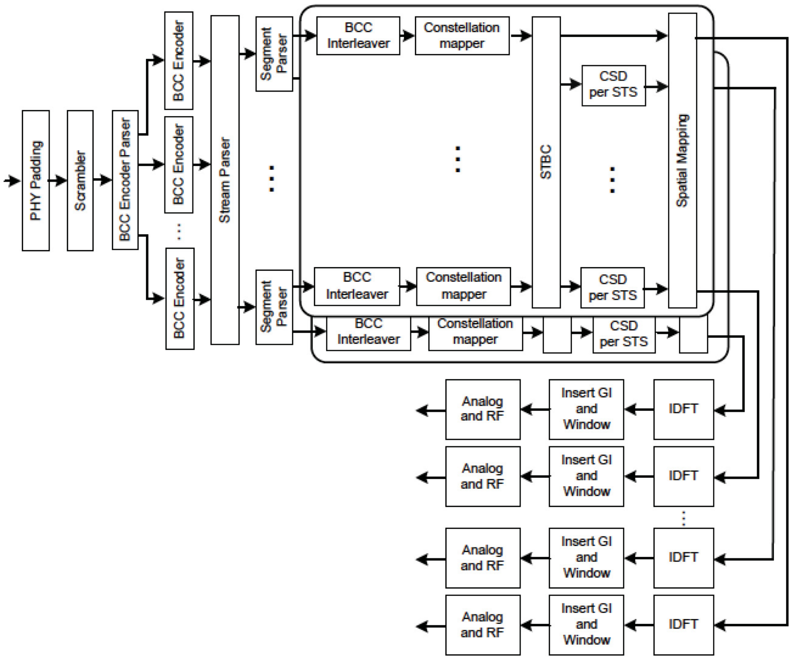
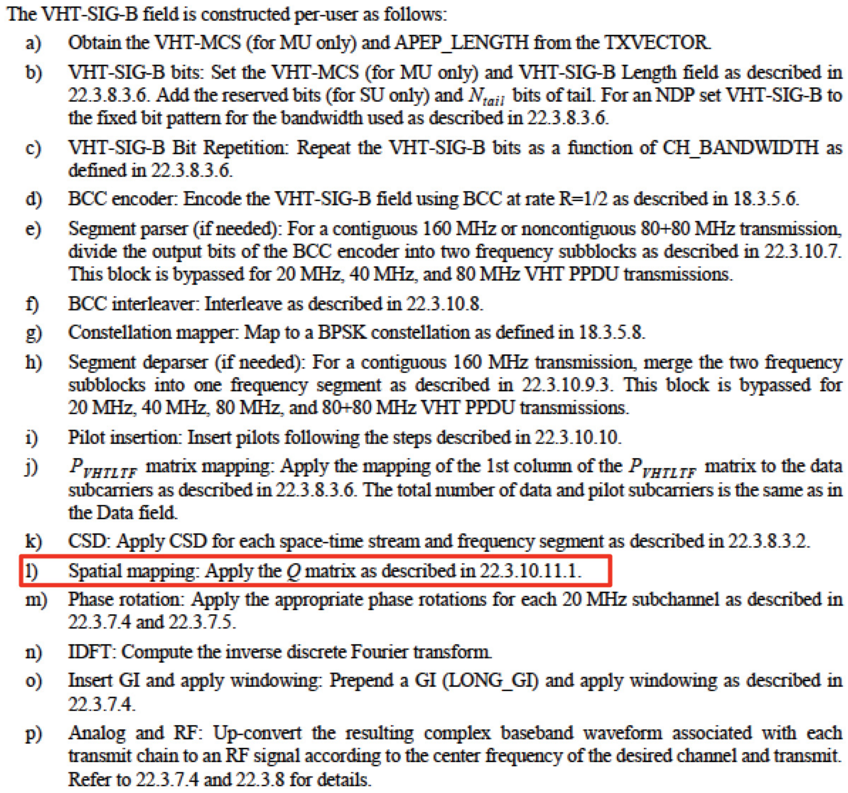
<tr><td>Delta SNR for space-time stream 1 for subcarrier $k = sscidx(Ns'-1)$</td><td>4</td><td>$\Delta SNR_{sscidx(Ns'-1), 1}$ as defined in Equation (8-2)</td></tr>
<tr><td>…</td><td>…</td><td>…</td></tr>
<tr><td>Delta SNR for space-time stream Nc for subcarrier $k = sscidx(Ns'-1)$</td><td>4</td><td>$\Delta SNR_{sscidx(Ns'-1), Nc}$ as defined in Equation (8-2)</td></tr>
<tr><td colspan="3">NOTE—<i>sscidx</i>() is defined in Table 8-53j.</td></tr>
</table>
<p>In Table 8-53i, Ns' is the number of subcarriers for which the Delta SNR subfield is sent back to the beamformer. Table 8-53j shows Ns', the exact subcarrier indices and their order for which the Delta SNR is sent back.</p>
<p><i>See</i>, <i>e.g.</i>, Table 8-53i IEEE 802.11ac Standard Clause 8.4.1.48</p>

<p>Transmit beamforming and DL-MU-MIMO require knowledge of the channel state to compute a steering matrix that is applied to the transmitted signal to optimize reception at one or more receivers. The STA transmitting using the steering matrix is called the VHT beamformer and a STA for which reception is optimized is called a VHT beamformee. An explicit feedback mechanism is used where the VHT beamformee directly measures the channel from the training symbols transmitted by the VHT beamformer and sends back a transformed estimate of the channel state to the VHT beamformer. The VHT beamformer then uses this estimate, perhaps combining estimates from multiple VHT beamformees, to derive the steering matrix.</p>
<p><i>See</i>, <i>e.g.</i>, IEEE 802.11ac Standard Clause 9.31.5.1</p>
</td></tr>
</table>

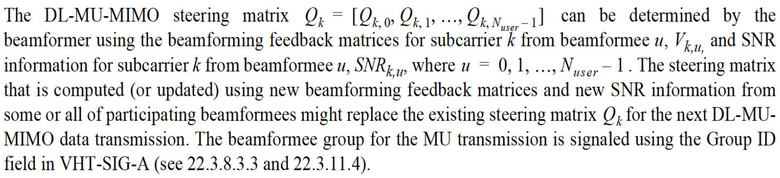
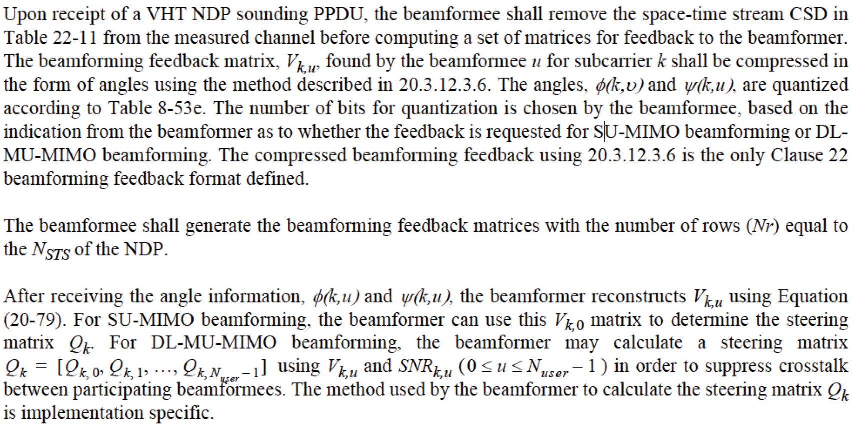
<table>
<tr><th>Claim 1</th><th>iPhone 12</th></tr>
<tr><td></td><td>

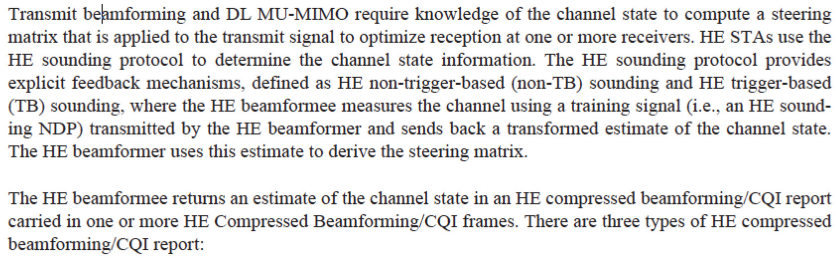
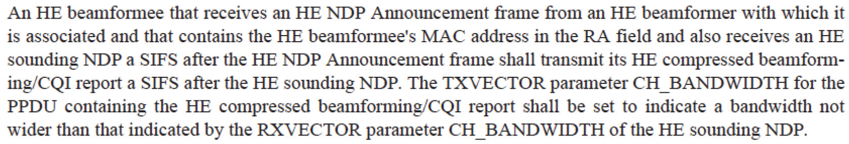


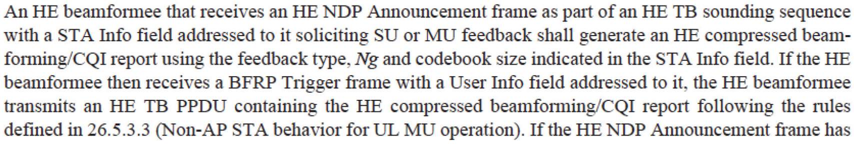
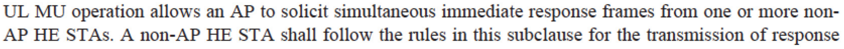
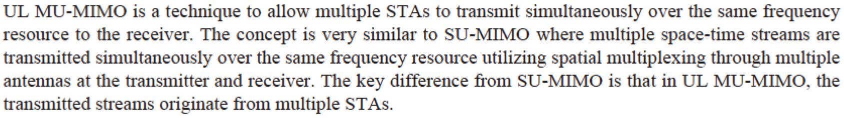
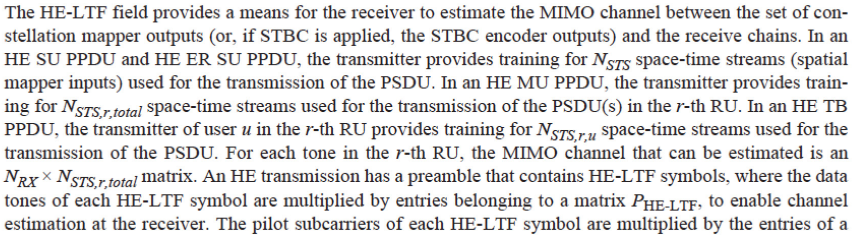
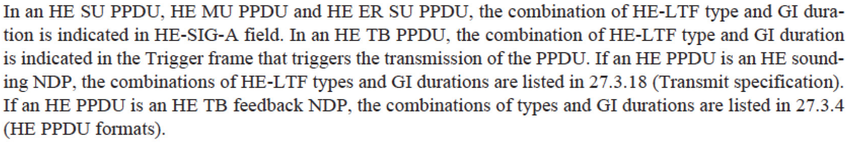
See, *e.g.*, IEEE 802.11ac Standard Clause 22.3.4.6(d)

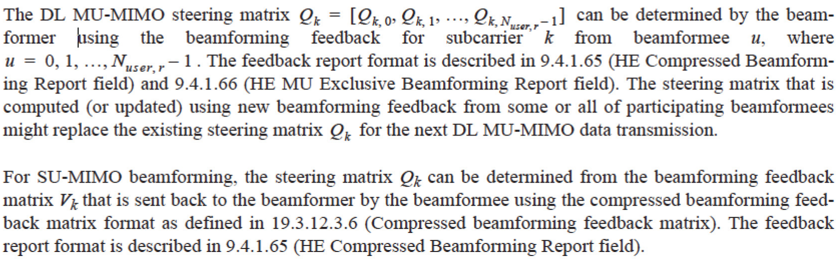
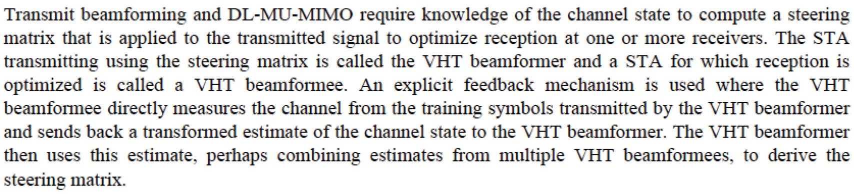
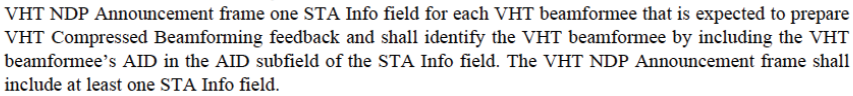
</td></tr>
</table>

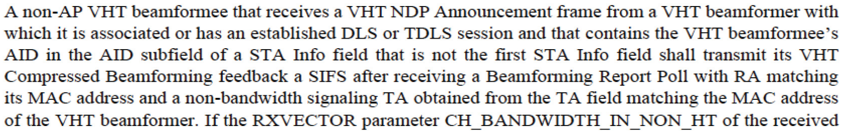
Claim 1	iPhone 12
	 The VHT-SIG-B field is constructed per-user as follows: a) Obtain the VHT-MCS (for MU only) and APEP_LENGTH from the TXVECTOR. b) VHT-SIG-B bits: Set the VHT-MCS (for MU only) and VHT-SIG-B Length field as described in 22.3.8.3.6. Add the reserved bits (for SU only) and N_{tail} bits of tail. For an NDP set VHT-SIG-B to the fixed bit pattern for the bandwidth used as described in 22.3.8.3.6. c) VHT-SIG-B Bit Repetition: Repeat the VHT-SIG-B bits as a function of CH_BANDWIDTH as defined in 22.3.8.3.6. d) BCC encoder: Encode the VHT-SIG-B field using BCC at rate R=1/2 as described in 18.3.5.6. e) Segment parser (if needed): For a contiguous 160 MHz or noncontiguous 80+80 MHz transmission, divide the output bits of the BCC encoder into two frequency subblocks as described in 22.3.10.7. This block is bypassed for 20 MHz, 40 MHz, and 80 MHz VHT PPDU transmissions. f) BCC interleaver: Interleave as described in 22.3.10.8. g) Constellation mapper: Map to a BPSK constellation as defined in 18.3.5.8. h) Segment deparser (if needed): For a contiguous 160 MHz transmission, merge the two frequency subblocks into one frequency segment as described in 22.3.10.9.3. This block is bypassed for 20 MHz, 40 MHz, 80 MHz, and 80+80 MHz VHT PPDU transmissions. i) Pilot insertion: Insert pilots following the steps described in 22.3.10.10. j) P_{VHTLTF} matrix mapping: Apply the mapping of the 1st column of the P_{VHTLTF} matrix to the data subcarriers as described in 22.3.8.3.6. The total number of data and pilot subcarriers is the same as in the Data field. k) CSD: Apply CSD for each space-time stream and frequency segment as described in 22.3.8.3.2. l) Spatial mapping: Apply the Q matrix as described in 22.3.10.11.1. m) Phase rotation: Apply the appropriate phase rotations for each 20 MHz subchannel as described in 22.3.7.4 and 22.3.7.5. n) IDFT: Compute the inverse discrete Fourier transform. o) Insert GI and apply windowing: Prepend a GI (LONG_GI) and apply windowing as described in 22.3.7.4. p) 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 22.3.7.4 and 22.3.8 for details. *See*, *e.g.*, IEEE 802.11ac Standard Clauses 22.3.4.8(l) and 22.3.4.9.1(m), 22.3.4.9.2(m), 22.3.4.10.4(a).

Claim 1	iPhone 12
	 The DL-MU-MIMO steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user}-1}]$ can be determined by the beamformer using the beamforming feedback matrices for subcarrier k from beamformee u, $V_{k,u}$, and SNR information for subcarrier k from beamformee u, $SNR_{k,u}$, where $u = 0, 1, \ldots, N_{user}-1$. The steering matrix that is computed (or updated) using new beamforming feedback matrices and new SNR information from some or all of participating beamformees might replace the existing steering matrix Q_k for the next DL-MU-MIMO data transmission. The beamformee group for the MU transmission is signaled using the Group ID field in VHT-SIG-A (see 22.3.8.3.3 and 22.3.11.4). *See*, *e.g.*, IEEE 802.11ac Standard Clause 22.3.11.1  Upon receipt of a VHT NDP sounding PPDU, the beamformee shall remove the space-time stream CSD in Table 22-11 from the measured channel before computing a set of matrices for feedback to the beamformer. The beamforming feedback matrix, $V_{k,u}$, found by the beamformee u for subcarrier k shall be compressed in the form of angles using the method described in 20.3.12.3.6. The angles, $\phi(k,\upsilon)$ and $\psi(k,u)$, are quantized according to Table 8-53e. The number of bits for quantization is chosen by the beamformee, based on the indication from the beamformer as to whether the feedback is requested for SU-MIMO beamforming or DL-MU-MIMO beamforming. The compressed beamforming feedback using 20.3.12.3.6 is the only Clause 22 beamforming feedback format defined. The beamformee shall generate the beamforming feedback matrices with the number of rows (Nr) equal to the N_{STS} of the NDP. After receiving the angle information, $\phi(k,u)$ and $\psi(k,u)$, the beamformer reconstructs $V_{k,u}$ using Equation (20-79). For SU-MIMO beamforming, the beamformer can use this $V_{k,0}$ matrix to determine the steering matrix Q_k. For DL-MU-MIMO beamforming, the beamformer may calculate a steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user}-1}]$ using $V_{k,u}$ and $SNR_{k,u}$ $(0 \le u \le N_{user}-1)$ in order to suppress crosstalk between participating beamformees. The method used by the beamformer to calculate the steering matrix Q_k is implementation specific. *See*, *e.g.*, IEEE 802.11ac Standard Clause 22.3.11.2
[1g] determine a set of weighting values based on the first signal information and the second signal information, wherein the set of weighting values is configured to be used by the transceiver to construct	The processor in the iPhone 12 determine a set of weighting values based on the first signal information and the second signal information, wherein the set of weighting values is configured to be used by the transceiver to construct one or more beam-formed transmission signals.

Claim 1	iPhone 12
one or more beam-formed transmission signals;	For example, the iPhone 12 determines an estimate of the channel state (e.g., by measuring the channel using a training signal) that includes a set of weighting values based on the first signal information and the second signal information. A transformed estimate of the channel state will ultimately be sent in a compressed beamforming report, e.g., the parameters of the beamforming feedback matrix. The iPhone 12 uses the derived estimate of the channel state, which includes the set of weighting values (e.g. data relevant to describe the MIMO channel), by configuring the set of weighting values to be used by the transceiver to construct one or more beam-formed transmission signals, e.g., by supporting multiple uplink spatial streams (*e.g.,* 2x2 or more streams) and/or transmit beamforming ("TxBF") to steer transmissions.  Transmit beamforming and DL MU-MIMO require knowledge of the channel state to compute a steering matrix that is applied to the transmit signal to optimize reception at one or more receivers. HE STAs use the HE sounding protocol to determine the channel state information. The HE sounding protocol provides explicit feedback mechanisms, defined as HE non-trigger-based (non-TB) sounding and HE trigger-based (TB) sounding, where the HE beamformee measures the channel using a training signal (i.e., an HE sounding NDP) transmitted by the HE beamformer and sends back a transformed estimate of the channel state. The HE beamformer uses this estimate to derive the steering matrix. The HE beamformee returns an estimate of the channel state in an HE compressed beamforming/CQI report carried in one or more HE Compressed Beamforming/CQI frames. There are three types of HE compressed beamforming/CQI report: *See*, *e.g.*, IEEE 802.11ax Standard, Section 26.7.1  An HE beamformee that receives an HE NDP Announcement frame from an HE beamformer with which it is associated and that contains the HE beamformee's MAC address in the RA field and also receives an HE sounding NDP a SIFS after the HE NDP Announcement frame shall transmit its HE compressed beamforming/CQI report a SIFS after the HE sounding NDP. The TXVECTOR parameter CH_BANDWIDTH for the PPDU containing the HE compressed beamforming/CQI report shall be set to indicate a bandwidth not wider than that indicated by the RXVECTOR parameter CH_BANDWIDTH of the HE sounding NDP. *See*, *e.g.*, IEEE 802.11ax Standard, Section 26.7.3

Claim 1	iPhone 12
	 An HE beamformee that receives an HE NDP Announcement frame as part of an HE TB sounding sequence with a STA Info field addressed to it soliciting SU or MU feedback shall generate an HE compressed beamforming/CQI report using the feedback type, *Ng* and codebook size indicated in the STA Info field. If the HE beamformee then receives a BFRP Trigger frame with a User Info field addressed to it, the HE beamformee transmits an HE TB PPDU containing the HE compressed beamforming/CQI report following the rules defined in 26.5.3.3 (Non-AP STA behavior for UL MU operation). If the HE NDP Announcement frame has *See*, *e.g.*, IEEE 802.11ax Standard, Section 26.7.3  UL MU operation allows an AP to solicit simultaneous immediate response frames from one or more non-AP HE STAs. A non-AP HE STA shall follow the rules in this subclause for the transmission of response *See*, *e.g.*, IEEE 802.11ax Standard, Section 26.5.3  UL MU-MIMO is a technique to allow multiple STAs to transmit simultaneously over the same frequency resource to the receiver. The concept is very similar to SU-MIMO where multiple space-time streams are transmitted simultaneously over the same frequency resource utilizing spatial multiplexing through multiple antennas at the transmitter and receiver. The key difference from SU-MIMO is that in UL MU-MIMO, the transmitted streams originate from multiple STAs. *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.3.2.1  The HE-LTF field provides a means for the receiver to estimate the MIMO channel between the set of constellation mapper outputs (or, if STBC is applied, the STBC encoder outputs) and the receive chains. In an HE SU PPDU and HE ER SU PPDU, the transmitter provides training for N_{STS} space-time streams (spatial mapper inputs) used for the transmission of the PSDU. In an HE MU PPDU, the transmitter provides training for $N_{STS,r,total}$ space-time streams used for the transmission of the PSDU(s) in the *r*-th RU. In an HE TB PPDU, the transmitter of user *u* in the *r*-th RU provides training for $N_{STS,r,u}$ space-time streams used for the transmission of the PSDU. For each tone in the *r*-th RU, the MIMO channel that can be estimated is an $N_{RX} \times N_{STS,r,total}$ matrix. An HE transmission has a preamble that contains HE-LTF symbols, where the data tones of each HE-LTF symbol are multiplied by entries belonging to a matrix $P_{\text{HE-LTF}}$, to enable channel estimation at the receiver. The pilot subcarriers of each HE-LTF symbol are multiplied by the entries of a *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.10.10  In an HE SU PPDU, HE MU PPDU and HE ER SU PPDU, the combination of HE-LTF type and GI duration is indicated in HE-SIG-A field. In an HE TB PPDU, the combination of HE-LTF type and GI duration is indicated in the Trigger frame that triggers the transmission of the PPDU. If an HE PPDU is an HE sounding NDP, the combinations of HE-LTF types and GI durations are listed in 27.3.18 (Transmit specification). If an HE PPDU is an HE TB feedback NDP, the combinations of types and GI durations are listed in 27.3.4 (HE PPDU formats).

Claim 1	iPhone 12
	See, *e.g.*, IEEE 802.11ax Standard, Section 27.3.10.10  The DL MU-MIMO steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user,r}-1}]$ can be determined by the beamformer using the beamforming feedback for subcarrier k from beamformee u, where $u = 0, 1, \ldots, N_{user,r}-1$. The feedback report format is described in 9.4.1.65 (HE Compressed Beamforming Report field) and 9.4.1.66 (HE MU Exclusive Beamforming Report field). The steering matrix that is computed (or updated) using new beamforming feedback from some or all of participating beamformees might replace the existing steering matrix Q_k for the next DL MU-MIMO data transmission. For SU-MIMO beamforming, the steering matrix Q_k can be determined from the beamforming feedback matrix V_k that is sent back to the beamformer by the beamformee using the compressed beamforming feedback matrix format as defined in 19.3.12.3.6 (Compressed beamforming feedback matrix). The feedback report format is described in 9.4.1.65 (HE Compressed Beamforming Report field). *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.15.1  Transmit beamforming and DL-MU-MIMO require knowledge of the channel state to compute a steering matrix that is applied to the transmitted signal to optimize reception at one or more receivers. The STA transmitting using the steering matrix is called the VHT beamformer and a STA for which reception is optimized is called a VHT beamformee. An explicit feedback mechanism is used where the VHT beamformee directly measures the channel from the training symbols transmitted by the VHT beamformer and sends back a transformed estimate of the channel state to the VHT beamformer. The VHT beamformer then uses this estimate, perhaps combining estimates from multiple VHT beamformees, to derive the steering matrix. *See*, *e.g.*, IEEE 802.11ac Standard Clause 9.31.5.1  A VHT beamformer shall initiate a sounding feedback sequence by transmitting a VHT NDP Announcement frame followed by a VHT NDP after a SIFS. The VHT beamformer shall include in the VHT NDP Announcement frame one STA Info field for each VHT beamformee that is expected to prepare VHT Compressed Beamforming feedback and shall identify the VHT beamformee by including the VHT beamformee's AID in the AID subfield of the STA Info field. The VHT NDP Announcement frame shall include at least one STA Info field. *See*, *e.g.*, IEEE 802.11ac Standard Clause 9.31.5.2

<table>
<tr><th>Claim 1</th><th>iPhone 12</th></tr>
<tr><td></td><td>

A non-AP VHT beamformee that receives a VHT NDP Announcement frame from a VHT beamformer with which it is associated or has an established DLS or TDLS session and that contains the VHT beamformee's AID in the AID subfield of a STA Info field that is not the first STA Info field shall transmit its VHT Compressed Beamforming feedback a SIFS after receiving a Beamforming Report Poll with RA matching its MAC address and a non-bandwidth signaling TA obtained from the TA field matching the MAC address of the VHT beamformer. If the RXVECTOR parameter CH_BANDWIDTH_IN_NON_HT of the received
<i>See</i>, <i>e.g.</i>, IEEE 802.11ac Standard Clause 9.31.5.2

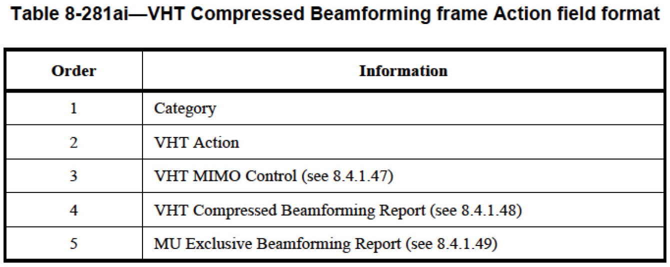
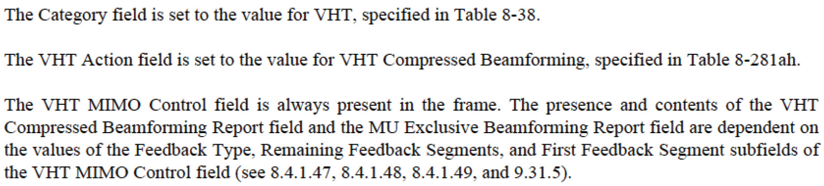
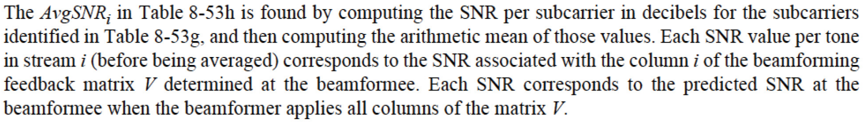
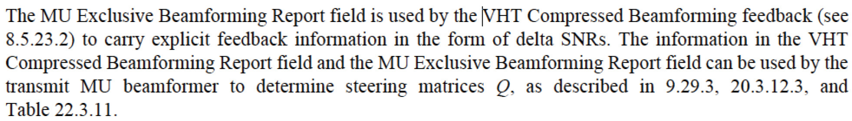



Table 8-281ai—VHT Compressed Beamforming frame Action field format
<table>
<tr><th>Order</th><th>Information</th></tr>
<tr><td>1</td><td>Category</td></tr>
<tr><td>2</td><td>VHT Action</td></tr>
<tr><td>3</td><td>VHT MIMO Control (see 8.4.1.47)</td></tr>
<tr><td>4</td><td>VHT Compressed Beamforming Report (see 8.4.1.48)</td></tr>
<tr><td>5</td><td>MU Exclusive Beamforming Report (see 8.4.1.49)</td></tr>
</table>

The Category field is set to the value for VHT, specified in Table 8-38.
The VHT Action field is set to the value for VHT Compressed Beamforming, specified in Table 8-281ah.
The VHT MIMO Control field is always present in the frame. The presence and contents of the VHT Compressed Beamforming Report field and the MU Exclusive Beamforming Report field are dependent on the values of the Feedback Type, Remaining Feedback Segments, and First Feedback Segment subfields of the VHT MIMO Control field (see 8.4.1.47, 8.4.1.48, 8.4.1.49, and 9.31.5).
<i>See</i>, <i>e.g.</i>, IEEE 802.11ac Standard Clause 8.5.23.2
<i>See</i> Tables 8-53(d)-(h) in IEEE 802.11ac Standard Clause 8.4.1.48

The $AvgSNR_i$ in Table 8-53h is found by computing the SNR per subcarrier in decibels for the subcarriers identified in Table 8-53g, and then computing the arithmetic mean of those values. Each SNR value per tone in stream i (before being averaged) corresponds to the SNR associated with the column i of the beamforming feedback matrix V determined at the beamformee. Each SNR corresponds to the predicted SNR at the beamformee when the beamformer applies all columns of the matrix V.
</td></tr>
</table>

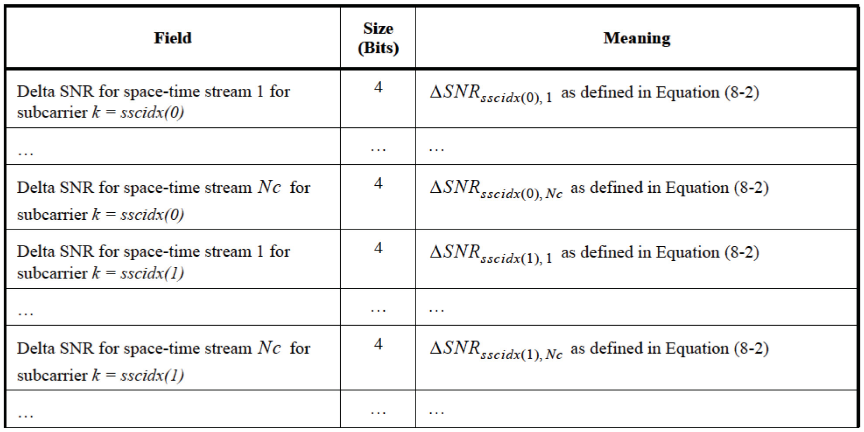
<table>
<tr><th>Claim 1</th><th>iPhone 12</th></tr>
<tr><td></td><td>

See, *e.g.*, IEEE 802.11ac Standard Clause 8.4.1.48



The MU Exclusive Beamforming Report field is used by the VHT Compressed Beamforming feedback (see 8.5.23.2) to carry explicit feedback information in the form of delta SNRs. The information in the VHT Compressed Beamforming Report field and the MU Exclusive Beamforming Report field can be used by the transmit MU beamformer to determine steering matrices *Q*, as described in 9.29.3, 20.3.12.3, and Table 22.3.11.

See, *e.g.*, IEEE 802.11ac Standard Clause 8.4.1.49



<table>
<tr><th>Field</th><th>Size (Bits)</th><th>Meaning</th></tr>
<tr><td>Delta SNR for space-time stream 1 for subcarrier $k = sscidx(0)$</td><td>4</td><td>$\Delta SNR_{sscidx(0),1}$ as defined in Equation (8-2)</td></tr>
<tr><td>…</td><td>…</td><td>…</td></tr>
<tr><td>Delta SNR for space-time stream Nc for subcarrier $k = sscidx(0)$</td><td>4</td><td>$\Delta SNR_{sscidx(0),Nc}$ as defined in Equation (8-2)</td></tr>
<tr><td>Delta SNR for space-time stream 1 for subcarrier $k = sscidx(1)$</td><td>4</td><td>$\Delta SNR_{sscidx(1),1}$ as defined in Equation (8-2)</td></tr>
<tr><td>…</td><td>…</td><td>…</td></tr>
<tr><td>Delta SNR for space-time stream Nc for subcarrier $k = sscidx(1)$</td><td>4</td><td>$\Delta SNR_{sscidx(1),Nc}$ as defined in Equation (8-2)</td></tr>
<tr><td>…</td><td>…</td><td>…</td></tr>
</table>

</td></tr>
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<table>
<tr><th>Claim 1</th><th>iPhone 12</th></tr>
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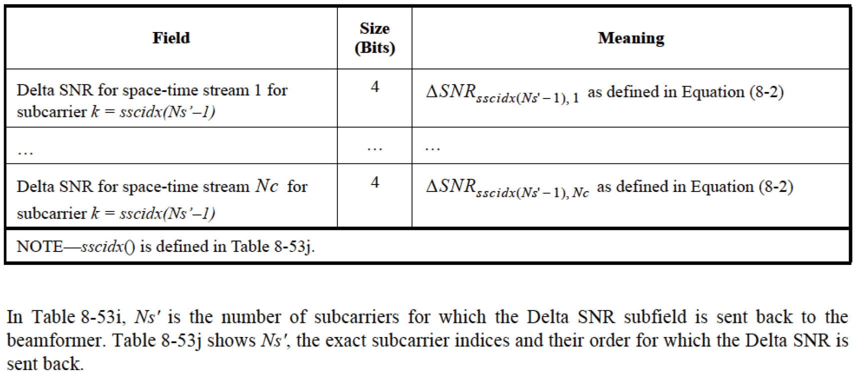
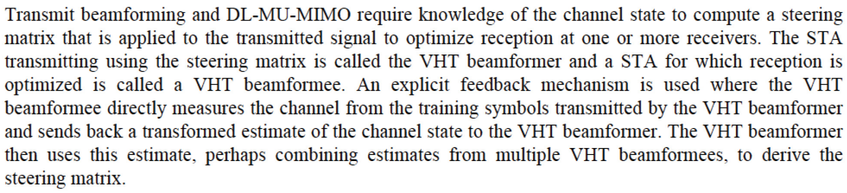


<table>
<tr><th>Field</th><th>Size (Bits)</th><th>Meaning</th></tr>
<tr><td>Delta SNR for space-time stream 1 for subcarrier <i>k</i> = <i>sscidx(Ns'–1)</i></td><td>4</td><td>$\Delta SNR_{sscidx(Ns'-1),1}$ as defined in Equation (8-2)</td></tr>
<tr><td>…</td><td>…</td><td>…</td></tr>
<tr><td>Delta SNR for space-time stream Nc for subcarrier <i>k</i> = <i>sscidx(Ns'–1)</i></td><td>4</td><td>$\Delta SNR_{sscidx(Ns'-1),Nc}$ as defined in Equation (8-2)</td></tr>
<tr><td colspan="3">NOTE—<i>sscidx</i>() is defined in Table 8-53j.</td></tr>
</table>

In Table 8-53i, Ns' is the number of subcarriers for which the Delta SNR subfield is sent back to the beamformer. Table 8-53j shows Ns', the exact subcarrier indices and their order for which the Delta SNR is sent back.

<i>See</i>, <i>e.g.</i>, Table 8-53i IEEE 802.11ac Standard Clause 8.4.1.48



Transmit beamforming and DL-MU-MIMO require knowledge of the channel state to compute a steering matrix that is applied to the transmitted signal to optimize reception at one or more receivers. The STA transmitting using the steering matrix is called the VHT beamformer and a STA for which reception is optimized is called a VHT beamformee. An explicit feedback mechanism is used where the VHT beamformee directly measures the channel from the training symbols transmitted by the VHT beamformer and sends back a transformed estimate of the channel state to the VHT beamformer. The VHT beamformer then uses this estimate, perhaps combining estimates from multiple VHT beamformees, to derive the steering matrix.

<i>See</i>, <i>e.g.</i>, IEEE 802.11ac Standard Clause 9.31.5.1
</td></tr>
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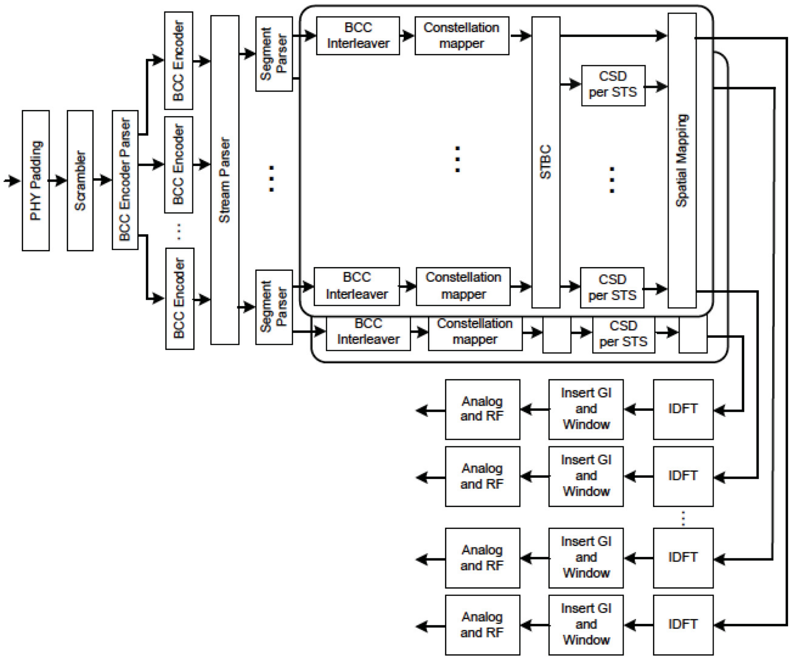
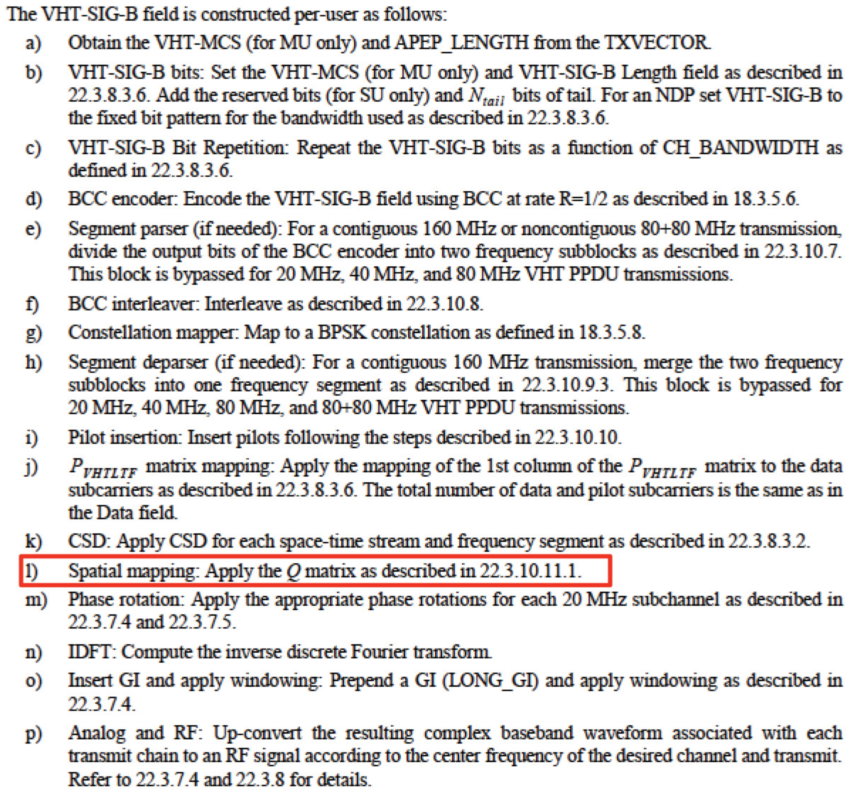
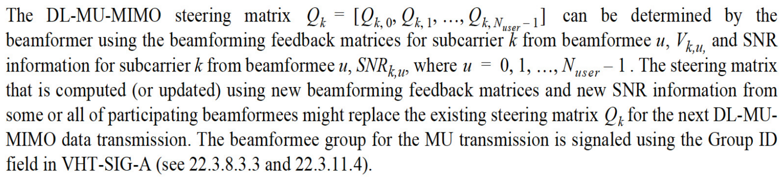
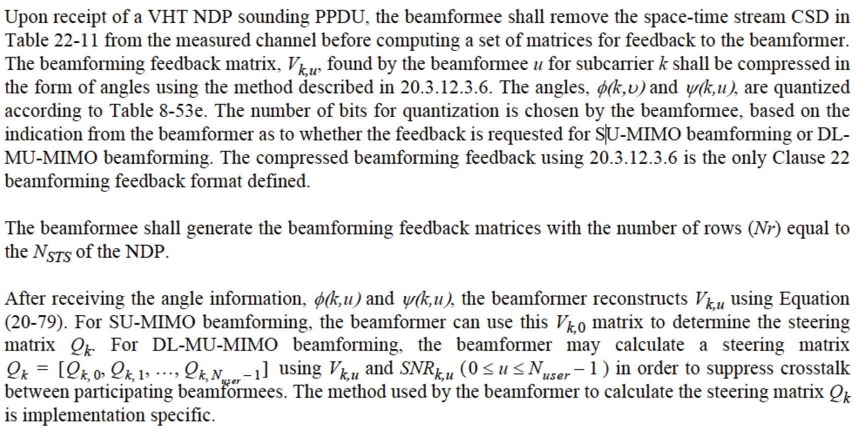
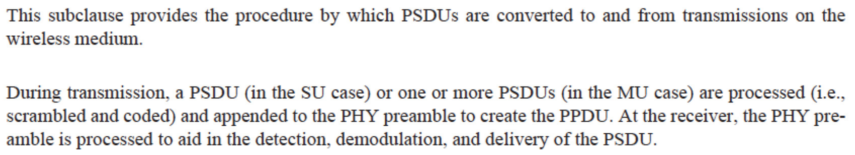
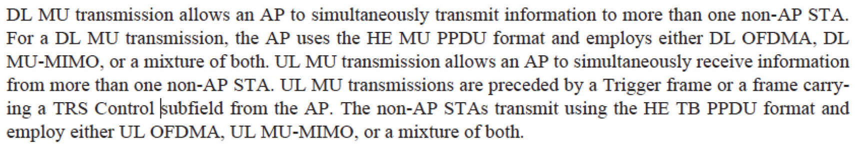
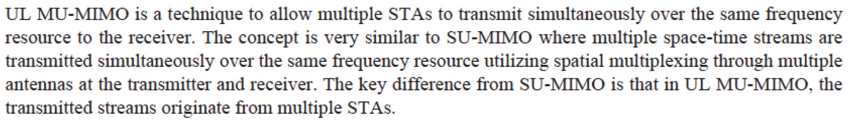
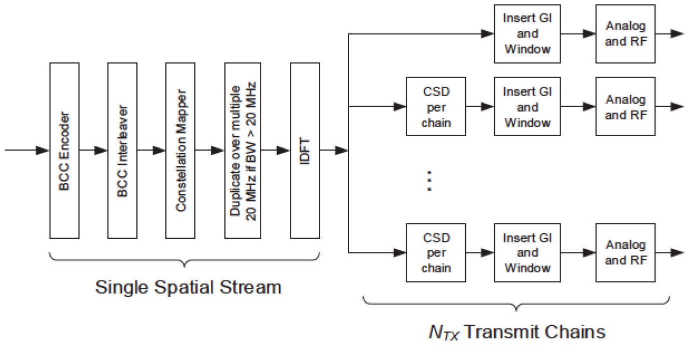
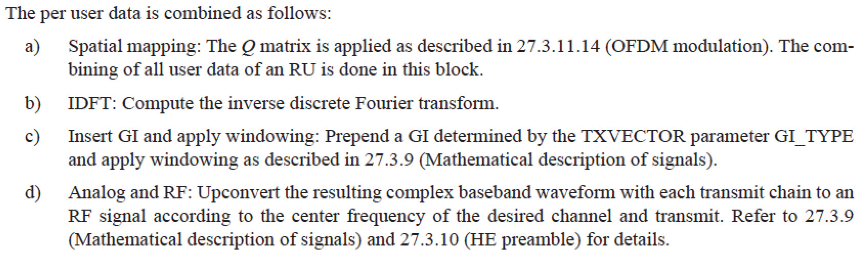
<table>
<tr><th>Claim 1</th><th>iPhone 12</th></tr>
<tr><td></td><td>


See, *e.g.*, IEEE 802.11ac Standard Clause 22.3.4.6(d)
</td></tr>
</table>

Claim 1	iPhone 12
	 The VHT-SIG-B field is constructed per-user as follows: a) Obtain the VHT-MCS (for MU only) and APEP_LENGTH from the TXVECTOR. b) VHT-SIG-B bits: Set the VHT-MCS (for MU only) and VHT-SIG-B Length field as described in 22.3.8.3.6. Add the reserved bits (for SU only) and N_{tail} bits of tail. For an NDP set VHT-SIG-B to the fixed bit pattern for the bandwidth used as described in 22.3.8.3.6. c) VHT-SIG-B Bit Repetition: Repeat the VHT-SIG-B bits as a function of CH_BANDWIDTH as defined in 22.3.8.3.6. d) BCC encoder: Encode the VHT-SIG-B field using BCC at rate R=1/2 as described in 18.3.5.6. e) Segment parser (if needed): For a contiguous 160 MHz or noncontiguous 80+80 MHz transmission, divide the output bits of the BCC encoder into two frequency subblocks as described in 22.3.10.7. This block is bypassed for 20 MHz, 40 MHz, and 80 MHz VHT PPDU transmissions. f) BCC interleaver: Interleave as described in 22.3.10.8. g) Constellation mapper: Map to a BPSK constellation as defined in 18.3.5.8. h) Segment deparser (if needed): For a contiguous 160 MHz transmission, merge the two frequency subblocks into one frequency segment as described in 22.3.10.9.3. This block is bypassed for 20 MHz, 40 MHz, 80 MHz, and 80+80 MHz VHT PPDU transmissions. i) Pilot insertion: Insert pilots following the steps described in 22.3.10.10. j) P_{VHTLTF} matrix mapping: Apply the mapping of the 1st column of the P_{VHTLTF} matrix to the data subcarriers as described in 22.3.8.3.6. The total number of data and pilot subcarriers is the same as in the Data field. k) CSD: Apply CSD for each space-time stream and frequency segment as described in 22.3.8.3.2. l) Spatial mapping: Apply the Q matrix as described in 22.3.10.11.1. m) Phase rotation: Apply the appropriate phase rotations for each 20 MHz subchannel as described in 22.3.7.4 and 22.3.7.5. n) IDFT: Compute the inverse discrete Fourier transform. o) Insert GI and apply windowing: Prepend a GI (LONG_GI) and apply windowing as described in 22.3.7.4. p) 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 22.3.7.4 and 22.3.8 for details. *See*, *e.g.*, IEEE 802.11ac Standard Clauses 22.3.4.8(l) and 22.3.4.9.1(m), 22.3.4.9.2(m), 22.3.4.10.4(a).

Claim 1	iPhone 12
	 The DL-MU-MIMO steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user}-1}]$ can be determined by the beamformer using the beamforming feedback matrices for subcarrier k from beamformee u, $V_{k,u,}$ and SNR information for subcarrier k from beamformee u, $SNR_{k,u}$, where $u = 0, 1, \ldots, N_{user} - 1$. The steering matrix that is computed (or updated) using new beamforming feedback matrices and new SNR information from some or all of participating beamformees might replace the existing steering matrix Q_k for the next DL-MU-MIMO data transmission. The beamformee group for the MU transmission is signaled using the Group ID field in VHT-SIG-A (see 22.3.8.3.3 and 22.3.11.4). *See*, *e.g.*, IEEE 802.11ac Standard Clause 22.3.11.1  Upon receipt of a VHT NDP sounding PPDU, the beamformee shall remove the space-time stream CSD in Table 22-11 from the measured channel before computing a set of matrices for feedback to the beamformer. The beamforming feedback matrix, $V_{k,u}$, found by the beamformee u for subcarrier k shall be compressed in the form of angles using the method described in 20.3.12.3.6. The angles, $\phi(k,\upsilon)$ and $\psi(k,u)$, are quantized according to Table 8-53e. The number of bits for quantization is chosen by the beamformee, based on the indication from the beamformer as to whether the feedback is requested for SU-MIMO beamforming or DL-MU-MIMO beamforming. The compressed beamforming feedback using 20.3.12.3.6 is the only Clause 22 beamforming feedback format defined. The beamformee shall generate the beamforming feedback matrices with the number of rows (Nr) equal to the N_{STS} of the NDP. After receiving the angle information, $\phi(k,u)$ and $\psi(k,u)$, the beamformer reconstructs $V_{k,u}$ using Equation (20-79). For SU-MIMO beamforming, the beamformer can use this $V_{k,0}$ matrix to determine the steering matrix Q_k. For DL-MU-MIMO beamforming, the beamformer may calculate a steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user}-1}]$ using $V_{k,u}$ and $SNR_{k,u}$ $(0 \le u \le N_{user} - 1)$ in order to suppress crosstalk between participating beamformees. The method used by the beamformer to calculate the steering matrix Q_k is implementation specific. *See*, *e.g.*, IEEE 802.11ac Standard Clause 22.3.11.2 To the extent Defendant disputes that the foregoing shows literal infringement, there would also be infringement under the doctrine of equivalents. For example, determining weighting values (e.g. angle information) (e.g. the derived estimate of the channel state), which includes data relevant to describe the MIMO channel is insubstantially different from the claim requirement because it performs substantially the same function

Claim 1	iPhone 12
	(determine a set of weighting values) in substantially the same way (determine angle information describing MIMO channel) to achieve substantially the same result (beamforming). For further example, constructing one or more beamformed transmission signals by supporting multiple uplink spatial streams (*e.g.,* 2x2 or more streams) and/or transmit beamforming ("TxBF") to steer transmissions is insubstantially different from the claim requirement because it performs substantially the same function in substantially the same way to achieve substantially the same result.
[1h] cause the transceiver to transmit a third signal to the remote station via the antenna, the third signal comprising content based on the set of weighting values.	The processor in the iPhone 12 causes the transceiver to transmit a third signal to the remote station via the antenna, the third signal comprising content based on the set of weighting values. For example, iPhone 12 transmits to the remote station (*e.g.*, a Wi-Fi access point) a signal that includes the beamforming feedback matrix.  This subclause provides the procedure by which PSDUs are converted to and from transmissions on the wireless medium. During transmission, a PSDU (in the SU case) or one or more PSDUs (in the MU case) are processed (i.e., scrambled and coded) and appended to the PHY preamble to create the PPDU. At the receiver, the PHY preamble is processed to aid in the detection, demodulation, and delivery of the PSDU. *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.1  DL MU transmission allows an AP to simultaneously transmit information to more than one non-AP STA. For a DL MU transmission, the AP uses the HE MU PPDU format and employs either DL OFDMA, DL MU-MIMO, or a mixture of both. UL MU transmission allows an AP to simultaneously receive information from more than one non-AP STA. UL MU transmissions are preceded by a Trigger frame or a frame carrying a TRS Control subfield from the AP. The non-AP STAs transmit using the HE TB PPDU format and employ either UL OFDMA, UL MU-MIMO, or a mixture of both. *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.1.1

Claim 1	iPhone 12
	 UL MU-MIMO is a technique to allow multiple STAs to transmit simultaneously over the same frequency resource to the receiver. The concept is very similar to SU-MIMO where multiple space-time streams are transmitted simultaneously over the same frequency resource utilizing spatial multiplexing through multiple antennas at the transmitter and receiver. The key difference from SU-MIMO is that in UL MU-MIMO, the transmitted streams originate from multiple STAs. *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.3.2.1  *See*, *e.g.*, Figure 27-13 IEEE 802.11ax Standard, Section 27.3.5  The per user data is combined as follows: a) Spatial mapping: The Q matrix is applied as described in 27.3.11.14 (OFDM modulation). The combining of all user data of an RU is done in this block. b) IDFT: Compute the inverse discrete Fourier transform. c) Insert GI and apply windowing: Prepend a GI determined by the TXVECTOR parameter GI_TYPE and apply windowing as described in 27.3.9 (Mathematical description of signals). d) 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 27.3.9 (Mathematical description of signals) and 27.3.10 (HE preamble) for details.

Claim 1	iPhone 12
	See, *e.g.*, IEEE 802.11ax Standard, Section 27.3.6.11.4 To the extent Defendant disputes that the foregoing shows literal infringement, there would also be infringement under the doctrine of equivalents. For example, the Accused Instrumentalities perform substantially the same function (transmit a third signal to the remote station via the antenna, the third signal comprising content based on the set of weighting values) in substantially the same way (transmit channel state estimate) to achieve substantially the same result (improve knowledge of the channel state to improve throughput).

Claim 2

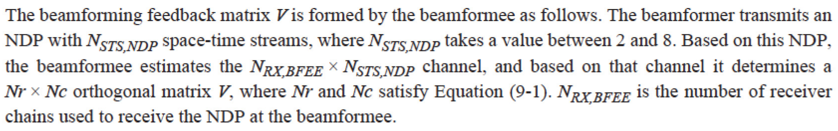
Claim 2	Accused Products
2. The receiver as recited in claim 1, wherein the first signal transmission and the second signal transmission comprise electromagnetic signals comprising one or more transmission peaks and one or more transmission nulls.	The iPhone 12 includes the receiver as recited in claim 1, wherein the first signal transmission and the second signal transmission comprise electromagnetic signals comprising one or more transmission peaks and one or more transmission nulls. *See supra* claim element [1d], including discussion regarding MU-MIMO sounding and channel estimation procedures, which shows electromagnetic signals comprising one or more transmission peaks and one or more transmission nulls.

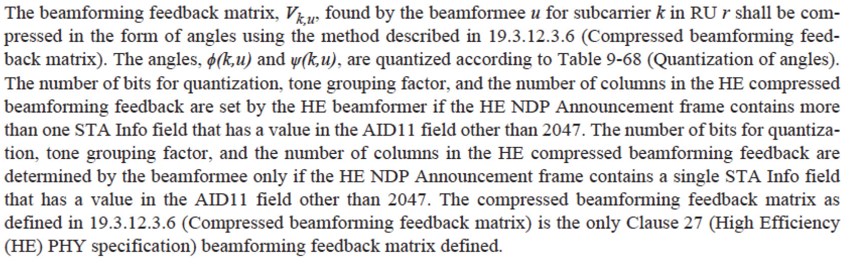
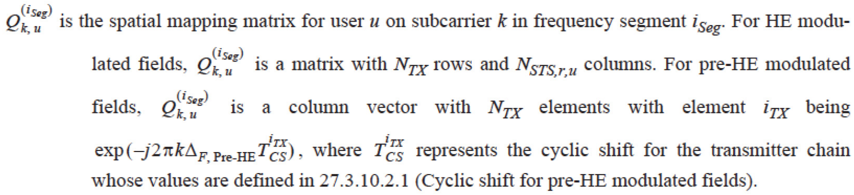
Claim 4

Claim 4	Accused Products
4. The receiver as recited in claim 1, wherein the content comprises data configured to be used by the remote station to modify the placement of one or more transmission peaks and one or more	The iPhone 12 includes the receiver as recited in claim 1, wherein the content comprises data configured to be used by the remote station to modify the placement of one or more transmission peaks and one or more transmission nulls in a subsequent signal transmission.

Claim 4	Accused Products
transmission nulls in a subsequent signal transmission.	*See supra* claim element [1d], including discussion regarding MU-MIMO sounding and channel estimation procedures, which shows electromagnetic signals comprising one or more transmission peaks and one or more transmission nulls.

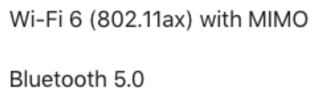
Claim 5

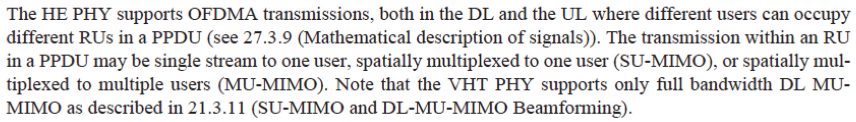
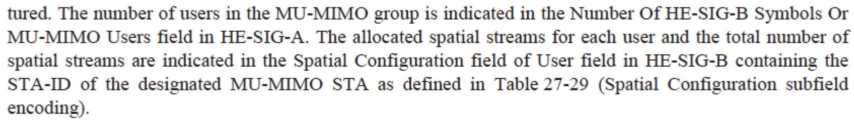
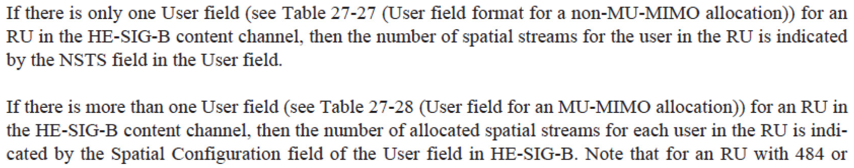
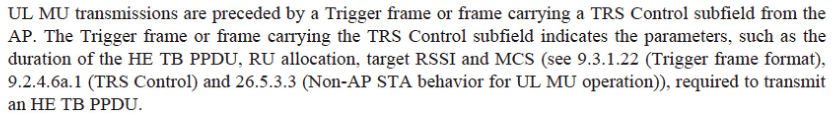
Claim 5	Accused Products
5. The receiver as recited in claim 4, wherein the set of weighting values is further based on one or more of: a transmit power level, a data transmit rate, an antenna direction, quality of service data, or timing data.	The iPhone 12 includes the receiver as recited in claim 4, wherein the set of weighting values is further based on one or more of: a transmit power level, a data transmit rate, an antenna direction, quality of service data, or timing data. For example, iPhone 12 calculates weights based on at least the subcarrier frequency which is based on the data transmission rate and antenna array directions.  The beamforming feedback matrix V is formed by the beamformee as follows. The beamformer transmits an NDP with $N_{STS,NDP}$ space-time streams, where $N_{STS,NDP}$ takes a value between 2 and 8. Based on this NDP, the beamformee estimates the $N_{RX,BFEE} \times N_{STS,NDP}$ channel, and based on that channel it determines a $Nr \times Nc$ orthogonal matrix V, where Nr and Nc satisfy Equation (9-1). $N_{RX,BFEE}$ is the number of receiver chains used to receive the NDP at the beamformee. *See*, *e.g.*, IEEE 802.11ax Standard, Section 9.4.1.65

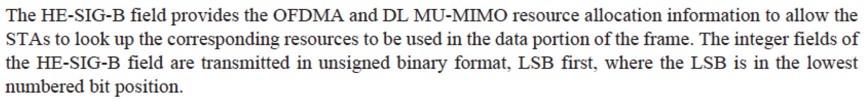
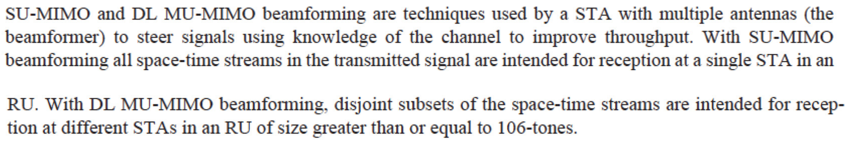
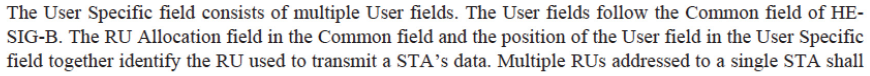
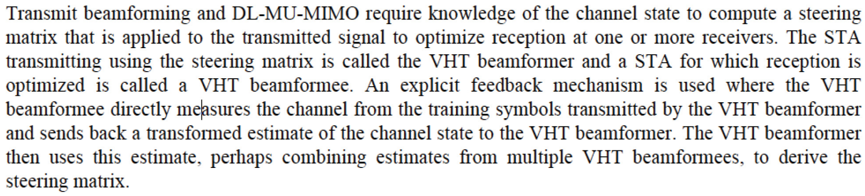
Claim 5	Accused Products
	 The beamforming feedback matrix, $V_{k,u}$, found by the beamformee u for subcarrier k in RU r shall be compressed in the form of angles using the method described in 19.3.12.3.6 (Compressed beamforming feedback matrix). The angles, $\phi(k,u)$ and $\psi(k,u)$, are quantized according to Table 9-68 (Quantization of angles). The number of bits for quantization, tone grouping factor, and the number of columns in the HE compressed beamforming feedback are set by the HE beamformer if the HE NDP Announcement frame contains more than one STA Info field that has a value in the AID11 field other than 2047. The number of bits for quantization, tone grouping factor, and the number of columns in the HE compressed beamforming feedback are determined by the beamformee only if the HE NDP Announcement frame contains a single STA Info field that has a value in the AID11 field other than 2047. The compressed beamforming feedback matrix as defined in 19.3.12.3.6 (Compressed beamforming feedback matrix) is the only Clause 27 (High Efficiency (HE) PHY specification) beamforming feedback matrix defined. *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.15.2  $Q_{k,u}^{(i_{Seg})}$ is the spatial mapping matrix for user u on subcarrier k in frequency segment i_{Seg}. For HE modulated fields, $Q_{k,u}^{(i_{Seg})}$ is a matrix with N_{TX} rows and $N_{STS,r,u}$ columns. For pre-HE modulated fields, $Q_{k,u}^{(i_{Seg})}$ is a column vector with N_{TX} elements with element i_{TX} being $\exp(-j2\pi k\Delta_{F,\text{Pre-HE}}T_{CS}^{i_{TX}})$, where $T_{CS}^{i_{TX}}$ represents the cyclic shift for the transmitter chain whose values are defined in 27.3.10.2.1 (Cyclic shift for pre-HE modulated fields). *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.9

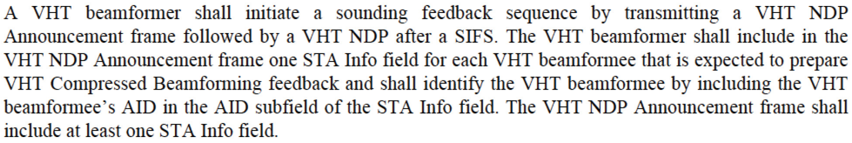
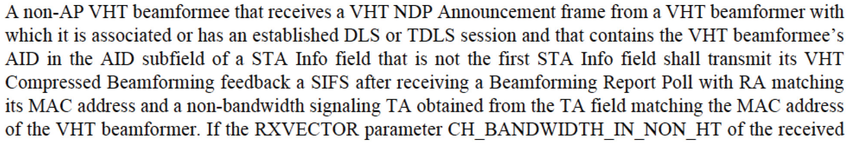
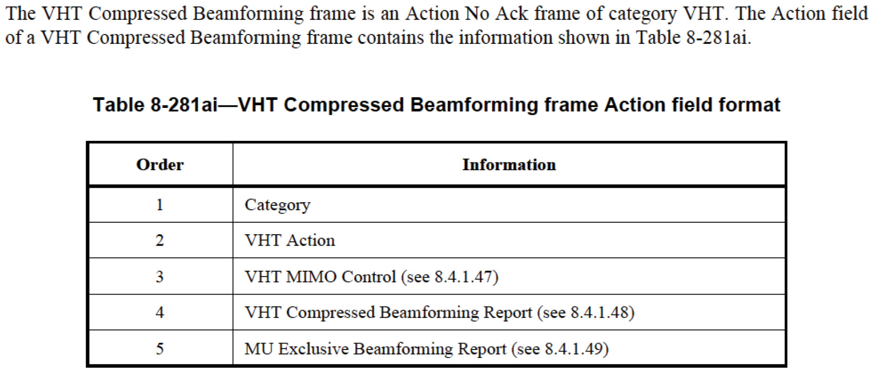
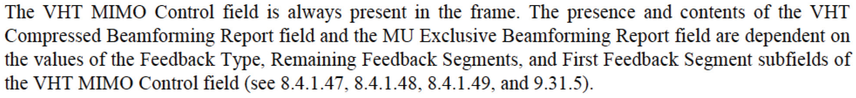
Claim 8

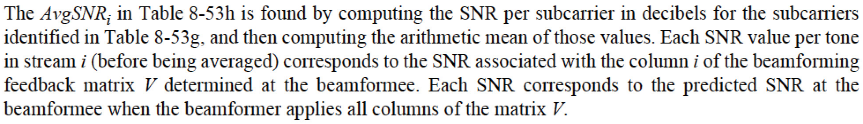
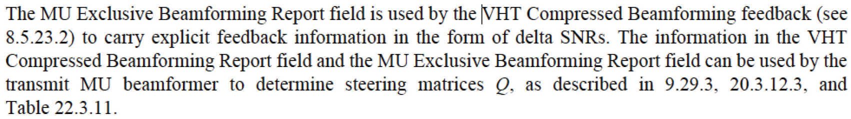
Claim 8	iPhone 12
[8pre] A method in a wireless communications system, the method comprising:	To the extent the preamble is limiting, each Accused Product practices the claimed method. For example, the iPhone 12 supports MU-MIMO technology.

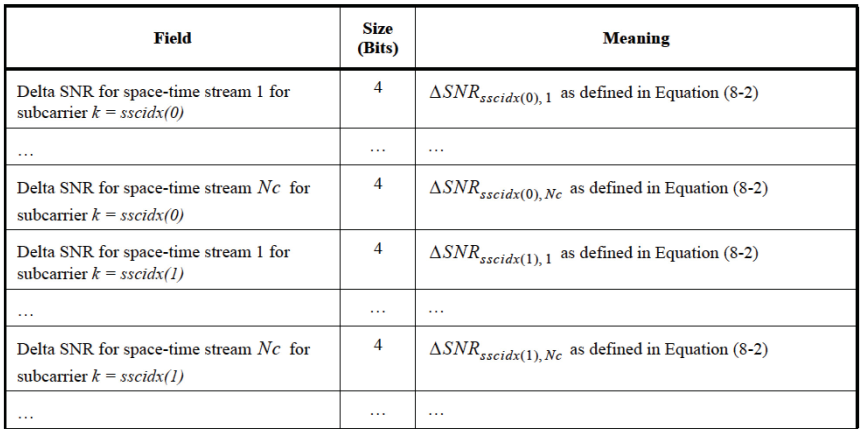
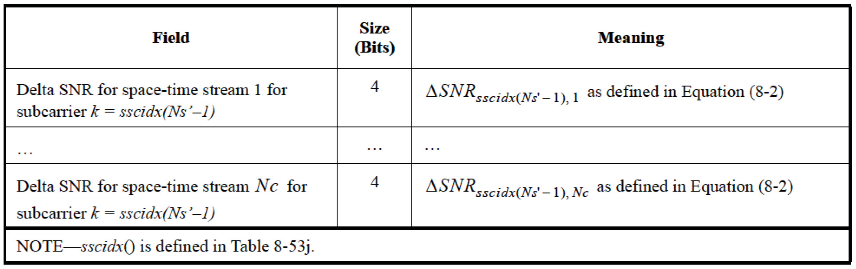
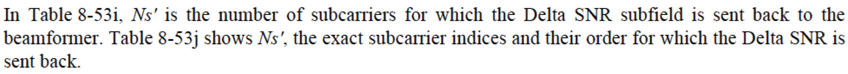
Claim 8	iPhone 12
	 Wi-Fi 6 (802.11ax) with MIMO Bluetooth 5.0 *See* iPhone 12 available at https://www.apple.com/iPhone/compare/?modelList=iPhoneXSmax,iPhone12,iPhone12mini Each Accused Product operates as a communicating device or station in a Wi-Fi network. Each Accused Product that supports or utilizes Wi-Fi 6 infringes in substantially the same manner as the iPhone 12 according to the exemplary descriptions of Wi-Fi 6 / 802.11ax functionality cited below. Each Accused Product that supports or utilizes MIMO / MU-MIMO technologies pursuant to IEEE 802.11ac wave 2 infringes in substantially the same manner as the iPhone 12 according to the exemplary descriptions of 802.11ac wave 2 functionality cited below.
[8a] receiving a first signal transmission from a remote station via a first antenna element of an antenna and a second signal transmission from the remote station via a second antenna element of the antenna simultaneously, wherein the first signal transmission and the second signal transmission comprise electromagnetic signals comprising one or more transmission peaks and one or more transmission nulls;	The iPhone 12 receives a first signal transmission from a remote station via a first antenna element of an antenna and a second signal transmission from the remote station via a second antenna element of the antenna simultaneously, wherein the first signal transmission and the second signal transmission comprise electromagnetic signals comprising one or more transmission peaks and one or more transmission nulls. For example, the iPhone 12 receives a first signal transmission from a remote station, such as a Wi-Fi Access Point, via a first antenna element of an antenna and a second signal transmission from the remote station via a second antenna element of the antenna simultaneously. For example, the iPhone 12 receives a first signal transmission from a remote station, such as a Wi-Fi Access Point, via a first antenna element of an antenna and a second signal transmission from the remote station via a second antenna element of the antenna

Claim 8	iPhone 12
	simultaneously, such as when the iPhone 12 receives first and second signals with its first and second antenna elements that contain training fields of a null data packet used for MU-MIMO sounding and channel estimation procedures.  The HE PHY supports OFDMA transmissions, both in the DL and the UL where different users can occupy different RUs in a PPDU (see 27.3.9 (Mathematical description of signals)). The transmission within an RU in a PPDU may be single stream to one user, spatially multiplexed to one user (SU-MIMO), or spatially multiplexed to multiple users (MU-MIMO). Note that the VHT PHY supports only full bandwidth DL MU-MIMO as described in 21.3.11 (SU-MIMO and DL-MU-MIMO Beamforming). *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.1.1  tured. The number of users in the MU-MIMO group is indicated in the Number Of HE-SIG-B Symbols Or MU-MIMO Users field in HE-SIG-A. The allocated spatial streams for each user and the total number of spatial streams are indicated in the Spatial Configuration field of User field in HE-SIG-B containing the STA-ID of the designated MU-MIMO STA as defined in Table 27-29 (Spatial Configuration subfield encoding). *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.2.5  If there is only one User field (see Table 27-27 (User field format for a non-MU-MIMO allocation)) for an RU in the HE-SIG-B content channel, then the number of spatial streams for the user in the RU is indicated by the NSTS field in the User field. If there is more than one User field (see Table 27-28 (User field for an MU-MIMO allocation)) for an RU in the HE-SIG-B content channel, then the number of allocated spatial streams for each user in the RU is indicated by the Spatial Configuration field of the User field in HE-SIG-B. Note that for an RU with 484 or *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.2.5  UL MU transmissions are preceded by a Trigger frame or frame carrying a TRS Control subfield from the AP. The Trigger frame or frame carrying the TRS Control subfield indicates the parameters, such as the duration of the HE TB PPDU, RU allocation, target RSSI and MCS (see 9.3.1.22 (Trigger frame format), 9.2.4.6a.1 (TRS Control) and 26.5.3.3 (Non-AP STA behavior for UL MU operation)), required to transmit an HE TB PPDU.

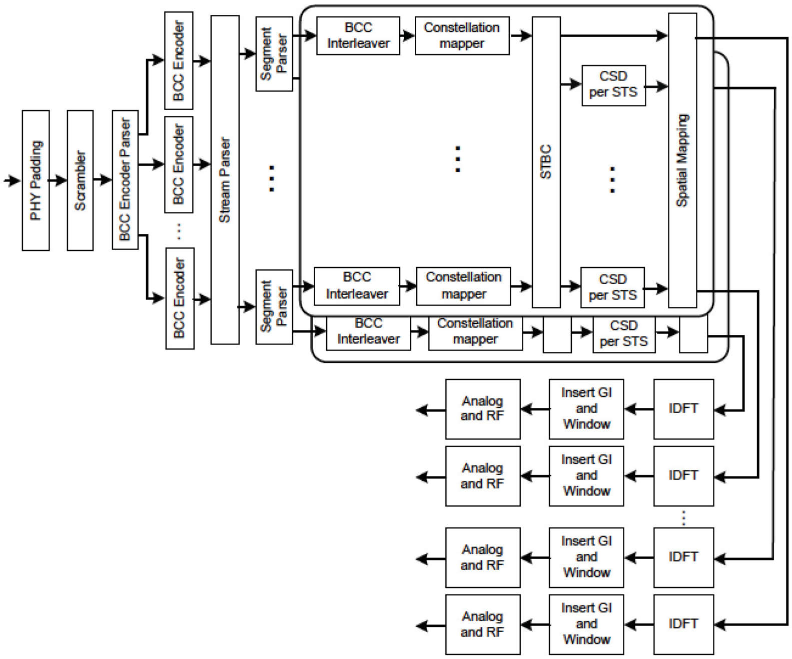
Claim 8	iPhone 12
	See, *e.g.*, IEEE 802.11ax Standard, Section 27.3.2.6  The HE-SIG-B field provides the OFDMA and DL MU-MIMO resource allocation information to allow the STAs to look up the corresponding resources to be used in the data portion of the frame. The integer fields of the HE-SIG-B field are transmitted in unsigned binary format, LSB first, where the LSB is in the lowest numbered bit position. *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.10.8  SU-MIMO and DL MU-MIMO beamforming are techniques used by a STA with multiple antennas (the beamformer) to steer signals using knowledge of the channel to improve throughput. With SU-MIMO beamforming all space-time streams in the transmitted signal are intended for reception at a single STA in an RU. With DL MU-MIMO beamforming, disjoint subsets of the space-time streams are intended for reception at different STAs in an RU of size greater than or equal to 106-tones. *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.15.1  The User Specific field consists of multiple User fields. The User fields follow the Common field of HE-SIG-B. The RU Allocation field in the Common field and the position of the User field in the User Specific field together identify the RU used to transmit a STA's data. Multiple RUs addressed to a single STA shall *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.10.8.5  Transmit beamforming and DL-MU-MIMO require knowledge of the channel state to compute a steering matrix that is applied to the transmitted signal to optimize reception at one or more receivers. The STA transmitting using the steering matrix is called the VHT beamformer and a STA for which reception is optimized is called a VHT beamformee. An explicit feedback mechanism is used where the VHT beamformee directly measures the channel from the training symbols transmitted by the VHT beamformer and sends back a transformed estimate of the channel state to the VHT beamformer. The VHT beamformer then uses this estimate, perhaps combining estimates from multiple VHT beamformees, to derive the steering matrix. *See*, *e.g.*, IEEE 802.11ac Standard Clause 9.31.5.1

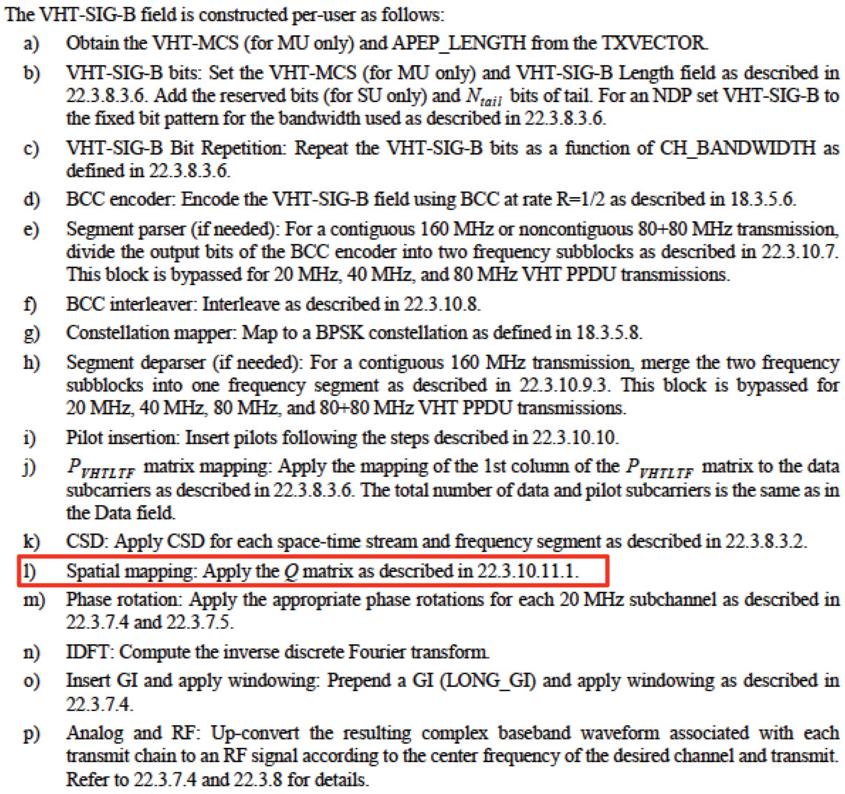
<table>
<tr><th>Claim 8</th><th>iPhone 12</th></tr>
<tr><td></td><td>

A VHT beamformer shall initiate a sounding feedback sequence by transmitting a VHT NDP Announcement frame followed by a VHT NDP after a SIFS. The VHT beamformer shall include in the VHT NDP Announcement frame one STA Info field for each VHT beamformee that is expected to prepare VHT Compressed Beamforming feedback and shall identify the VHT beamformee by including the VHT beamformee’s AID in the AID subfield of the STA Info field. The VHT NDP Announcement frame shall include at least one STA Info field.
<i>See</i>, <i>e.g.</i>, IEEE 802.11ac Standard Clause 9.31.5.2

A non-AP VHT beamformee that receives a VHT NDP Announcement frame from a VHT beamformer with which it is associated or has an established DLS or TDLS session and that contains the VHT beamformee’s AID in the AID subfield of a STA Info field that is not the first STA Info field shall transmit its VHT Compressed Beamforming feedback a SIFS after receiving a Beamforming Report Poll with RA matching its MAC address and a non-bandwidth signaling TA obtained from the TA field matching the MAC address of the VHT beamformer. If the RXVECTOR parameter CH_BANDWIDTH_IN_NON_HT of the received
<i>See</i>, <i>e.g.</i>, IEEE 802.11ac Standard Clause 9.31.5.2

The VHT Compressed Beamforming frame is an Action No Ack frame of category VHT. The Action field of a VHT Compressed Beamforming frame contains the information shown in Table 8-281ai.
Table 8-281ai—VHT Compressed Beamforming frame Action field format
<table>
<tr><th>Order</th><th>Information</th></tr>
<tr><td>1</td><td>Category</td></tr>
<tr><td>2</td><td>VHT Action</td></tr>
<tr><td>3</td><td>VHT MIMO Control (see 8.4.1.47)</td></tr>
<tr><td>4</td><td>VHT Compressed Beamforming Report (see 8.4.1.48)</td></tr>
<tr><td>5</td><td>MU Exclusive Beamforming Report (see 8.4.1.49)</td></tr>
</table>
<i>See</i>, <i>e.g.</i>, IEEE 802.11ac Standard Clause 8.5.23.2

The VHT MIMO Control field is always present in the frame. The presence and contents of the VHT Compressed Beamforming Report field and the MU Exclusive Beamforming Report field are dependent on the values of the Feedback Type, Remaining Feedback Segments, and First Feedback Segment subfields of the VHT MIMO Control field (see 8.4.1.47, 8.4.1.48, 8.4.1.49, and 9.31.5).
</td></tr>
</table>

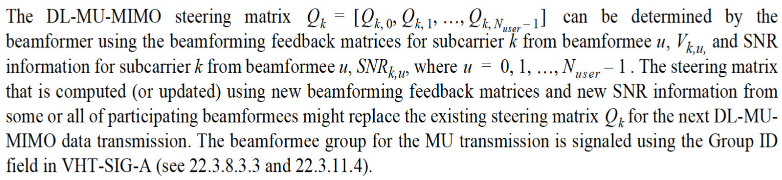
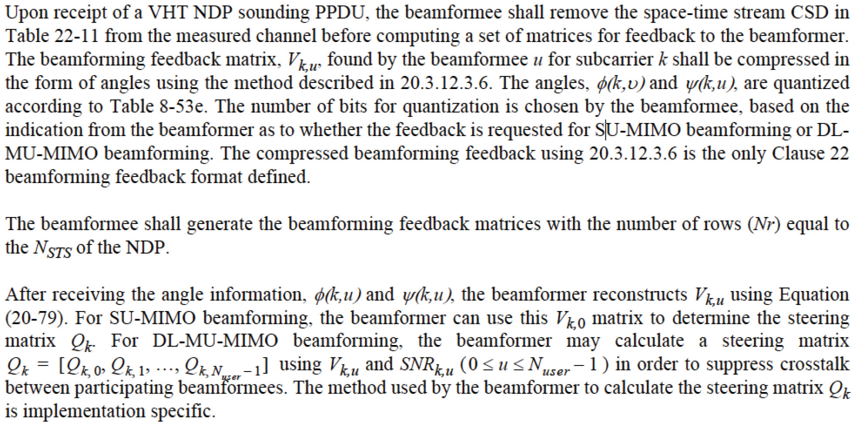
Claim 8	iPhone 12
	See, *e.g.*, IEEE 802.11ac Standard Clause 8.5.23.2 *See* Tables 8-53(d)-(h) in IEEE 802.11ac Standard Clause 8.4.1.48  The $AvgSNR_i$ in Table 8-53h is found by computing the SNR per subcarrier in decibels for the subcarriers identified in Table 8-53g, and then computing the arithmetic mean of those values. Each SNR value per tone in stream *i* (before being averaged) corresponds to the SNR associated with the column *i* of the beamforming feedback matrix *V* determined at the beamformee. Each SNR corresponds to the predicted SNR at the beamformee when the beamformer applies all columns of the matrix *V*. *See*, *e.g.*, IEEE 802.11ac Standard Clause 8.4.1.48  The MU Exclusive Beamforming Report field is used by the VHT Compressed Beamforming feedback (see 8.5.23.2) to carry explicit feedback information in the form of delta SNRs. The information in the VHT Compressed Beamforming Report field and the MU Exclusive Beamforming Report field can be used by the transmit MU beamformer to determine steering matrices *Q*, as described in 9.29.3, 20.3.12.3, and Table 22.3.11. *See*, *e.g.*, IEEE 802.11ac Standard Clause 8.4.1.49

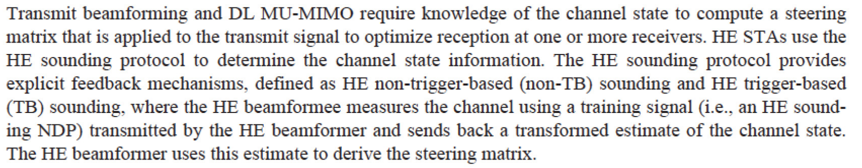
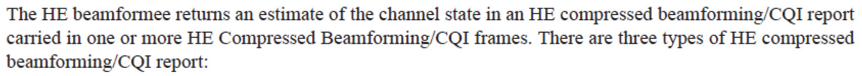
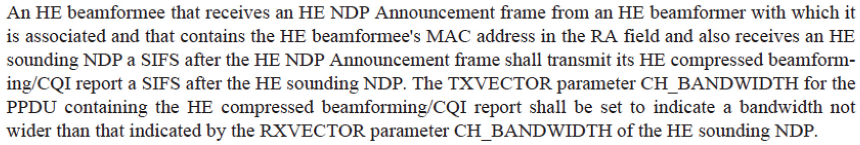
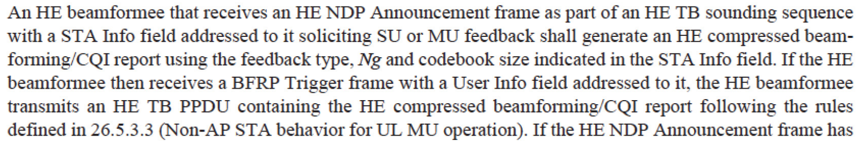
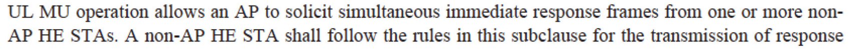
<table>
<tr><th>Claim 8</th><th>iPhone 12</th></tr>
<tr><td></td><td>

<table>
<tr><th>Field</th><th>Size (Bits)</th><th>Meaning</th></tr>
<tr><td>Delta SNR for space-time stream 1 for subcarrier *k* = *sscidx(0)*</td><td>4</td><td>$\Delta SNR_{sscidx(0),\,1}$ as defined in Equation (8-2)</td></tr>
<tr><td>…</td><td>…</td><td>…</td></tr>
<tr><td>Delta SNR for space-time stream Nc for subcarrier *k* = *sscidx(0)*</td><td>4</td><td>$\Delta SNR_{sscidx(0),\,Nc}$ as defined in Equation (8-2)</td></tr>
<tr><td>Delta SNR for space-time stream 1 for subcarrier *k* = *sscidx(1)*</td><td>4</td><td>$\Delta SNR_{sscidx(1),\,1}$ as defined in Equation (8-2)</td></tr>
<tr><td>…</td><td>…</td><td>…</td></tr>
<tr><td>Delta SNR for space-time stream Nc for subcarrier *k* = *sscidx(1)*</td><td>4</td><td>$\Delta SNR_{sscidx(1),\,Nc}$ as defined in Equation (8-2)</td></tr>
<tr><td>…</td><td>…</td><td>…</td></tr>
</table>

<table>
<tr><th>Field</th><th>Size (Bits)</th><th>Meaning</th></tr>
<tr><td>Delta SNR for space-time stream 1 for subcarrier *k* = *sscidx(Ns’–1)*</td><td>4</td><td>$\Delta SNR_{sscidx(Ns'-1),\,1}$ as defined in Equation (8-2)</td></tr>
<tr><td>…</td><td>…</td><td>…</td></tr>
<tr><td>Delta SNR for space-time stream Nc for subcarrier *k* = *sscidx(Ns’–1)*</td><td>4</td><td>$\Delta SNR_{sscidx(Ns'-1),\,Nc}$ as defined in Equation (8-2)</td></tr>
<tr><td colspan="3">NOTE—*sscidx*() is defined in Table 8-53j.</td></tr>
</table>

In Table 8-53i, Ns' is the number of subcarriers for which the Delta SNR subfield is sent back to the beamformer. Table 8-53j shows Ns', the exact subcarrier indices and their order for which the Delta SNR is sent back.

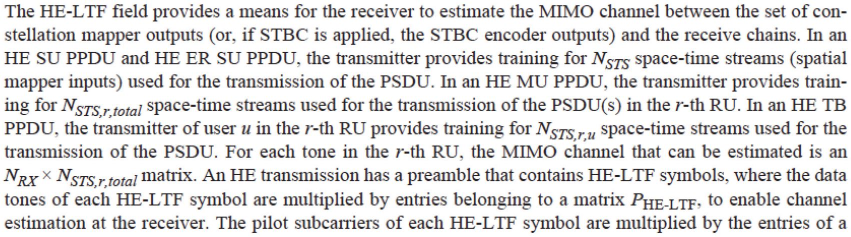
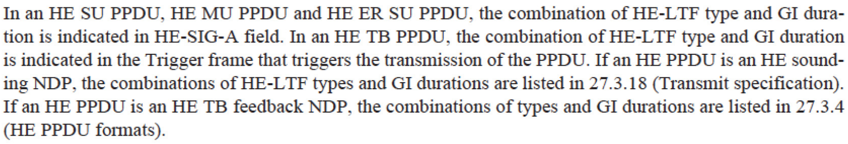
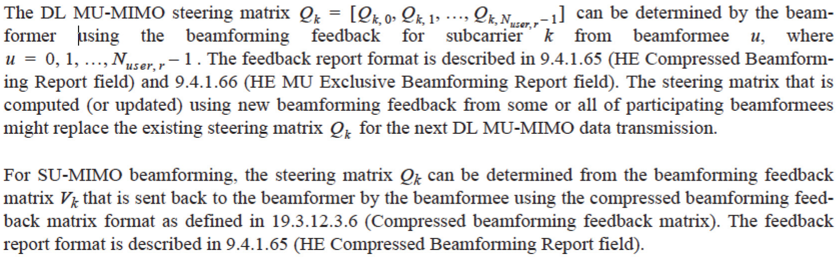
See, *e.g.*, Table 8-53i IEEE 802.11ac Standard Clause 8.4.1.48
</td></tr>
</table>

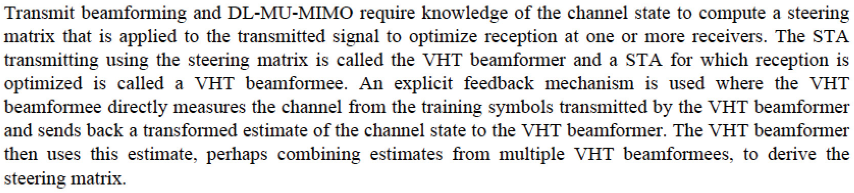
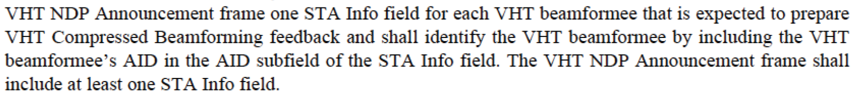
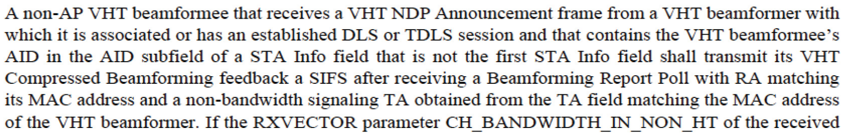
Claim 8	iPhone 12
	Transmit beamforming and DL-MU-MIMO require knowledge of the channel state to compute a steering matrix that is applied to the transmitted signal to optimize reception at one or more receivers. The STA transmitting using the steering matrix is called the VHT beamformer and a STA for which reception is optimized is called a VHT beamformee. An explicit feedback mechanism is used where the VHT beamformee directly measures the channel from the training symbols transmitted by the VHT beamformer and sends back a transformed estimate of the channel state to the VHT beamformer. The VHT beamformer then uses this estimate, perhaps combining estimates from multiple VHT beamformees, to derive the steering matrix. *See*, *e.g.*, IEEE 802.11ac Standard Clause 9.31.5.1 

Claim 8	iPhone 12
	See, *e.g.*, IEEE 802.11ac Standard Clause 22.3.4.6(d)  The VHT-SIG-B field is constructed per-user as follows: a) Obtain the VHT-MCS (for MU only) and APEP_LENGTH from the TXVECTOR. b) VHT-SIG-B bits: Set the VHT-MCS (for MU only) and VHT-SIG-B Length field as described in 22.3.8.3.6. Add the reserved bits (for SU only) and N_{tail} bits of tail. For an NDP set VHT-SIG-B to the fixed bit pattern for the bandwidth used as described in 22.3.8.3.6. c) VHT-SIG-B Bit Repetition: Repeat the VHT-SIG-B bits as a function of CH_BANDWIDTH as defined in 22.3.8.3.6. d) BCC encoder: Encode the VHT-SIG-B field using BCC at rate R=1/2 as described in 18.3.5.6. e) Segment parser (if needed): For a contiguous 160 MHz or noncontiguous 80+80 MHz transmission, divide the output bits of the BCC encoder into two frequency subblocks as described in 22.3.10.7. This block is bypassed for 20 MHz, 40 MHz, and 80 MHz VHT PPDU transmissions. f) BCC interleaver: Interleave as described in 22.3.10.8. g) Constellation mapper: Map to a BPSK constellation as defined in 18.3.5.8. h) Segment deparser (if needed): For a contiguous 160 MHz transmission, merge the two frequency subblocks into one frequency segment as described in 22.3.10.9.3. This block is bypassed for 20 MHz, 40 MHz, 80 MHz, and 80+80 MHz VHT PPDU transmissions. i) Pilot insertion: Insert pilots following the steps described in 22.3.10.10. j) P_{VHTLTF} matrix mapping: Apply the mapping of the 1st column of the P_{VHTLTF} matrix to the data subcarriers as described in 22.3.8.3.6. The total number of data and pilot subcarriers is the same as in the Data field. k) CSD: Apply CSD for each space-time stream and frequency segment as described in 22.3.8.3.2. l) Spatial mapping: Apply the Q matrix as described in 22.3.10.11.1. m) Phase rotation: Apply the appropriate phase rotations for each 20 MHz subchannel as described in 22.3.7.4 and 22.3.7.5. n) IDFT: Compute the inverse discrete Fourier transform. o) Insert GI and apply windowing: Prepend a GI (LONG_GI) and apply windowing as described in 22.3.7.4. p) 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 22.3.7.4 and 22.3.8 for details.

Claim 8	iPhone 12
	See, *e.g.*, IEEE 802.11ac Standard Clauses 22.3.4.8(l) and 22.3.4.9.1(m), 22.3.4.9.2(m), 22.3.4.10.4(a).  The DL-MU-MIMO steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user}-1}]$ can be determined by the beamformer using the beamforming feedback matrices for subcarrier k from beamformee u, $V_{k,u}$, and SNR information for subcarrier k from beamformee u, $SNR_{k,u}$, where $u = 0, 1, \ldots, N_{user} - 1$. The steering matrix that is computed (or updated) using new beamforming feedback matrices and new SNR information from some or all of participating beamformees might replace the existing steering matrix Q_k for the next DL-MU-MIMO data transmission. The beamformee group for the MU transmission is signaled using the Group ID field in VHT-SIG-A (see 22.3.8.3.3 and 22.3.11.4). *See*, *e.g.*, IEEE 802.11ac Standard Clause 22.3.11.1  Upon receipt of a VHT NDP sounding PPDU, the beamformee shall remove the space-time stream CSD in Table 22-11 from the measured channel before computing a set of matrices for feedback to the beamformer. The beamforming feedback matrix, $V_{k,u}$, found by the beamformee u for subcarrier k shall be compressed in the form of angles using the method described in 20.3.12.3.6. The angles, $\phi(k,\upsilon)$ and $\psi(k,u)$, are quantized according to Table 8-53e. The number of bits for quantization is chosen by the beamformee, based on the indication from the beamformer as to whether the feedback is requested for SU-MIMO beamforming or DL-MU-MIMO beamforming. The compressed beamforming feedback using 20.3.12.3.6 is the only Clause 22 beamforming feedback format defined. The beamformee shall generate the beamforming feedback matrices with the number of rows (Nr) equal to the N_{STS} of the NDP. After receiving the angle information, $\phi(k,u)$ and $\psi(k,u)$, the beamformer reconstructs $V_{k,u}$ using Equation (20-79). For SU-MIMO beamforming, the beamformer can use this $V_{k,0}$ matrix to determine the steering matrix Q_k. For DL-MU-MIMO beamforming, the beamformer may calculate a steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user}-1}]$ using $V_{k,u}$ and $SNR_{k,u}$ $(0 \le u \le N_{user} - 1)$ in order to suppress crosstalk between participating beamformees. The method used by the beamformer to calculate the steering matrix Q_k is implementation specific. *See*, *e.g.*, IEEE 802.11ac Standard Clause 22.3.11.2.
[8b] determining first signal information for the first signal transmission;	The iPhone 12 determines first signal information for the first signal transmission.

Claim 8	iPhone 12
	For example, the iPhone 12 determines the first signal information for the first signal transmission, by determining symbols corresponding to e.g. a first space-time stream using e.g. the training fields of a null data packet for MU-MIMO sounding and channel estimation, which allows for determining, e.g., an estimate of the channel state, e.g., a transformed estimate of the channel state to be transmitted in a compressed beamforming report, e.g., the parameters in the beamforming feedback matrix.  Transmit beamforming and DL MU-MIMO require knowledge of the channel state to compute a steering matrix that is applied to the transmit signal to optimize reception at one or more receivers. HE STAs use the HE sounding protocol to determine the channel state information. The HE sounding protocol provides explicit feedback mechanisms, defined as HE non-trigger-based (non-TB) sounding and HE trigger-based (TB) sounding, where the HE beamformee measures the channel using a training signal (i.e., an HE sounding NDP) transmitted by the HE beamformer and sends back a transformed estimate of the channel state. The HE beamformer uses this estimate to derive the steering matrix.  The HE beamformee returns an estimate of the channel state in an HE compressed beamforming/CQI report carried in one or more HE Compressed Beamforming/CQI frames. There are three types of HE compressed beamforming/CQI report: *See*, *e.g.*, IEEE 802.11ax Standard, Section 26.7.1  An HE beamformee that receives an HE NDP Announcement frame from an HE beamformer with which it is associated and that contains the HE beamformee's MAC address in the RA field and also receives an HE sounding NDP a SIFS after the HE NDP Announcement frame shall transmit its HE compressed beamforming/CQI report a SIFS after the HE sounding NDP. The TXVECTOR parameter CH_BANDWIDTH for the PPDU containing the HE compressed beamforming/CQI report shall be set to indicate a bandwidth not wider than that indicated by the RXVECTOR parameter CH_BANDWIDTH of the HE sounding NDP. *See*, *e.g.*, IEEE 802.11ax Standard, Section 26.7.3  An HE beamformee that receives an HE NDP Announcement frame as part of an HE TB sounding sequence with a STA Info field addressed to it soliciting SU or MU feedback shall generate an HE compressed beamforming/CQI report using the feedback type, *Ng* and codebook size indicated in the STA Info field. If the HE beamformee then receives a BFRP Trigger frame with a User Info field addressed to it, the HE beamformee transmits an HE TB PPDU containing the HE compressed beamforming/CQI report following the rules defined in 26.5.3.3 (Non-AP STA behavior for UL MU operation). If the HE NDP Announcement frame has *See*, *e.g.*, IEEE 802.11ax Standard, Section 26.7.3  UL MU operation allows an AP to solicit simultaneous immediate response frames from one or more non-AP HE STAs. A non-AP HE STA shall follow the rules in this subclause for the transmission of response

Claim 8	iPhone 12
	See, *e.g.*, IEEE 802.11ax Standard, Section 26.5.3  The HE-LTF field provides a means for the receiver to estimate the MIMO channel between the set of constellation mapper outputs (or, if STBC is applied, the STBC encoder outputs) and the receive chains. In an HE SU PPDU and HE ER SU PPDU, the transmitter provides training for N_{STS} space-time streams (spatial mapper inputs) used for the transmission of the PSDU. In an HE MU PPDU, the transmitter provides training for $N_{STS,r,total}$ space-time streams used for the transmission of the PSDU(s) in the r-th RU. In an HE TB PPDU, the transmitter of user u in the r-th RU provides training for $N_{STS,r,u}$ space-time streams used for the transmission of the PSDU. For each tone in the r-th RU, the MIMO channel that can be estimated is an $N_{RX} \times N_{STS,r,total}$ matrix. An HE transmission has a preamble that contains HE-LTF symbols, where the data tones of each HE-LTF symbol are multiplied by entries belonging to a matrix $P_{\text{HE-LTF}}$, to enable channel estimation at the receiver. The pilot subcarriers of each HE-LTF symbol are multiplied by the entries of a *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.10.10  In an HE SU PPDU, HE MU PPDU and HE ER SU PPDU, the combination of HE-LTF type and GI duration is indicated in HE-SIG-A field. In an HE TB PPDU, the combination of HE-LTF type and GI duration is indicated in the Trigger frame that triggers the transmission of the PPDU. If an HE PPDU is an HE sounding NDP, the combinations of HE-LTF types and GI durations are listed in 27.3.18 (Transmit specification). If an HE PPDU is an HE TB feedback NDP, the combinations of types and GI durations are listed in 27.3.4 (HE PPDU formats). *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.10.10  The DL MU-MIMO steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user,r}-1}]$ can be determined by the beamformer using the beamforming feedback for subcarrier k from beamformee u, where $u = 0, 1, \ldots, N_{user,r} - 1$. The feedback report format is described in 9.4.1.65 (HE Compressed Beamforming Report field) and 9.4.1.66 (HE MU Exclusive Beamforming Report field). The steering matrix that is computed (or updated) using new beamforming feedback from some or all of participating beamformees might replace the existing steering matrix Q_k for the next DL MU-MIMO data transmission. For SU-MIMO beamforming, the steering matrix Q_k can be determined from the beamforming feedback matrix V_k that is sent back to the beamformer by the beamformee using the compressed beamforming feedback matrix format as defined in 19.3.12.3.6 (Compressed beamforming feedback matrix). The feedback report format is described in 9.4.1.65 (HE Compressed Beamforming Report field). *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.15.1

Claim 8	iPhone 12
	 Transmit beamforming and DL-MU-MIMO require knowledge of the channel state to compute a steering matrix that is applied to the transmitted signal to optimize reception at one or more receivers. The STA transmitting using the steering matrix is called the VHT beamformer and a STA for which reception is optimized is called a VHT beamformee. An explicit feedback mechanism is used where the VHT beamformee directly measures the channel from the training symbols transmitted by the VHT beamformer and sends back a transformed estimate of the channel state to the VHT beamformer. The VHT beamformer then uses this estimate, perhaps combining estimates from multiple VHT beamformees, to derive the steering matrix. *See*, *e.g.*, IEEE 802.11ac Standard Clause 9.31.5.1  A VHT beamformer shall initiate a sounding feedback sequence by transmitting a VHT NDP Announcement frame followed by a VHT NDP after a SIFS. The VHT beamformer shall include in the VHT NDP Announcement frame one STA Info field for each VHT beamformee that is expected to prepare VHT Compressed Beamforming feedback and shall identify the VHT beamformee by including the VHT beamformee's AID in the AID subfield of the STA Info field. The VHT NDP Announcement frame shall include at least one STA Info field. *See*, *e.g.*, IEEE 802.11ac Standard Clause 9.31.5.2  A non-AP VHT beamformee that receives a VHT NDP Announcement frame from a VHT beamformer with which it is associated or has an established DLS or TDLS session and that contains the VHT beamformee's AID in the AID subfield of a STA Info field that is not the first STA Info field shall transmit its VHT Compressed Beamforming feedback a SIFS after receiving a Beamforming Report Poll with RA matching its MAC address and a non-bandwidth signaling TA obtained from the TA field matching the MAC address of the VHT beamformer. If the RXVECTOR parameter CH_BANDWIDTH_IN_NON_HT of the received *See*, *e.g.*, IEEE 802.11ac Standard Clause 9.31.5.2

<table>
<tr><th>Claim 8</th><th>iPhone 12</th></tr>
<tr><td></td><td>

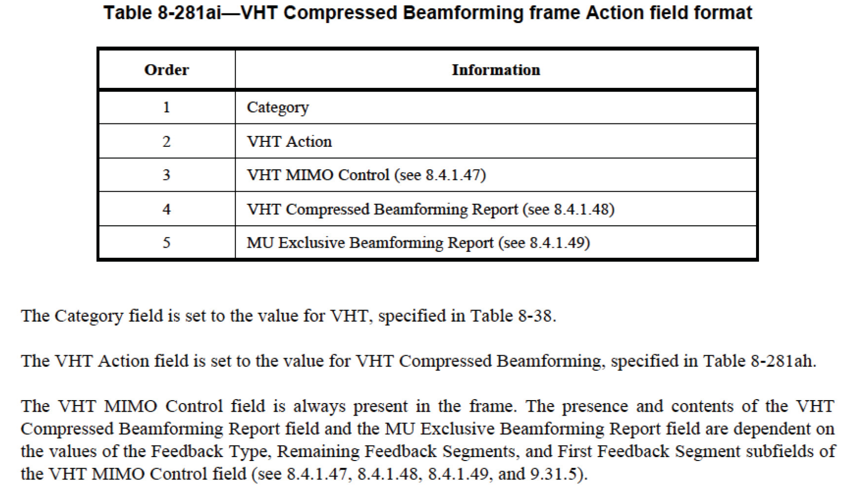
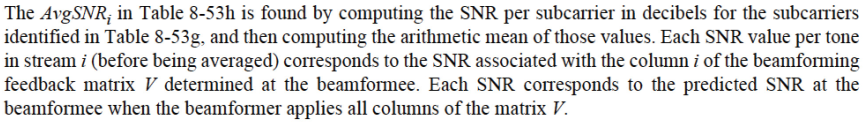
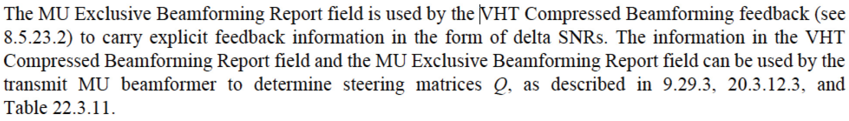



Table 8-281ai—VHT Compressed Beamforming frame Action field format
<table>
<tr><th>Order</th><th>Information</th></tr>
<tr><td>1</td><td>Category</td></tr>
<tr><td>2</td><td>VHT Action</td></tr>
<tr><td>3</td><td>VHT MIMO Control (see 8.4.1.47)</td></tr>
<tr><td>4</td><td>VHT Compressed Beamforming Report (see 8.4.1.48)</td></tr>
<tr><td>5</td><td>MU Exclusive Beamforming Report (see 8.4.1.49)</td></tr>
</table>

The Category field is set to the value for VHT, specified in Table 8-38.
The VHT Action field is set to the value for VHT Compressed Beamforming, specified in Table 8-281ah.
The VHT MIMO Control field is always present in the frame. The presence and contents of the VHT Compressed Beamforming Report field and the MU Exclusive Beamforming Report field are dependent on the values of the Feedback Type, Remaining Feedback Segments, and First Feedback Segment subfields of the VHT MIMO Control field (see 8.4.1.47, 8.4.1.48, 8.4.1.49, and 9.31.5).
<i>See</i>, <i>e.g.</i>, IEEE 802.11ac Standard Clause 8.5.23.2
<i>See</i> Tables 8-53(d)-(h) in IEEE 802.11ac Standard Clause 8.4.1.48

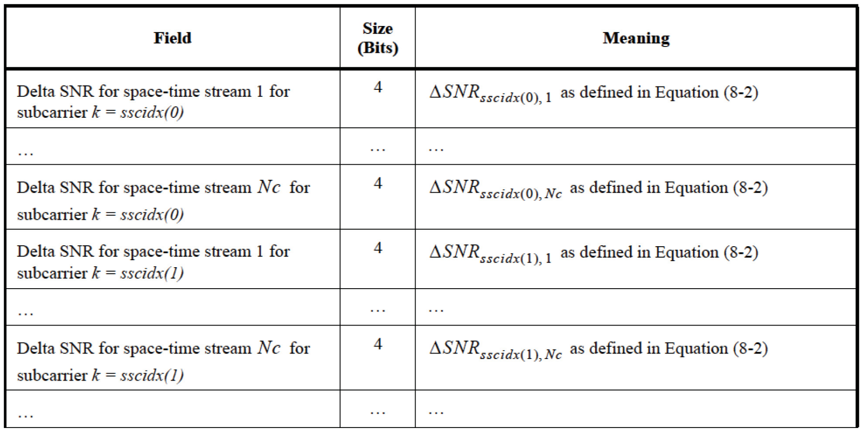

The $AvgSNR_i$ in Table 8-53h is found by computing the SNR per subcarrier in decibels for the subcarriers identified in Table 8-53g, and then computing the arithmetic mean of those values. Each SNR value per tone in stream i (before being averaged) corresponds to the SNR associated with the column i of the beamforming feedback matrix V determined at the beamformee. Each SNR corresponds to the predicted SNR at the beamformee when the beamformer applies all columns of the matrix V.
<i>See</i>, <i>e.g.</i>, IEEE 802.11ac Standard Clause 8.4.1.48
</td></tr>
</table>

<table>
<tr><th>Claim 8</th><th>iPhone 12</th></tr>
<tr><td></td><td>



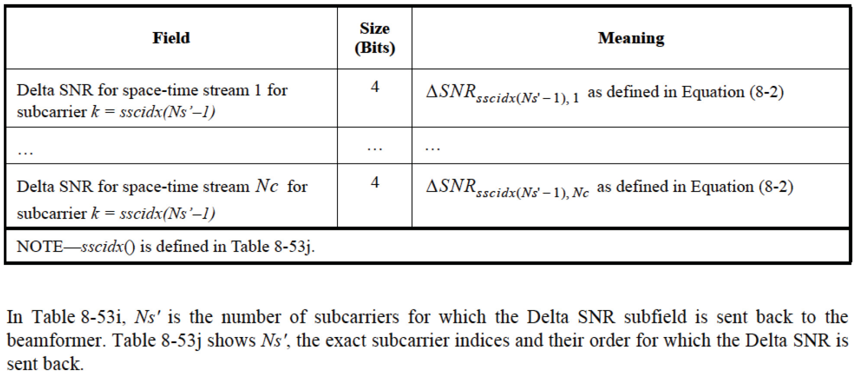
The MU Exclusive Beamforming Report field is used by the VHT Compressed Beamforming feedback (see 8.5.23.2) to carry explicit feedback information in the form of delta SNRs. The information in the VHT Compressed Beamforming Report field and the MU Exclusive Beamforming Report field can be used by the transmit MU beamformer to determine steering matrices Q, as described in 9.29.3, 20.3.12.3, and Table 22.3.11.

See, *e.g.*, IEEE 802.11ac Standard Clause 8.4.1.49



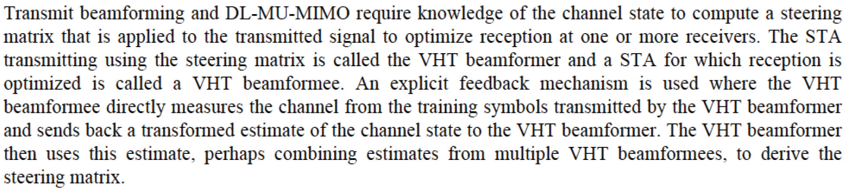
<table>
<tr><th>Field</th><th>Size (Bits)</th><th>Meaning</th></tr>
<tr><td>Delta SNR for space-time stream 1 for subcarrier $k = sscidx(0)$</td><td>4</td><td>$\Delta SNR_{sscidx(0),1}$ as defined in Equation (8-2)</td></tr>
<tr><td>…</td><td>…</td><td>…</td></tr>
<tr><td>Delta SNR for space-time stream Nc for subcarrier $k = sscidx(0)$</td><td>4</td><td>$\Delta SNR_{sscidx(0),Nc}$ as defined in Equation (8-2)</td></tr>
<tr><td>Delta SNR for space-time stream 1 for subcarrier $k = sscidx(1)$</td><td>4</td><td>$\Delta SNR_{sscidx(1),1}$ as defined in Equation (8-2)</td></tr>
<tr><td>…</td><td>…</td><td>…</td></tr>
<tr><td>Delta SNR for space-time stream Nc for subcarrier $k = sscidx(1)$</td><td>4</td><td>$\Delta SNR_{sscidx(1),Nc}$ as defined in Equation (8-2)</td></tr>
<tr><td>…</td><td>…</td><td>…</td></tr>
</table>

</td></tr>
</table>

<table>
<tr><th>Claim 8</th><th>iPhone 12</th></tr>
<tr><td></td><td>

<table>
<tr><th>Field</th><th>Size (Bits)</th><th>Meaning</th></tr>
<tr><td>Delta SNR for space-time stream 1 for subcarrier <i>k</i> = <i>sscidx(Ns'–1)</i></td><td>4</td><td>$\Delta SNR_{sscidx(Ns'-1),1}$ as defined in Equation (8-2)</td></tr>
<tr><td>…</td><td>…</td><td>…</td></tr>
<tr><td>Delta SNR for space-time stream Nc for subcarrier <i>k</i> = <i>sscidx(Ns'–1)</i></td><td>4</td><td>$\Delta SNR_{sscidx(Ns'-1),Nc}$ as defined in Equation (8-2)</td></tr>
<tr><td colspan="3">NOTE—<i>sscidx</i>() is defined in Table 8-53j.</td></tr>
</table>

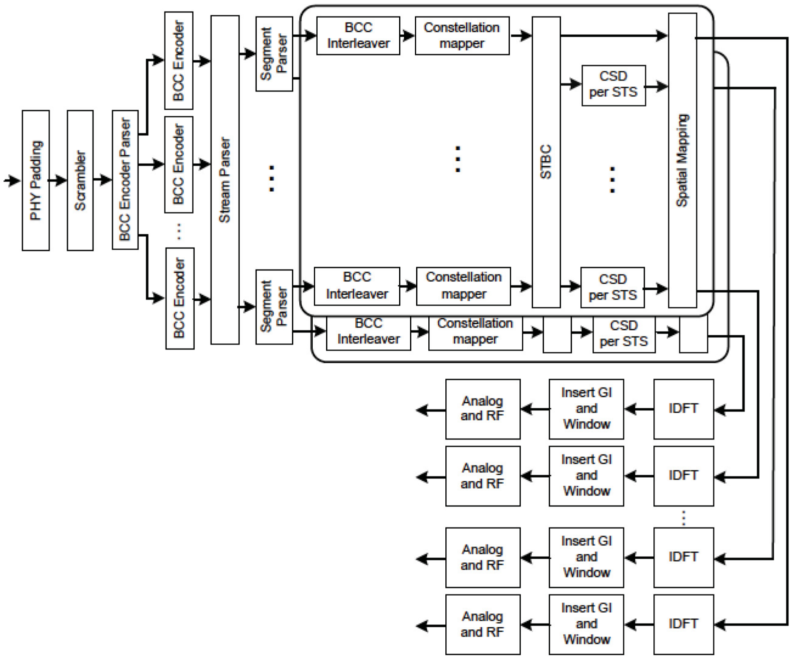
In Table 8-53i, Ns' is the number of subcarriers for which the Delta SNR subfield is sent back to the beamformer. Table 8-53j shows Ns', the exact subcarrier indices and their order for which the Delta SNR is sent back.

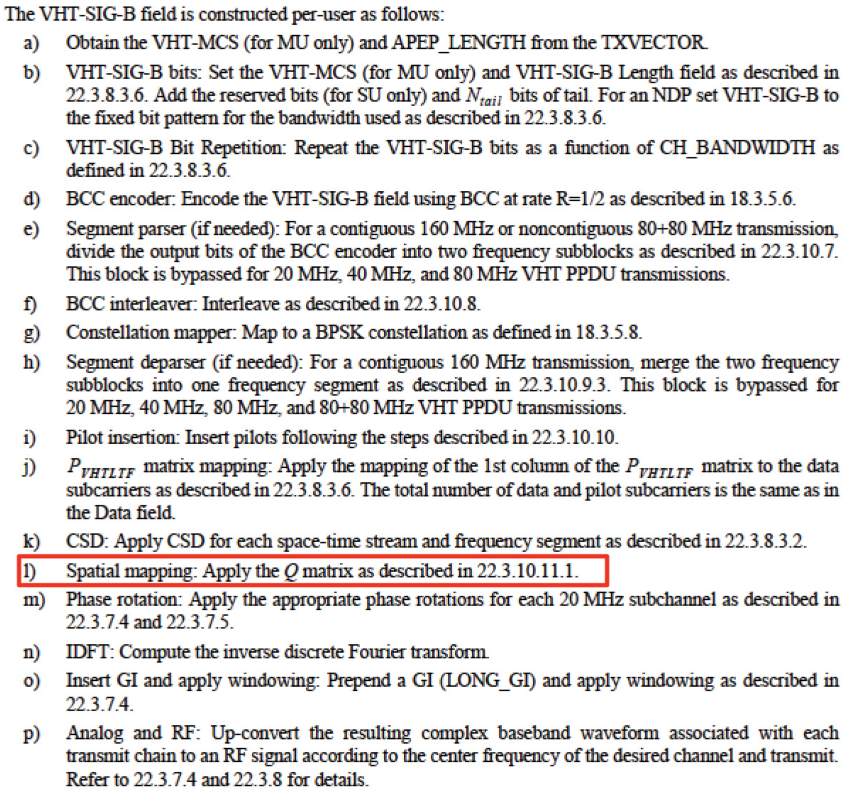
<i>See</i>, <i>e.g.</i>, Table 8-53i IEEE 802.11ac Standard Clause 8.4.1.48

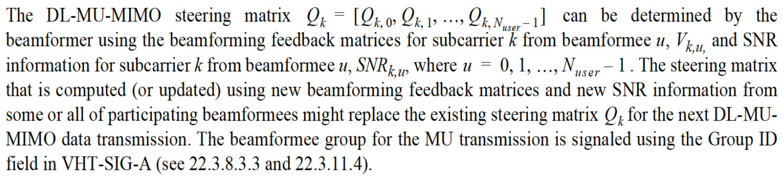
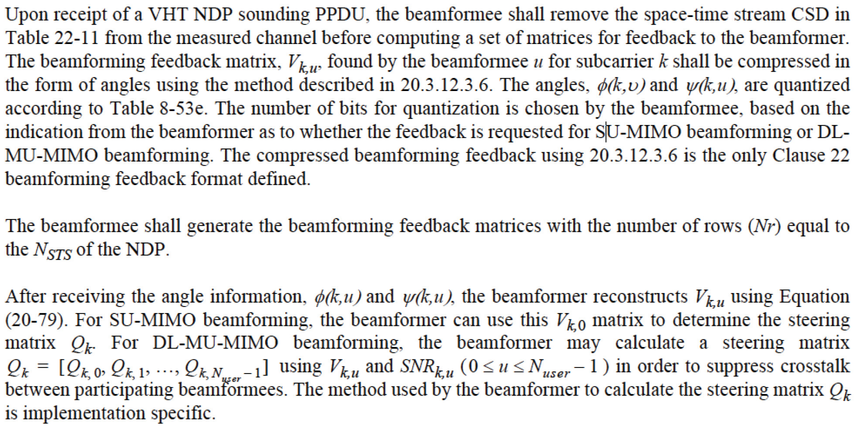


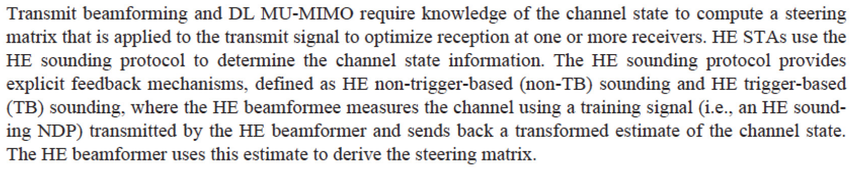
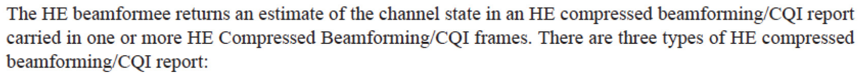
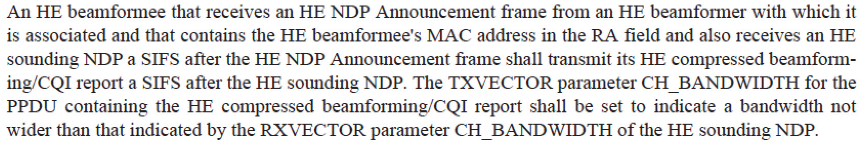
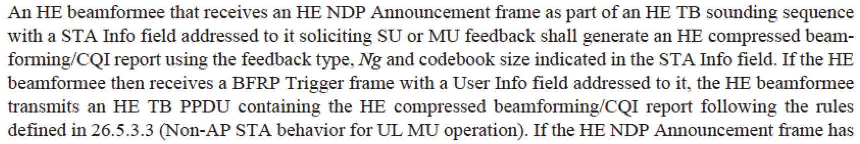
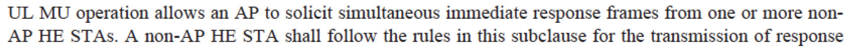
Transmit beamforming and DL-MU-MIMO require knowledge of the channel state to compute a steering matrix that is applied to the transmitted signal to optimize reception at one or more receivers. The STA transmitting using the steering matrix is called the VHT beamformer and a STA for which reception is optimized is called a VHT beamformee. An explicit feedback mechanism is used where the VHT beamformee directly measures the channel from the training symbols transmitted by the VHT beamformer and sends back a transformed estimate of the channel state to the VHT beamformer. The VHT beamformer then uses this estimate, perhaps combining estimates from multiple VHT beamformees, to derive the steering matrix.

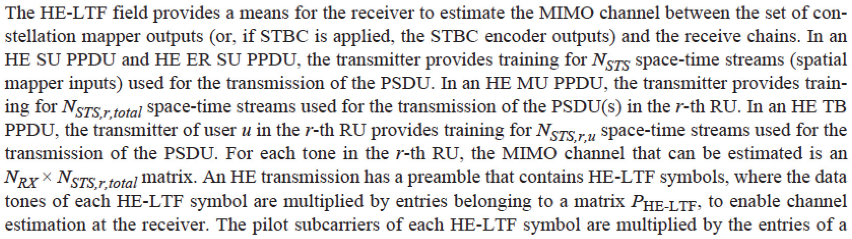
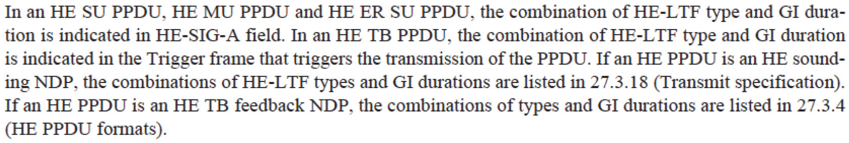
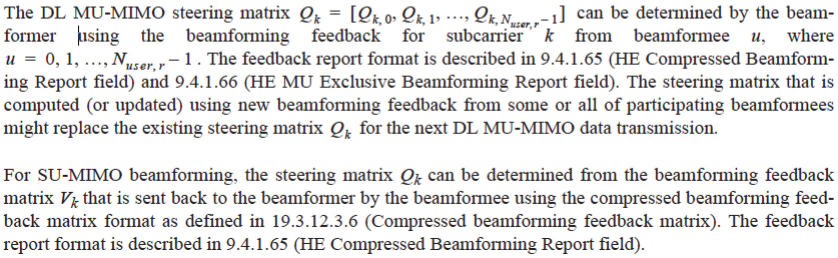
<i>See</i>, <i>e.g.</i>, IEEE 802.11ac Standard Clause 9.31.5.1
</td></tr>
</table>

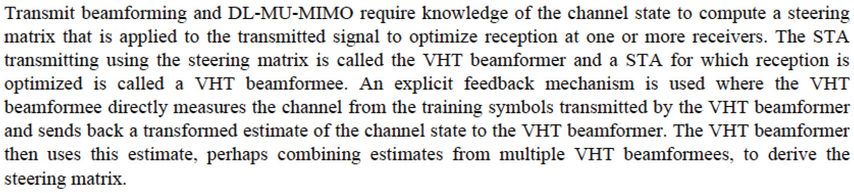
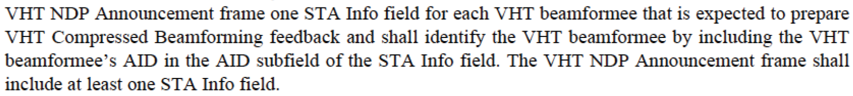
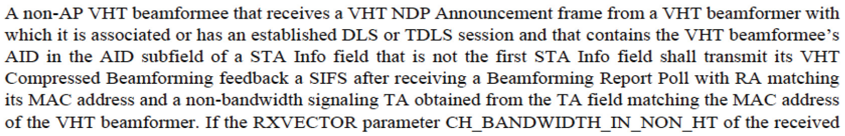
Claim 8	iPhone 12
	 *See*, *e.g.*, IEEE 802.11ac Standard Clause 22.3.4.6(d)

Claim 8	iPhone 12
	 The VHT-SIG-B field is constructed per-user as follows: a) Obtain the VHT-MCS (for MU only) and APEP_LENGTH from the TXVECTOR. b) VHT-SIG-B bits: Set the VHT-MCS (for MU only) and VHT-SIG-B Length field as described in 22.3.8.3.6. Add the reserved bits (for SU only) and N_{tail} bits of tail. For an NDP set VHT-SIG-B to the fixed bit pattern for the bandwidth used as described in 22.3.8.3.6. c) VHT-SIG-B Bit Repetition: Repeat the VHT-SIG-B bits as a function of CH_BANDWIDTH as defined in 22.3.8.3.6. d) BCC encoder: Encode the VHT-SIG-B field using BCC at rate R=1/2 as described in 18.3.5.6. e) Segment parser (if needed): For a contiguous 160 MHz or noncontiguous 80+80 MHz transmission, divide the output bits of the BCC encoder into two frequency subblocks as described in 22.3.10.7. This block is bypassed for 20 MHz, 40 MHz, and 80 MHz VHT PPDU transmissions. f) BCC interleaver: Interleave as described in 22.3.10.8. g) Constellation mapper: Map to a BPSK constellation as defined in 18.3.5.8. h) Segment deparser (if needed): For a contiguous 160 MHz transmission, merge the two frequency subblocks into one frequency segment as described in 22.3.10.9.3. This block is bypassed for 20 MHz, 40 MHz, 80 MHz, and 80+80 MHz VHT PPDU transmissions. i) Pilot insertion: Insert pilots following the steps described in 22.3.10.10. j) P_{VHTLTF} matrix mapping: Apply the mapping of the 1st column of the P_{VHTLTF} matrix to the data subcarriers as described in 22.3.8.3.6. The total number of data and pilot subcarriers is the same as in the Data field. k) CSD: Apply CSD for each space-time stream and frequency segment as described in 22.3.8.3.2. l) Spatial mapping: Apply the Q matrix as described in 22.3.10.11.1. m) Phase rotation: Apply the appropriate phase rotations for each 20 MHz subchannel as described in 22.3.7.4 and 22.3.7.5. n) IDFT: Compute the inverse discrete Fourier transform. o) Insert GI and apply windowing: Prepend a GI (LONG_GI) and apply windowing as described in 22.3.7.4. p) 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 22.3.7.4 and 22.3.8 for details. *See*, *e.g.*, IEEE 802.11ac Standard Clauses 22.3.4.8(l) and 22.3.4.9.1(m), 22.3.4.9.2(m), 22.3.4.10.4(a).

Claim 8	iPhone 12
	 The DL-MU-MIMO steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user}-1}]$ can be determined by the beamformer using the beamforming feedback matrices for subcarrier k from beamformee u, $V_{k,u}$, and SNR information for subcarrier k from beamformee u, $SNR_{k,u}$, where $u = 0, 1, \ldots, N_{user} - 1$. The steering matrix that is computed (or updated) using new beamforming feedback matrices and new SNR information from some or all of participating beamformees might replace the existing steering matrix Q_k for the next DL-MU-MIMO data transmission. The beamformee group for the MU transmission is signaled using the Group ID field in VHT-SIG-A (see 22.3.8.3.3 and 22.3.11.4). *See*, *e.g.*, IEEE 802.11ac Standard Clause 22.3.11.1  Upon receipt of a VHT NDP sounding PPDU, the beamformee shall remove the space-time stream CSD in Table 22-11 from the measured channel before computing a set of matrices for feedback to the beamformer. The beamforming feedback matrix, $V_{k,u}$, found by the beamformee u for subcarrier k shall be compressed in the form of angles using the method described in 20.3.12.3.6. The angles, $\phi(k,\upsilon)$ and $\psi(k,u)$, are quantized according to Table 8-53e. The number of bits for quantization is chosen by the beamformee, based on the indication from the beamformer as to whether the feedback is requested for SU-MIMO beamforming or DL-MU-MIMO beamforming. The compressed beamforming feedback using 20.3.12.3.6 is the only Clause 22 beamforming feedback format defined. The beamformee shall generate the beamforming feedback matrices with the number of rows (Nr) equal to the N_{STS} of the NDP. After receiving the angle information, $\phi(k,u)$ and $\psi(k,u)$, the beamformer reconstructs $V_{k,u}$ using Equation (20-79). For SU-MIMO beamforming, the beamformer can use this $V_{k,0}$ matrix to determine the steering matrix Q_k. For DL-MU-MIMO beamforming, the beamformer may calculate a steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user}-1}]$ using $V_{k,u}$ and $SNR_{k,u}$ $(0 \le u \le N_{user} - 1)$ in order to suppress crosstalk between participating beamformees. The method used by the beamformer to calculate the steering matrix Q_k is implementation specific. *See*, *e.g.*, IEEE 802.11ac Standard Clause 22.3.11.2.
[8c] determining second signal information for the second signal transmission, wherein the second signal information is different than the first signal information;	The iPhone 12 determines second signal information for the second signal transmission, wherein the second signal information is different than the first signal information. For example, the iPhone 12 determines the second signal information for the second signal transmission, by determining symbols corresponding to e.g. a second space-time stream using e.g. the training fields of a null data packet for MU-MIMO sounding and

Claim 8	iPhone 12
	channel estimation, which allows for determining , e.g., an estimate of the channel state, e.g., a transformed estimate of the channel state to be transmitted in a compressed beamforming report, e.g., the parameters in the beamforming feedback matrix.  Transmit beamforming and DL MU-MIMO require knowledge of the channel state to compute a steering matrix that is applied to the transmit signal to optimize reception at one or more receivers. HE STAs use the HE sounding protocol to determine the channel state information. The HE sounding protocol provides explicit feedback mechanisms, defined as HE non-trigger-based (non-TB) sounding and HE trigger-based (TB) sounding, where the HE beamformee measures the channel using a training signal (i.e., an HE sounding NDP) transmitted by the HE beamformer and sends back a transformed estimate of the channel state. The HE beamformer uses this estimate to derive the steering matrix.  The HE beamformee returns an estimate of the channel state in an HE compressed beamforming/CQI report carried in one or more HE Compressed Beamforming/CQI frames. There are three types of HE compressed beamforming/CQI report: *See*, *e.g.*, IEEE 802.11ax Standard, Section 26.7.1  An HE beamformee that receives an HE NDP Announcement frame from an HE beamformer with which it is associated and that contains the HE beamformee's MAC address in the RA field and also receives an HE sounding NDP a SIFS after the HE NDP Announcement frame shall transmit its HE compressed beamforming/CQI report a SIFS after the HE sounding NDP. The TXVECTOR parameter CH_BANDWIDTH for the PPDU containing the HE compressed beamforming/CQI report shall be set to indicate a bandwidth not wider than that indicated by the RXVECTOR parameter CH_BANDWIDTH of the HE sounding NDP. *See*, *e.g.*, IEEE 802.11ax Standard, Section 26.7.3  An HE beamformee that receives an HE NDP Announcement frame as part of an HE TB sounding sequence with a STA Info field addressed to it soliciting SU or MU feedback shall generate an HE compressed beamforming/CQI report using the feedback type, *Ng* and codebook size indicated in the STA Info field. If the HE beamformee then receives a BFRP Trigger frame with a User Info field addressed to it, the HE beamformee transmits an HE TB PPDU containing the HE compressed beamforming/CQI report following the rules defined in 26.5.3.3 (Non-AP STA behavior for UL MU operation). If the HE NDP Announcement frame has *See*, *e.g.*, IEEE 802.11ax Standard, Section 26.7.3  UL MU operation allows an AP to solicit simultaneous immediate response frames from one or more non-AP HE STAs. A non-AP HE STA shall follow the rules in this subclause for the transmission of response *See*, *e.g.*, IEEE 802.11ax Standard, Section 26.5.3

Claim 8	iPhone 12
	 The HE-LTF field provides a means for the receiver to estimate the MIMO channel between the set of constellation mapper outputs (or, if STBC is applied, the STBC encoder outputs) and the receive chains. In an HE SU PPDU and HE ER SU PPDU, the transmitter provides training for N_{STS} space-time streams (spatial mapper inputs) used for the transmission of the PSDU. In an HE MU PPDU, the transmitter provides training for $N_{STS,r,total}$ space-time streams used for the transmission of the PSDU(s) in the r-th RU. In an HE TB PPDU, the transmitter of user u in the r-th RU provides training for $N_{STS,r,u}$ space-time streams used for the transmission of the PSDU. For each tone in the r-th RU, the MIMO channel that can be estimated is an $N_{RX} \times N_{STS,r,total}$ matrix. An HE transmission has a preamble that contains HE-LTF symbols, where the data tones of each HE-LTF symbol are multiplied by entries belonging to a matrix $P_{\text{HE-LTF}}$, to enable channel estimation at the receiver. The pilot subcarriers of each HE-LTF symbol are multiplied by the entries of a *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.10.10  In an HE SU PPDU, HE MU PPDU and HE ER SU PPDU, the combination of HE-LTF type and GI duration is indicated in HE-SIG-A field. In an HE TB PPDU, the combination of HE-LTF type and GI duration is indicated in the Trigger frame that triggers the transmission of the PPDU. If an HE PPDU is an HE sounding NDP, the combinations of HE-LTF types and GI durations are listed in 27.3.18 (Transmit specification). If an HE PPDU is an HE TB feedback NDP, the combinations of types and GI durations are listed in 27.3.4 (HE PPDU formats). *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.10.10  The DL MU-MIMO steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user,r}-1}]$ can be determined by the beamformer using the beamforming feedback for subcarrier k from beamformee u, where $u = 0, 1, \ldots, N_{user,r}-1$. The feedback report format is described in 9.4.1.65 (HE Compressed Beamforming Report field) and 9.4.1.66 (HE MU Exclusive Beamforming Report field). The steering matrix that is computed (or updated) using new beamforming feedback from some or all of participating beamformees might replace the existing steering matrix Q_k for the next DL MU-MIMO data transmission. For SU-MIMO beamforming, the steering matrix Q_k can be determined from the beamforming feedback matrix V_k that is sent back to the beamformer by the beamformee using the compressed beamforming feedback matrix format as defined in 19.3.12.3.6 (Compressed beamforming feedback matrix). The feedback report format is described in 9.4.1.65 (HE Compressed Beamforming Report field). *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.15.1

Claim 8	iPhone 12
	 Transmit beamforming and DL-MU-MIMO require knowledge of the channel state to compute a steering matrix that is applied to the transmitted signal to optimize reception at one or more receivers. The STA transmitting using the steering matrix is called the VHT beamformer and a STA for which reception is optimized is called a VHT beamformee. An explicit feedback mechanism is used where the VHT beamformee directly measures the channel from the training symbols transmitted by the VHT beamformer and sends back a transformed estimate of the channel state to the VHT beamformer. The VHT beamformer then uses this estimate, perhaps combining estimates from multiple VHT beamformees, to derive the steering matrix. *See*, *e.g.*, IEEE 802.11ac Standard Clause 9.31.5.1  A VHT beamformer shall initiate a sounding feedback sequence by transmitting a VHT NDP Announcement frame followed by a VHT NDP after a SIFS. The VHT beamformer shall include in the VHT NDP Announcement frame one STA Info field for each VHT beamformee that is expected to prepare VHT Compressed Beamforming feedback and shall identify the VHT beamformee by including the VHT beamformee's AID in the AID subfield of the STA Info field. The VHT NDP Announcement frame shall include at least one STA Info field. *See*, *e.g.*, IEEE 802.11ac Standard Clause 9.31.5.2  A non-AP VHT beamformee that receives a VHT NDP Announcement frame from a VHT beamformer with which it is associated or has an established DLS or TDLS session and that contains the VHT beamformee's AID in the AID subfield of a STA Info field that is not the first STA Info field shall transmit its VHT Compressed Beamforming feedback a SIFS after receiving a Beamforming Report Poll with RA matching its MAC address and a non-bandwidth signaling TA obtained from the TA field matching the MAC address of the VHT beamformer. If the RXVECTOR parameter CH_BANDWIDTH_IN_NON_HT of the received *See*, *e.g.*, IEEE 802.11ac Standard Clause 9.31.5.2

<table>
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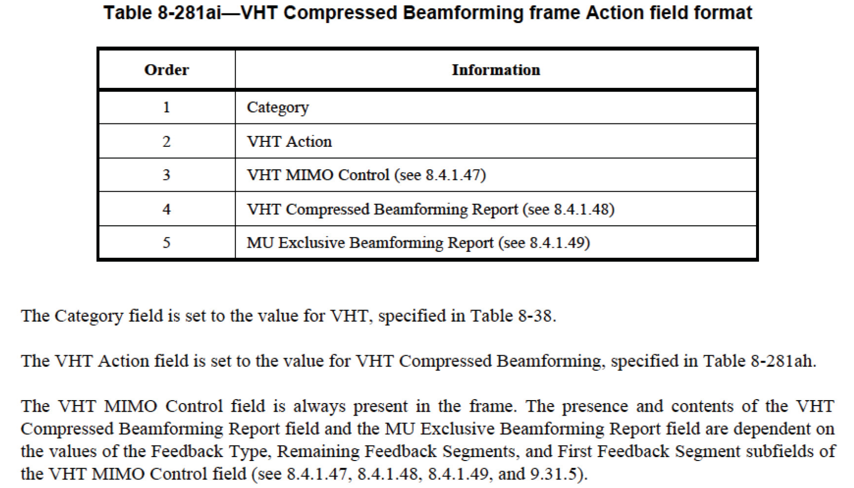
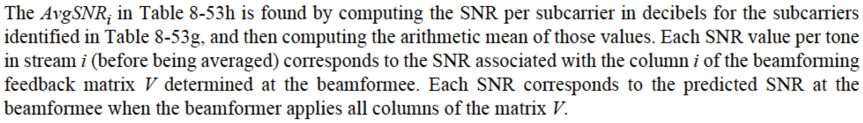
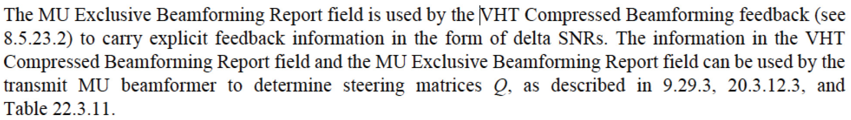
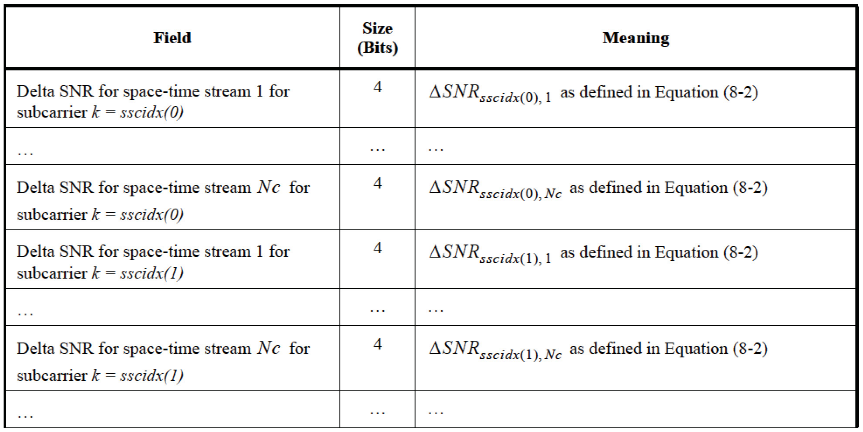
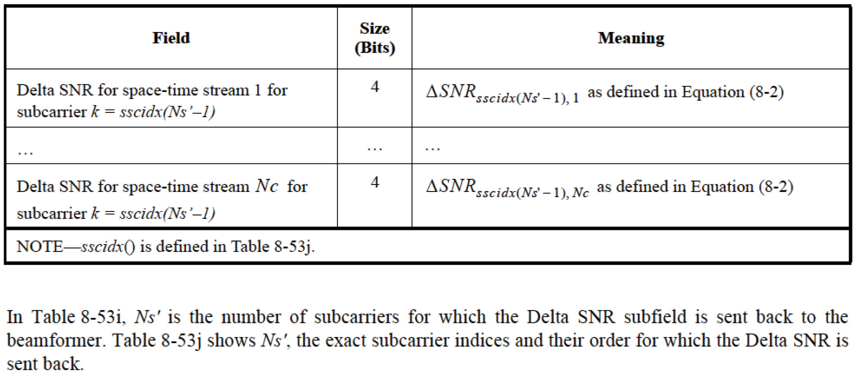
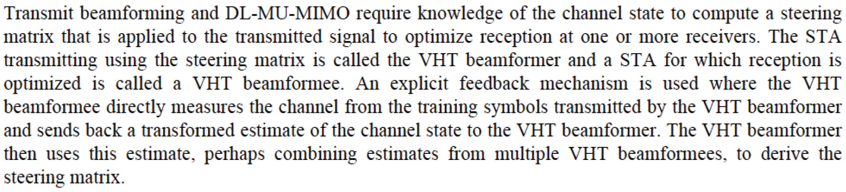
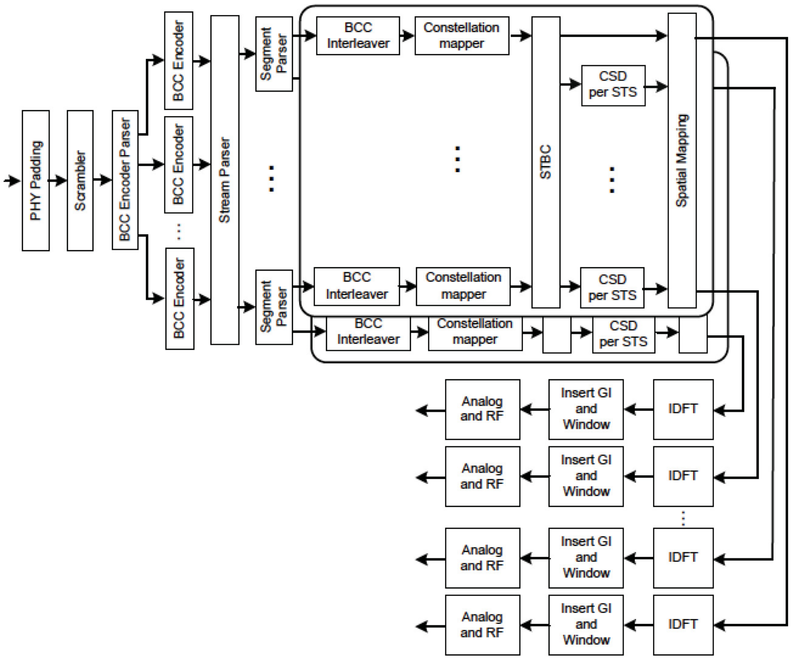
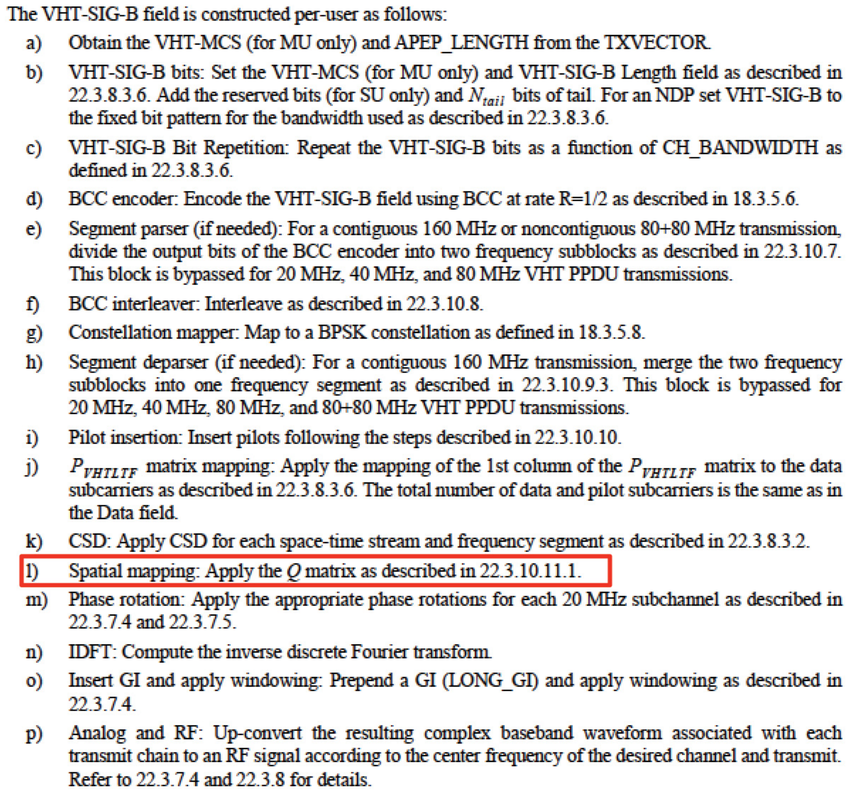


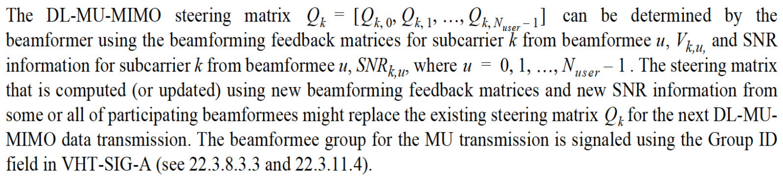
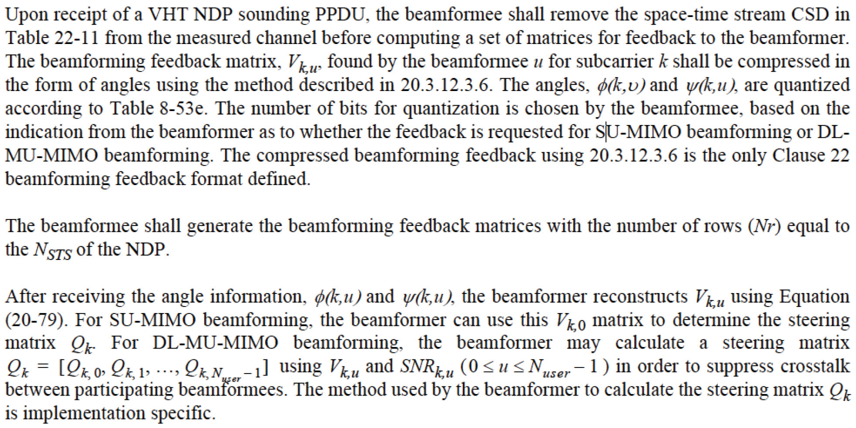
Table 8-281ai—VHT Compressed Beamforming frame Action field format
<table>
<tr><th>Order</th><th>Information</th></tr>
<tr><td>1</td><td>Category</td></tr>
<tr><td>2</td><td>VHT Action</td></tr>
<tr><td>3</td><td>VHT MIMO Control (see 8.4.1.47)</td></tr>
<tr><td>4</td><td>VHT Compressed Beamforming Report (see 8.4.1.48)</td></tr>
<tr><td>5</td><td>MU Exclusive Beamforming Report (see 8.4.1.49)</td></tr>
</table>
<p>The Category field is set to the value for VHT, specified in Table 8-38.</p>
<p>The VHT Action field is set to the value for VHT Compressed Beamforming, specified in Table 8-281ah.</p>
<p>The VHT MIMO Control field is always present in the frame. The presence and contents of the VHT Compressed Beamforming Report field and the MU Exclusive Beamforming Report field are dependent on the values of the Feedback Type, Remaining Feedback Segments, and First Feedback Segment subfields of the VHT MIMO Control field (see 8.4.1.47, 8.4.1.48, 8.4.1.49, and 9.31.5).</p>
<p><i>See</i>, <i>e.g.</i>, IEEE 802.11ac Standard Clause 8.5.23.2
<i>See</i> Tables 8-53(d)-(h) in IEEE 802.11ac Standard Clause 8.4.1.48</p>

<p>The $AvgSNR_i$ in Table 8-53h is found by computing the SNR per subcarrier in decibels for the subcarriers identified in Table 8-53g, and then computing the arithmetic mean of those values. Each SNR value per tone in stream i (before being averaged) corresponds to the SNR associated with the column i of the beamforming feedback matrix V determined at the beamformee. Each SNR corresponds to the predicted SNR at the beamformee when the beamformer applies all columns of the matrix V.</p>
<p><i>See</i>, <i>e.g.</i>, IEEE 802.11ac Standard Clause 8.4.1.48</p>
</td></tr>
</table>

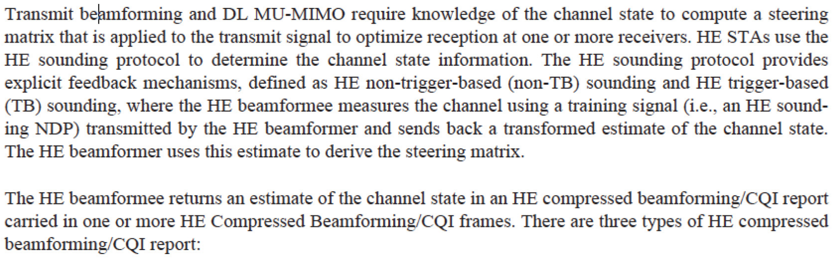
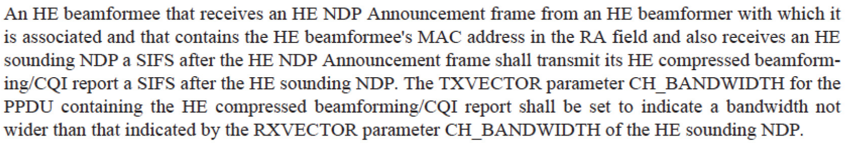
<table>
<tr><th>Claim 8</th><th>iPhone 12</th></tr>
<tr><td></td><td>

The MU Exclusive Beamforming Report field is used by the VHT Compressed Beamforming feedback (see 8.5.23.2) to carry explicit feedback information in the form of delta SNRs. The information in the VHT Compressed Beamforming Report field and the MU Exclusive Beamforming Report field can be used by the transmit MU beamformer to determine steering matrices <i>Q</i>, as described in 9.29.3, 20.3.12.3, and Table 22.3.11.
<i>See</i>, <i>e.g.</i>, IEEE 802.11ac Standard Clause 8.4.1.49

<table>
<tr><th>Field</th><th>Size (Bits)</th><th>Meaning</th></tr>
<tr><td>Delta SNR for space-time stream 1 for subcarrier $k = sscidx(0)$</td><td>4</td><td>$\Delta SNR_{sscidx(0),1}$ as defined in Equation (8-2)</td></tr>
<tr><td>…</td><td>…</td><td>…</td></tr>
<tr><td>Delta SNR for space-time stream Nc for subcarrier $k = sscidx(0)$</td><td>4</td><td>$\Delta SNR_{sscidx(0),Nc}$ as defined in Equation (8-2)</td></tr>
<tr><td>Delta SNR for space-time stream 1 for subcarrier $k = sscidx(1)$</td><td>4</td><td>$\Delta SNR_{sscidx(1),1}$ as defined in Equation (8-2)</td></tr>
<tr><td>…</td><td>…</td><td>…</td></tr>
<tr><td>Delta SNR for space-time stream Nc for subcarrier $k = sscidx(1)$</td><td>4</td><td>$\Delta SNR_{sscidx(1),Nc}$ as defined in Equation (8-2)</td></tr>
<tr><td>…</td><td>…</td><td>…</td></tr>
</table>
</td></tr>
</table>

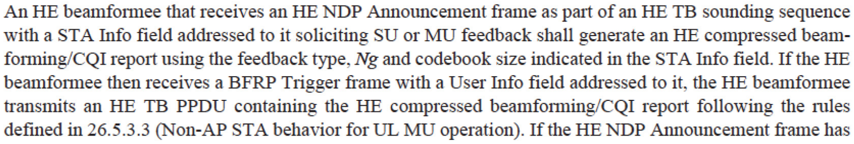
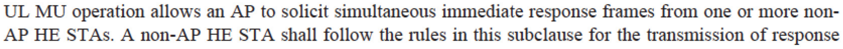
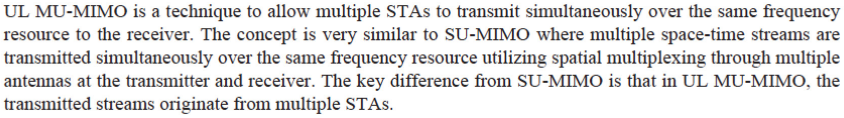
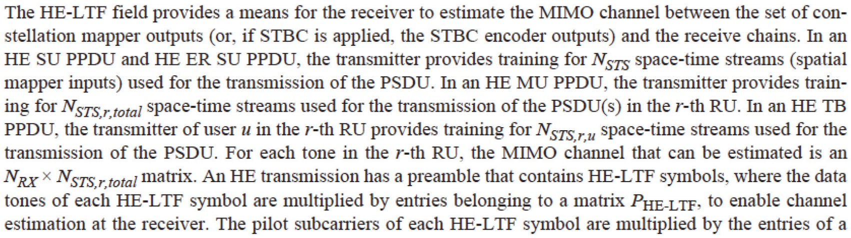
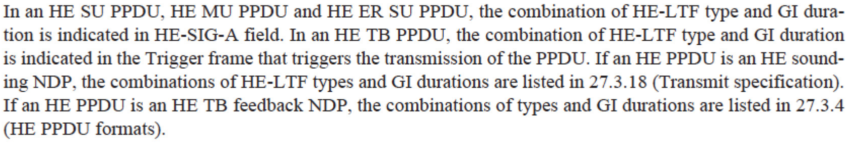
<table>
<tr><th>Claim 8</th><th>iPhone 12</th></tr>
<tr><td></td><td>

<table>
<tr><th>Field</th><th>Size (Bits)</th><th>Meaning</th></tr>
<tr><td>Delta SNR for space-time stream 1 for subcarrier $k = sscidx(Ns'-1)$</td><td>4</td><td>$\Delta SNR_{sscidx(Ns'-1),1}$ as defined in Equation (8-2)</td></tr>
<tr><td>…</td><td>…</td><td>…</td></tr>
<tr><td>Delta SNR for space-time stream Nc for subcarrier $k = sscidx(Ns'-1)$</td><td>4</td><td>$\Delta SNR_{sscidx(Ns'-1),Nc}$ as defined in Equation (8-2)</td></tr>
<tr><td colspan="3">NOTE—<i>sscidx</i>() is defined in Table 8-53j.</td></tr>
</table>
<p>In Table 8-53i, Ns' is the number of subcarriers for which the Delta SNR subfield is sent back to the beamformer. Table 8-53j shows Ns', the exact subcarrier indices and their order for which the Delta SNR is sent back.</p>
<p><i>See</i>, <i>e.g.</i>, Table 8-53i IEEE 802.11ac Standard Clause 8.4.1.48</p>

<p>Transmit beamforming and DL-MU-MIMO require knowledge of the channel state to compute a steering matrix that is applied to the transmitted signal to optimize reception at one or more receivers. The STA transmitting using the steering matrix is called the VHT beamformer and a STA for which reception is optimized is called a VHT beamformee. An explicit feedback mechanism is used where the VHT beamformee directly measures the channel from the training symbols transmitted by the VHT beamformer and sends back a transformed estimate of the channel state to the VHT beamformer. The VHT beamformer then uses this estimate, perhaps combining estimates from multiple VHT beamformees, to derive the steering matrix.</p>
<p><i>See</i>, <i>e.g.</i>, IEEE 802.11ac Standard Clause 9.31.5.1</p>
</td></tr>
</table>

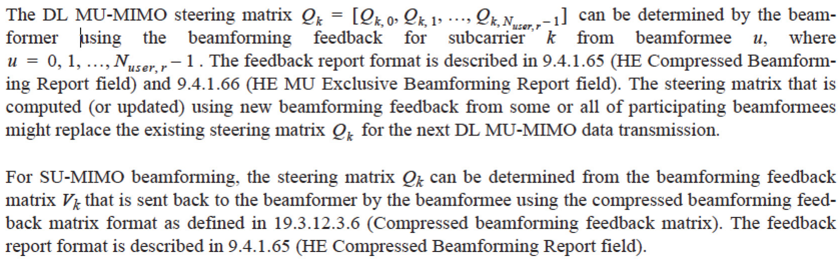
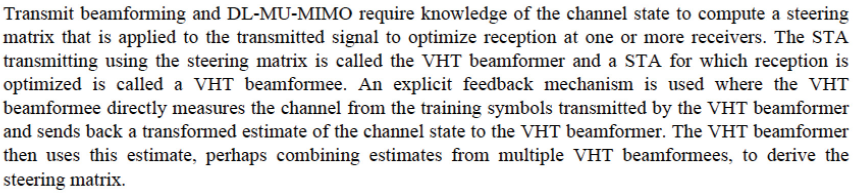
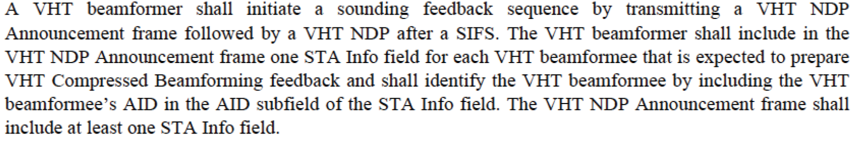
Claim 8	iPhone 12
	 *See*, *e.g.*, IEEE 802.11ac Standard Clause 22.3.4.6(d)

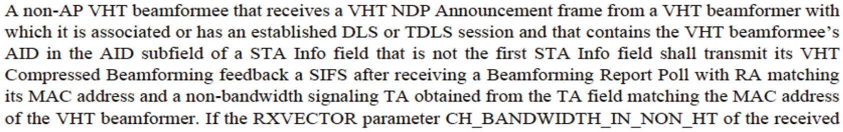
Claim 8	iPhone 12
	 The VHT-SIG-B field is constructed per-user as follows: a) Obtain the VHT-MCS (for MU only) and APEP_LENGTH from the TXVECTOR. b) VHT-SIG-B bits: Set the VHT-MCS (for MU only) and VHT-SIG-B Length field as described in 22.3.8.3.6. Add the reserved bits (for SU only) and N_{tail} bits of tail. For an NDP set VHT-SIG-B to the fixed bit pattern for the bandwidth used as described in 22.3.8.3.6. c) VHT-SIG-B Bit Repetition: Repeat the VHT-SIG-B bits as a function of CH_BANDWIDTH as defined in 22.3.8.3.6. d) BCC encoder: Encode the VHT-SIG-B field using BCC at rate R=1/2 as described in 18.3.5.6. e) Segment parser (if needed): For a contiguous 160 MHz or noncontiguous 80+80 MHz transmission, divide the output bits of the BCC encoder into two frequency subblocks as described in 22.3.10.7. This block is bypassed for 20 MHz, 40 MHz, and 80 MHz VHT PPDU transmissions. f) BCC interleaver: Interleave as described in 22.3.10.8. g) Constellation mapper: Map to a BPSK constellation as defined in 18.3.5.8. h) Segment deparser (if needed): For a contiguous 160 MHz transmission, merge the two frequency subblocks into one frequency segment as described in 22.3.10.9.3. This block is bypassed for 20 MHz, 40 MHz, 80 MHz, and 80+80 MHz VHT PPDU transmissions. i) Pilot insertion: Insert pilots following the steps described in 22.3.10.10. j) P_{VHTLTF} matrix mapping: Apply the mapping of the 1st column of the P_{VHTLTF} matrix to the data subcarriers as described in 22.3.8.3.6. The total number of data and pilot subcarriers is the same as in the Data field. k) CSD: Apply CSD for each space-time stream and frequency segment as described in 22.3.8.3.2. l) Spatial mapping: Apply the Q matrix as described in 22.3.10.11.1. m) Phase rotation: Apply the appropriate phase rotations for each 20 MHz subchannel as described in 22.3.7.4 and 22.3.7.5. n) IDFT: Compute the inverse discrete Fourier transform. o) Insert GI and apply windowing: Prepend a GI (LONG_GI) and apply windowing as described in 22.3.7.4. p) 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 22.3.7.4 and 22.3.8 for details. *See*, *e.g.*, IEEE 802.11ac Standard Clauses 22.3.4.8(l) and 22.3.4.9.1(m), 22.3.4.9.2(m), 22.3.4.10.4(a).

Claim 8	iPhone 12
	 The DL-MU-MIMO steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user}-1}]$ can be determined by the beamformer using the beamforming feedback matrices for subcarrier k from beamformee u, $V_{k,u,}$ and SNR information for subcarrier k from beamformee u, $SNR_{k,u}$, where $u = 0, 1, \ldots, N_{user} - 1$. The steering matrix that is computed (or updated) using new beamforming feedback matrices and new SNR information from some or all of participating beamformees might replace the existing steering matrix Q_k for the next DL-MU-MIMO data transmission. The beamformee group for the MU transmission is signaled using the Group ID field in VHT-SIG-A (see 22.3.8.3.3 and 22.3.11.4). *See*, *e.g.*, IEEE 802.11ac Standard Clause 22.3.11.1  Upon receipt of a VHT NDP sounding PPDU, the beamformee shall remove the space-time stream CSD in Table 22-11 from the measured channel before computing a set of matrices for feedback to the beamformer. The beamforming feedback matrix, $V_{k,u}$, found by the beamformee u for subcarrier k shall be compressed in the form of angles using the method described in 20.3.12.3.6. The angles, $\phi(k,\upsilon)$ and $\psi(k,u)$, are quantized according to Table 8-53e. The number of bits for quantization is chosen by the beamformee, based on the indication from the beamformer as to whether the feedback is requested for SU-MIMO beamforming or DL-MU-MIMO beamforming. The compressed beamforming feedback using 20.3.12.3.6 is the only Clause 22 beamforming feedback format defined. The beamformee shall generate the beamforming feedback matrices with the number of rows (Nr) equal to the N_{STS} of the NDP. After receiving the angle information, $\phi(k,u)$ and $\psi(k,u)$, the beamformer reconstructs $V_{k,u}$ using Equation (20-79). For SU-MIMO beamforming, the beamformer can use this $V_{k,0}$ matrix to determine the steering matrix Q_k. For DL-MU-MIMO beamforming, the beamformer may calculate a steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user}-1}]$ using $V_{k,u}$ and $SNR_{k,u}$ $(0 \le u \le N_{user} - 1)$ in order to suppress crosstalk between participating beamformees. The method used by the beamformer to calculate the steering matrix Q_k is implementation specific. *See*, *e.g.*, IEEE 802.11ac Standard Clause 22.3.11.2.

Claim 8	iPhone 12
[8d] determining a set of weighting values based on the first signal information and the second signal information, wherein the set of weighting values is configured to be used by the remote station to construct one or more beam-formed transmission signals; and	The iPhone 12 determines a set of weighting values based on the first signal information and the second signal information, wherein the set of weighting values is configured to be used by the remote station to construct one or more beam-formed transmission signals. For example, the iPhone 12 determines an estimate of the channel state (e.g., by measuring the channel using a training signal) that includes a set of weighting values based on the first signal information and the second signal information. A transformed estimate of the channel state will ultimately be sent in a compressed beamforming report, e.g., the parameters of the beamforming feedback matrix, which include weighting values configured to be used by the remote station (e.g., a Wi-Fi access point) to construct one or more beamformed transmission signals.  Transmit beamforming and DL MU-MIMO require knowledge of the channel state to compute a steering matrix that is applied to the transmit signal to optimize reception at one or more receivers. HE STAs use the HE sounding protocol to determine the channel state information. The HE sounding protocol provides explicit feedback mechanisms, defined as HE non-trigger-based (non-TB) sounding and HE trigger-based (TB) sounding, where the HE beamformee measures the channel using a training signal (i.e., an HE sounding NDP) transmitted by the HE beamformer and sends back a transformed estimate of the channel state. The HE beamformer uses this estimate to derive the steering matrix. The HE beamformee returns an estimate of the channel state in an HE compressed beamforming/CQI report carried in one or more HE Compressed Beamforming/CQI frames. There are three types of HE compressed beamforming/CQI report: *See*, *e.g.*, IEEE 802.11ax Standard, Section 26.7.1  An HE beamformee that receives an HE NDP Announcement frame from an HE beamformer with which it is associated and that contains the HE beamformee's MAC address in the RA field and also receives an HE sounding NDP a SIFS after the HE NDP Announcement frame shall transmit its HE compressed beamforming/CQI report a SIFS after the HE sounding NDP. The TXVECTOR parameter CH_BANDWIDTH for the PPDU containing the HE compressed beamforming/CQI report shall be set to indicate a bandwidth not wider than that indicated by the RXVECTOR parameter CH_BANDWIDTH of the HE sounding NDP. *See*, *e.g.*, IEEE 802.11ax Standard, Section 26.7.3

Claim 8	iPhone 12
	 An HE beamformee that receives an HE NDP Announcement frame as part of an HE TB sounding sequence with a STA Info field addressed to it soliciting SU or MU feedback shall generate an HE compressed beamforming/CQI report using the feedback type, *Ng* and codebook size indicated in the STA Info field. If the HE beamformee then receives a BFRP Trigger frame with a User Info field addressed to it, the HE beamformee transmits an HE TB PPDU containing the HE compressed beamforming/CQI report following the rules defined in 26.5.3.3 (Non-AP STA behavior for UL MU operation). If the HE NDP Announcement frame has *See*, *e.g.*, IEEE 802.11ax Standard, Section 26.7.3  UL MU operation allows an AP to solicit simultaneous immediate response frames from one or more non-AP HE STAs. A non-AP HE STA shall follow the rules in this subclause for the transmission of response *See*, *e.g.*, IEEE 802.11ax Standard, Section 26.5.3  UL MU-MIMO is a technique to allow multiple STAs to transmit simultaneously over the same frequency resource to the receiver. The concept is very similar to SU-MIMO where multiple space-time streams are transmitted simultaneously over the same frequency resource utilizing spatial multiplexing through multiple antennas at the transmitter and receiver. The key difference from SU-MIMO is that in UL MU-MIMO, the transmitted streams originate from multiple STAs. *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.3.2.1  The HE-LTF field provides a means for the receiver to estimate the MIMO channel between the set of constellation mapper outputs (or, if STBC is applied, the STBC encoder outputs) and the receive chains. In an HE SU PPDU and HE ER SU PPDU, the transmitter provides training for N_{STS} space-time streams (spatial mapper inputs) used for the transmission of the PSDU. In an HE MU PPDU, the transmitter provides training for $N_{STS,r,total}$ space-time streams used for the transmission of the PSDU(s) in the *r*-th RU. In an HE TB PPDU, the transmitter of user *u* in the *r*-th RU provides training for $N_{STS,r,u}$ space-time streams used for the transmission of the PSDU. For each tone in the *r*-th RU, the MIMO channel that can be estimated is an $N_{RX} \times N_{STS,r,total}$ matrix. An HE transmission has a preamble that contains HE-LTF symbols, where the data tones of each HE-LTF symbol are multiplied by entries belonging to a matrix $P_{\text{HE-LTF}}$, to enable channel estimation at the receiver. The pilot subcarriers of each HE-LTF symbol are multiplied by the entries of a *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.10.10  In an HE SU PPDU, HE MU PPDU and HE ER SU PPDU, the combination of HE-LTF type and GI duration is indicated in HE-SIG-A field. In an HE TB PPDU, the combination of HE-LTF type and GI duration is indicated in the Trigger frame that triggers the transmission of the PPDU. If an HE PPDU is an HE sounding NDP, the combinations of HE-LTF types and GI durations are listed in 27.3.18 (Transmit specification). If an HE PPDU is an HE TB feedback NDP, the combinations of types and GI durations are listed in 27.3.4 (HE PPDU formats).

Claim 8	iPhone 12
	See, *e.g.*, IEEE 802.11ax Standard, Section 27.3.10.10  The DL MU-MIMO steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user,r}-1}]$ can be determined by the beamformer using the beamforming feedback for subcarrier k from beamformee u, where $u = 0, 1, \ldots, N_{user,r} - 1$. The feedback report format is described in 9.4.1.65 (HE Compressed Beamforming Report field) and 9.4.1.66 (HE MU Exclusive Beamforming Report field). The steering matrix that is computed (or updated) using new beamforming feedback from some or all of participating beamformees might replace the existing steering matrix Q_k for the next DL MU-MIMO data transmission. For SU-MIMO beamforming, the steering matrix Q_k can be determined from the beamforming feedback matrix V_k that is sent back to the beamformer by the beamformee using the compressed beamforming feedback matrix format as defined in 19.3.12.3.6 (Compressed beamforming feedback matrix). The feedback report format is described in 9.4.1.65 (HE Compressed Beamforming Report field). *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.15.1  Transmit beamforming and DL-MU-MIMO require knowledge of the channel state to compute a steering matrix that is applied to the transmitted signal to optimize reception at one or more receivers. The STA transmitting using the steering matrix is called the VHT beamformer and a STA for which reception is optimized is called a VHT beamformee. An explicit feedback mechanism is used where the VHT beamformee directly measures the channel from the training symbols transmitted by the VHT beamformer and sends back a transformed estimate of the channel state to the VHT beamformer. The VHT beamformer then uses this estimate, perhaps combining estimates from multiple VHT beamformees, to derive the steering matrix. *See*, *e.g.*, IEEE 802.11ac Standard Clause 9.31.5.1  A VHT beamformer shall initiate a sounding feedback sequence by transmitting a VHT NDP Announcement frame followed by a VHT NDP after a SIFS. The VHT beamformer shall include in the VHT NDP Announcement frame one STA Info field for each VHT beamformee that is expected to prepare VHT Compressed Beamforming feedback and shall identify the VHT beamformee by including the VHT beamformee's AID in the AID subfield of the STA Info field. The VHT NDP Announcement frame shall include at least one STA Info field. *See*, *e.g.*, IEEE 802.11ac Standard Clause 9.31.5.2

<table>
<tr><th>Claim 8</th><th>iPhone 12</th></tr>
<tr><td></td><td>

A non-AP VHT beamformee that receives a VHT NDP Announcement frame from a VHT beamformer with which it is associated or has an established DLS or TDLS session and that contains the VHT beamformee's AID in the AID subfield of a STA Info field that is not the first STA Info field shall transmit its VHT Compressed Beamforming feedback a SIFS after receiving a Beamforming Report Poll with RA matching its MAC address and a non-bandwidth signaling TA obtained from the TA field matching the MAC address of the VHT beamformer. If the RXVECTOR parameter CH_BANDWIDTH_IN_NON_HT of the received

<i>See</i>, <i>e.g.</i>, IEEE 802.11ac Standard Clause 9.31.5.2

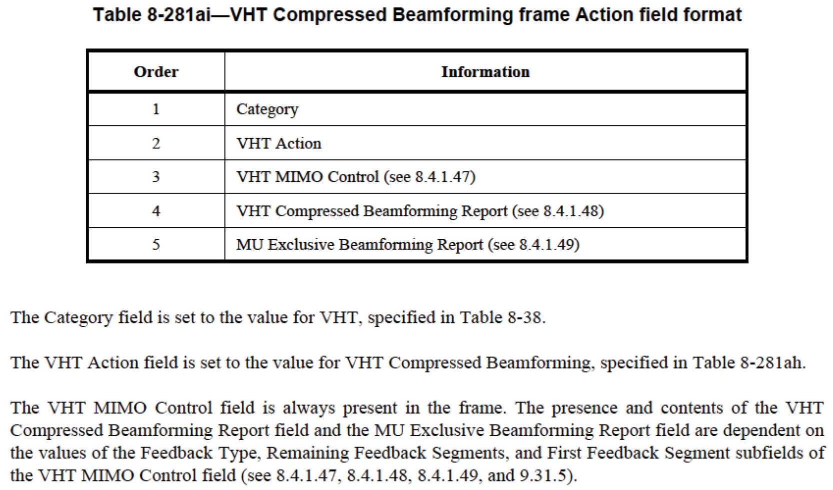


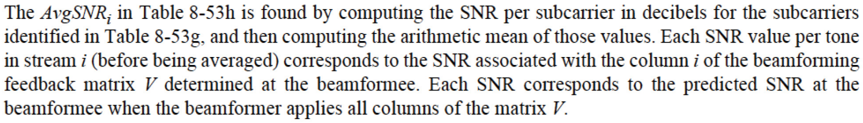
Table 8-281ai—VHT Compressed Beamforming frame Action field format
<table>
<tr><th>Order</th><th>Information</th></tr>
<tr><td>1</td><td>Category</td></tr>
<tr><td>2</td><td>VHT Action</td></tr>
<tr><td>3</td><td>VHT MIMO Control (see 8.4.1.47)</td></tr>
<tr><td>4</td><td>VHT Compressed Beamforming Report (see 8.4.1.48)</td></tr>
<tr><td>5</td><td>MU Exclusive Beamforming Report (see 8.4.1.49)</td></tr>
</table>
The Category field is set to the value for VHT, specified in Table 8-38.

The VHT Action field is set to the value for VHT Compressed Beamforming, specified in Table 8-281ah.

The VHT MIMO Control field is always present in the frame. The presence and contents of the VHT Compressed Beamforming Report field and the MU Exclusive Beamforming Report field are dependent on the values of the Feedback Type, Remaining Feedback Segments, and First Feedback Segment subfields of the VHT MIMO Control field (see 8.4.1.47, 8.4.1.48, 8.4.1.49, and 9.31.5).

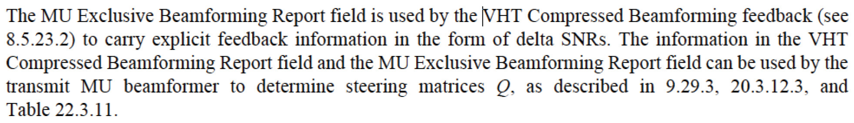
<i>See</i>, <i>e.g.</i>, IEEE 802.11ac Standard Clause 8.5.23.2

<i>See</i> Tables 8-53(d)-(h) in IEEE 802.11ac Standard Clause 8.4.1.48


The $AvgSNR_i$ in Table 8-53h is found by computing the SNR per subcarrier in decibels for the subcarriers identified in Table 8-53g, and then computing the arithmetic mean of those values. Each SNR value per tone in stream i (before being averaged) corresponds to the SNR associated with the column i of the beamforming feedback matrix V determined at the beamformee. Each SNR corresponds to the predicted SNR at the beamformee when the beamformer applies all columns of the matrix V.
</td></tr>
</table>

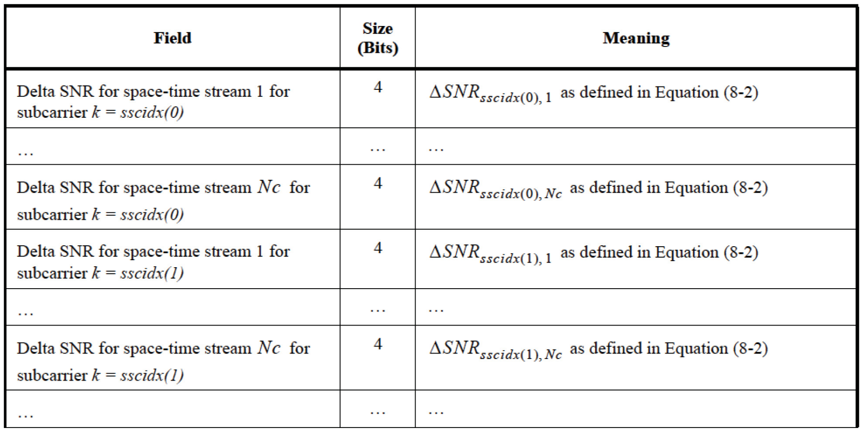
<table>
<tr><th>Claim 8</th><th>iPhone 12</th></tr>
<tr><td></td><td>

See, *e.g.*, IEEE 802.11ac Standard Clause 8.4.1.48



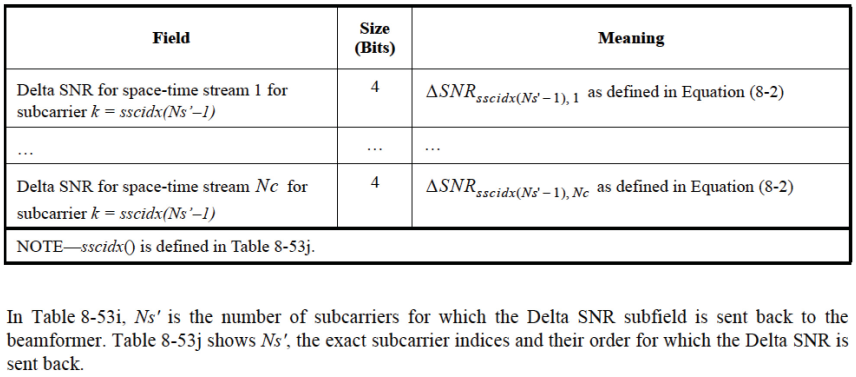
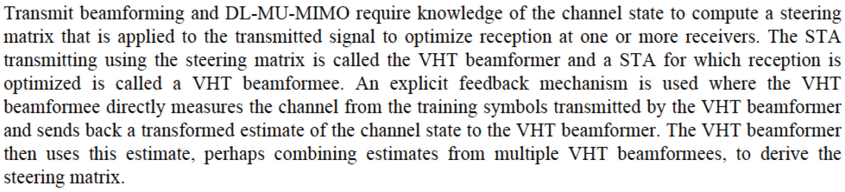
The MU Exclusive Beamforming Report field is used by the VHT Compressed Beamforming feedback (see 8.5.23.2) to carry explicit feedback information in the form of delta SNRs. The information in the VHT Compressed Beamforming Report field and the MU Exclusive Beamforming Report field can be used by the transmit MU beamformer to determine steering matrices Q, as described in 9.29.3, 20.3.12.3, and Table 22.3.11.

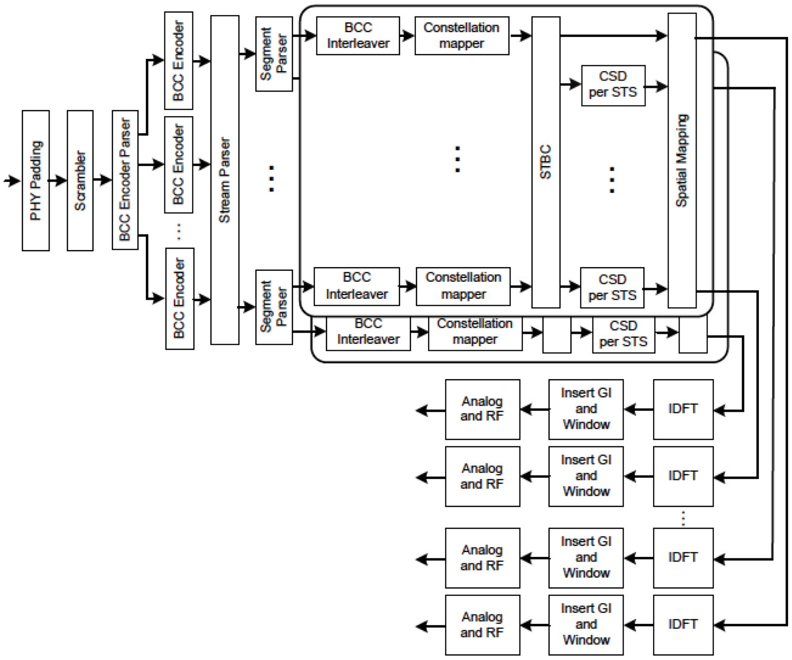
See, *e.g.*, IEEE 802.11ac Standard Clause 8.4.1.49

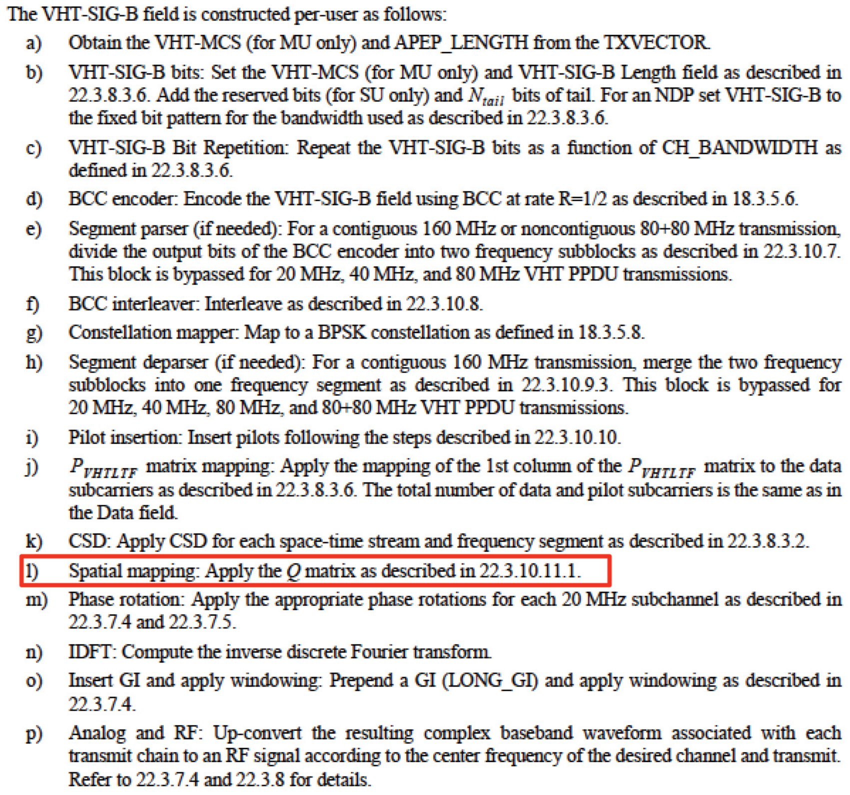


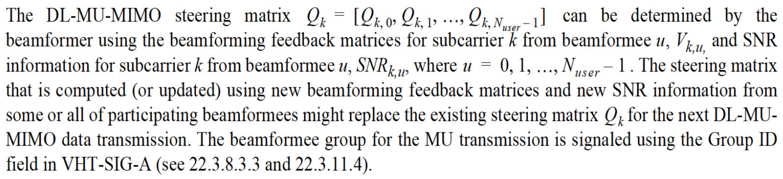
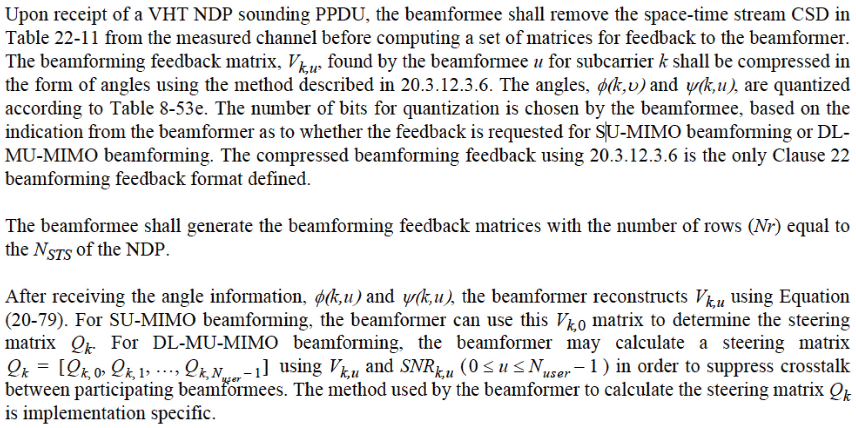
Field	Size (Bits)	Meaning
Delta SNR for space-time stream 1 for subcarrier $k = sscidx(0)$	4	$\Delta SNR_{sscidx(0),1}$ as defined in Equation (8-2)
…	…	…
Delta SNR for space-time stream Nc for subcarrier $k = sscidx(0)$	4	$\Delta SNR_{sscidx(0),Nc}$ as defined in Equation (8-2)
Delta SNR for space-time stream 1 for subcarrier $k = sscidx(1)$	4	$\Delta SNR_{sscidx(1),1}$ as defined in Equation (8-2)
…	…	…
Delta SNR for space-time stream Nc for subcarrier $k = sscidx(1)$	4	$\Delta SNR_{sscidx(1),Nc}$ as defined in Equation (8-2)
…	…	…

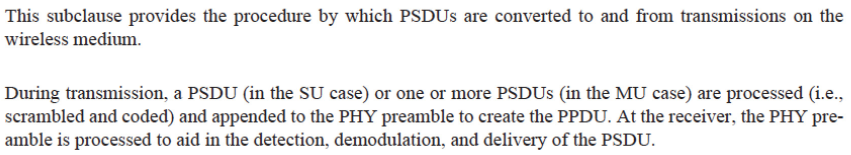
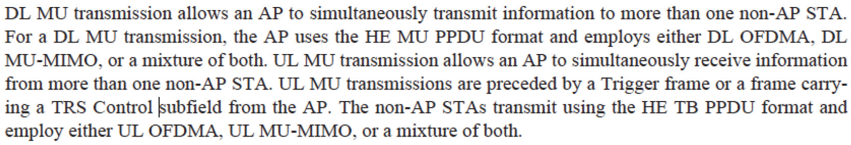
</td></tr>
</table>

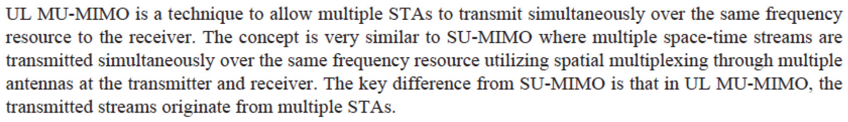
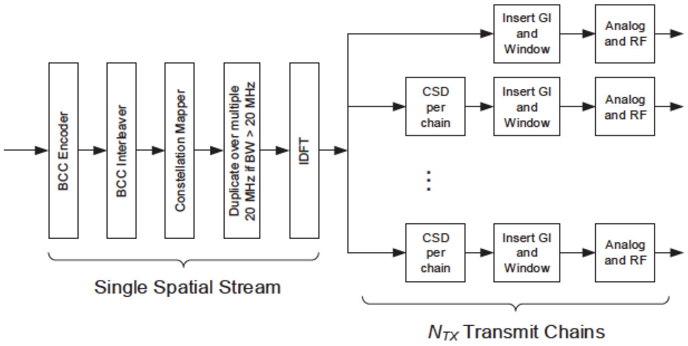
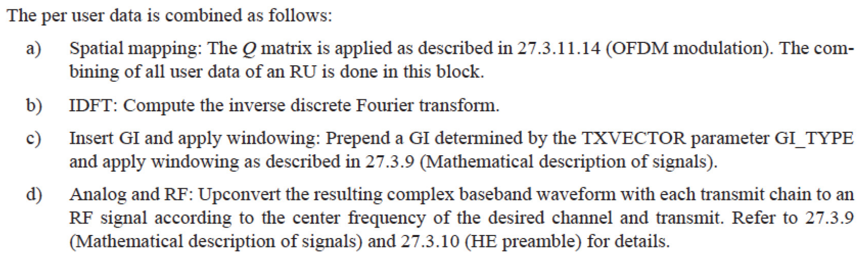
<table>
<tr><th>Claim 8</th><th>iPhone 12</th></tr>
<tr><td></td><td>

<table>
<tr><th>Field</th><th>Size (Bits)</th><th>Meaning</th></tr>
<tr><td>Delta SNR for space-time stream 1 for subcarrier $k = sscidx(Ns'-1)$</td><td>4</td><td>$\Delta SNR_{sscidx(Ns'-1),1}$ as defined in Equation (8-2)</td></tr>
<tr><td>…</td><td>…</td><td>…</td></tr>
<tr><td>Delta SNR for space-time stream Nc for subcarrier $k = sscidx(Ns'-1)$</td><td>4</td><td>$\Delta SNR_{sscidx(Ns'-1),Nc}$ as defined in Equation (8-2)</td></tr>
<tr><td colspan="3">NOTE—<i>sscidx</i>() is defined in Table 8-53j.</td></tr>
</table>
<p>In Table 8-53i, Ns' is the number of subcarriers for which the Delta SNR subfield is sent back to the beamformer. Table 8-53j shows Ns', the exact subcarrier indices and their order for which the Delta SNR is sent back.</p>
<p><i>See</i>, <i>e.g.</i>, Table 8-53i IEEE 802.11ac Standard Clause 8.4.1.48</p>

<p>Transmit beamforming and DL-MU-MIMO require knowledge of the channel state to compute a steering matrix that is applied to the transmitted signal to optimize reception at one or more receivers. The STA transmitting using the steering matrix is called the VHT beamformer and a STA for which reception is optimized is called a VHT beamformee. An explicit feedback mechanism is used where the VHT beamformee directly measures the channel from the training symbols transmitted by the VHT beamformer and sends back a transformed estimate of the channel state to the VHT beamformer. The VHT beamformer then uses this estimate, perhaps combining estimates from multiple VHT beamformees, to derive the steering matrix.</p>
<p><i>See</i>, <i>e.g.</i>, IEEE 802.11ac Standard Clause 9.31.5.1</p>
</td></tr>
</table>

Claim 8	iPhone 12
	 *See*, *e.g.*, IEEE 802.11ac Standard Clause 22.3.4.6(d)

Claim 8	iPhone 12
	 The VHT-SIG-B field is constructed per-user as follows: a) Obtain the VHT-MCS (for MU only) and APEP_LENGTH from the TXVECTOR. b) VHT-SIG-B bits: Set the VHT-MCS (for MU only) and VHT-SIG-B Length field as described in 22.3.8.3.6. Add the reserved bits (for SU only) and N_{tail} bits of tail. For an NDP set VHT-SIG-B to the fixed bit pattern for the bandwidth used as described in 22.3.8.3.6. c) VHT-SIG-B Bit Repetition: Repeat the VHT-SIG-B bits as a function of CH_BANDWIDTH as defined in 22.3.8.3.6. d) BCC encoder: Encode the VHT-SIG-B field using BCC at rate R=1/2 as described in 18.3.5.6. e) Segment parser (if needed): For a contiguous 160 MHz or noncontiguous 80+80 MHz transmission, divide the output bits of the BCC encoder into two frequency subblocks as described in 22.3.10.7. This block is bypassed for 20 MHz, 40 MHz, and 80 MHz VHT PPDU transmissions. f) BCC interleaver: Interleave as described in 22.3.10.8. g) Constellation mapper: Map to a BPSK constellation as defined in 18.3.5.8. h) Segment deparser (if needed): For a contiguous 160 MHz transmission, merge the two frequency subblocks into one frequency segment as described in 22.3.10.9.3. This block is bypassed for 20 MHz, 40 MHz, 80 MHz, and 80+80 MHz VHT PPDU transmissions. i) Pilot insertion: Insert pilots following the steps described in 22.3.10.10. j) P_{VHTLTF} matrix mapping: Apply the mapping of the 1st column of the P_{VHTLTF} matrix to the data subcarriers as described in 22.3.8.3.6. The total number of data and pilot subcarriers is the same as in the Data field. k) CSD: Apply CSD for each space-time stream and frequency segment as described in 22.3.8.3.2. l) Spatial mapping: Apply the Q matrix as described in 22.3.10.11.1. m) Phase rotation: Apply the appropriate phase rotations for each 20 MHz subchannel as described in 22.3.7.4 and 22.3.7.5. n) IDFT: Compute the inverse discrete Fourier transform. o) Insert GI and apply windowing: Prepend a GI (LONG_GI) and apply windowing as described in 22.3.7.4. p) 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 22.3.7.4 and 22.3.8 for details. *See*, *e.g.*, IEEE 802.11ac Standard Clauses 22.3.4.8(l) and 22.3.4.9.1(m), 22.3.4.9.2(m), 22.3.4.10.4(a).

Claim 8	iPhone 12
	 The DL-MU-MIMO steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user}-1}]$ can be determined by the beamformer using the beamforming feedback matrices for subcarrier k from beamformee u, $V_{k,u}$, and SNR information for subcarrier k from beamformee u, $SNR_{k,u}$, where $u = 0, 1, \ldots, N_{user}-1$. The steering matrix that is computed (or updated) using new beamforming feedback matrices and new SNR information from some or all of participating beamformees might replace the existing steering matrix Q_k for the next DL-MU-MIMO data transmission. The beamformee group for the MU transmission is signaled using the Group ID field in VHT-SIG-A (see 22.3.8.3.3 and 22.3.11.4). *See*, *e.g.*, IEEE 802.11ac Standard Clause 22.3.11.1  Upon receipt of a VHT NDP sounding PPDU, the beamformee shall remove the space-time stream CSD in Table 22-11 from the measured channel before computing a set of matrices for feedback to the beamformer. The beamforming feedback matrix, $V_{k,u}$, found by the beamformee u for subcarrier k shall be compressed in the form of angles using the method described in 20.3.12.3.6. The angles, $\phi(k,\upsilon)$ and $\psi(k,u)$, are quantized according to Table 8-53e. The number of bits for quantization is chosen by the beamformee, based on the indication from the beamformer as to whether the feedback is requested for SU-MIMO beamforming or DL-MU-MIMO beamforming. The compressed beamforming feedback using 20.3.12.3.6 is the only Clause 22 beamforming feedback format defined. The beamformee shall generate the beamforming feedback matrices with the number of rows (Nr) equal to the N_{STS} of the NDP. After receiving the angle information, $\phi(k,u)$ and $\psi(k,u)$, the beamformer reconstructs $V_{k,u}$ using Equation (20-79). For SU-MIMO beamforming, the beamformer can use this $V_{k,0}$ matrix to determine the steering matrix Q_k. For DL-MU-MIMO beamforming, the beamformer may calculate a steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user}-1}]$ using $V_{k,u}$ and $SNR_{k,u}$ $(0 \le u \le N_{user}-1)$ in order to suppress crosstalk between participating beamformees. The method used by the beamformer to calculate the steering matrix Q_k is implementation specific. *See*, *e.g.*, IEEE 802.11ac Standard Clause 22.3.11.2. To the extent Defendant disputes that the foregoing shows literal infringement, there would also be infringement under the doctrine of equivalents. For example, determining weighting values (e.g. angle information) (e.g. the derived estimate of the channel state), which includes data relevant to describe the MIMO channel is insubstantially different from the claim requirement because it performs substantially the same

Claim 8	iPhone 12
	function (determine a set of weighting values) in substantially the same way (determine angle information describing MIMO channel) to achieve substantially the same result (beamforming). For further example, constructing one or more beamformed transmission signals by supporting multiple uplink spatial streams (*e.g.,* 2x2 or more streams) and/or transmit beamforming ("TxBF") to steer transmissions is insubstantially different from the claim requirement because it performs substantially the same function in substantially the same way to achieve substantially the same result.
[8e] transmitting to the remote station a third signal comprising content based on the set of weighting values.	The iPhone 12 transmits to the remote station a third signal comprising content based on the set of weighting values. For example, iPhone 12 transmits to the remote station (*e.g.*, a Wi-Fi access point) a signal that includes the beamforming feedback matrix.  This subclause provides the procedure by which PSDUs are converted to and from transmissions on the wireless medium. During transmission, a PSDU (in the SU case) or one or more PSDUs (in the MU case) are processed (i.e., scrambled and coded) and appended to the PHY preamble to create the PPDU. At the receiver, the PHY preamble is processed to aid in the detection, demodulation, and delivery of the PSDU. *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.1  DL MU transmission allows an AP to simultaneously transmit information to more than one non-AP STA. For a DL MU transmission, the AP uses the HE MU PPDU format and employs either DL OFDMA, DL MU-MIMO, or a mixture of both. UL MU transmission allows an AP to simultaneously receive information from more than one non-AP STA. UL MU transmissions are preceded by a Trigger frame or a frame carrying a TRS Control subfield from the AP. The non-AP STAs transmit using the HE TB PPDU format and employ either UL OFDMA, UL MU-MIMO, or a mixture of both. *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.1.1

Claim 8	iPhone 12
	 UL MU-MIMO is a technique to allow multiple STAs to transmit simultaneously over the same frequency resource to the receiver. The concept is very similar to SU-MIMO where multiple space-time streams are transmitted simultaneously over the same frequency resource utilizing spatial multiplexing through multiple antennas at the transmitter and receiver. The key difference from SU-MIMO is that in UL MU-MIMO, the transmitted streams originate from multiple STAs. *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.3.2.1  *See*, *e.g.*, Figure 27-13 IEEE 802.11ax Standard, Section 27.3.5  The per user data is combined as follows: a) Spatial mapping: The Q matrix is applied as described in 27.3.11.14 (OFDM modulation). The combining of all user data of an RU is done in this block. b) IDFT: Compute the inverse discrete Fourier transform. c) Insert GI and apply windowing: Prepend a GI determined by the TXVECTOR parameter GI_TYPE and apply windowing as described in 27.3.9 (Mathematical description of signals). d) 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 27.3.9 (Mathematical description of signals) and 27.3.10 (HE preamble) for details.

Claim 8	iPhone 12
	See, *e.g.*, IEEE 802.11ax Standard, Section 27.3.6.11.4. To the extent Defendant disputes that the foregoing shows literal infringement, there would also be infringement under the doctrine of equivalents. For example, the Accused Instrumentalities perform substantially the same function (transmit a third signal to the remote station via the antenna, the third signal comprising content based on the set of weighting values) in substantially the same way (transmit channel state estimate) to achieve substantially the same result (improve knowledge of the channel state to improve throughput).

Claim 9

Claim 9	Accused Products
9. The method as recited in claim 8, further comprising: transmitting the third signal to the remote station via the antenna.	iPhone 12 performs the method of claim 8 and further transmits the third signal to the remote station via the antenna. *See supra* claim element [1h].

Claim 11

Claim 11	Accused Products
11. The method as recited in claim 8, wherein the set of weighting values is further based on one or more of: a	The iPhone 12 performs the method of claim 8, wherein the set of weighting values is further based on one or more of: a transmit power level, a data transmit rate, an antenna direction, quality of service data, or timing data.

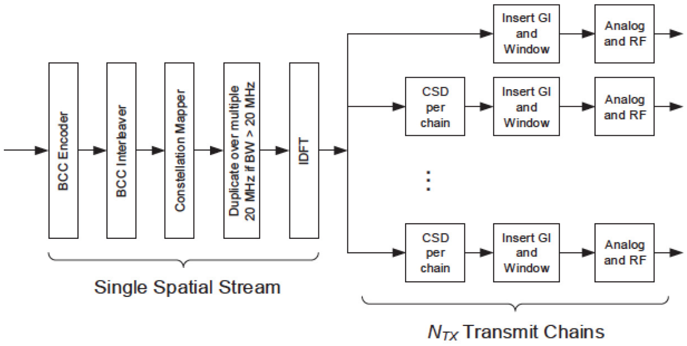
Claim 11	Accused Products
transmit power level, a data transmit rate, an antenna direction, quality of service data, or timing data.	*See supra* claim 5.

Claim 12

Claim 12	Accused Products
12. The method as recited in claim 11, wherein the content comprises data configured to be used by the remote station to modify the placement of one or more transmission peaks and one or more transmission nulls in a subsequent signal transmission.	The iPhone 12 performs the method of claim 11, wherein the content comprises data configured to be used by the remote station to modify the placement of one or more transmission peaks and one or more transmission nulls in a subsequent signal transmission. *See supra* claims 4, 11, including discussion regarding MU-MIMO sounding and channel estimation procedures, which shows electromagnetic signals comprising one or more transmission peaks and one or more transmission nulls.

Claim 15

Claim 15	Accused Products
[15pre] An apparatus for use in a wireless communications system, the apparatus comprising:	To the extent the preamble is limiting, the iPhone 12 includes an apparatus for use in a wireless communications system. *See supra* claim element [1pre].

Claim 15	Accused Products
	 *See*, *e.g.*, Figure 27-13 IEEE 802.11ax Standard, Section 27.3.5
[15a] an antenna;	The iPhone 12 includes an antenna. *See supra* claim element [1a].
[15b] a transceiver operatively coupled to the antenna; and	The iPhone 12 includes a transceiver operatively coupled to the antenna. *See supra* claim elements [1a] and [1b].

Claim 15	Accused Products
[15c] a processor operatively coupled to the transceiver, the processor configured to:	The iPhone 12 includes a processor operatively coupled to the transceiver. The *See supra* claim element [1c].
[15d] receive a first signal transmission from a remote station via the antenna,	The processor in the iPhone 12 receives a first signal transmission from a remote station via the antenna. *See supra* claim element [1d].
[15e] the first signal transmission comprising first signal information, wherein the first signal information comprises one or more of: a transmit power level, a data transmit rate, an antenna direction, quality of service data, or timing data;	The iPhone 12 the first signal transmission comprising first signal information, wherein the first signal information comprises one or more of: a transmit power level, a data transmit rate, an antenna direction, quality of service data, or timing data. *See supra* claim element [1e].
[15f] receive a second signal transmission from the remote station via the antenna, the second signal transmission comprising second signal information;	The processor in the iPhone 12 receives a second signal transmission from the remote station via the antenna, the second signal transmission comprising second signal information. *See supra* claim element [1f].
[15g] determine a set of weighting values based on the first signal information and the second signal information, wherein the set of weighting values is configured to be used by the transceiver to construct one or more beam-formed transmission signals;	The processor in the iPhone 12 determines a set of weighting values based on the first signal information and the second signal information, wherein the set of weighting values is configured to be used by the transceiver to construct one or more beam-formed transmission signals. *See supra* claim element [1g].

Claim 15	Accused Products
[15h] cause the transceiver to generate a third signal comprising content based on the set of weighting values.	The processor in the iPhone 12 causes the transceiver to generate a third signal comprising content based on the set of weighting values. *See supra* claim element [1h].

Claim 16

Claim 16	Accused Products
16. The apparatus as recited in claim 15, wherein the first signal transmission and the second signal transmission comprise electromagnetic signals comprising one or more transmission peaks and one or more transmission nulls.	The iPhone 12 includes the apparatus as recited in claim 15, wherein the first signal transmission and the second signal transmission comprise electromagnetic signals comprising one or more transmission peaks and one or more transmission nulls. *See supra* claim element [1d], including discussion regarding MU-MIMO sounding and channel estimation procedures, which shows electromagnetic signals comprising one or more transmission peaks and one or more transmission nulls.