IEEE P802.11
Wireless LANs

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| D1 Comment Resolution, brianh, part 3 |
| Date: 2011-07-17 |
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##### Baseline is 11ac D1.0. Changes indicated by a mixture of Word track-changes and instructions. For equation changes, Latex notation is sometimes used. E.g. a\_{xyz}^b denotes axyzb

PHY CIDs addressed: 2938, 2220, 2368, 2221, 2275, 2457, 2413, 2416 [8]

##### PHY

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| 2938 | Loc, Peter | 111.00 | 22.2.2 | With the proliferation of 802.11 products, it is becoming more difficult to find contiguous 80 MHz channels to deploy a VHT network that meets the requirements of supported bandwidths, especially in Enterprise environment as well as in European countries and Japan. | Add CBW40+40 to the CH\_BANDWIDTH as an optional mode. Consider submission 802.11-10/1159r1, Sept 2010 as the basis for the specification of this mode. | **Decline. This discussion was addressed during SFD development, and group decided that the value of 40+40 MHz did not merit inclusion in the SFD. See 11/1042r0.** | PHY |

**Discussion:**

1. Related docs 10/1159r1, 10/846r1, 10/1274r2 assume that the implementation cost of 40+40 is the same as 80, and find benefits for 40+40. However, this ignores the associated implementation costs.
	1. A STA with N spatial streams over 40+40 requires 2N RF chains and 2N sets of converters, so its complexity is actually comparable to 2N-SS 40 MHz, yet its spectral efficiency is only half as good.
	2. Thus 40+40 is not good direction for the industry
2. Arguably these comments could be applied to the merits of 160 MHz over 80+80. However:
	1. 5.725-5.85 is not adjacent to other spectrum, so can never be used for 160 MHz (but could be used for 80 MHz or 80+80 MHz)
	2. 5.15-5.25 is not adjacent to non-DFS spectrum, so can never be used for 160 MHz by a DFS-incapable implementation (but could be used for 80 MHz or 80+80 MHz)
3. 40+40 is not interoperable with 80
	1. 40+40 is not identical to 80 when the two frequency segments are placed adjacent to each other
	2. This is different from 80+80 and 160, which are interoperable with each other
		1. An 80+80 implementation could simply place its two RF chains adjacent to each other to communicate with 160 devices
	3. But if a 40+40 device places its two 40 MHz wide RF chains adjacent to each other to communicate with 80 devices, then effectively, each 40 MHz RF chain much operate with only 1 guard tone (corresponding to the 3 DC tones of 80)
	4. This is not practical, and hence most 40+40 STAs would need a separate mode to support 80 MHz. This is a huge burden on implementation (not present in the case of 80+80)
	5. Another option is to require 80 devices to support 40+40 tone allocation, but 40+40 devices would not have to support 80
		1. But this is an additional burden on 80 devices
4. 40+40 (216 data tones) has lower throughput than 80 (234 data tones)
5. US has six 80 MHz channels. Europe and Japan have four 80 MHz channels
	1. (True that one 80 MHz channel is currently not available in EU due to TDWR. TDWR is present in certain areas, but not everywhere, so a range of technical solutions may lead to mutually satisafactory sharing of this bandwidth in many areas)
	2. Even with three channels, we saw in 2.4 GHz that three channels works well.

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| 2220 | Dehghan, Hossein | 137.32 | 22.3.8.1 | Define "Non-VHT portion of the VHT preamble" |  | **Accept in principle. See 11/1042r0** | PHY |

**Discussion:** Since this is in a title, it is difficult to add a definition. Instead, define it visually, in Fig 22-8, ahead of time. Since this term is used in another place without definition, add a reference to this figure there. For changes, see the roll-up after next CID.

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| 2368 | Hart, Brian | 118.08 | 22.3.2 | All VHT-LTF symbols and each VHT-LTF symbol are confusing called the/a "VHT-LTF field".  | Here and elsewhere, define all VHT-LT symbols as "the VHT-LTF field" and each VHT-LTF symbol as "a VHT-LTF subfield/symbol". VHT-LTFs => VHT-LTF in fig 22-1. Merge all the VHT-LTF boxes in fig 22-8. Create a new equation for all VHT-LTF symbols in 22.3.8.2.5, and use that in eqn 22-8. Search for VHT-LTF and make other changes as required. e.g. P147L65 "six or eight fields" => "six or eight subfields" | **Accept in principle. See 11/1042r0** | PHY |

**Discussion:** Basically, search for every instance of “VHT-LTF” and replace by “VHT-LTF symbol” when meaning one symbol in the VHT-LTF field. Update figures. While changing figures, add “(non-)VHT portion” and “(pre-)VHT modulated fields”.

**Update figures:**



**Change:**

**9.27.3 Link adaptation using the VHT format of the HT Control field**

In the latter case, the MFB shall be computed based on the NDP frame following the NDPA frame. The number

of VHT-LTF symbols sent in the NDP frame is determined by the total number of spatial dimensions to be sounded

for the purpose of beamforming.



**Figure 22-1—VHT PPDU format**

**22.3.3 Transmitter block diagram**

Figure 22-2 through Figure 22-7 show example transmitter block diagrams. Specifically, Figure 22-2 shows

the transmit process for the L-SIG and VHT-SIG-A fields of a VHT packet. These transmit blocks are also

used to generate the non-VHT portion of the VHT packet (see Figure 22-8 (Timing boundaries for VHT PPDU fields)), except that the BCC encoder and interleaver are not used when generating the L-STF and L-LTF fields. Figure 22-3 shows the transmit process for generating the VHT-SIG-B field of the VHT PPDUs. Figure 22-4 shows the transmitter blocks used to generate the Data field of 20 MHz, 40 MHz and 80 MHz SU VHT PPDUs. A subset of these transmitter blocks consisting of the constellation mapper and CSD blocks, as well as the blocks to the right of, and including, the spatial mapping block, are also used to generate the VHT-STF and VHT-LTF fields. This is illustrated in Figure 22-11 for the VHT-LTF symbols. A similar set of transmit blocks, but without the multiplication by , applies to the generation of the VHT-STF field. Figure 22-5 shows the transmit process for generating the Data field of MU VHT PPDUs. Figure 22-6 and Figure 22-7 show the transmit process for generating the Data field of contiguous 160 MHz and non-contiguous 80+80 MHz VHT PPDUs, respectively.

**22.3.4.6 Construction of VHT-LTF**

The VHT-LTF symbols allow the receiver to estimate the MIMO channel.

**Table 22-4—Timing-related constants *(continued)***

Duration of each VHTLTF symbol

**Table 22-5—Frequently used parameters *(continued)***

Number of VHT long training symbols (see 22.3.8.2.5 (VHT-LTF definition))

**22.3.7 Mathematical description of signals**

The transmitted RF signal is derived by up-converting the complex baseband signal, which consists of several

fields. The timing boundaries for the various fields are shown in Figure 22-8 where *NVHTLTF* is the number

of VHT-LTF symbols and is defined in Table 22-11 (Number of VHT-LTFs required for different numbers of

space time streams).



**Figure 22-8—Timing boundaries for VHT PPDU fields**

This general representation holds for all subfields. In the remainder of this subclause, pre-VHT modulated

fields refer to the L-STF, L-LTF, L-SIG and VHT-SIG-A fields, while VHT modulated fields refer to the

VHT-STF, VHT-LTF, VHT-SIG-B and Data fields, as shown in Figure 22-8 (Timing boundaries for VHT PPDU fields). For notational simplicity, the parameter BW is omitted from some bandwidth dependent terms.

**22.3.8.2.5 VHT-LTF definition**

The VHT Long Training (VHT-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. The transmitter provides training for the space time streams (spatial mapper inputs) used for

the transmission of the PSDU. All VHT transmissions have a preamble that contains a single section of VHTLTF

symbols, where the data tones of each VHT-LTF symbol are multiplied by entries belonging to a matrix P, to enable channel estimation at the receiver. The pilot tones of each VHT-LTF symbol are multiplied by the entries of a matrix R defined in the following text. The multiplication of the pilot tones in the VHT-LTF symbol by

the R matrix instead of the P matrix is to allow receivers to track phase and frequency offset during MIMO

channel estimation using the VHT-LTF. The number of VHT-LTF symbols, *NVHTLTF*, is a function of the

total number of space-time streams as shown in Table 22-11 (Number of VHT-LTFs required for

different numbers of space time streams). As a result, the VHT-LTF field consists of one, two, four, six or eight symbols that are necessary for the demodulation of the VHT-SIG-B and Data fields in the PPDU or for channel estimation in an NDP.

The generation of the time domain VHT-LTF symbols per frequency segment is shown in Figure 22-11 where

AVHTLTFk is given in Equation (22-29).

**Figure 22-11—Generation of VHT-LTF symbols per frequency segment**

The time domain representation of the waveform transmitted on frequency segment *iSeg* of transmit chain

*iTX* during VHT-LTF symbol *n*, 1 <= n <= *NVHTLTF*, shall be as described by Equation (22-31).

As indicated by Equations (22-8) and (22-31), the duration of each VHT-LTF symbol is *TVHT-LTF* regardless of

the Short GI field setting in VHT-SIG-A.



**Figure 22-15—VHT NDP format**

NOTE—The number of VHT-LTF symbols in the NDP is determined by the NSTS field in VHT-SIG-A.

**22.3.11.3 Group ID**

If the Group ID field in VHT-SIG-A (see 22.3.8.2.3 (VHT-SIG-A definition)) is in the range of 2 to 62 it indicates

that the packet as a MU-MIMO packet. In this case, the value identifies the recipients of an MUMIMO

packet, with the group definition information having been previously sent by the AP to MU-MIMO

capable STAs using the Group ID Management frame as defined in 8.5.16.3 (Group ID Management frame

format). The group definition determines the position of the space-time streams of a user within the total

space-time streams transmitted in an MU transmission. When an MU-MIMO data packet is received, each

STA identifies whether it is a member of the group for this packet by detecting the Group ID field in VHTSIG-

A. If a STA finds that it is a member of the group for the MU-MIMO data packet, the STA reads the

number of space-time streams from the NSTS field corresponding to its user position within the group as determined

by the group definition of the corresponding Group ID. At this point, a STA is also able to identify

which streams correspond to its own signal and which streams correspond to interference. For an MU-MIMO

transmission, VHT-LTF symbols are used to measure not only the channel for the designated signals but also to measure the channel for the interfering signals. While receiving an MU-MIMO transmission, it is recommended

that the receiver use its channel knowledge to all spatial streams (including those that are interference) to do

receive processing, in order to reduce potential interference from other users' space-time streams due to the

imperfect MU beamforming done at the AP.

**Table 22-11—Number of VHT-LTF symbols required for different numbers of space time streams**

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| 2221 | Dehghan, Hossein | 137.35 | 22.3.8.1.1 | Should VHT-SIG-A be mentioned here, since it is not part of the non-VHT portion of the VHT preamble (even if it uses the CS in Table 22-8)? |  | **Decline: Agreed that VHT-SIGA-A should be mentioned for the reasons given, but note that it is mentioned. See 11/1042r0.** | PHY |

**Discussion:** See the highlighted text below.

**22.3.8.1.1 Cyclic shift definition**

The cyclic shift value *TCSiTX* for the L-STF, L-LTF, L-SIG and VHT-SIG-A fields of the packet for transmitter

*iTX* out of total *NTX* are defined in Table 22-8 (Cyclic shift values for L-STF, L-LTF, L-SIG and VHT-SIGA

fields of the packet).

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| 2275 | Edgar, Richard | 139.46 | 22.3.8.1.4 | Allow L-SIG TXOP protection in SU VHT transmissions. This provides valuable additional protection in the presence of legacy 802.11a stations.Since the length of SU VHT frames can be determined based on the VHT-SIG fields, the L-SIG LENGTH field can be used for L-SIG TXOP protection.Note that dropping L-SIG TXOP has been previously justified in connection to not signalling VHT length in VHT-SIG [see e.g. 11-10-0534-01-00ac-duration-in-l-sig.ppt]. However, since then the 802.11ac TG has recognised the benefits of signalling VHT length in VHT-SIG and included this in D1.0. | Modify this paragraph to allow L-SIG TXOP protection for SU VHT transmissions. | **Decline. See 11/1042r0r0** | PHY |

**Discussion:**

* The VHTSIGB Length field does not reliably indicate the number of OFDM symbols in the PPDU, and hence cannot replace the LSIG Rate/Length mechanism, as follows.
	+ From 9.12.6, the A-MPDU Length excludes the A-MPDU subframe padding octets. Therefore the A-MPDU subframes **need not be multiples of 4 octets**.
	+ VHT-SIGB indicates the **rounded-up** number of 32-bit words in the PSDU. This creates **ambiguities** for selected MCSs. Consider MCS0, NSS=1, 20 MHz, where there are 26 data bits per OFDM symbol, which is not a multiple of 32-bits and so we have a recipe for trouble. Consider the following Matlab code that lists the PSDU lengths for which the VHTSIGB length predicts the wrong number of OFDM symbols in the Data field.

for nPsduOctet=1:100

if ceil((nPsduOctet\*8+16+6)/26) ~= ceil((4\*ceil(nPsduOctet/4)\*8+16+6)/26)

fprintf('%d,', nPsduOctet);

end

end

1,2,3,5,6,7,9,10,13,21,22,23,25,26,29,33,37,38,39,41,42,45,46,49,53,54,55,57,58,59,61,62,65,73,74,75,77,78,81,85,89,90,91,93,94,97,98

* As well, for VHT NDPs, the VHTSIGB Length field is not present, so only the LSIG Rate/Length mechanism can identify the PPDU format
* Presently for SU frames, decoding VHT-SIGB is optional. This is a complexity reduction option, and may offer power savings when a) there is little padding on average, or b) the MAC-PHY integration is very tight so the RX MAC, upon detecting EOF, can minimize PHY RX processing in realtime. Adding LSIG TXOP protection makes it impossible to implement these desirable benefits.
* LSIG TXOP protection has problems as described for instance in 10/531r1, slides 6-10 [regardless of whether VHT length is explicitly signaled or not]

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| 2457 | Hart, Brian | 139.39 | 22.3.8.1.4 | "where Rate … 6 Mbps" but this section is also used for NON\_HT\_DUP\_OFDM, so Rate can be anything | Keep this for VHT FORMAT, use L\_DATARATE for NON\_HT\_DUP\_OFDM subformat | **Accept in principle. See 11/1042r0r0.** | PHY |
| 2413 | Hart, Brian | 139.49 | 22.3.8.1.4 | "where TXTIME is defined in 22.4.3" but this section is also used for NON\_HT\_DUP | "where TXTIME is defined in 17.4.3 for a NOT\_HT/NON\_HT\_DUP\_OFDM format/subformat PPDU or 22.4.3 for a VHT format PPDU" or similar ("NOT\_HT/NON\_HT\_DUP\_OFDM format/subformat" is a hack that should be improved upon). Update 22.3.10.12 P174L6 appropriately - shouldn't start with "note", should be "Excepting LSIG Rate field is set by L\_DATARATE and Length field is calculated according to 17.xxx as described in 22.3.8.1.4" | **Accept in principle. See 11/1042r0r0.** | PHY |

**Discussion:** L-STF, L-LTF and L-SIG are indeed used by NON\_HT\_DUP\_OFDM PPDUs, from:

***22.3.10.12 Non-HT duplicate transmission***

*Non-HT duplicate transmission is used to transmit to non-HT OFDM STAs, HT STAs, or VHT STAs*

*that may be present in a part of a 40 MHz, 80 MHz or 160 MHz channel. The VHT-SIG-A, VHT-STF, VHTLTF*

*and VHT-SIG-B fields are not transmitted. The L-STF, L-LTF, and L-SIG fields shall be transmitted in*

*the same way as in the VHT transmission. Note that for the non-HT duplicate transmission, the Length field*

*in L-SIG doesn’t include VHT-SIG-A, VHT-STF, VHT-LTF and VHT-SIG-B.*

However, (22-14) assumes 6 Mbps (not 9,12..54 Mbps), so is unsuitable for NON\_HT\_DUP\_OFDM PPDUs in general



**Change:**

For VHT format PPDUs, the Rate field shall be set to represent 6 Mbps for the 20 MHz channel spacing column of Table 17-6 (Contents of the SIGNAL field). For non-HT duplicate format PPDUs, the Rate field is defined in 17.3.4.2 (RATE field) using the L\_DATARATE parameter in the TXVECTOR.

For VHT format PPDUs, the Length field shall be set according to the equation

... (22-14)

where TXTIME (in μs) is defined in 22.4.3 (TXTIME and PSDU\_LENGTH calculation). A STA shall not

transmit a VHT PPDU if the Length value calculated using Equation (22-14) exceeds 4095 octets. The LSB

of the binary expression of the Length value shall be mapped to B5. For non-HT duplicate format PPDUs, the Length field is defined in 17.3.4.3 (PLCP LENGTH field) using th L\_LENGTH parameter in the TXVECTOR.

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| 2416 | Hart, Brian | 140.21 | 22.3.8.1.4 | Dk,BW -> Dk,20; dM'BW(k) -> dM'20(k); M'BW(k) -> M'20(k) (these are 20MHz mappings) | As in comment | **Accept. See 11/1042r0r0.** | PHY |

**Change:**

In the following equations, replace BW by 20 (3 places)

