IEEE P802.11
Wireless LANs

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| Proposed Draft Text: Phase Noise per 160 MHz |
| Date: 2020-12-14 |
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Abstract

This submission shows

* Allowing for phase noise per 160MHz

Baseline is D0.2 + 20/1337r6

Revisions:

* Rev 0: Initial version of the document.
* Rev 1: Added new figures, updated author name in footer

**Discussion**

Consider two EHT implementations that support 8SS \* 320 MHz

1. An implementation that only supports 8SS \* 320MHz via 8 converter pairs (for a 320MHz passband) and one PLL generating a single RF LO
2. An implementation that supports two modes of operation; either:
3. 16SS \* 160MHz via 16 converter pairs (for a 160MHz passband) and one PLL generating a single RF LO, and
4. 8SS \* 320MHz via 16 converter pairs (for a 160MHz passband) and two PLLs generating two RF LOs nominally separated by 160MHz that are used to mix two 160 MHz frequency portions to adjacent RF spectrum anda thereby create a composite signal of 320 MHz nominal bandwifth.

Both PLLs must be locked to the same oscillator so are subject to the same ppm offset. This same oscillator also drives the DAC clock.

Sidebar:

* In implementation A, because of the DAC clock, the separation between tones nominally at ±80MHz is actually 160 \* (1 + ppm) and the width of the transmission is 320MHz \* (1+ppm).
* In implementation B.2, because the PLLs produce (fc±80MHz) \* (1+ppm), then the separation between the two center frequencies is again 160MHz \* (1 + ppm), and the width of the composite transmission is 160MHz \* (1+ppm) + 160MHz \* (1+ppm) = 320MHz \* (1+ppm) again.

Much the same ideas can be expressed in more detail by way of two figures and some embedded math:





For both architectures, it is observed that the 5 identified frequency points (at the end of each figure) map to identical RF frequencies, and there is no additional carrier offset between the two frequency portions in Implementation B.2. In the absence of phase noise between the two RF LOs, implementations A and B.2 have identical outputs.

Take-away

For a receiver to support a transmitter that implements 320 MHz via two 160MHz frequency portions each with its own DAC pair and PLL/RF LO locked to the same oscillator, the receiver can use a single time-domain carrier frequency offset corrector, a single FFT, yet independent CPE/STO estimation per 160MHz frequency portion (i.e. two pilot estimation units).

This is equivalent to the requirements on 80+80MHz in VHT and HE; and such transmitter implementation flexibility should be retained in EHT. Since the notion of two segments is being removed from EHT, some modifications to the language are advised for clarity, as defined below.

**OPTION A (similar to VHT/HE)**

**36.3.10.4 Transmitted signal**

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The transmitted signal is described in complex baseband signal notation. The actual transmitted signal on

transmit chain $i\_{TX}$ is related to the complex baseband signal by the relation

shown in Equation (36-7).

$r\_{RF}^{i\_{TX}}\left(t\right)=Re\left\{r\_{PPDU}^{i\_{TX}}\left(t\right)exp\left(j2πf\_{c}t\right)\right\}, i\_{TX}=1,,\cdots ,N\_{TX}$ (36-7)

where

 $r\_{PPDU}^{i\_{TX}}\left(t\right)$ represents the complex baseband signal of transmit chain $i\_{TX}$.

 $f\_{c}$ represents the center frequency of the transmitted PPDU. Table 36-16 (Center frequency of the transmitted PPDU) shows$f\_{c}$ as a function of the channel starting frequency, dot11CurrentChannelWidth and CH\_BANDWIDTH, where $f\_{CH,start}$, $f\_{c,idx0}$, $f\_{P20,idx}$, $f\_{P40,idx}$, $f\_{P80,idx}$ , and $f\_{P160,idx}$ are described in 36.3.10.3 (Channel frequencies).

NOTE – An alternative method to generate a 320 MHz PPDU is described in 36.3.18.3 (Transmit center frequency and symbol clock frequency tolerance).

**36.3.18.4.4 Transmitter modulation accuracy (EVM) test**

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The transmitter modulation accuracy test procedure for the occupied subcarriers of the PPDU is similar as in steps of the transmit modulation accuracy test procedure defined in 27.3.19.4.4 (Transmitter modulation accuracy (EVM) test) as follows.

a) Start of PPDU shall be detected.

b) Transition from L-STF to L-LTF shall be detected and fine timing shall be established.

c) Coarse and fine frequency offsets shall be estimated.

d) Symbols in a PPDU shall be derotated according to estimated frequency offset. Sampling offset drift shall be also compensated.

e) For each EHT-LTF symbol, transform the symbol into subcarrier received values, estimate the

phase from the pilot subcarriers, and derotate the subcarrier values according to the estimated phase. For a 320MHz PPDU, the phase estimation is robust to uncorrelated phase noise in the lower and upper 160MHz frequency portions of the PPDU.

f) Estimate the complex channel response coefficient for each of the subcarriers and each of the

transmit streams.

g) For each of the data OFDM symbols, transform the symbol into subcarrier received values, estimate the phase from the pilot subcarriers, and compensate the subcarrier values according to the estimated phase, group the results from all of the receiver chains in each subcarrier to a vector, and multiply the vector by a zero-forcing equalization matrix generated from the estimated channel. For a 320MHz PPDU, the phase estimation is robust to uncorrelated phase noise in the lower and upper 160MHz frequency portions of the PPDU.

h) For each data-carrying subcarrier in each spatial stream of RU under test, find the closest constellation point and compute the Euclidean distance from it.

i) Compute the average across PPDUs of the RMS of all errors per PPDU as given by Equation (36-89).

**36.3.18.3 Transmit center frequency and symbol clock frequency tolerance**

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Transmit signals with TXVECTOR parameter CH\_BANDWIDTH set to CBW320 may be generated using two separate RF LOs, one for each of the lower and upper 160 MHz frequency portions.

NOTE—The signal phase of the two 160 MHz frequency portions might not be correlated.

**OPTION B (avoids referring to two RF LOs)**

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where

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 $f\_{c}$ represents the center frequency of the transmitted PPDU. Table 36-16 (Center frequency of the transmitted PPDU) shows$f\_{c}$ as a function of the channel starting frequency, dot11CurrentChannelWidth and CH\_BANDWIDTH, where $f\_{CH,start}$, $f\_{c,idx0}$, $f\_{P20,idx}$, $f\_{P40,idx}$, $f\_{P80,idx}$ , and $f\_{P160,idx}$ are described in 36.3.10.3 (Channel frequencies).

NOTE – From 36.3.18.4.4 (Transmitter modulation accuracy (EVM) test), a 320 MHz PPDU with uncorrelated phase noise in the lower and upper frequency portions is also allowed.

**36.3.18.4.4 Transmitter modulation accuracy (EVM) test**

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d) Symbols in a PPDU shall be derotated according to estimated frequency offset. Sampling offset drift shall be also compensated.

e) For each EHT-LTF symbol, transform the symbol into subcarrier received values, estimate the

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f) Estimate the complex channel response coefficient for each of the subcarriers and each of the

transmit streams.

g) For each of the data OFDM symbols, transform the symbol into subcarrier received values, estimate the phase from the pilot subcarriers, and compensate the subcarrier values according to the estimated phase, group the results from all of the receiver chains in each subcarrier to a vector, and multiply the vector by a zero-forcing equalization matrix generated from the estimated channel. For a 320MHz PPDU, the phase estimation is robust to uncorrelated phase noise in the lower and upper 160MHz frequency portions of the PPDU.

h) For each data-carrying subcarrier in each spatial stream of RU under test, find the closest constellation point and compute the Euclidean distance from it.

i) Compute the average across PPDUs of the RMS of all errors per PPDU as given by Equation (36-89).

36.3.18.3 Transmit center frequency and symbol clock frequency tolerance

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