IEEE P802.11
Wireless LANs

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| **Proposed Draft Text: EHT LTF Sequence** |
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Abstract

This submission proposes the draft text on EHT-STF for 802.11be D0.1.

Revisions:

* Rev 0: Initial version of the document.
* Rev1: simplify the sequence by refering the original equations
* Rev2: Add more TBD
* Rev3: resolve more comments
* Rev4: add 320M 2x and 4x LTF sequences
* Rev5: resolve Alice’s comment

References:

[1] 802.11-20/0566r95 Compendium of Stras Polls and Potential Changes to the Specification Framework Document

34.3.11.10 EHT-LTF

The EHT-LTF field provides a means for the receiver to estimate the MIMO channel between the set of constellation mapper outputs and the receive chains. In an EHT MU PPDU, the transmitter provides training for *NSTS, r, total* space-time streams used for the transmission of the PSDU(s) in the r-th RU. In an EHT TB PPDU, the transmitter of user *u* in the *r*-th RU/MRU provides training for *NSTS, r, u* space-time streams used for the transmission of the PSDU. For each subcarrier in the r-th RU/MRU, the MIMO channel that can be estimated is an *NRX × NSTS, r, total* matrix. An EHT transmission has a preamble that contains EHT-LTF symbols, where the data tones of each EHT-LTF symbol are multiplied by entries belonging to a matrix *PEHT-LTF*(Which is TBD), to enable channel estimation at the receiver. When single stream pilot is used in EHT-LTF, the pilot subcarriers of each EHT-LTF symbol are multiplied by the entries of a matrix *RHE-LTF*(Which is TBD) to allow receivers to track phase and/or frequency offset during MIMO channel estimation using the EHT-LTF. Single stream pilots shall be used for all spatial multiplexing modes (both UL and DL) defined in EHT. *PEHT-LTF*(Which is TBD) is defined such that each modulated spatial stream in an RU/MRU is active on all sub-carriers in that RU/MRU for which the EHT-LTF sequence takes a non-zero value. This is applicable to multi-AP transmission modes as well

In an EHT MU PPDU with a single RU/MRU (the RU/MRU having an MU-MIMO allocation or an SU allocation), the number of EHT-LTF symbols, *NEHT-LTF*, is a function of the total number of space-time streams *NSTS* as shown in Table TBD.

In an EHT MU PPDU, *NEHT-LTF* is indicated in the U-SIG field. In an EHT MU PPDU with more than one RU/MRU, *NEHT-LTF* may take a value that is greater than or equal to the maximum value of the initial number of EHT-LTF symbols for each RU/MRU, where the initial number of EHT-LTF symbols is calculated as a function of *NSTS, r, total* (where *r* is the index of the RU/MRU) based on Table TBD.

In an EHT TB PPDU, *NEHT-LTF* is indicated in the Trigger frame that triggers the transmission of the PPDU. In a non-OFDMA EHT TB PPDU, the number of EHT-LTF symbols, *NEHT-LTF*, is a function of the total number of space-time streams, *NSTS*, as shown in Table TBD. For an OFDMA HE TB PPDU, *NEHT\_LTF* may be greater than or equal to the maximum value of the initial number of EHT-LTF symbols for each RU/MRU *r*, which is calculated as a function of *NSTS, r, total*, separately based on Table TBD.

An EHT PPDU supports 3 EHT-LTF types: 1x EHT-LTF, 2x EHT-LTF and 4x EHT-LTF. Table TBD (EHT-LTF type and GI duration combinations for various EHT PPDU formats) defines whether a particular EHT-LTF type and GI duration combination is mandatory, conditional mandatory or optional for each EHT PPDU format.

In an EHT MU PPDU, the combination of EHT-LTF type and GI duration is indicated in U-SIG field. In an EHT TB PPDU, the combination of EHT-LTF type and GI duration is indicated in the Trigger frame that triggers the transmission of the PPDU. If an EHT PPDU is an EHT sounding NDP, the combinations of EHT-LTF types and GI durations are listed in TBD (EHT sounding NDP).

The duration of each EHT-LTF symbol excluding GI is *TEHT-LTF*, defined in Equation (34-xx).

$$T\_{EHT-LTF}=\left\{\begin{matrix}T\_{EHT-LTF-1x}, if 1x EHT-LTF\\T\_{EHT-LTF-2x}, if 2x EHT-LTF\\T\_{EHT-LTF-4x}, if 4x EHT-LTF\end{matrix}\right. (34-xx)$$

where $T\_{EHT-LTF-1x}$,$T\_{EHT-LTF-2x}$, $T\_{EHT-LTF-4x}$ are defined in Table xxx (Timing-related constants).

In a 20 MHz transmission, the 1x EHT-LTF sequence transmitted on subcarriers [–122: 122] is given by Equation (27-41) with *HELTF*-122,122replaced by *EHTLTF*-122,122.

In a 20 MHz transmission, the 2x EHT-LTF sequence transmitted on subcarriers [–122: 122] is given by Equation (27-42) with *HELTF*-122,122replaced by *EHTLTF*-122,122.

In a 20 MHz transmission, the 4x EHT-LTF sequence transmitted on subcarriers [–122: 122] is given by Equation (27-43) with *HELTF*-122,122replaced by *EHTLTF*-122,122.

In a 40 MHz transmission, the 1x EHT-LTF sequence transmitted on subcarriers [–244: 244] is given by Equation (27-44) with *HELTF*-244,244replaced by *EHTLTF*-244,244. .

In a 40 MHz transmission, the 2x EHT-LTF sequence transmitted on subcarriers [–244: 244] is given by Equation (27-45) with *HELTF*-244,244replaced by *EHTLTF*-244,244.

In a 40 MHz transmission, the 4x EHT-LTF sequence transmitted on subcarriers [–244: 244] is given by Equation (27-46) with *HELTF*-244,244replaced by *EHTLTF*-244,244.

In an 80 MHz transmission, the 1x EHT-LTF sequence transmitted on subcarriers [–500: 500] is given by Equation (27-47) with *HELTF*-500,500replaced by *EHTLTF*-500,500.

In an 80 MHz transmission, the 2x EHT-LTF sequence transmitted on subcarriers [–500: 500] is given by Equation Equation (27-48) with *HELTF*-500,500replaced by *EHTLTF*-500,500.

In an 80 MHz transmission, the 4x EHT-LTF sequence transmitted on subcarriers [–500: 500] is given by Equation Equation (27-49) with *HELTF*-500,500replaced by *EHTLTF*-500,500.

In a 160 MHz transmission using a 1x EHT-LTF, the 1x EHT-LTF sequence is given by Equation (27-50) with *HELTF*-1012,1012replaced by *EHTLTF*-1012, 1012.

In a 160 MHz transmission using a 2x EHT-LTF, the 2x EHT-LTF sequence is given by Equation (27-51) with *HELTF*-1012,1012replaced by *EHTLTF*-1012, 1012.

In a 160 MHz transmission using a 4x EHT-LTF, the 4x EHT-LTF sequence is given by Equation (27-52) with *HELTF*-1012,1012replaced by *EHTLTF*-1012, 1012.

In a 320 MHz transmission using a 1x EHT-LTF, the 1x EHT-LTF sequence is given by Equation (34-xx).

$EHTLTF\_{-2036,2036}=\{LTF\_{80MHz\\_1st\\_1x},0\_{23}, LTF\_{80MHz\\_2nd\\_1x},0\_{23},LTF\_{80MHz\\_3rd\\_1x}, 0\_{23}, LTF\_{80MHz\\_4th\\_1x}\}$ (34-xx)

where

$0\_{23}$ means number of 23 consecutive 0s

*LTF*80MHz\_1st\_1x = {*LTF*80MHz\_left\_1x, 0, *LTF*80MHz\_right\_1x}

*LTF*80MHz\_2nd\_1x = {*LTF*80MHz\_left\_1x, 0, *LTF*80MHz\_right\_1x}

*LTF*80MHz\_3rd\_1x = {-*LTF*80MHz\_left\_1x, 0, -*LTF*80MHz\_right\_1x}

*LTF*80MHz\_4th\_1x = {-*LTF*80MHz\_left\_1x, 0, -*LTF*80MHz\_right\_1x}

*LTF*80MHz\_left\_1x and *LTF*80MHz\_right\_1x is in the section 27.3.11.10 HE-LTF

In a 320 MHz transmission using a 2x EHT-LTF, the 2x EHT-LTF sequence is given by Equation (34-xx).

$EHTLTF\_{-2036,2036}=\{ [C(1)×LTF80\\_2x(1:245), C(2)×LTF80\\_2x(246:500), 0, C(3)×LTF80\\_2x(502:756), C(4)×LTF80\\_2x(757:1001)], 0\_{23}, [C(5)×LTF80\\_2x(1:245), C(6)×LTF80\\_2x(246:500), 0, C(7)×LTF80\\_2x(502:756), C(8)×LTF80\\_2x(757:1001)],0\_{23} , [C(9)×LTF80\\_2x(1:245), C(10)×LTF80\\_2x(246:500), 0, C(11)×LTF80\\_2x(502:756), C(12)×LTF80\\_2x(757:1001)],0\_{23} , [C(13)×LTF80\\_2x(1:245), C(14)×LTF80\\_2x(246:500), 0, C(15)×LTF80\\_2x(502:756), C(16)×LTF80\\_2x(757:1001)] \}$ (34-xx)

Where,

C = [+1 +1 +1 +1, +1 -1 +1 -1, +1 -1 -1 +1, +1 +1 -1 -1];

LTF80\_2x = [ +1 0 +1 0 +1 0 -1 0 -1 0 +1 0 -1 0 +1 0 +1 0 +1 0 +1 0 -1 0 +1 0 -1 0 +1 0 +1 0 -1 0 -1 0 +1 0 -1 0 -1 0 -1 0 -1 0 -1 0 +1 0 -1 0 +1 0 -1 0 +1 0 +1 0 -1 0 -1 0 +1 0 -1 0 +1 0 +1 0 +1 0 +1 0 -1 0 +1 0 -1 0 -1 0 -1 0 +1 0 +1 0 -1 0 +1 0 +1 0 +1 0 +1 0 +1 0 -1 0 +1 0 -1 0 -1 0 -1 0 -1 0 -1 0 +1 0 +1 0 -1 0 +1 0 +1 0 -1 0 -1 0 +1 0 +1 0 +1 0 -1 0 -1 0 +1 0 +1 0 -1 0 +1 0 -1 0 -1 0 -1 0 -1 0 +1 0 -1 0 +1 0 -1 0 -1 0 +1 0 +1 0 -1 0 +1 0 +1 0 +1 0 +1 0 +1 0 -1 0 +1 0 -1 0 -1 0 +1 0 +1 0 -1 0 -1 0 +1 0 -1 0 +1 0 +1 0 +1 0 +1 0 -1 0 +1 0 -1 0 -1 0 -1 0 +1 0 +1 0 -1 0 +1 0 +1 0 +1 0 +1 0 +1 0 -1 0 +1 0 -1 0 -1 0 -1 0 +1 0 +1 0 +1 0 +1 0 -1 0 -1 0 +1 0 -1 0 +1 0 +1 0 +1 0 +1 0 -1 0 +1 0 +1 0 +1 0 +1 0 -1 0 -1 0 +1 0 -1 0 -1 0 -1 0 -1 0 -1 0 +1 0 -1 0 +1 0 +1 0 +1 0 +1 0 -1 0 -1 0 +1 0 -1 0 +1 0 +1 0 +1 0 +1 0 -1 0 +1 0 -1 0 -1 0 -1 0 +1 0 +1 0 -1 0 +1 0 +1 0 +1 0 +1 0 +1 0 -1 0 +1 0 -1 0 +1 0 +1 0 +1 0 -1 0 +1 0 -1 0 +1 0 +1 0 +1 0 -1 0 -1 0 +1 0 -1 0 +1 0 +1 0 +1 0 -1 0 -1 0 +1 0 -1 0 +1 0 +1 0 +1 0 +1 0 -1 0 +1 0 +1 0 +1 0 +1 0 -1 0 -1 0 +1 0 -1 0 -1 0 -1 0 -1 0 -1 0 +1 0 -1 0 +1 0 -1 0 -1 0 -1 0 +1 0 +1 0 -1 0 +1 0 -1 0 -1 0 -1 0 -1 0 +1 0 -1 0 +1 0 +1 0 +1 0 -1 0 -1 0 +1 0 -1 0 -1 0 -1 0 -1 0 -1 0 +1 0 -1 0 +1 0 +1 0 -1 0 -1 0 +1 0 0 0 0 0 0 0 -1 0 -1 0 -1 0 -1 0 -1 0 -1 0 -1 0 +1 0 +1 0 -1 0 +1 0 -1 0 -1 0 -1 0 -1 0 +1 0 -1 0 +1 0 -1 0 -1 0 +1 0 +1 0 -1 0 +1 0 +1 0 +1 0 +1 0 +1 0 -1 0 +1 0 -1 0 +1 0 -1 0 -1 0 +1 0 +1 0 -1 0 +1 0 -1 0 -1 0 -1 0 -1 0 +1 0 -1 0 +1 0 +1 0 +1 0 -1 0 -1 0 +1 0 -1 0 -1 0 -1 0 -1 0 -1 0 +1 0 -1 0 +1 0 -1 0 -1 0 -1 0 -1 0 -1 0 +1 0 -1 0 +1 0 +1 0 -1 0 -1 0 +1 0 +1 0 -1 0 -1 0 -1 0 +1 0 +1 0 -1 0 +1 0 -1 0 -1 0 -1 0 -1 0 +1 0 -1 0 +1 0 -1 0 -1 0 +1 0 +1 0 -1 0 +1 0 +1 0 +1 0 +1 0 +1 0 -1 0 +1 0 -1 0 -1 0 +1 0 +1 0 -1 0 -1 0 +1 0 -1 0 +1 0 +1 0 +1 0 +1 0 -1 0 +1 0 -1 0 -1 0 -1 0 +1 0 +1 0 -1 0 +1 0 +1 0 +1 0 +1 0 +1 0 -1 0 +1 0 -1 0 +1 0 +1 0 +1 0 +1 0 +1 0 +1 0 -1 0 -1 0 +1 0 -1 0 +1 0 +1 0 +1 0 +1 0 -1 0 +1 0 +1 0 +1 0 +1 0 -1 0 -1 0 +1 0 -1 0 -1 0 -1 0 -1 0 -1 0 +1 0 -1 0 +1 0 +1 0 +1 0 +1 0 -1 0 -1 0 +1 0 -1 0 +1 0 +1 0 +1 0 +1 0 -1 0 +1 0 -1 0 -1 0 -1 0 +1 0 +1 0 -1 0 +1 0 +1 0 +1 0 +1 0 +1 0 -1 0 +1 0 -1 0 +1 0 +1 0 -1 0 -1 0 +1 0 +1 0 +1 0 -1 0 -1 0 -1 0 +1 0 -1 0 +1 0 -1 0 -1 0 -1 0 +1 0 +1 0 -1 0 +1 0 -1 0 -1 0 -1 0 -1 0 +1 0 -1 0 -1 0 -1 0 -1 0 +1 0 +1 0 -1 0 +1 0 +1 0 +1 0 +1 0 +1 0 -1 0 +1 0 +1 0 +1 0 +1 0 +1 0 -1 0 -1 0 +1 0 -1 0 +1 0 +1 0 +1 0 +1 0 -1 0 +1 0 -1 0 -1 0 -1 0 +1 0 +1 0 -1 0 +1 0 +1 0 +1 0 +1 0 +1 0 -1 0 +1 0 +1];

$0\_{23}$ Means number of 23 consecutive 0s.

In a 320 MHz transmission using a 4x EHT-LTF, the 4x EHT-LTF sequence is given by Equation (34-xx).

$EHTLTF\_{-2036,2036}=\{$LTF80M\_4x\_left, $0\_{5}$, LTF80M\_4x\_right, $0\_{23}$, ...

LTF80M\_4x\_left, $0\_{5}$, $-$LTF80M\_4x\_right, $0\_{23}$, ...

$-$LTF80M\_4x\_left, $0\_{5}$, $-$LTF80M\_4x\_right, $0\_{23}$, ...

$-$LTF80M\_4x\_left, $0\_{5}$, LTF80M\_4x\_right$\}$ (34-xx)

Where,

LTF80M\_4x\_left =[+1 -1 -1 -1 -1 +1 -1 -1 +1 -1 -1 -1 +1 +1 -1 -1 -1 +1 -1 -1 +1 -1 +1 +1 +1 -1 +1 -1 +1 -1 -1 -1 -1 +1 +1 +1 +1 +1 -1 -1 +1 -1 +1 -1 -1 -1 +1 +1 -1 -1 +1 -1 -1 -1 +1 +1 +1 -1 -1 +1 +1 -1 -1 +1 -1 +1 +1 -1 +1 -1 +1 +1 +1 -1 +1 -1 +1 +1 +1 +1 +1 +1 -1 -1 -1 +1 -1 +1 -1 -1 -1 +1 -1 -1 +1 +1 +1 +1 +1 +1 -1 +1 -1 +1 +1 -1 +1 -1 +1 -1 +1 -1 +1 -1 -1 +1 +1 +1 +1 -1 -1 -1 -1 -1 -1 -1 -1 +1 -1 -1 +1 -1 -1 +1 +1 +1 -1 +1 -1 -1 -1 +1 +1 +1 -1 +1 +1 -1 -1 +1 -1 -1 -1 +1 +1 +1 +1 -1 +1 +1 +1 +1 +1 +1 -1 +1 -1 -1 +1 -1 +1 -1 -1 +1 +1 +1 +1 +1 -1 +1 +1 -1 -1 +1 +1 +1 -1 +1 +1 -1 +1 +1 -1 -1 +1 +1 -1 -1 -1 -1 +1 +1 +1 +1 +1 -1 +1 +1 +1 +1 +1 -1 +1 -1 +1 -1 -1 +1 -1 -1 -1 -1 -1 +1 -1 -1 -1 +1 +1 -1 +1 -1 +1 -1 -1 -1 -1 -1 +1 +1 +1 +1 -1 +1 -1 -1 +1 +1 -1 -1 -1 +1 +1 +1 +1 +1 -1 +1 -1 +1 -1 -1 +1 +1 +1 -1 +1 +1 +1 +1 +1 -1 +1 +1 -1 +1 -1 +1 -1 -1 -1 -1 -1 +1 -1 -1 -1 -1 -1 +1 +1 +1 +1 -1 -1 +1 +1 -1 -1 +1 -1 -1 +1 -1 -1 -1 +1 +1 -1 -1 +1 -1 -1 -1 -1 -1 +1 +1 -1 +1 -1 +1 +1 -1 +1 -1 -1 -1 -1 -1 -1 +1 -1 -1 -1 -1 +1 +1 +1 -1 +1 +1 -1 -1 +1 -1 -1 -1 +1 +1 +1 -1 +1 -1 +1 -1 -1 -1 +1 -1 +1 -1 +1 -1 -1 -1 +1 -1 -1 +1 -1 +1 +1 -1 -1 -1 +1 +1 -1 -1 -1 -1 +1 -1 +1 +1 -1 +1 -1 +1 +1 +1 +1 +1 +1 -1 -1 +1 -1 -1 -1 +1 -1 +1 -1 -1 -1 +1 +1 +1 +1 +1 +1 -1 +1 -1 +1 +1 +1 -1 +1 -1 +1 +1 -1 +1 -1 -1 +1 +1 -1 -1 +1 +1 +1 -1 -1 -1 +1 -1 -1 +1 +1 -1 -1 -1 +1 -1 +1 -1 -1 +1 +1 +1 +1 +1 -1 -1 -1 -1 +1 -1 +1 -1 +1 +1 +1 -1 +1 -1 -1 +1 -1 -1 -1 +1 +1 -1 -1 -1 +1 -1 -1 +1 -1 -1 -1 -1 +1 -1 +1 +1 -1 -1 -1 +1 -1 -1];

LTF80M\_4x\_right =[ -1 -1 +1 -1 +1 +1 +1 +1 +1 +1 -1 -1 -1 -1 +1 -1 -1 +1 -1 -1 -1 +1 +1 -1 -1 -1 +1 -1 -1 +1 -1 +1 +1 +1 -1 +1 -1 +1 -1 -1 -1 -1 +1 +1 +1 +1 +1 -1 -1 +1 -1 +1 -1 -1 -1 +1 +1 -1 -1 +1 -1 -1 -1 +1 +1 +1 -1 -1 +1 +1 -1 -1 +1 -1 +1 +1 -1 +1 -1 +1 +1 +1 -1 +1 -1 +1 +1 +1 +1 +1 +1 -1 -1 -1 +1 -1 +1 -1 -1 -1 +1 -1 -1 +1 +1 +1 +1 +1 +1 -1 +1 -1 +1 +1 -1 +1 -1 -1 -1 -1 +1 +1 -1 -1 -1 +1 +1 -1 +1 -1 -1 +1 -1 -1 -1 +1 -1 +1 -1 +1 -1 -1 -1 +1 -1 +1 -1 +1 +1 +1 -1 -1 -1 +1 -1 -1 +1 +1 -1 +1 +1 +1 -1 -1 -1 -1 +1 -1 -1 -1 -1 -1 -1 +1 -1 +1 +1 -1 +1 -1 +1 +1 -1 -1 -1 -1 -1 +1 -1 -1 +1 +1 -1 -1 -1 +1 -1 -1 +1 -1 -1 +1 +1 -1 -1 +1 +1 +1 +1 -1 -1 -1 -1 -1 +1 -1 -1 -1 -1 -1 +1 -1 +1 -1 +1 +1 -1 +1 +1 +1 +1 +1 -1 +1 +1 +1 -1 -1 +1 -1 +1 -1 +1 +1 +1 +1 +1 -1 -1 -1 +1 +1 -1 -1 -1 -1 -1 -1 -1 -1 +1 +1 +1 +1 +1 -1 +1 -1 +1 -1 -1 +1 +1 +1 -1 +1 +1 +1 +1 +1 -1 +1 +1 -1 +1 -1 +1 -1 -1 -1 -1 -1 +1 -1 -1 -1 -1 -1 +1 +1 +1 +1 -1 -1 +1 +1 -1 -1 +1 -1 -1 +1 -1 -1 -1 +1 +1 -1 -1 +1 -1 -1 -1 -1 -1 +1 +1 -1 +1 -1 +1 +1 -1 +1 -1 -1 -1 -1 -1 -1 +1 -1 -1 -1 -1 +1 +1 +1 -1 +1 +1 -1 -1 +1 -1 -1 -1 +1 +1 +1 -1 +1 -1 -1 -1 +1 +1 -1 +1 +1 -1 +1 +1 +1 +1 +1 +1 +1 +1 -1 -1 -1 -1 +1 +1 -1 +1 -1 +1 -1 +1 -1 +1 -1 -1 +1 -1 +1 -1 -1 -1 -1 -1 -1 +1 +1 -1 +1 +1 +1 -1 +1 -1 +1 +1 +1 -1 -1 -1 -1 -1 -1 +1 -1 +1 -1 -1 -1 +1 -1 +1 -1 -1 +1 -1 +1 +1 -1 -1 +1 +1 -1 -1 -1 +1 +1 +1 -1 +1 +1 -1 -1 +1 +1 +1 -1 +1 -1 +1 +1 -1 -1 -1 -1 -1 +1 +1 +1 +1 -1 +1 -1 +1 -1 -1 -1 +1 -1 +1 +1 -1 +1 +1 +1 -1 -1 +1 +1 +1 -1 +1 +1 -1 +1 +1 +1 +1 -1 ];

$0\_{5}$ means number of 5 consecutive 0s;

$0\_{23}$ means number of 23 consecutive 0s