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Wireless LANs

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| Proposed Text Draft on UHR-LTF |
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This document is based on the following IEEE contributions on DRU and 11bn SFD.

1. [11-24/2046r0](https://mentor.ieee.org/802.11/dcn/23/11-23-2200-03-00bn-distribution-bandwidth-of-dru.pptx): 11-24-1901-00-00bn-dru-ltf-sequence-design-for-40mhz-dbw, Chenchen Liu
2. [11-24/1567r](https://mentor.ieee.org/802.11/dcn/23/11-23-2200-03-00bn-distribution-bandwidth-of-dru.pptx)0: 11-24-1567-00-00bn-ltf-design-for-dru, Ron Porat
3. [11-24/2046r1](https://mentor.ieee.org/802.11/dcn/23/11-23-2200-03-00bn-distribution-bandwidth-of-dru.pptx): 11-24-2046-01-00bn-draft-text-on-dru, Jianhan Liu

* + - 1. **UHR-LTF**

The UHR-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 UHR MU PPDU, the transmitter provides training for *NSS* *r* *total* spatial streams used for the transmission of the PSDU(s) in the *r*-th RU, MRU or DRU. In an UHR

TB PPDU, the transmitter of user *u* in the *r*-th RU, MRU or DRU provides training for *NSS* *r* *u* spatial streams used for the transmission of the PSDU. For each subcarrier in the *r*-th RU, MRU or DRU, the MIMO channel that can

be estimated is an $N\_{RX}×N\_{SS,r,total}$ matrix. An UHR transmission has a preamble that contains UHR-LTF symbols, where the data tones of each UHR-LTF symbol are multiplied by entries belonging to a matrix $P\_{UHR-LTF}$, to enable channel estimation at the receiver. When single stream pilots are used in 2x or 4x UHR-LTF, the pilot subcarriers of each UHR-LTF symbol are multiplied by the entries of a matrix $R\_{UHR-LTF}$ to allow receivers to track phase and/or frequency offset during MIMO channel estimation using the UHR- LTF. Single stream pilots shall be used for all spatial multiplexing modes (both UL and DL) defined in UHR except when 1x UHR-LTF is used. $P\_{UHR-LTF}$ is defined such that each modulated spatial stream in an RU, MRU or DRU is active on all subcarriers in that RU, MRU or DRU for which the UHR-LTF sequence takes a nonzero value.

In an UHR MU PPDU, *N*UHR-LTF is indicated in the UHR-SIG field. In a non-OFDMA UHR MU PPDU or

UHR sounding NDP, the initial number of UHR-LTF symbols, initial *N*UHR-LTF , is a function of the total number of spatial streams *NSS* as shown in [Table 38-t1 (Initial number of UHR-LTFs required for different](#_bookmark157) [number of spatial streams)](#_bookmark157).

**Table 38-t1—Initial number of UHR-LTFs required for different number of spatial streams**

|  |  |
| --- | --- |
| *NSS* | **Initial** *N*UHR-LTF |
| 1 | 1 |
| 2 | 2 |
| 3–4 | 4 |
| 5–6 | 6 |
| 7–8 | 8 |

In order to improve the MIMO channel estimation for the reception of non-OFDMA UHR MU PPDU or UHR sounding NDP, the number of UHR-LTFs may be larger than the initial number of UHR-LTFs determined by the total number of spatial streams. If additional UHR-LTFs are used, then the total number of UHR-LTFs (which is signalled separately from *NSS* ) shall be no more than twice the initial number of UHR- LTFs determined by the number of spatial streams as shown in [Table 38-t1 (Initial number of UHR-LTFs](#_bookmark157) [required for different number of spatial streams)](#_bookmark157), and chosen from the set {2 4 8}. Supporting additional UHR-LTFs is optional for the receiver.

The maximum number of supported UHR-LTFs shall be no less than the value indicated in [Table 38-t1](#_bookmark157) [(Initial number of UHR-LTFs required for different number of spatial streams)](#_bookmark157) based on the maximum number of supported spatial streams, which is the highest *NSS* value indicated by the STA in Beamformee SS subfield and Supported UHR-MCS And NSS Set field over all supported bandwidths and UHR-MCSs in the UHR Capabilities element.

In an OFDMA UHR MU PPDU, *N*UHR-LTF may take a value that is greater than or equal to the maximum

value of the initial number of UHR-LTF symbols for each RU, MRU or DRU, where the initial number of UHR- LTF symbols is calculated as a function of *NSS* *r* *total* (where *r* is the index of the RU, MRU or DRU) based on [Table 38-t1 (Initial number of UHR-LTFs required for different number of spatial streams)](#_bookmark157).

In an UHR TB PPDU, *N*UHR-LTF is indicated in the Trigger frame that triggers the transmission of the PPDU. For an UHR TB PPDU, *N*UHR-LTF may be greater than or equal to the maximum value of the initial number of UHR-LTF symbols for each RU, MRU or DRU *r*, which is calculated as a function of *NSS* *r* *total* , separately based on [Table 38-t1 (Initial number of UHR-LTFs required for different number of spatial streams)](#_bookmark157).

An UHR PPDU supports three UHR-LTF types: 1**×** UHR-LTF, 2**×** UHR-LTF, and 4**×** UHR-LTF. [Table 38-t2](#_bookmark158) [(UHR-LTF type and GI duration combinations for various UHR PPDU formats)](#_bookmark158) defines whether a particular UHR-LTF type and GI duration combination is mandatory, optional, or not supported for each UHR PPDU format.

**Table 38-t2—UHR-LTF type and GI duration combinations for various UHR PPDU formats**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **UHR-LTF type and GI duration combination** | **UHR MU PPDU** | **UHR sounding NDP** | **UHR TB PPDU** | **UHR ELR PPDU** |
| 1**×** UHR-LTF and 1.6 µs GI | N/A | N/A | M (See NOTE) | N/A |
| 2**×** UHR-LTF and 0.8 µs GI | M | M | N/A | TBD |
| 2**×** UHR-LTF and 1.6 µs GI | M | M | M | TBD |
| 4**×** UHR-LTF and 0.8 µs GI | O | N/A | N/A | N/A |
| 4**×** UHR-LTF and 3.2 µs GI | M | O | M | N/A |
| M = MandatoryO = OptionalN/A = Not supported by the PPDU formatNOTE—1× UHR-LTF and 1.6 µs GI are only allowed for UL non-OFDMA transmission for two or more users.If a STA does not support transmission or reception of a particular PPDU format, then the M/O designation is not applicable for the transmission or reception, respectively, of that PPDU format. |

In an UHR MU PPDU, the combination of UHR-LTF type and GI duration is indicated in UHR-SIG field. In an UHR TB PPDU, the combination of UHR-LTF type and GI duration is indicated in the Trigger frame that triggers the transmission of the PPDU. If an UHR PPDU is an UHR sounding NDP, the combinations of UHR-LTF types and GI durations are listed in [38.3.21 (UHR sounding NDP)](#_bookmark274).

*T*UHR-LTF , described in [Table 38-t3 (Timing-related constants)](#_bookmark63), is given by [Equation (38-e1)](#_bookmark159).

$T\_{UHR-LTF}=\left\{\begin{matrix}T\_{UHR-LTF-1x}, if 1x UHR-LTF \\T\_{UHR-LTF-2x}, if 2x UHR-LTF \\T\_{UHR-LTF-4x}, if 4x UHR-LTF \end{matrix}\right.$(38-e1)

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

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

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

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

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

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

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

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

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

In a 160 MHz transmission, the 1 UHR-LTF sequence transmitted on subcarriers [–1012: 1012] is given by Equation (27-50) with *HELTF*–1012 1012 replaced by *UHRLTF*–1012 1012 .

In a 160 MHz transmission, the 2 UHR-LTF sequence transmitted on subcarriers [–1012: 1012] is given by Equation (27-51) with *HELTF*–1012 1012 replaced by *UHRLTF*–1012 1012 .

In a 160 MHz transmission, the 4 UHR-LTF sequence transmitted on subcarriers [–1012: 1012] is given by Equation (27-52) with *HELTF*–1012 1012 replaced by *UHRLTF*–1012 1012 .

In a 320 MHz transmission, the 1 UHR-LTF sequence transmitted on subcarriers [–2036: 2036] is given by Equation (36-38) with *EHTLTF*–2036, 2036 replaced by *UHRLTF*–2036, 2036 .

In a 320 MHz transmission, the 2 UHR-LTF sequence transmitted on subcarriers [–2036: 2036] is given by Equation (36-39) with *EHTLTF*–2036, 2036 replaced by *UHRLTF*–2036, 2036 .

In a 320 MHz transmission, the 4 UHR-LTF sequence transmitted on subcarriers [–2036: 2036] is given by Equation (36-40) with *EHTLTF*–2036, 2036 replaced by *UHRLTF*–2036, 2036 .

For a non-OFDMA transmission when preamble puncturing is applied, a single large size MRU spans the nonpunctured portions of the PPDU bandwidth. In the puncturing case, the values of the UHR-LTF sequence (defined in Equation (27-41) to Equation (27-52) and Equation (36-38) to Equation (36-40)) are replaced by zero for subcarriers that fall outside the aforementioned single large size MRU. This is also applicable to an UHR sounding NDP with preamble puncturing. The mapping of the non-OFDMA puncturing pattern signalled in the U-SIG field to the corresponding large size MRU is defined in Table 36-30 (Definition of the Punctured Channel Information field in the U-SIG for an EHT MU PPDU using non-OFDMA transmissions).

For an OFDMA transmission, the values of the UHR-LTF sequence (defined in Equation (27-41) to Equation (27-52) and [Equation (36-38)](#_bookmark160) to [Equation (36-40)](#_bookmark162)) are replaced by zero, for all subcarriers that are unassigned or punctured as well as for DC tones or null subcarriers.

The generation of the time domain symbols of a 1 UHR-LTF is equivalent to modulating every fourth subcarriers in an OFDM symbol of 12.8 µs excluding GI, and then transmitting only the first quarter of the OFDM symbol in the time domain as shown in [Figure 38-f2 (Generation of 1× UHR-LTF symbols)](#_bookmark167).

CSD per SS

CSD per SS

Truncate ¼ of Time Symbol

IDFT

Truncate ¼ of Time Symbol

IDFT

IDFT

Insert GI and Window

Insert GI and Window

Insert GI and Window

Truncate ¼ of Time Symbol

Analog and RF

Analog and RF

Analog and RF

AUHR-LTF

Modulate Every 4th Tone

**Figure 38-f2—Generation of 1× UHR-LTF symbols**

**...**

**...**

**...**

**...**

**...**

**...**

Spatial Mapping

There are no pilot subcarriers in the UHR-LTF field when 1 UHR-LTF is used.

The generation of the time domain symbols of a 2 UHR-LTF is equivalent to modulating every second subcarriers in an OFDM symbol of 12.8 µs excluding GI, and then transmitting only the first half of the OFDM symbol in the time domain as shown in [Figure 38-f3 (Generation of 2× UHR-LTF symbols)](#_bookmark169).

CSD per SS

IDFT

IDFT

Truncate ½ of Time Symbol

CSD per SS

Truncate ½ of Time Symbol

Insert GI and Window

Truncate ½ of Time Symbol

IDFT

Analog and RF

Analog and RF

Analog and RF

**...**

**...**

**...**

**...**

**...**

**...**

Modulate Every 2nd Tone

AUHR-LTF

Spatial Mapping

Insert GI and Window

Insert GI and Window

**Figure 38-f3—Generation of 2× UHR-LTF symbols**

In an UHR MU PPDU, the time domain representation of the UHR-LTF waveform transmitted on the transmit chain *iTX* shall be as described in [Equation (38-e2)](#_bookmark168).

In an UHR TB PPDU, the time domain representation of the UHR-LTF waveform of user *u* in the *r*-th RU, MRU or DRU transmitted on the transmit chain *iTX* shall be as described in [Equation (38-e3)](#_bookmark170).