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Abstract

This document contains Proposed Draft Text (PDT) for the UHR-STF subclause of the proposed TGbn (UHR, Ultra High Reliability) amendment to the 802.11 standard.

**Revision information**

The following is a summary of the important changes that occurred within each revision of this document:

|  |  |
| --- | --- |
| **Revision** | **Major changes** |
| 0 | Initial revision |
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**Introduction**

Interpretation of a Motion to Adopt.

A motion to approve this submission means that the editing instructions and any changed or added material are actioned in the TGbn Draft. The abstract, revision information, introduction, explanation of the proposed changes and references sections are not part of the adopted material.

***Editing instructions formatted like this are intended to be copied into the TGbn Draft (i.e. they are instructions to the 802.11 editor on how to merge the text with the baseline documents).***

**Explanation of the proposed changes:**

The proposed changes to the 802.11 TGbn draft within this document are based on the following motions adopted by the TGbn task group:

**Relevant passing motions:**

The proposed changes to the 802.11 TGbn draft within this document are based on the following motions adopted by the TGbn task group.

[Motion #15, [1]]

* Global CSD is used for DRU UHR-STF transmission to solve unintentional beamforming issue
* Global CSD is applied in each distribution BW

[Motion #16, [1] ]

* DRU transmission reuses the 8 CSD table/values in 11ax/be for global CSD allocation

[Motion #18, [1]]

* The UHR-STF for DRU in a TB PPDU uses 11ax/11be trigger based STF sequences.

[Motion #19, [1]]

* For UHR-STF corresponding to distribution bandwidth for DRU,
	+ STF sequence depends on PPDU BW.
	+ Occupied STF tones are the same as that of the largest RRU corresponding to the distribution BW within PPDU BW.

[Motion #59, [1]]

* DRU index based global CSD start index assignment will be used for DRU UHR-STF transmission
* Global CSD start index assignment for DRU UHR-STF transmission will be based on the following table

|  |  |
| --- | --- |
| DRU size | Global CSD starting index for DBW 20MHz |
| DRU26, i=1:9 | {1,2,3,4,5,5,6,7,8} |
| DRU52, i=1:4 | {2,4,6,8} |
| DRU106, i=1:2 | {3,7} |

|  |  |
| --- | --- |
| DRU size | Global CSD starting index for DBW 40MHz |
| DRU26, i=1:18 | {1,5,2,6,3,3,7,4,8,1,5,2,6,7,3,7,4,8} |
| DRU52, i=1:8 | {1,2,3,4,5,6,7,8} |
| DRU106, i=1:4 | {2,4,6,8} |
| DRU242, i=1:2 | {3,7} |

|  |  |
| --- | --- |
| DRU size | Global CSD starting index for DBW 80MHz |
| DRU52, i=1:16 | {1,5,2,6,3,7,4,8,1,5,2,6,3,7,4,8} |
| DRU106, i=1:8 | {1,2,3,4,5,6,7,8} |
| DRU242, i=1:4 | {2,4,6,8} |
| DRU484, i=1:2 | {3,7} |

[Motion #70, [1]]

* In DRU transmission, global CSD provides CSD start index i for each DRU. If Nss for this DRU is larger than 1, then it will use CSD[mod(i: i+Nss-1, 8)] for each ss

[Motion #82, [1]]

* ELR PPDU has 3dB boosting applied on both ELR-STF and ELR-LTF
	+ ELR PPDU has ELR-STF duration and sequence same as that of UHR DL SU/MU PPDU
		- 4us using EHT-STF sequence for 20MHz
* ELR PPDU defines a fixed/single mode of LTF+GI
	+ 11bn supports 2x LTF+1.6us GI only for ELR PPDU
	+ 11bn uses two UHR-LTF symbols for ELR PPDU

Note that ELR-STF/ELR-LTF are the short names of UHR-STF/UHR-LTF for ELR PPDU

**Text to be adopted begins here.**

***TGbn editor: Please add the following subclause 38.3.14.10 UHR-STF to the 802.11bn draft D0.1:***

# 38.3.14.10 UHR-STF

## 38.3.14.10.1 UHR-STF for RRUs

The main purpose of the UHR-STF field is to improve automatic gain control estimation in a MIMO transmission. The UHR-STF field is positioned immediately after the UHR-SIG field for UHR MU PPDU. The UHR-STF field is positioned immediately after the U-SIG field for UHR TB PPDU. The UHR-STF field is positioned immediately after the ELR-MARK field for UHR ELR PPDU. The duration of the UHR-STF field for UHR MU PPDU and UHR ELR PPDU is *T*UHR-STF-NT (periodicity of 0.8 μs with 5 periods as given in Table 38-xx (Timing-related constants)) and the duration of the UHR-STF field for UHR TB PPDU is *T*UHR-STF-T (periodicity of 1.6 μs with 5 periods as given in Table 38-xx (Timing-related constants)). 3dB power boosting shall be applied on UHR-STF in UHR ELR PPDU.

For a 20 MHz transmission, the frequency domain sequence for a UHR MU PPDU and a UHR ELR PPDU is given by Equation (38-x1).

*UHRS*-112:16:112 = *HES*-112:16:112 (38-x1)

where *UHRSa:b:c* means coefficients of the UHR-STF on every *b* subcarrier indices from *a* to *c* subcarrier indices and coefficients on other subcarrier indices are set to zero and *HES*-112:16:112 is defiend in Equation (27-23).

For a 40 MHz transmission, the frequency domain sequence for a UHR MU PPDU is given by Equation (38-x2).

*UHRS*-240:16:240 = *HES*-240:16:240  (38-x2)

where *HES*-240:16:240 is defined in Equation (27-24).

For an 80 MHz transmission, the frequency domain sequence for a UHR MU PPDU is given by Equation (38-x3).

*UHRS*-496:16:496 = *HES*-496:16:496 (38-x3)

where *HES*-496:16:496 is defined in Equation (27-25).

For a 160 MHz transmission, the frequency domain sequence for a UHR MU PPDU is given by Equation (38-x4).

*UHRS*-1008:16:1008 = *HES*-1008:16:1008 (38-x4)

where *HES*-1008:16:1008 is defined in Equation (27-26).

For a 320 MHz transmission, the frequency domain sequence for a UHR MU PPDU is given by Equation (38-x5).

*UHRS*-2032:16:2032 = *EHTS*-2032:16:2032 (38-x5)

where *EHTS*-2032:16:2032 is defined in Equation (36-29).

For a 20 MHz transmission, the frequency domain sequence for a UHR TB PPDU is given by Equation (38-x6).

*UHRS*-120:8:120 = *HES*-120:8:120 (38-x6)

where *HES*-120:8:120 is defined in Equation (27-28).

For a 40 MHz transmission, the frequency domain sequence for a UHR TB PPDU is given by Equation (38-x7).

*UHRS*-248:8:248 = *HES*-248:8:248 (38-x7)

where *HES*-248:8:248 is defined in Equation (27-30).

For an 80 MHz transmission, the frequency domain sequence for a UHR TB PPDU is given by Equation (38-x8).

*UHRS*-504:8:504 = *HES*-504:8:504 (38-x8)

where *HES*-504:8:504 is defined in Equation (27-32).

For a 160 MHz transmission, the frequency domain sequence for a UHR TB PPDU is given by Equation (38-x9).

*UHRS*-1016:8:1016 = *HES*-1016:8:1016 (38-x9)

where *HES*-1016:8:1016 is defined in Equation (27-34).

For a 320 MHz transmission, the frequency domain sequence for a UHR TB PPDU is given by Equation (38-x10).

*UHRS*-2040:8:2040 = *EHTS*-2040:8:2040 (38-x10)

where *EHTS*-2040:8:2040 is defined in Equation (36-34).

The coefficients in Equation (38-x1) to Equation (38-x10) are set to zero if those values are corresponding to subcarrier indices that are not modulated in the Data field, such as subcarriers falling within RRUs that have no users assigned to them in OFDMA or subcarriers that are punctured.

The time domain representation of the signal for a UHR MU PPDU and a UHR ELR PPDU on transmit chain *iTX* shall be as specified in Equation (38-x11).

$$r\_{UHR-STF}^{\left(i\_{TX}\right)}\left(t\right)=w\_{T\_{UHR-STF-NT}}\left(t\right)\sum\_{r=0}^{N\_{RU}-1}\frac{α\_{r}β\_{r}}{\sqrt{N\_{SS,r,total}}}η\_{UHR-STF} (38-x11)$$

$$\sum\_{k\in K\_{r}}^{}\sum\_{u=0}^{N\_{user,r}-1}\sum\_{m=1}^{N\_{SS,r,u}}\left(\left[Q\_{k,u}\right]\_{i\_{TX},m}UHRS\_{k}∙exp\left(j2πk∆\_{F,UHR}\left(t-T\_{CS, UHR}\left(M\_{r,u}+m\right)\right)\right)\right)$$

where

$α\_{r}$ is defined in 38.3.13.4 (Transmitted signal)

$β\_{r}$ is the per-RU power normalization factor and defined by $β\_{r}={\left(\sqrt{\frac{\left|K\_{r}\right|}{\left|K\_{r}^{UHR-STF}\right|}}\right)}/{\left(\sqrt{\sum\_{r=0}^{N\_{RU}-1}α\_{r}^{2}\left|K\_{r}\right|}\right)}$

$η\_{UHR-STF }= \left\{\begin{array}{c}\sqrt{2} ,for UHR ELR PPDU\\1 ,for UHR MU PPDU \end{array}\right.$

$\left|K\_{r}\right|$ is the cardinality of the set of subcarriers $K\_{r}$, as defined in 38.3.13 (Mathematical description of signals)

$K\_{r}^{UHR-STF}$ is the set of subcarriers that have nonzero values within $K\_{r}$ in the UHR-STF field

$T\_{CS, UHR}\left(M\_{r,u}+m\right)$ represents the cyclic shift for space-time stream $M\_{r,u}+m$ as defined in 38.3.14.2.2 (Cyclic shift for UHR modulated field)

$Q\_{k,u}$ is defined in 38.3.13.4 (Transmitted signal)

$w\_{T\_{UHR-STF-NT}}$ is the windowing function for UHR-STF field in the UHR MU PPDU

$\left|K\_{r}^{UHR-STF}\right|$ is the cardinality of the set of subcarriers $K\_{r}^{UHR-STF}$

$N\_{RU},N\_{SS,r,total},N\_{user,r}$ and $N\_{SS,r,u}$ are defined in Table 38-x (Frequently used parameters).

The time domain representation of the signal for a UHR TB PPDU transmitted by user *u* in the *r-*th RRU on transmit chain *iTX* shall be as specified in Equation (38-x12).

$$r\_{UHR-STF,r,u}^{\left(i\_{TX}\right)}\left(t\right)=\frac{1}{\sqrt{\left|K\_{r}^{UHR-STF}\right|N\_{SS,r,u}}}w\_{T\_{UHR-STF-T}}\left(t\right) (38-x12)$$

$$\sum\_{k\in K\_{r}}^{}\sum\_{m=1}^{N\_{SS,r,u}}\left(\left[Q\_{k,u}\right]\_{i\_{TX},m}UHRS\_{k}∙exp\left(j2π∆\_{F,UHR}\left(t-T\_{CS, UHR}\left(M\_{r,u}+m\right)\right)\right)\right)$$

where

$w\_{T\_{UHR-STF-T}}$ is the windowing function for UHR-STF field in the UHR TB PPDU

$Q\_{k,u}$ is defined in 38.3.13.4 (Transmitted signal)

Other variables in Equation (38-x11) and Equation (38-x12) are defined in 38.3.12 (Timing-related parameters) and 38.3.13 (Mathematical description of signals).

It is recommended that the spatial mapping matrix applied to UHR-STF and beyond is chosen such that it preserves the smoothness of the physical channel, achieved by limiting the variation of each element's real and imaginary values in the spatial mapping matrix across successive tones within one RU.

## 38.3.14.10.2 UHR-STF for DRUs

The same UHR-STF sequences are used in UHR TB PPDUs for both UHR DRU and UHR RRU. For a DRU with a given distribution bandwidth (DBW) transmitted in a UL TB PPDU, UHR-STF sequence depends on the PPDU BW, the occupied STF tones are the same as that of the largest RRU corresponding to the distribution BW within the PPDU BW.

When transmitting a DRU with a given DBW in a UHR TB PPDU:

* The PPDU BW determines which UHR-STF sequence is used
* The DBW determines which tones in the UHR-STF field are modulated. Let *KSTF*,242,*n*, *KSTF*,484,*n* and *KSTF*,996,*n* be the set of UHR-STF tones modulated when transmitting the *n-*th 242-tone, 484-tone and 996-tone RRU lowest in frequency, respectively, in a *WP* MHz UHR TB PPDU (*WP* ≥ DBW). Then, *KSTF*,242,*n* is the set of UHR-STF tones that are modulated when transmitting a DRU with DBW of 20 MHz located in the *n-*th lowest 20 MHz within the UHR TB PPDU. *KSTF*,484,*n* is the set of UHR-STF tones that are modulated when transmitting a DRU with DBW of 40 MHz located in the *n-*th lowest 40 MHz within the UHR TB PPDU. *KSTF*,996,*n* is the set of UHR-STF tones that are modulated when transmitting a DRU with DBW of 80 MHz located in the *n-*th lowest 80 MHz within the UHR TB PPDU.

The maximum DBW is 80 MHz in 80 MHz, 160 MHz, and 320 MHz UHR TB PPDUs. DRUs with DBW of 20 or 40MHz or 60MHz are allowed within each 80 MHz frequency subblock.

## 38.3.14.10.3 CSD for DRU transmission

CSD is used for DRU UHR-STF transmission to solve unintentional beamforming issue. It is applied in each distribution BW. For each DRU user, a unique CSD index will be assigned according to its DRU index to minimize CSD collision.

DRU transmission reuses the existing 8 CSD table (Table 21-11 – Cyclic shift values for the VHT modulated fields of a PPDU) for the CSD allocation.

Like per stream CSD in UL MU-MIMO, CSD index for each DRU assignment can be defined based on DRU index. For a DRU assignment in a distribution BW, it is assigned with a CSD start index i. If number of streams (Nss) for this DRU is larger than 1, then it will use CSD [mod(i-1:i+Nss-2,8)+ones(1,Nss)] for each stream.

## 38.3.14.10.4 CSD index assignment for DRU UHR-STF transmission

For DRU UHR-STF transmission, DRU index based CSD start index assignment defined in Tables 38-yy1-yy3 shall be followed for distribution BW of 20MHz, 40MHz, and 80MHz, respectively.

**Table 38-yy1: CSD starting index for DBW20**

|  |  |
| --- | --- |
| DRU size | CSD starting index for DBW20 |
| DRU26, *i*=1:9 | {1,2,3,4,5,5,6,7,8} |
| DRU52, *i*=1:4 | {2,4,6,8} |
| DRU106, *i*=1:2 | {3,7} |

**Table 38-yy2: CSD starting index for DBW40**

|  |  |
| --- | --- |
| DRU size | CSD starting index for DBW40 |
| DRU26, *i*=1:18 | {1,5,2,6,3,3,7,4,8,1,5,2,6,7,3,7,4,8} |
| DRU52, *i*=1:8 | {1,2,3,4,5,6,7,8} |
| DRU106, *i*=1:4 | {2,4,6,8} |
| DRU242, *i*=1:2 | {3,7} |

**Table 38-yy3: CSD starting index for DBW80**

|  |  |
| --- | --- |
| DRU size | CSD starting index for DBW80 |
| DRU52, *i*=1:16 | {1,5,2,6,3,7,4,8,1,5,2,6,3,7,4,8} |
| DRU106, *i*=1:8 | {1,2,3,4,5,6,7,8} |
| DRU242, *i*=1:4 | {2,4,6,8} |
| DRU484, *i*=1:2 | {3,7} |

**Text to be adopted ends here.**

# References

[1] 11-24-0171-21-00bn-tgbn-motions-list-part-1

[2] IEEE P802.11be D7.0