IEEE P802.11
Wireless LANs

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| Draft Spec Text for Section 33.3.6 (Timing-related parameters) and 33.3.7 (Mathematical description of signals) |
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Abstract

This submission contains spec text for Sec. 33.3.6 (Timing-related parameters) and Sec. 33.3.7 (Mathematical description of signals) to be incorporated in P802.11bd D0.1. The text reflects the related passed motions recorded in 11-19/0514r10.

Revisions:

* Rev 0: Initial version of the document.

33. Next Generation V2X (NGV) PHY specification

* + 1. Timing-related parameters

Table 33-x1 (Timing-related constants) defines the timing-related parameters for NGV format.

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| Table 33-x1 Timing-related constants  |
| Parameter | CBW10 | CBW20 | Description |
| *NSD* | 52 | 108 | Number of complex data numbers per frequency segment |
| *NSP* | 4 | 6 | Number of pilot values per frequency segment |
| *NST* | 56 | 114 | Total number of subcarriers per frequency segment. See NOTE. |
| *NSR* | 28 | 58 | Highest data subcarrier index per frequency segment |
| *∆F* | 156.25 kHz | Subcarrier frequency spacing |
| *TDFT* | 6.4 µs | IDFT/DFT period |
| *TGI* | 1.6 µs = *TDFT* /4 | Guard interval duration |
| *TGI2* | 3.2 µs | Double guard interval |
| *TSYM* | 8 µs = *TDFT* + *TGI =* 1.25 *TDFT*  | symbol interval |
| *TL-STF* | 16 µs = 10 x *TDFT* /4 | Non-HT Short Training field duration |
| *TL-LTF* | 16 µs = 2 x *TDFT* + *TGI2* | Non-HT Long Training field duration |
| *TL-SIG* | 16 µs | Non-HT SIGNAL field duration |
| *TRL-SIG* | 16 µs | Repeated Non-HT SIGNAL field duration |
| *TNGV-SIG* | 16 µs | NGV Signal field duration |
| *TRNGV-SIG* | 16 µs | Repeated NGV Signal field duration |
| *TNGV-STF* | 8 µs | NGV Short Training field duration |
| *TNGV-LTF-2X* | 8 µs | Duration of each NGV-LTF-2x symbol |
| *TNGV-LTF-1X* | TBD | Duration of each NGV-LTF-1x symbol |
| *TNGV-LTF* | *T*NGV-LTF-2X or *T*NGV-LTF-1X or *T*NGV-LTF-2X-Repeat or *T*NGV-LTF-1X-Repeat depending upon the LTF duration used | Duration of each OFDM symbol in NGV LTF field |
| *Nservice* | 16 | Number of bits in the SERVICE field |
| *Ntail* | 6 | Number of tail bits per BCC encoder |
| NOTE—*NST* = *NSD* + *NSP* |

Table 33-x2 (Frequently used parameters) defines parameters used frequently in Clause 33 (Next Generation V2X (V2X) PHY specification).

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| Table 33-x2 Frequently used parameters  |
| Symbol | Explanation |
| *NCBPS* | Number of coded bits per symbol. |
| *NCBPSS* | Number of coded bits per symbol per spatial stream. |
| *NDBPS* | Number of data bits per symbol. |
| *NBPSCS* | Number of coded bits per subcarrier per spatial stream. |
| *NRX* | Number of receive chains |
| *NSTS* | For pre-NGV modulated fields, NSTS = 1. For NGV modulated fields, NSTS is the number of space-time streams. |
| *NSS* | Number of spatial streams. |
| *NTX* | Number of transmit chains. |
| *NNGV-LTF* | Number of NGV-LTF symbols. |
| *R* | *R*is the coding rate. |

* + 1. Mathematical description of signals

33.3.7.1 Notation

For a description of the conventions used for the mathematical description of the signals, see 17.3.2.5 (Mathematical conventions in the signal descriptions), and 21.3.7.1 (Notation).

33.3.7.2 Subcarrier indices in use

For description on subcarrier indices over which the signal is transmitted for 10MHz non-HT PPDUs, see 19.3.7 (Mathematical description of signals).

For a 10 MHz NGV PPDU transmission, the 10 MHz is divided into 64 subcarriers. The signal is transmitted on subcarriers –28 to –1 and 1 to 28, with 0 being the center (DC) subcarrier.

For a 20 MHz NGV PPDU transmission, the 20 MHz is divided into 128 subcarriers. The signal is transmitted on subcarriers –58 to –2 and 2 to 58.

33.3.7.3 Transmitted signal

The transmitted signal is described in complex baseband signal notation. The actual transmitted signal is related to the complex baseband signal by the relation shown in Equation (33-x1).

$r\_{RF}^{i\_{TX}}=Re\left\{r\_{PPDU}^{i\_{TX}}\left(t\right)∙exp⁡(j2πf\_{c}t)\right\}$, $ i\_{TX}=1,…, N\_{TX}$ (33-x1)

where

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

$f\_{c}$ represents the center frequency of the PPDU.

The transmitted RF signal is derived by upconverting the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure 33-x1 (Timing boundaries for NGV PPDU fields) where *NNGV-LTF* is the number of NGV-LTF symbols and uses the same definition as in Table 21-13 (Number of VHT-LTFs required for different numbers of space-time streams).

L-STF

L-LTF

L-SIG

RL-SIG

NGV-SIG

RNGV-SIG

NGV-STF

Data Symbol

……

Data Symbol

NGV-LTF Symbol

……

NGV-LTF Symbol

$$t\_{L-LTF}$$

$$t=0$$

$$t\_{L-SIG}$$

$$t\_{RL-SIG}$$

$$t\_{NGV-SIG}$$

$$t\_{RNGV-SIG}$$

$$t\_{NGV-STF}$$

$$t\_{NGV-LTF}$$

$$t\_{NGV-Data}$$

Non-NGV portion

Pre-NGV modulated fields

NGV portion

NGV modulated fields

Midamble

……

Data Symbol

NGV LTF

Data

**Figure 33-x1 – Timing boundaries for NGV PPDU fields**

The time offset, $t\_{Field}$, determines the starting time of the corresponding field relative to the start of L-STF (*t* = 0).

The signal transmitted on transmit chain $i\_{TX}$ shall be as shown in Equation (33-x2).

$$r\_{PPDU}^{i\_{TX}}\left(t\right)=r\_{L-STF}^{i\_{TX}}\left(t\right)+r\_{L-LTF}^{i\_{TX}}\left(t-t\_{L-LTF}\right)+r\_{L-SIG}^{i\_{TX}}\left(t-t\_{L-SIG}\right)+r\_{RL-SIG}^{i\_{TX}}\left(t-t\_{RL-SIG}\right)+ r\_{NGV-SIG}^{i\_{TX}}(t-t\_{NGV-SIG}) + r\_{RNGV-SIG}^{i\_{TX}}(t-t\_{RNGV-SIG}) + r\_{NGV-STF}^{i\_{TX}}(t-t\_{NGV-STF}) + r\_{NGV-LTF}^{i\_{TX}}(t-t\_{NGV-LTF}) + r\_{NGV-Data}^{i\_{TX}}(t-t\_{NGV-Data}) $$

  (33-x2)

where

$$1 \leq i\_{TX} \leq N\_{TX}$$

$$t\_{L-LTF} =T\_{L-STF}$$

$$t\_{L-SIG} =t\_{L-LTF} +T\_{L-LTF}$$

$$t\_{RL-SIG} =t\_{L-SIG} +T\_{L-SIG}$$

$$t\_{NGV-SIG} =t\_{RL-SIG} +T\_{RL-SIG}$$

$$t\_{NGV-SIG} =t\_{RL-SIG} +T\_{RL-SIG}$$

$$t\_{RNGV-SIG} =t\_{NGV-SIG} + T\_{NGV-SIG}$$

$$t\_{NGV-STF} =t\_{RNGV-SIG} +T\_{RNGV-SIG}$$

$$t\_{NGV-LTF} =t\_{NGV-STF} + T\_{NGV-STF}$$

$$t\_{NGV-Data} =t\_{NGV-LTF} + N\_{NGV-LTF}T\_{NGV-LTF}$$

Each field, $r\_{Field}^{i\_{TX}}\left(t\right)$ , is defined as the summation of one or more subfields, where each subfield is defined to be an inverse discrete Fourier transform as specified in Equation (33-x3).

$$r\_{Subfield}^{i\_{TX}}\left(t\right)=\frac{1}{\sqrt{N\_{Field}^{Tone}N\_{Norm}}}w\_{T\_{Subfield}}\left(t\right)\sum\_{k=-N\_{SR}}^{N\_{SR}}\sum\_{m=1}^{N\_{STS}}\left[Q\_{k}\right]\_{i\_{TX},m} Υ\_{k,BW} X\_{k}^{m}exp\left(j2πkΔ\_{F}\left(t-T\_{GI,Field}-T\_{CS,NGV}\left(m\right)\right)\right)$$

 (33-x3)

This general representation holds for all subfields. The total power of the time domain NGV modulated field signals summed over all transmit chains should not exceed the total power of the time domain pre-NGV modulated field signals summed over all transmit chains. For notational simplicity, the parameter BW is omitted from some bandwidth dependent terms.

In Equation (33-x3) the following notions are used:

$N\_{Field}^{Tone}$ Table 33-x3 (Tone scaling factor and guard interval duration values for PHY fields) summarizes the various values of $N\_{Field}^{Tone}$ as a function of bandwidth.

$N\_{Norm}$ For pre-NGV modulated fields, $N\_{Norm}=N\_{TX}$. For NGV modulated fields, $N\_{Norm}=N\_{STS}$ where $N\_{STS}$ is given in Table 33-x2 (Frequently used parameters).

$w\_{T\_{Subfield}}\left(t\right)$ is a windowing function. An example function, $w\_{T\_{Subfield}}\left(t\right)$, is given in 17.3.2.5 (Mathematical conventions in the signal descriptions). $T\_{Subfield}$ is *TL-STF* for L-STF, *TL-LTF* for L-LTF, *TL-SIG* for L-SIG, *TRL-SIG* for RL-SIG, *TNGV-SIG* for NGV-SIG, *TRNGV-SIG* for RNGV-SIG*, TNGV-STF* for NGV-STF and *TNGV-LTF* for NGV-LTF. $T\_{Subfield}$ is *TSYM* for Data.

$Q\_{k}$ is the spatial mapping matrix for the subcarrier *k*. For pre-NGV modulated fields, $Q\_{k}$ is a column vector with $N\_{TX}$ elements with element $i\_{TX}$ being $e^{-j2πk∆\_{F}T\_{CS}^{i\_{TX}}}$, where $T\_{CS}^{i\_{TX}}$ represents the cyclic shift for transmitter chain $i\_{TX}$ whose values are given in Table 21-10 (Cyclic shift values for L-STF, L-LTF, L-SIG, and NGV-SIG fields of the PPDU). For NGV modulated fields, $Q\_{k}$ is a matrix with $N\_{TX}$ rows and $N\_{STS}$ columns.

$ Υ\_{k,BW}$ is defined in 33.3.7.3 (Definition of tone rotation)

$Δ\_{F}$ is the subcarrier frequency spacing given in Table 33-x1 (Timing-related constants).

$ X\_{k}^{m}$ is the frequency domain symbol in subcarrier *k* of space-time stream $m$. Some of the $ X\_{k}^{m}$ within $-N\_{SR}\leq k \leq N\_{SR}$ have a value of 0. Examples of such cases include the DC tones, guard tones on each side of the transmit spectrum, as well as the unmodulated tones of L-STF and NGV-STF fields. Note that the multiplication matrices$ A\_{NGV-LTF}^{k}$ and $P\_{NGV-LTF}$ are included in the calculation of $ X\_{k}^{m}$

 for the NGV-LTF field.

$T\_{GI,Field}$ is the guard interval duration used for each OFDM symbol in the field. For L-STF and NGV-STF, $T\_{GI,Field} = T\_{GI}$ but it can be omitted from Equation (33-x3) due to the periodic property of L-STF and NGV-STF over every 1.6 µs. For the L-SIG, RLSIG, NGV-SIG, RNGV-SIG, NGV-LTF and Data fields, $T\_{GI,Field}$ is defined in the “Guard interval duration” column of Table 33-x3 (Tone scaling factor and guard interval duration values for PHY fields).

$T\_{CS, NGV}(m)$ For pre-NGV modulated fields, $T\_{CS, NGV}\left(m\right)=0$. For NGV modulated fields, $T\_{CS, NGV}(m)$ represents the cyclic shift per space-time stream, whose value is TBD.

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| Table 33-x3 Tone scaling factor and guard interval duration values for PHY fields |
| Field |  $N\_{Field}^{Tone} $as a function of bandwidth  | Guard interval duration |
| 10 MHz | 20 MHz |  |
| L-STF | 12 | 24 | - |
| L-LTF | 52 | 104 | *TGI2* |
| L-SIG | 52 | 104 | *TGI* |
| RL-SIG | 52 | 104 | *TGI* |
| NGV-SIG | 52 | 104 | *TGI* |
| RNGV-SIG | 52 | 104 | *TGI* |
| NGV-STF | 12 | 24 | *-* |
| NGV-LTF-1x  | 28 | 58 | *TGI* |
| NGV-LTF-2x | 56 | 114 | *TGI* |
| NGV-LTF-2x-Repeat | 56 | 114 | *TGI* |
| NGV-LTF-1x-Repeat | 28 | 58 | *TGI* |
| Data | 56 | 114 | *TGI* |

33.3.7.3 Definition of tone rotation

The function $ Υ\_{k,BW}$ is used to represent a rotation of the tones. BW in $ Υ\_{k,BW}$ is determined by the TXVECTOR parameter CH\_BANDWIDTH as defined in Table 33-xx (CH\_BANDWIDTH).

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| Table 33-x4 CH\_BANDWIDTH and $ Υ\_{k,BW}$ |
| CH\_BANDWIDTH |  |
| CBW10 | *k*10 |
| CBW20 | *k*20 |

For a 10 MHz NGV PPDU transmission,

$ Υ\_{k,10} = 1$ (33-x4)

For a 20 MHz NGV PPDU transmission, tone rotation values are TBD.