IEEE P802.11
Wireless LANs

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| Draft Spec Text for Section 33.8 (NGV-Preamble) |
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Abstract

This submission contains spec text for section 33.8 NGV preamble to be incorporated in P802.11bd D0.1 based on the motions in 11-19/0514r10 frd-sfd motion block.

Revisions:

* Rev 0: Initial version of the document.

# NGV preamble

### 33.8.1 Introduction

A NGV preamble is defined to carry the required information to operate in a system with multiple transmit and multiple receive antennas. To maintain compatibility with non-NGV STAs, specific non-NGV fields are defined that can be received by non-NGV STAs compliant with Clause 17 (Orthogonal frequency division multiplexing (OFDM) PHY specification). The non-NGV fields are followed by NGV fields specific to NGV STAs.

### 33.8.2 Non-NGV portion of NGV format preamble

### 33.8.2.1 Cyclic shift for pre-NGV modulated fields

TBD

### 33.8.2.2 L-STF definition

The L-STF field for a 10 MHz or 20 MHz transmission is defined by Equation (19-8) and Equation (19-9), respectively, in 19.3.9.3.3 (L-STF definition).

The time domain representation of the signal on transmit chain $i\_{TX}$ shall be as specified in Equation (33-x1).

$r\_{L-STF}^{\left(i\_{TX}\right)}\left(t\right)=\frac{1}{\sqrt{N\_{TX}N\_{L-STF}^{Tone}}}w\_{T\_{L-STF}}(t)\sum\_{k=-N\_{SR}}^{N\_{SR}}γ\_{k,BW}S\_{k}exp⁡(j2πk∆\_{F,NGV}(t-T\_{cs}^{i\_{TX}})$ (33-x1)

where

$T\_{cs}^{i\_{TX}}$ represents the cyclic shift for transmit chain $i\_{TX}$ with a value given in TBD

$γ\_{k,BW}$ is TBD

$N\_{L-STF}^{Tone}$ has the value given in Table 33-x1 (Tone scaling factor and guard interval duration values for PHY fields)

### 33.8.2.3 L-LTF definition

For a 10 MHz or 20 MHz transmission,  the L-LTF pattern in the NGV preamble is defined by Equation (19-11) and Equation (19-12) in 19.3.9.3.4 (L-LTF definition), respectively.

The time domain representation of the signal on transmit chain $i\_{TX}$ shall be as defined in Equation (33-x2).

$r\_{L-LTF}^{\left(i\_{TX}\right)}\left(t\right)=\frac{1}{\sqrt{N\_{TX}N\_{L-LTF}^{Tone}}}w\_{T\_{L-LTF}}(t)\sum\_{k=-N\_{SR}}^{N\_{SR}}γ\_{k,BW}S\_{k}exp⁡(j2πk∆\_{F,NGV}(t-T\_{cs}^{i\_{TX}})$ (33-x2)

where

$T\_{cs}^{i\_{TX}}$ represents the cyclic shift for transmitter chain $i\_{TX}$ with a value given in TBD

$γ\_{k,BW}$ is TBD

$N\_{L-LTF}^{Tone}$ has the value given in Table33-x1 (Tone scaling factor and guard interval duration values for PHY fields)

### 33.8.2.4 L-SIG definition

The L-SIG field is used to communicate rate and length information. The structure of the L-SIG field is defined in Figure 17-5 (SIGNAL field bit assignment).

In a NGV PPDU, the RATE field shall be set to the value representing 3 Mb/s in the 10 MHz channel spacing column of Table 17-6 (Contents of the SIGNAL field). In a non-HT duplicate PPDU, the RATE field is defined in 17.3.4.2 (RATE field) using the L\_DATARATE parameter in the TXVECTOR.

The LENGTH field shall be set to the value given by Equation (33-x3).

$Length= \frac{TXTIME-40}{8}×3-3$ (33-x3)

where

TXTIME (in µs) is defined in 33.x.x. (TXTIME and PSDU\_LENGTH calculation)

The LSB of the binary expression of the Length value shall be mapped to B5. In a non-HT duplicate PPDU, the LENGTH field is defined in 17.3.4.3 (PHY LENGTH field) using the L\_LENGTH parameter in the TXVECTOR.

The Reserved (R) field shall be set to 0.

The Parity (P) field has the even parity of bits 0-16.

The SIGNAL TAIL field shall be set to 0.

The L-SIG field shall be encoded, interleaved, and mapped following the steps described in 17.3.5.6 (Convolutional encoder), 17.3.5.7 (Data interleaving), and 17.3.5.8 (Subcarrier modulation mapping). The stream of 48 complex numbers generated by these steps is denoted by $d\_{k}, k=0,\cdots ,47$ and are mapped to subcarriers [-26, 26]. Pilots shall be inserted as described in 17.3.5.9 (Pilot subcarriers).

The time domain waveform of the L-SIG field shall be as given by Equation (33-x4).

$r\_{L-SIG}^{\left(i\_{TX}\right)}\left(t\right)=\frac{1}{\sqrt{N\_{TX}N\_{L-SIG}^{Tone}}}w\_{T\_{L-SIG}}(t)\sum\_{i\_{BW}}^{N\_{10MHz}-1}\sum\_{k=-N\_{SR}}^{N\_{SR}}\left(\begin{matrix}γ\_{k-K\_{shift}(i\_{BW}),BW}(D\_{k,20}+p\_{0}p\_{k})\\ ∙exp⁡(j2π(k-K\_{shift}\left(i\_{BW}\right))∆\_{F,NGV}(t-T\_{GI}-T\_{cs}^{i\_{TX}})\end{matrix}\right)$ (33-x4)

Where

$$N\_{10MHz}= \left\{\begin{matrix}1, ifdot11CurrentChannelWidth indicates 10MHz\\2, ifdot11CurrentChannelWidth indicates 20MHz\end{matrix}\right.$$

$K\_{shift}\left(i\right)=(N\_{10MHz}-1-2i)∙32$

$D\_{k,20}=\left\{\begin{matrix}0, k=0,\pm 7,\pm 21\\d\_{M\_{20}^{r}(k)}, otherwise\end{matrix}\right.$ (33-x5)

$M\_{20}^{r}\left(k\right)=\left\{\begin{matrix}k+26, -26\leq k\leq -22\\k+25, -20\leq k\leq -8\\\begin{matrix}k+24, -6\leq k\leq -1\\k+23, 1\leq k\leq -6\\\begin{matrix}k+22, 8\leq k\leq 20\\k+21, 22\leq k\leq 26\end{matrix}\end{matrix}\end{matrix}\right.$ (33-x6)

$p\_{k}$ is defined in 17.3.5.10 (OFDM modulation)

$p\_{0}$ is the first pilot value in the sequence defined in 17.3.5.10 (OFDM modulation)

$N\_{L-SIG}^{Tone}$ has the value given in Table 33-x1 (Tone scaling factor and guard interval duration values for NGV fields)

$γ\_{k,BW}$ is defined in TBD

$T\_{cs}^{i\_{TX}}$ represents the cyclic shift for transmitter chain $i\_{TX}$ with a value given in TBD

NOTE—$M\_{20}^{r}\left(k\right)$ is a “reverse” function of the function M$\left(k\right)$ defined in 17.3.5.10 (OFDM modulation).

### 33.8.2.5 RL-SIG definition

The RL-SIG field is a repeat of the L-SIG field and is used to differentiate an NGV PPDU from a non-NGV PPDU. RL-SIG shall be modulated same as L-SIG.

The time domain waveform of the RL-SIG field shall be as given by Equation (33- x7).

$r\_{RL-SIG}^{\left(i\_{TX}\right)}\left(t\right)=\frac{1}{\sqrt{N\_{TX}N\_{RL-SIG}^{Tone}}}w\_{T\_{L-SIG}}(t)\sum\_{i\_{BW}}^{N\_{10MHz}-1}\sum\_{k=-N\_{SR}}^{N\_{SR}}\left(\begin{matrix}γ\_{k-K\_{shift}(i\_{BW}),BW}(D\_{k,20}+p\_{0}p\_{k})\\ ∙exp⁡(j2π(k-K\_{shift}\left(i\_{BW}\right))∆\_{F,NGV}(t-T\_{GI}-T\_{cs}^{i\_{TX}})\end{matrix}\right)$ (33-x7)

Where

$N\_{RL-SIG}^{Tone}$ has the value given in Table 33-x1 (Tone scaling factor and guard interval duration values for NGV fields)

### 33.8.3 NGV portion of NGV format preamble

### 33.8.3.1 Introduction

The NGV portion of the NGV format preamble consists of the NGV-SIG, RNGV-SIG, NGV-STF, and NGV-LTF fields.

### 32.8.3.2 Cyclic shift for NGV modulated fields

TBD

### 32.8.3.3 NGV-SIG definition

The NGV-SIG field carries information required to interpret NGV PPDUs. The NGV-SIG field contains the fields listed in Table 33-x2 (Fields in the NGV-SIG field).

 Table (33-x2) Fields in the NGV-SIG field

|  |  |  |  |
| --- | --- | --- | --- |
| Bit | Field | Number of bits  | Description |
|  | BW | 1bit | Set to 0 for 10 MHz, 1 for 20 MHz.  |
|  | NSTS | 1bit  | Set to 0 for 1 space time stream Set to 1 for 2 space tiem stream  |
|  | MCS | TBD | For a NGV-PPDU, Set to n for NGV-MCS index n  |
|  | Midamble Periodicity  | 2bit  | Set to 0 to indicate a midamble periodicity is 4. Other value is TBD  |
|  | LTF mode | 1 bit  | Set to 0 indicate a NGV-LTF-1x Set to 1 indicate a NGV-LTF-2x  |
|  | Reserved  | TBD  |  |
|  | CRC | TBD |  |
|  | Tail | 6bit  | Used to terminate the trellis of the convolutional decoder.Set to 0. |

The NGV-SIG field is composed of one OFDM symbol, containing 24 data bits, as shown in Table 33-x2 (Fields in the NGV-SIG field). NGV-SIG is transmitted before NGV-STF. The NGV-SIG symbol shall be BCC encoded at rate, R = 1/2, be interleaved, be mapped to a BPSK constellation, and have pilots inserted following the steps described in 17.3.5.6 (Convolutional encoder), 17.3.5.7 (Data interleaving), 17.3.5.8 (Subcarrier modulation mapping), and 17.3.5.9 (Pilot subcarriers). The stream of 48 complex numbers generated by these steps (before pilot insertion) is denoted by $d\_{k}, k=0,\cdots ,47.$

The time domain waveform for the NGV-SIG field in a NGV PPDU shall be as specified in Equation (33-x8).

$r\_{NGV-SIG}^{\left(i\_{TX}\right)}\left(t\right)=\frac{1}{\sqrt{N\_{TX}N\_{NGV-SIG}^{Tone}}}w\_{T\_{NGV-SIG}}(t)\sum\_{i\_{BW}}^{N\_{10MHz}-1}\sum\_{k=-N\_{SR}}^{N\_{SR}}\left(\begin{matrix}γ\_{k-K\_{shift}(i\_{BW}),BW}(D\_{k,20}+p\_{0}p\_{k})\\ ∙exp⁡(j2π(k-K\_{shift}\left(i\_{BW}\right))∆\_{F,NGV}(t-T\_{GI}-T\_{cs}^{i\_{TX}})\end{matrix}\right)$(33-x8)

where

$N\_{10MHz}$ and $K\_{shift}\left(i\right)$ are defined in 33.8.2.4 (L-SIG definition)

$$ D\_{k,20}=\left\{\begin{matrix}0, k=0,\pm 7,\pm 21\\d\_{M\_{20}^{r}(k)}, otherwise\end{matrix}\right.$$

 $M\_{20}^{r}\left(k\right)$ is defined in Equation (33-x6)

$p\_{k}$ and $p\_{0}$ are defined in 17.3.5.10 (OFDM modulation)

$N\_{NGV-SIG}^{Tone}$ has the value given in Table 33-x1 (Tone scaling factor and guard interval duration values for PHY fields)

$γ\_{k,BW}$ is TBD

$T\_{cs}^{i\_{TX}}$ represents the cyclic shift for transmitter chain  with a value given in TBD

NOTE—In NGV PPDUs, the NGV-SIG is transmitted with the same number of subcarriers and the same cyclic shifts as the preceding non-NGV portion of the preamble.

### 33.8.3.4 RNGV-SIG definition

The RNGV-SIG field is a repeat of the NGV-SIG field and is configured identically to the NGV-SIG.

The time domain waveform of the RNGV-SIG field shall be as given by Equation (33- x8).

$r\_{RNGV-SIG}^{\left(i\_{TX}\right)}\left(t\right)=\frac{1}{\sqrt{N\_{TX}N\_{RNGV-SIG}^{Tone}}}w\_{T\_{RNGV-SIG}}(t)\sum\_{i\_{BW}}^{N\_{10MHz}-1}\sum\_{k=-N\_{SR}}^{N\_{SR}}\left(\begin{matrix}γ\_{k-K\_{shift}(i\_{BW}),BW}(D\_{k,20}+p\_{0}p\_{k})\\ ∙exp⁡(j2π(k-K\_{shift}\left(i\_{BW}\right))∆\_{F,NGV}(t-T\_{GI}-T\_{cs}^{i\_{TX}})\end{matrix}\right)$ (33-x8)

Where

$N\_{RNGV-SIG}^{Tone}$ has the value given in Table 33-x1 (Tone scaling factor and guard interval duration values for NGV fields)

### 33.8.3.4 NGV-STF definition

The main purpose of the NGV-STF field is to improve automatic gain control estimation in a MIMO transmission. The duration of the NGV-STF field is 8 µs. The frequency domain sequence used to construct the NGV-STF field in a 10 MHz transmission is identical to the VHT-STF field for 20MHz transmission. In a 20 MHz, the NGV-STF field is constructed by using the frequency domain sequence for the VHT-STF field of 40MHz transmission and applying appropriate phase rotations per 10 MHz subchannel.

For a 10 MHz transmission, the frequency domain sequence is given by Equation (33-x9).

$NGVS\_{-28,28}=VHTS\_{-28,28}$ (33-x9)

Where $VHTS\_{-28,28}$ is defined in Equation (21-29)

For a 20 MHz transmission, the frequency domain sequence is given by Equation (33-x10).

$NGVS\_{-58,58}=VHTS\_{-58,58}$ (33-x10)

Where $VHTS\_{-58,58}$ is defined in Equation (21-30)

NOTE—Equation (33-x9), Equation (33-x10) do not show the phase rotation per 10 MHz subchannel

The time domain representation of the signal on transmit chain  shall be as specified in Equation (21-33).

$r\_{NGV-STF}^{\left(i\_{TX}\right)}\left(t\right)=\frac{1}{\sqrt{N\_{STS}N\_{NGV-STF}^{Tone}}}w\_{T\_{NGV-STF}}(t)\sum\_{k=-N\_{SR}}^{N\_{SR}}\sum\_{m=1}^{N\_{STS}}\left(\begin{matrix}\left[Q\_{k}\right]\_{i\_{TX},m}γ\_{k,BW}NGVS\_{k}\\ ∙exp⁡(j2πk)∆\_{F,NGV}(t-T\_{CS,NGV}(m))\end{matrix}\right)$ (33-x11)

where

$N\_{NGV-STF}^{Tone}$ has the value given in Table 33-x1 (Tone scaling factor and guard interval duration values for PHY fields)

$T\_{CS,NGV}(m)$ is given in TBD

$Q\_{k}$ is defined in 33.3.7.3 (Transmitted signal)

$γ\_{k,BW}$ is defined in TBD

### 32.8.3.5 NGV-LTF definition

The NGV Long Training field (NGV-LTF) field provides a means for the receiver to estimate the MIMO channel between the set of constellation mapper outputs and the receive chains. The transmitter provides training for *NSTS* space-time streams (spatial mapper inputs) used for the transmission of the PSDU(s). For each tone, the MIMO channel that can be estimated is an *NRX*  *NSTS* matrix. A NGV transmission has a preamble that contains NGV-LTF symbols, where the data tones of each NGV-LTF symbol are multiplied by entries belonging to a matrix *PNGV-LTF*, to enable channel estimation at the receiver. The pilot tones of each NGV-LTF symbol are multiplied by the entries of a matrix *RNGV-LTF* defined in the following text. The multiplication of the pilot tones in the NGV-LTF symbol by the *RNGV-LTF* matrix instead of the *PNGV-LTF* matrix allows receivers to track phase and frequency offset during MIMO channel estimation using the NGV-LTF. The number of NGV-LTF symbols, *NNGV-LTF*, is a function of the number of space-time streams *NSTS* as shown in Table 33-x3 (Number of NGV-LTFs required for different numbers of space-time streams). As a result the NGV-LTF field consists of one or two symbols.

|  |
| --- |
| Table 33-x3 Number of NGV- LTFs required for different numbers of space-time streams |
| *NSTS* | *NNGV-LTF* |
| 1 | 1 |
| 2 | 2 |

An NGV PPDU supports 2 NGV-LTF type: NGV-LTF-1x and NGV-LTF-2x. The NGV-LTF symbol is repeated when BPSK modulation is applied to the NGV-data field in NGV PPDU.

The duration of each NGV-LTF symbol excluding GI is *TNGV-LTF*, defined in equation (33-x12)

$T\_{NGV-LTF}=\left\{\begin{matrix}T\_{NGV-LTF-1x} ,if NGV-LTF-1x\\T\_{NGV-LTF-1x-Repeat},if NGV-LTF-1x Repeat\\\begin{matrix}T\_{NGV-LTF-2x} ,if NGV-LTF-2x\\T\_{NGV-LTF-2x-Repeat},if NGV-LTF-2x Repeat\end{matrix}\end{matrix}\right.$ (33-x12)

Let LTFleft and LTFright be the sequences defined in Equation (33-x13) and Equation (33-x14), respectively.

$LTF\_{left}=\left\{1, 1, -1, -1, 1, 1, -1, 1, -1, 1, 1 ,1 ,1 ,1 ,1,-1,-1, 1,1,-1,1,-1,1,1,1,1\right\}$ (33-x13)

$LTF\_{right}=\left\{1, -1, -1, 1, 1, -1, 1, -1,1, -1, -1 ,-1 ,-1 ,-1 ,1,1,-1, -1,1,-1,1,-1,1,1,1,1\right\}$ (33-x14)

NOTE—$LTF\_{left}$ is identical to the leftmost 26 elements of Equation (17-8), and $LTF\_{right}$ is identical to the rightmost 26 elements of Equation (17-8).

In a 10 MHz transmission, the 1x NGV-LTF sequence transmitted is given by Equation (33-x15).

$NGV-LTF\_{-28,28}=TBD $ (33-x15)

In a 10 MHz transmission, the 2x NGV-LTF sequence transmitted is given by Equation (33-x16).

 $NGV-LTF\_{-28,28}\begin{matrix}= \left\{1, 1,LTF\_{left},0,LTF\_{right},-1,-1\right\}\\=VHT-LTF\_{-28,28}\end{matrix}$ (33- x16)

Where

$VHT-LTF\_{-28,28}$ is defiend in equation (21-36)

In a 20 MHz transmission, the NGV-LTF-1x sequence transmitted is given by Equation (33-x17).

 $NGV-LTF\_{-58,58}=TBD$ (33-x17)

In a 20 MHz transmission, the NGV-LTF-2x sequence transmitted is given by Equation (33-x18).

 $NGV-LTF\_{-58,58}\begin{matrix}=\left\{LTF\_{left},1,LTF\_{right},-1,-1,-1,1,0,0,0,-1,1,1,-1,LTF\_{left},1,LTF\_{right}\right\}\\= VHT-LTF\_{-58,58}\end{matrix}$ (33-x18)

$VHT-LTF\_{-58,58}$ is defiend in equation (21-37)

NOTE—Equation (33-x15), Equation (33-x16), Equation (33-x17), and Equation (33-x18) do not show the phase rotation per 10 MHz subchannel.

The generation of the time domain NGV-LTF symbols is shown in Figure 33-x1 (Generation of NGV-LTF symbols)



Figure 33-x1 Generation of NGV-LTF symbols

The generation of time domain symbol of NGV-LTF-1x is equivalent to modulating every other tone in an OFDM symbol of 3.2 μs excluding GI, and then only transmit the first half of the OFDM symbol in time domain, as shown in Figure 33-x2 (Generation of NGV-LTF-1x symbols).



Figure 33-x2 Generation of NGV-LTF-1x symbols

 $A\_{NGV-LTF}^{k}$ is given by Equation (33-x19).

$A\_{NGV-LTF}^{k}=\left\{\begin{matrix}R\_{NGV-LTF},if k\in k\_{pilot}\\P\_{NGV-LTF},otherwise\end{matrix}\right.$ (33-x19)

where

$k\_{pilot}$ is the set of subcarrier indices for the pilot tones.
For a 10 MHz transmission,$ K\_{pilot}=\left\{\begin{matrix}\left\{\pm 7,\pm 21\right\}, if NGV-LTF-2x and NGV-LTF-2x Repeat\\TBD,if NGV-LTF-1x and NGV-LTF-1x Repeat\end{matrix}\right. $ .
For a 20 MHz transmission,$ K\_{pilot}=\left\{\begin{matrix} \left\{\pm 11,\pm 25,\pm 53\right\},if NGV-LTF-2x and NGV-LTF-2x Repeat\\TBD, if NGV-LTF-1x and NGV-LTF-1x Repeat\end{matrix}\right.$

$R\_{NGV-LTF}$ is a $N\_{NGV-LTF}×N\_{NGV-LTF}$ matrix whose elements are defined in Equation (33-x20).

$\left[R\_{NGV-LTF}\right]\_{m,n}=\left[P\_{NGV-LTF}\right]\_{1,n}, 1\leq m,n\leq N\_{NGV-LTF}$ (33-x20)

$P\_{NGV-LTF}$ is defined in Equation (33-x21)

The time domain representation of the waveform transmitted on transmit chain *iTX* shall be as described by Equation (33-x21).

$r\_{NGV-LTF}^{\left(i\_{TX}\right)}\left(t\right)=\frac{1}{\sqrt{N\_{STS}N\_{NGV-LTF}^{Tone}}}\sum\_{n=0}^{N\_{NGV-LTF}-1}w\_{T\_{NGV-LTF}}(t-nT\_{NGV-LTF})\sum\_{k=-N\_{SR}}^{N\_{SR}}\sum\_{m=1}^{N\_{STS}}\left(\begin{matrix}\left[Q\_{k}\right]\_{i\_{TX},m}γ\_{k,BW}[A\_{NGV-LTF}^{k}]\_{m,\left(n+1\right)}NGV-LTF\_{k}\\ ∙exp⁡(j2πk∆\_{F,NGV}(t-nT\_{NGV-LTF}-T\_{GI}-T\_{CS,NGV}(m))\end{matrix}\right)$ (33-x21)

where

$N\_{NGV-LTF}^{Tone}$ has the value given in Table 33-x1 (Tone scaling factor and guard interval duration values for PHY fields)

$T\_{CS,NGV}(m)$ is given in TBD

$Q\_{k}$ 33.3.7.3 (Transmitted signal)

$γ\_{k,BW}$ is defined in TBD

$A\_{NGV-LTF}^{k}$ is defined in Equation (33-x19)

$P\_{NGV-LTF}= P\_{4×4},N\_{STS}\leq 4$ (33-x22)

where

$P\_{4×4}$ is defined in Equation (19-27)

**References:**

[1] 11-19/0514r10 frd-sfd motion block