



**IEEE Standard for Information Technology—  
Telecommunications and Information Exchange between Systems  
Local and Metropolitan Area Networks—  
Specific Requirements**

**Part 11: Wireless LAN Medium Access Control  
(MAC) and Physical Layer (PHY) Specifications**

**Amendment 1:  
Enhancements for High-Efficiency WLAN**

IEEE Computer Society

Developed by the  
LAN/MAN Standards Committee

**IEEE Std 802.11ax™-2021**  
(Amendment to IEEE Std 802.11-2020)

If the TXVECTOR parameter BEAM\_CHANGE is 0, the time domain representation of the L-LTF field shall be as specified in Equation (27-10). The equation applies to signals up to a contiguous 160 MHz PPDU bandwidth and noncontiguous 80+80 MHz PPDU bandwidth.

$$r_{L-LTF}^{(i_{Seg}, i_{TX})}(t) = \frac{\varepsilon}{\sqrt{N_{STS} \cdot N_{L-LTF}^{Tone} \cdot \frac{|\Omega_{20MHz}|}{N_{20MHz}}}} w_{T_{L-LTF}}(t) \quad (27-10)$$

$$\sum_{i_{BW}=0}^{N_{20MHz}-1} \sum_{k=-26}^{26} \sum_{m=1}^{N_{STS}} \eta_{L-LTF, k} \left( \left[ Q_{4(k-K_{Shift}(i_{BW}))}^{(i_{Seg})} \right]_{i_{TX}, m} \left[ A_{HE-LTF}^{4(k-K_{Shift}(i_{BW}))} \right]_{m, 1} L_{k, 20} \right) \cdot \exp(j2\pi(k - K_{Shift}(i_{BW}))\Delta_{F, Pre-HE}(t - T_{GI, L-LTF} - T_{CS, HE}(m)))$$

where

$T_{CS, HE}(m)$  represents the cyclic shift for space-time stream  $m$  as defined in 27.3.11.2.2

$Q_k^{(i_{Seg})}$  is defined in 27.3.10

$A_{HE-LTF}^k$  is defined in Equation (27-55)

### 27.3.11.5 L-SIG field

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.

In an HE PPDU, the RATE field shall be set to the value representing 6 Mb/s in the “Rate (20 MHz channel spacing)” column of Table 17-6. In a non-HT duplicate PPDU, the RATE field is defined in 17.3.4.2 using the L\_DATARATE parameter in the TXVECTOR.

For an HE TB PPDU, the LENGTH field is set to the TXVECTOR parameter L\_LENGTH. For an HE SU PPDU, HE ER SU PPDU, and HE MU PPDU, the LENGTH field is set to the value given by the Equation (27-11).

$$\text{Length} = \left\lceil \frac{\text{TXTIME} - \text{SignalExtension} - 20}{4} \right\rceil \times 3 - 3 - m \quad (27-11)$$

where

TXTIME is defined in 27.4.3 (in  $\mu\text{s}$ )

$m$  is 1 for an HE MU PPDU and HE ER SU PPDU and 2 otherwise

SignalExtension is 0  $\mu\text{s}$  if the TXVECTOR parameter NO\_SIG\_EXTN is true and is aSignalExtension as defined in Table 27-54 if the TXVECTOR parameter NO\_SIG\_EXTN is false

In a non-HT duplicate PPDU, the LENGTH field is defined in 17.3.4.3 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, 17.3.5.7, and 17.3.5.8. The stream of 48 complex numbers generated by these steps is denoted by

If transmitting an HE TB PPDU for which the TXVECTOR parameter TRIGGER\_METHOD is TRIGGER\_FRAME, each transmitter of an HE TB PPDU shall append a PE field with a duration  $T_{PE}$  calculated using Equation (27-114), except for an HE TB feedback NDP (see 27.3.4), which has  $T_{PE} = 0$ .

$$T_{PE} = \left\lfloor \frac{\left( \frac{\text{LENGTH} + m + 3}{3} \times 4 - T_{\text{HE-PREAMBLE}} \right) - N_{SYM} T_{SYM} - N_{MA} N_{\text{HE-LTF}} T_{\text{HE-LTF-SYM}}}{4} \right\rfloor \times 4 \quad (27-114)$$

where

$m = 2$  for an HE TB PPDU

LENGTH is the value indicated by the UL Length subfield in the Common Info field in the Trigger frame

$T_{\text{HE-PREAMBLE}}$  is the value for an HE TB PPDU in Equation (27-121)

$T_{\text{HE-STF-T}}$ ,  $T_{\text{HE-LTF-SYM}}$ ,  $T_{\text{RL-SIG}}$ , and  $T_{\text{HE-SIG-A}}$  are defined in Table 27-12

$N_{MA}$  is the number of midamble periods in the current PPDU

$$N_{SYM} = \left\lfloor \left( \frac{\text{LENGTH} + m + 3}{3} \times 4 - T_{\text{HE-PREAMBLE}} - N_{MA} N_{\text{HE-LTF}} T_{\text{HE-LTF-SYM}} \right) / T_{SYM} \right\rfloor - b_{\text{PE-Disambiguity}} \quad (27-115)$$

$b_{\text{PE-Disambiguity}}$  is the value of the TXVECTOR parameter HE\_TB\_PE\_DISAMBIGUITY

There are multiple methods for computing  $N_{MA}$  for an HE TB PPDU that yield the same result; one example is as follows. The duration of one midamble period is defined in Equation (27-116).

$$T_{MA} = M_{MA} T_{SYM} + N_{\text{HE-LTF}} T_{\text{HE-LTF-SYM}} \quad (27-116)$$

where  $M_{MA}$  is the midamble periodicity indicated by the Number of HE-LTF Symbols And Midamble Periodicity subfield of the Common Info field in the Trigger frame. Equation (27-117) for computing  $N_{MA}$  can be used instead of Equation (27-112).

$$N_{MA} = \begin{cases} 0, & \text{if Doppler} = 0 \\ \max\left(0, \left\lfloor \frac{\text{LENGTH} + 3 + m}{3} \times 4 - T_{\text{HE-PREAMBLE}} - (b_{\text{PE-Disambiguity}} + 2) \cdot T_{SYM} \right\rfloor / T_{MA} \right), & \text{if Doppler} = 1 \end{cases} \quad (27-117)$$

where Doppler is indicated by the Doppler subfield of the Common Info field of the Trigger frame.

If transmitting an HE TB PPDU for which the TXVECTOR parameter TRIGGER\_METHOD is TRS, each transmitter of the HE TB PPDU shall append a PE field with the duration  $T_{PE}$  equal to the value specified in the TXVECTOR parameter DEFAULT\_PE\_DURATION.

The PE Disambiguity field of the HE-SIG-A field for an HE SU, HE ER SU (see Table 27-18), or HE MU PPDU (see Table 27-20) shall be set to 1 if the condition in Equation (27-118) is met; otherwise, it shall be set to 0.

The PE Disambiguity subfield in the Common Info field of the Trigger frame (see Table 9-29g) shall be set to 1 if the condition in Equation (27-118) is met for the HE TB PPDU solicited by the Trigger frame. Otherwise, it shall be set to 0.

$$T_{PE} + 4 \times \left( \left\lceil \frac{\text{TXTIME} - \text{SignalExtension} - 20}{4} \right\rceil - \left( \frac{\text{TXTIME} - \text{SignalExtension} - 20}{4} \right) \right) \geq T_{SYM} \quad (27-118)$$

where

- $T_{PE}$  is the PE field duration
- $T_{SYM}$  is the symbol duration of the Data field as defined in 27.3.9
- TXTIME is defined in 27.4.3 (in  $\mu\text{s}$ )
- SignalExtension is 0  $\mu\text{s}$  if TXVECTOR parameter NO\_SIG\_EXTN is true and is aSignalExtension as defined in Table 27-54 if TXVECTOR parameter NO\_SIG\_EXTN is false

The receiver computes  $N_{SYM}$ ,  $T_{PE}$ , and  $N_{MA}$  using Equation (27-119), Equation (27-120), and Equation (27-122), respectively.

$$N_{SYM} = \left\lfloor \left( \frac{\text{L\_LENGTH} + m + 3}{3} \times 4 - T_{\text{HE-PREAMBLE}} - N_{MA} N_{\text{HE-LTF}} T_{\text{HE-LTF-SYM}} \right) / T_{SYM} \right\rfloor - b_{\text{PE-Disambiguity}} \quad (27-119)$$

$$T_{PE} = \left\lfloor \frac{\left( \frac{\text{L\_LENGTH} + m + 3}{3} \times 4 - T_{\text{HE-PREAMBLE}} \right) - N_{SYM} T_{SYM} - N_{MA} N_{\text{HE-LTF}} T_{\text{HE-LTF-SYM}}}{4} \right\rfloor \times 4 \quad (27-120)$$

where

- L\_LENGTH is the value indicated by the LENGTH field of the L-SIG field
- $T_{\text{HE-PREAMBLE}} =$  (27-121)

$$\begin{cases} T_{\text{RL-SIG}} + T_{\text{HE-SIG-A}} + T_{\text{HE-STF-T}} + N_{\text{HE-LTF}} T_{\text{HE-LTF-SYM}}, & \text{for an HE TB PPDU} \\ T_{\text{RL-SIG}} + T_{\text{HE-SIG-A}} + T_{\text{HE-STF-NT}} + N_{\text{HE-LTF}} T_{\text{HE-LTF-SYM}}, & \text{for an HE SU PPDU} \\ T_{\text{RL-SIG}} + T_{\text{HE-SIG-A}} + N_{\text{HE-SIG-B}} T_{\text{HE-SIG-B}} + T_{\text{HE-STF-NT}} + N_{\text{HE-LTF}} T_{\text{HE-LTF-SYM}}, & \text{for an HE MU PPDU} \\ T_{\text{RL-SIG}} + T_{\text{HE-SIG-A-R}} + T_{\text{HE-STF-NT}} + N_{\text{HE-LTF}} T_{\text{HE-LTF-SYM}}, & \text{for an HE ER SU PPDU} \end{cases}$$

where

$T_{\text{RL-SIG}}$ ,  $T_{\text{HE-STF-T}}$ ,  $T_{\text{HE-STF-NT}}$ ,  $T_{\text{HE-LTF-SYM}}$ ,  $T_{\text{HE-SIG-A}}$ ,  $T_{\text{HE-SIG-A-R}}$ , and  $T_{\text{HE-SIG-B}}$  are defined in Table 27-12

$N_{\text{HE-SIG-B}}$  and  $N_{\text{HE-LTF}}$  are defined in Table 27-15

$b_{\text{PE-Disambiguity}}$  is the value indicated by the PE Disambiguity subfield of the HE-SIG-A field for an HE SU, HE ER SU, or HE MU PPDU or the value indicated by the PE Disambiguity subfield in the Common Info field in the Trigger frame (see Table 9-29g) for an HE TB PPDU

$N_{MA}$  may be computed by multiple methods that yield the same result, one example of which is given in Equation (27-122)