IEEE P802.11
Wireless LANs

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| Proposed Draft Text (PDT-PHY): An update to Preamble: U-SIG for D0.3 |
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Abstract

 This submission proposes updates to U-SIG section for TGbe D0.3.

* U-SIG
* General

The U-SIG field carries information necessary to interpret EHT PPDUs. The integer fields of the U-SIG field are transmitted in unsigned binary format, LSB first, where the LSB is in the lowest numbered bit position.

* Content

The U-SIG field is designed to bring forward compatibility to the EHT preamble via the introduction of version independent fields. These are fields that will be consistent in location and interpretation across multiple IEEE 802.11 PHY amendments. The intent of the version independent content is to achieve better coexistence among future IEEE 802.11 generations. In addition, the U-SIG can have some version dependent fields that are fields specific to a PHY amendment. The U-SIG includes version independent bits followed by version dependent bits. PHY version identifier field shall be one of the version independent fields in the U-SIG. The purpose of the PHY version identifier is to simplify autodetection for future IEEE 802.11 generations, i.e., the value of this field is used to identify the exact PHY version starting with this amendment.

The size of the U-SIG for EHT MU PPDU and EHT TB PPDU is two symbols. For forward compatibility, EHT Release 1 defines an extended range (ER) preamble while not defining an ER PPDU. This enables an EHT Release 1 STA to decode and interpret the version independent content in the U-SIG of an ER PPDU that may be introduced in future releases or amendments. The size of U-SIG for an ER preamble is four symbols.

EHT divides reserved bits in the PHY preamble or any reserved/un-used states of the fields in the PHY preamble into two categories: Validate and Disregard. If an EHT device encounters a PPDU where any of the Validate bits in the preamble are not set to the default values for those bits specified in the EHT specification, or field values of any field in the EHT PHY preamble is set to a Validate state as defined in the EHT specification, it shall defer for the duration of the PPDU, pass the information in the version independent fields to MAC, and shall terminate the reception of the PPDU. On the other hand, if an EHT device sees Disregard bits set to any value, or field values of any of the EHT PHY preamble fields as set to a Disregard state as defined in EHT specification, it shall ignore these bits/states, and continue receiver processing subject to absence of any of the other Validate bits in the preamble being set to non-default values and any of the other fields in the preamble not being set to a Validate state.For further details on receive behavior when encountered with Validate and Disregard bits/states, please refer to [xxxx].

The U-SIG field for an EHT MU PPDU contains the fields listed in Table 36-19 (U-SIG field of an EHT MU PPDU). The version independent bits are B0-B19 of U-SIG-1 and rest of the bits are version dependent.

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| * U-SIG field of an EHT MU PPDU
 |
| Two parts of U-SIG | Bit | Field | Number of bits | Description |
| U-SIG-1 | B0–B2 | PHY Version Identifier | 3 | Differentiate between different PHY amendments. Set to 0 for EHT.Values 1–7 are Validate. |
|  | B3–B5 | BW | 3 | Set to 0 for 20 MHz.Set to 1 for 40 MHz.Set to 2 for 80 MHz.Set to 3 for 160 MHz.Set to 4 for 320 MHz-1.Set to 5 for 320 MHz-1.Values 6 and 7 are Validate. |
|  | B6 | UL/DL | 1 | Indicates whether the PPDU is sent UL or DL. Set to 1 if the PPDU is addressed to an AP. Set to 0 otherwise. See the TXVECTOR parameter UPLINK\_FLAG. |
|  | B7–B12 | BSS Color | 6 | An identifier of the BSS.See the TXVECTOR parameter BSS\_COLOR. |
|  | B13–B19 | TXOP | 7 | Set to 127 to indicate no duration information if the TXVECTOR parameter TXOP\_DURATION is UNSPECIFIED.Set to a value less than 127 to indicate duration information for NAV setting and protection of the TXOP as follows:If the TXVECTOR parameter TXOP\_DURATION is less than 512, then B0 is set to 0 and B1–B6 is set to floor(TXOP\_DURATION/8).Otherwise, B0 is set to 1 and B1–B6 is set to floor((TXOP\_DURATION-512)/8),where B0 indicates TXOP length granularity. Set to 0 for 8 µs; otherwise set to 1 for 128 µs.B1–B6 indicates the scaled value of the TXOP\_DURATION. |
|  | B20–B24 | Disregard | 5 | Disregard and set to 1. |
|  | B25 | Validate | 1 | Validate and set to 1. |
| U-SIG-2 | B0–B1 | PPDU Type And Compression Mode | 2 | If B6 of U-SIG-1 is set to 0, a value of 0 indicates a DL OFDMA PPDU.A value of 1 indicates an EHT SU transmission or an EHT sounding NDP.A value of 2 indicates a non-OFDMA DL MU-MIMO transmission.NOTE—If B6 of U-SIG-1 is set to 1, a value of 0 indicates a TB PPDU.Undefined values of this field are Validate.For further clarifications on all states of this field, please refer to Table TBD.  |
|  | B2 | Validate | 1 | Validate and set to 1. Maybe used for an expanded set of PPDU types or compressed modes in future releases of amendments. |
|  | B3–B7 | Punctured Channel Information | 5 | If B0–B1 of U-SIG-2 is set to 1 or 2, which is the non-OFDMA case B3–B7 points to the entry of a bandwidth dependent table (defined in Table 36-20 (5-bit punctured channel indication for the non-OFDMA case in an EHT MU PPDU)) to signal the non-OFDMA puncturing pattern of the entire PPDU bandwidth. Undefined values of this field are Validate.If B0–B1 of U-SIG-2 is set to 0, which is the OFDMA case,If B3-B5 of U-SIG-1 is set to a value between 2 and 5, which indicates an 80/160/320 MHz PPDU, B3–B6 of U-SIG-2 is a 4-bit bitmap that tells which 20 MHz channel is punctured in the relevant 80 MHz segment, where B3 applies to the lowest frequency 20 MHz channel and B6 to the highest frequency 20 MHz channel. For each of the bits  B3–B6, a value of 0 indicates that the corresponding 20 MHz channel is punctured, and a value of 1 is used otherwise. Release 1 defines the following allowed punctured patterns 0111, 1011, 1101,1110, 0011, 1100, 1001 for an 80 MHz segment. Any field values other than the allowed punctured patterns are Validate. Field value may vary from one 80 MHz to the other.If B3-B5 of U-SIG-1 is set to 0 or 1, which indicates a 20/40 MHz PPDU, B3-B6 of U-SIG-2 are set to all 1’s. Other values are Validate. B7 is Disregard and set to 1. |
|  | B8 | Validate | 1 | Validate and set to 1. Maybe used for an expanded set of puncturing modes in future releases or amendments. |
|  | B9–B10 | EHT-SIG MCS | 2 | Indicates the MCS used for modulating the EHT-SIG.Set to 0 for EHT-MCS 0.Set to 1 for EHT-MCS 1.Set to 2 for EHT-MCS 3.Set to 3 for EHT-MCS 0 + DCM. |
|  | B11–B15 | Number Of EHT-SIG Symbols | 5 | Indicates the number of EHT-SIG symbols. Set to a value that is the number of EHT-SIG symbols minus 1. The value of this shall be the same in every 80 MHz segment. |
|  | B16–B19 | CRC | 4 | CRC for bits 0–41 of the U-SIG field (see 36.3.11.7.3 (CRC computation)). Bits 0–41 of the U-SIG field correspond to bits 0–25 of U-SIG-1 followed by bits 0–15 of U-SIG-2. |
|  | B20–B25 | Tail | 6 | Used to terminate the trellis of the convolutional decoder. Set to 0. |

**States of UL/DL Bit and PPDU Type And Compression Mode Fields**

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| --- | --- |
| **U-SIG Fields** | **Description** |
| UL/DL | EHT PPDU Type and EHT-SIG Mode | EHT PPDU Type | EHT-SIG Present? | RU Allocation Table Present? | Total Number of Users in the PPDU | Note |
| 0 (DL) | 0 | EHT MU | Yes | Yes | ≥ 1 | DL OFDMA (including non-MU-MIMO and MU-MIMO) |
| 1 | EHT MU | Yes | No | 1 | SU or NDP (Not to AP. Typically, “DL”) |
| 2 | EHT MU | Yes | No | > 1 | DL MU-MIMO (non-OFDMA) |
| 3 | - | - | - | - | Validate |
| 1 (UL) | 0 | EHT TB | No | - | ≥ 1 | UL OFDMA (including non-MU-MIMO and MU-MIMO) |
| 1 | EHT MU | Yes | No | 1 | SU or NDP (To AP. I.e., “UL”) |
| 2-3 | - | - | - | - | Validate |

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| * 5-bit punctured channel indication for the non-OFDMA case in an EHT MU PPDU
 |
| PPDU bandwidth | Cases | Puncturing pattern | Field value |
|
| 20/40 MHz | No puncturing | [1 1 1 1] | 0 |
| 80 MHz | No puncturing | [1 1 1 1] | 0 |
| 20 MHz puncturing | [x 1 1 1] | 1 |
| [1 x 1 1] | 2 |
| [1 1 x 1] | 3 |
| [1 1 1 x] | 4 |
| 160 MHz | No puncturing | [1 1 1 1 1 1 1 1] | 0 |
| 20 MHz puncturing | [x 1 1 1 1 1 1 1] | 1 |
| [1 x 1 1 1 1 1 1] | 2 |
| [1 1 x 1 1 1 1 1] | 3 |
| [1 1 1 x 1 1 1 1] | 4 |
| [1 1 1 1 x 1 1 1] | 5 |
| [1 1 1 1 1 x 1 1] | 6 |
| [1 1 1 1 1 1 x 1] | 7 |
| [1 1 1 1 1 1 1 x] | 8 |
| 40 MHz puncturing | [x x 1 1 1 1 1 1] | 9 |
| [1 1 x x 1 1 1 1] | 10 |
| [1 1 1 1 x x 1 1] | 11 |
| [1 1 1 1 1 1 x x] | 12 |
| 320 MHz | No puncturing | [1 1 1 1 1 1 1 1] | 0 |
| 40 MHz puncturing | [x 1 1 1 1 1 1 1] | 1 |
| [1 x 1 1 1 1 1 1] | 2 |
| [1 1 x 1 1 1 1 1] | 3 |
| [1 1 1 x 1 1 1 1] | 4 |
| [1 1 1 1 x 1 1 1] | 5 |
| [1 1 1 1 1 x 1 1] | 6 |
| [1 1 1 1 1 1 x 1] | 7 |
| [1 1 1 1 1 1 1 x] | 8 |
| 80 MHz puncturing | [x x 1 1 1 1 1 1] | 9 |
| [1 1 x x 1 1 1 1] | 10 |
| [1 1 1 1 x x 1 1] | 11 |
| [1 1 1 1 1 1 x x] | 12 |
| 320–80–40 | [x x x 1 1 1 1 1] | 13 |
| [x x 1 x 1 1 1 1] | 14 |
| [x x 1 1 x 1 1 1] | 15 |
| [x x 1 1 1 x 1 1] | 16 |
| [x x 1 1 1 1 x 1] | 17 |
| [x x 1 1 1 1 1 x] | 18 |
| [x 1 1 1 1 1 x x] | 19 |
| [1 x 1 1 1 1 x x] | 20 |
| [1 1 x 1 1 1 x x] | 21 |
| [1 1 1 x 1 1 x x] | 22 |
| [1 1 1 1 x 1 x x] | 23 |
| [1 1 1 1 1 x x x] | 24 |

NOTE—In the puncturing patterns in the above table, a “1” denotes a nonpunctured subchannel and an “x” denotes a punctured subchannel. The puncturing granularity for 80 MHz and 160 MHz PPDU bandwidth is 20 MHz, and the puncturing granularity for 320 MHz PPDU bandwidth is 40 MHz.

The U-SIG field for an EHT TB PPDU contains the fields listed in Table 36-21 (U-SIG field of an EHT TB PPDU). The version independent bits are B0-B19 of U-SIG-1 and rest of the bits are version dependent.

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| * U-SIG field of an EHT TB PPDU
 |
| Two parts of U-SIG | Bit | Field | Number of bits | Description |
| U-SIG-1 | B0–B2 | Version Identifier | 3 | Differentiate between different PHY amendments. Set to 0 for EHT.Values 1–7 are Validate. |
|  | B3–B5 | BW | 3 | Set to 0 for 20 MHz.Set to 1 for 40 MHz.Set to 2 for 80 MHz.Set to 3 for 160 MHz.Set to 4 for 320 MHz-1.Set to 5 for 320 MHz-1.Values 6 and 7 are Validate. |
|  | B6 | UL/DL | 1 | Set to 1 to indicate that the PPDU is addressed to the AP. |
|  | B7–B12 | BSS Color | 6 | An identifier of the BSS.See the TXVECTOR parameter BSS\_COLOR. |
|  | B13–B19 | TXOP | 7 | Set to 127 to indicate no duration information if the TXVECTOR parameter TXOP\_DURATION is UNSPECIFIED.Set to a value less than 127 to indicate duration information for NAV setting and protection of the TXOP as follows:If the TXVECTOR parameter TXOP\_DURATION is less than 512, then B0 is set to 0 and B1–B6 is set to floor(TXOP\_DURATION/8).Otherwise, B0 is set to 1 and B1–B6 is set to floor((TXOP\_DURATION-512)/8),where B0 indicates TXOP length granularity. Set to 0 for 8 µs; otherwise set to 1 for 128 µs.B1–B6 indicates the scaled value of the TXOP\_DURATION. |
|  | B20–B25 (TBD) | Disregard (TBD) | 6 (TBD) | Disregard. (TBD)  |
| U-SIG-2 | B0–B1 | PPDU Type And Compressed Mode | 2 | Set to a value of 0 for a TB PPDU.For further clarifications on all states of this field, please refer to Table TBD. |
|  | B2 | Validate  | 1  | Validate and set to 1.  |
|  | B3–B6 (TBD) | Spatial Reuse 1 (TBD) | 4 (TBD) | Indicates whether or not specific spatial reuse modes are allowed in a subband of the PPDU during the transmission of this PPDU, and if PSR spatial reuse is allowed, indicates a value that is used to determine a limit on the transmit power of the PSRT PPDU.If the Bandwidth field indicates 20 MHz or 40 MHz, then this field applies to the first 20 MHz subband.If the Bandwidth field indicates 80 MHz, then this field applies to the first 40 MHz subband of the 80 MHz operating band.If the Bandwidth field indicates 160 MHz, then this field applies to the first 80 MHz subband of the 160 MHz operating band.If the Bandwidth field indicates 320 MHz-1 or 320 MHz-2, then this field applies to the first 160 MHz subband of the 320 MHz operating band.Set to the value of the SPATIAL\_REUSE(1) parameter of the TXVECTOR, which contains a value from Table 27-23 (Spatial Reuse field encoding for an HE TB PPDU) for an HE TB PPDU (see 26.11.6 (SPATIAL\_REUSE)) and 26.10 (Spatial reuse operation)). |
|  | B7–B10 (TBD) | Spatial Reuse 2 (TBD) | 4 (TBD) | Indicates whether or not specific spatial reuse modes are allowed in a subband of the PPDU during the transmission of this PPDU, and if PSR spatial reuse is allowed, indicates a value that is used to determine a limit on the transmit power of the PSRT PPDU.If the Bandwidth field indicates 40 MHz, this field applies to the second 20 MHz subband. If the STA operating channel width is 20 MHz, then this field is set to the same value as the Spatial Reuse 1 field. If the STA operating channel width is 40 MHz in the 2.4 GHz band, this field is set to the same value as the Spatial Reuse 1 field.If the Bandwidth field indicates 80 MHz, then this field applies to the second 40 MHz subband of the 80 MHz operating band.If the Bandwidth field indicates 160 MHz, then this field applies to the second 80 MHz subband of the 160 MHz operating band.If the Bandwidth field indicates 320 MHz-1 or 320 MHz-2, then this field applies to the second 160 MHz subband of the 320 MHz operating band.Set to the value of the SPATIAL\_REUSE(1) parameter of the TXVECTOR, which contains a value from Table 27-23 (Spatial Reuse field encoding for an HE TB PPDU) for an HE TB PPDU (see 26.11.6 (SPATIAL\_REUSE) and 26.10 (Spatial reuse operation)). |
|  | B11–B15  | Disregard | 5  | Disregard.   |
|  | B16–B19 | CRC | 4 | CRC for bits 0–41 of the U-SIG field (see 36.3.11.7.3 (CRC computation)). Bits 0–41 of the U-SIG field correspond to bits 0–25 of U-SIG-1 followed by bits 0–15 of U-SIG-2. |
|  | B20–B25 | Tail | 6 | Used to terminate the trellis of the convolutional decoder. Set to 0. |

The U-SIG field for an ER preamble contains the fields listed in Table 36-22 (U-SIG field of an ER preamble). The version independent bits are B0-B19 of U-SIG-1 and rest of the bits are version dependent.

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| * U-SIG field of an ER preamble
 |
| Two parts of U-SIG | Bit | Field | Number of bits | Description |
| U-SIG-1 | B0–B2 | Version Identifier | 3 | Differentiate between different PHY amendments. NOTE—Expected to take a value other than 0 as EHT does not define an ER PPDU. |
|  | B3–B5 | BW | 3 | Set to 0 for 20 MHz.Set to 1 for 40 MHz.Set to 2 for 80 MHz.Set to 3 for 160 MHz.Set to 4 for 320 MHz-1.Set to 5 for 320 MHz-1.Values 6 and 7 are Validate. |
|  | B6 | UL/DL | 1 | Indicates whether the PPDU is sent UL or DL. Set to 1 if the PPDU is addressed to an AP. Set to 0 otherwise. See the TXVECTOR parameter UPLINK\_FLAG. |
|  | B7–B12 | BSS Color | 6 | An identifier of the BSS.See the TXVECTOR parameter BSS\_COLOR. |
|  | B13–B19 | TXOP | 7 | Set to 127 to indicate no duration information if the TXVECTOR parameter TXOP\_DURATION is UNSPECIFIED.Set to a value less than 127 to indicate duration information for NAV setting and protection of the TXOP as follows:If the TXVECTOR parameter  TXOP\_DURATION is less than 512, then B0 is set to 0 and    B1–B6 is set to floor(TXOP\_DURATION/8).Otherwise, B0 is set to 1 and B1–B6 is set to floor((TXOP\_DURATION-512)/8),where B0 indicates TXOP length granularity. Set to 0 for 8 µs; otherwise set to 1 for 128 µs.B1–B6 indicates the scaled value of the TXOP\_DURATION. |
|  | B20–B25 | Disregard  | 6  | Disregard  |
| U-SIG-2 | B0–B15 | Disregard  | 16  | Disregard  |
|  | B16–B19 | CRC | 4 | CRC for bits 0–41 of the U-SIG field (see 36.3.11.7.3 (CRC computation)). Bits 0–41 of the U-SIG field correspond to bits 0–25 of U-SIG-1 followed by bits 0–15 of U-SIG-2. |
|  | B20–B25 | Tail | 6 | Used to terminate the trellis of the convolutional decoder. Set to 0. |

* CRC computation

The CRC computation defined in this subclause applies to U-SIG, the Common field of EHT-SIG, and the User Block field of EHT-SIG.

The CRC is calculated over bits 0 to 41 of the U-SIG field. Bits 0 to 41 of the U-SIG field correspond to bits 0–25 of U-SIG-1 followed by bits 0–15 of U-SIG-2.

The value of the CRC field shall be the 1s complement of



where





 is defined in 19.3.9.4.4 (CRC calculation for HT-SIG).



 is the serial input shown in Figure 36-33 (CRC calculation).

The CRC field is transmitted from *c*4 to *c*7 with *c*7 first.

Figure 36-33 (CRC calculation) shows the operation of the CRC. First, the shift register is reset to all 1s. The bits are then passed through the XOR operation at the input. When the last bit has entered, the output is generated by shifting the bits out of the shift register, *c*7 first, through an inverter.

As an example, if bits  are given by {1 1 0 1 1 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0 1 1 0 1 0}, the output bits , where  is output first, are {0 1 1 1}.

* Encoding and modulation

For an EHT MU PPDU and EHT TB PPDU, the U-SIG field is composed of two parts, U-SIG-1 and           U-SIG-2, each containing 26 data bits. U-SIG-1 is transmitted before U-SIG-2. The data bits of the U-SIG OFDM symbols shall be BCC encoded at rate, , interleaved, mapped to a BPSK constellation, and have pilots inserted following the steps described in 17.3.5.6 (Convolutional encoder), 27.3.12.8 (BCC interleavers), 17.3.5.8 (Subcarrier modulation mapping), and 17.3.5.9 (Pilot subcarriers), respectively. This process happens on a per-80 MHz frequency segment basis as U-SIG field may have different contents in different 80 MHz frequency segments, while always having identical content in every 20 MHz segment of a given 80 MHz segment. For every 80 MHz segment in the EHT PPDU, the first and second half of the stream of 104 complex numbers generated by these steps (before pilot insertion) is divided into two groups of 52 complex numbers, where respectively, the first 52 complex numbers form the first OFDM symbol of U-SIG and the second 52 complex numbers form the second OFDM symbol of U-SIG.

For U-SIG in 80 MHz frequency segment , the complex number assigned to the *k-*th data subcarrier of the *n-*th symbol is denoted as . The time domain waveform for the U-SIG field of an EHT MU PPDU and EHT TB PPDU, transmitted on frequency segment  and transmit chain , shall be as specified in Equation (36-11).

where

 is given in Table 36-9 (Timing-related constants).







 is the power scale factor of the pre-EHT modulated fields within an OFDM symbol for an EHT TB PPDU, defined in TBD.

 and  are defined in 17.3.5.10 (OFDM modulation).

 is defined in Table 36-17 (Number of modulated subcarriers and guard interval duration values for pre-EHT modulated fields).

 represents the cyclic shift for transmit chain  with a value given in 36.3.11.2.1 (Cyclic shift for pre-EHT modulated fields).

For an ER preamble, the U-SIG field is composed of four parts, i.e., U-SIG-1, U-SIG-1-R, U-SIG-2, and     U-SIG-2-R, each part containing 26 data bits. These four parts are transmitted sequentially from U-SIG-1 to U-SIG-2-R. The data bits of U-SIG-1 and U-SIG-2 shall be BCC encoded at rate , interleaved, mapped to a BPSK constellation, and have pilots inserted. U-SIG-1-R has the same encoded bits as U-SIG-1 and the encoded bits shall be mapped to a QBPSK constellation without interleaving and have pilots inserted. The constellation mapping of the U-SIG field in an ER preamble is the same as that of the           HE-SIG-A field in an HE ER SU PPDU, and is shown in Figure 36-34 (Data subcarrier constellation of U-SIG symbols). The QBPSK constellation on U-SIG-1R is used to differentiate an ER preamble from an EHT MU PPDU and an EHT TB PPDU. U-SIG-2-R has the same encoded bits as U-SIG-2 and the encoded bits shall be mapped to a BPSK constellation without interleaving and have pilots inserted. BCC encoding, data interleaving, constellation mapping, and pilot insertion follow the steps described in 17.3.5.6 (Convolutional encoder), 27.3.12.8 (BCC interleavers), 17.3.5.8 (Subcarrier modulation mapping), and 17.3.5.9 (Pilot subcarriers), respectively.

For U-SIG in 80 MHz frequency segment , the complex number assigned to the *k*-th data subcarrier of the *n*-th symbol is denoted as . The time domain waveform for the U-SIG field of an EHT ER SU PPDU, transmitted on frequency segment  and transmit chain , shall be as specified in   Equation (36-19).

*

where

 is a phase rotation vector defined as .