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22
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Abstract: This amendment defines modifications to both the IEEE 802.11 physical layer (PHY) and the medium access control (MAC) sublayer for high efficiency operation in frequency bands between 1 GHz and 6 GHz.

Keywords: high efficiency, PHY, physical layer, MAC, medium access control, OFDMA, orthogonal frequency division multiple access, wireless local area network, WLAN

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This introduction is not part of IEEE P802.11ax /D0.2, June 2016, IEEE Standard for Information technology—Telecommunications and information exchange between systems—Local and metropolitan area network—Specific requirements—Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications—Amendment 6: Enhancements for high efficiency in frequency bands between 1 GHz and 6 GHz.

This amendment defines modifications to both the IEEE 802.11 physical layer (PHY) and the medium access control (MAC) sublayer for high efficiency operation in frequency bands between 1 GHz and 6 GHz.

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32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65

1
2
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5
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7
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9
10
11
12
13
14
15
16
17
18
19
20
21
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24
25
26
27
28
29
30
31
32
33
34
35
36
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45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65

Contents

1			
2			
3			
4		Editorial Notes	1
5			
6	3.	Definitions, acronyms, and abbreviations.....	3
7			
8		3.2 Definitions specific to IEEE 802.11	3
9		3.4 Abbreviations and acronyms	3
10			
11			
12	4.	General description	5
13			
14		4.3 Components of the IEEE Std 802.11 architecture	5
15		4.3.12a High efficiency (HE) STA	5
16			
17			
18	6.	Layer management.....	7
19			
20		6.1 Overview of management model.....	7
21		6.2 Generic management primitives	7
22		6.3 MLME SAP interface	7
23		6.3.7 Associate.....	7
24		6.3.7.2 MLME-ASSOCIATE.request.....	7
25		6.3.7.3 MLME-ASSOCIATE.confirm	7
26		6.3.8 Reassociate.....	8
27		6.3.8.2 MLME-REASSOCIATE.request	8
28		6.3.8.3 MLME-REASSOCIATE.confirm	8
29		6.3.11 Start.....	9
30		6.3.11.2 MLME-START.request.....	9
31			
32			
33			
34			
35	9.	Frame formats	11
36			
37		9.2 MAC frame formats.....	11
38		9.2.4 Frame fields	11
39		9.2.4.1 Frame Control field.....	11
40		9.2.4.6 HT Control field.....	11
41		9.2.5 Duration/ID field (QoS STA)	15
42		9.2.5.2 Setting for single and multiple protection under enhanced distributed channel	
43		access (EDCA) 15	
44		9.2.5.7 Setting for control response frames	16
45			
46		9.3 Format of individual frame types.....	16
47		9.3.1 Control frames	16
48		9.3.1.3 CTS frame format	16
49		9.3.1.8 BlockAckReq frame format	16
50		9.3.1.9 BlockAck frame format	17
51		9.3.1.23 Trigger frame format	20
52		9.3.2 Data frames	24
53		9.3.3 Management frames.....	24
54		9.3.3.1 Beacon frame format	24
55		9.3.3.5 Association Request frame format.....	24
56		9.3.3.6 Association Response frame format	25
57		9.3.3.7 Reassociation Request frame format	25
58		9.3.3.8 Reassociation Response frame format	25
59		9.3.3.9 Probe Request frame format	26
60		9.3.3.10 Probe Response frame format.....	26
61			
62			
63			
64			
65			

1	9.4	Management and Extension frame body components	26
2	9.4.1	Fields that are not elements	26
3	9.4.1.62	HE Compressed Beamforming Report field	26
4	9.4.1.63	HE MU Exclusive Beamforming Report field	27
5	9.4.2	Elements	27
6	9.4.2.1	General	27
7	9.4.2.196	TWT element	27
8	9.4.2.213	HE Capabilities element	31
9	9.4.2.214	HE Operation element	35
10	9.7	Aggregate MPDU (A-MPDU)	36
11	9.7.3	A-MPDU contents	36
12			
13			
14			
15	10.	MAC sublayer functional description	39
16			
17			
18	10.3	DCF	39
19	10.3.1	General	39
20	10.3.2	Procedures common to the DCF and EDCAF	39
21	10.3.2.1	CS mechanism	39
22	10.3.2.4	Setting and resetting the NAV	39
23	10.3.2.8a	MU-RTS/CTS procedure(#1432)	39
24	10.3.2.11	MU acknowledgment procedure	42
25	10.7	Multirate support	45
26	10.7.6	Rate selection for Control frames	45
27	10.7.6.5	Rate selection for control response frames	45
28			
29	10.9	HT Control field operation	45
30	10.22	HCF	46
31	10.22.2	HCF contention based channel access (EDCA)	46
32	10.22.2.9	Truncation of TXOP	46
33	10.24	Block acknowledgement (block ack)	47
34	10.24.10	GCR block ack	47
35	10.44	Target wake time (TWT)	48
36	10.44.1	TWT overview	48
37	10.44.2	Individual TWT agreements	48
38	10.44.3	Implicit TWT operation	49
39	10.44.4	Broadcast TWT operation	50
40	10.44.4.1	General	50
41	10.44.4.2	Rules for TWT scheduling STA	51
42	10.44.4.3	Negotiation of TBTT and listen interval	51
43			
44			
45			
46			
47			
48	25.	High Efficiency (HE) MAC specification	53
49			
50	25.1	Introduction	53
51	25.2	Channel Access	53
52	25.2.1	Updating two NAVs	53
53	25.3	Fragmentation	54
54	25.3.1	General	54
55	25.3.2	Procedure at the originator	54
56	25.3.3	Procedure at the receiver	54
57	25.4	Block acknowledgement	55
58	25.4.1	Selection of BlockAck and BlockAckReq variants	55
59	25.5	MU operation	56
60	25.5.1	HE DL MU operation	56
61	25.5.1.1	General	56
62	25.5.1.2	HE MU PPDU payload	56
63			
64			
65			

1	25.5.2	UL MU operation.....	56
2	25.5.2.1	General.....	56
3	25.5.2.2	Rules for soliciting UL MU frames.....	57
4	25.5.2.3	STA behavior.....	58
5	25.5.2.4	UL MU CS mechanism.....	59
6	25.5.2.5	HE buffer status feedback operation for UL MU.....	59
7	25.5.2.6	UL OFDMA-based random access.....	60
8	25.5.3	HE MU cascading operation.....	61
9	25.6	HE sounding protocol.....	61
10	25.7	TWT operation.....	62
11	25.8	Receive operating mode.....	62
12	25.8.1	General.....	62
13	25.8.2	Rules for ROM indication.....	62
14	25.9	Spatial reuse operation.....	63
15	25.9.1	General.....	63
16	25.9.2	Color code based CCA rules.....	63
17	25.9.3	Adaptive CCA and transmit power control.....	63
18	25.10A	MPDU operation.....	64
19	25.10.1	General.....	64
20	25.10.2A	MPDU padding for a HE MU PPDU.....	64
21	25.10.3A	MPDU padding for an HE trigger-based PPDU(#1585).....	64
22	25.10.4A	MPDU with multiple TIDs.....	65
23	25.11	TXVECTOR parameters STA_ID_LIST, UPLINK_FLAG and BSS_COLOR for an HE PPDU.....	65
24	25.12	HE PPDU post FEC padding and packet extension.....	66
25	25.13	Power management.....	66
26	25.13.1	Intra-PPDU power save for HE non-AP STAs.....	66
27	25.13.2	Power save with UL OFDMA-based random access.....	67
28	26.	High Efficiency (HE) PHY specification.....	69
29	26.1	Introduction.....	69
30	26.1.1	Introduction to the HE PHY.....	69
31	26.1.2	Scope.....	70
32	26.1.3	HE PHY functions.....	70
33	26.1.3.1	General.....	70
34	26.1.3.2	PHY management entity (PLME).....	70
35	26.1.3.3	Service specification method.....	70
36	26.1.4	PPDU formats.....	71
37	26.2	HE PHY service interface.....	72
38	26.2.1	Introduction.....	72
39	26.2.2	TXVECTOR and RXVECTOR parameters.....	72
40	26.3	HE PHY.....	73
41	26.3.1	Introduction.....	73
42	26.3.2	HE PPDU formats.....	73
43	26.3.3	Transmitter block diagram.....	75
44	26.3.4	Overview of the PPDU encoding process.....	82
45	26.3.5	HE modulation and coding schemes (HE-MCSs).....	82
46	26.3.6	Timing-related parameters.....	83
47	26.3.7	OFDMA and SU tone allocation.....	87
48	26.3.7.1	Resource unit, guard and DC subcarriers(#1951).....	89
49	26.3.7.2	Null subcarriers.....	95
50	26.3.7.3	Pilot tones.....	95
51	26.3.8	Mathematical description of signals.....	96
52			
53			
54			
55			
56			
57			
58			
59			
60			
61			
62			
63			
64			
65			

1	26.3.9 HE preamble	102
2	26.3.9.1 Introduction.....	102
3	26.3.9.2 Cyclic shift for pre-HE modulated fields.....	102
4	26.3.9.3 L-STF.....	102
5	26.3.9.4 L-LTF.....	103
6	26.3.9.5 L-SIG	104
7	26.3.9.6 RL-SIG.....	106
8	26.3.9.7 HE-SIG-A	106
9	26.3.9.8 HE-SIG-B	114
10	26.3.9.9 HE-STF	122
11	26.3.9.10 HE-LTF	125
12	26.3.10 Data field.....	135
13	26.3.10.1 General.....	135
14	26.3.10.2 Pre-FEC encoding process.....	136
15	26.3.10.3 SERVICE field	139
16	26.3.10.4 Coding.....	139
17	26.3.10.5 Stream parser	144
18	26.3.10.6 Segment parser.....	144
19	26.3.10.7 BCC interleavers.....	145
20	26.3.10.8 Constellation mapping	145
21	26.3.10.9 Space-time block coding.....	146
22	26.3.10.10 LDPC tone mapper	146
23	26.3.10.11 Segment deparser.....	148
24	26.3.10.12 Pilot subcarriers	149
25	26.3.10.13 OFDM modulation.....	154
26	26.3.10.14 Dual carrier modulation	155
27	26.3.11 Packet extension(#1781).....	155
28	26.3.12 Non-HT duplicate transmission	158
29	26.3.13 MU-MIMO	158
30	26.3.13.1 Introduction.....	158
31	26.3.13.2 Minimum RU size in MU-MIMO(#1507) transmission.....	158
32	26.3.13.3 DL MU-MIMO	158
33	26.3.13.4 UL MU-MIMO	160
34	26.3.14 Transmit specification.....	162
35	26.3.14.1 Transmit spectral mask	162
36	26.3.14.2 Spectral flatness	162
37	26.3.14.3 Transmit center frequency and symbol clock frequency tolerance	162
38	26.3.14.4 Modulation accuracy.....	162
39	26.3.15 HE transmit procedure	162
40	26.3.16 HE receive procedure.....	162
41	26.4 HE PLME	162
42	26.4.1 PLME_SAP sublayer management primitives	162
43	26.4.2 PHY MIB.....	162
44	26.4.3 TXTIME and PSDU_LENGTH calculation.....	162
45	26.4.4 HE PHY	164
46	26.5 Parameters for HE-MCSs(#552).....	164
47	Annex C	207
48	C.3 MIB Detail	207
49		
50		
51		
52		
53		
54		
55		
56		
57		
58		
59		
60		
61		
62		
63		
64		
65		

List of figures

1		
2		
3		
4	Figure 9-12—VHT Control Middle subfield of the VHT variant HT Control field	12
5	Figure 9-14a—A-Control subfield of the HE variant HT Control field(#360)	13
6	Figure 9-14b—Control subfield format	13
7	Figure 9-14c—Control Information subfield format when Control ID subfield is 0	14
8	Figure 9-14d—Control Information subfield format when Control ID subfield is 1	14
9	Figure 9-14e—Control Information subfield format when Control ID subfield is 2	15
10		
11	Figure 9-27—Block Ack Starting Sequence Control subfield(#515).....	16
12	Figure 9-32—BA Control field.....	17
13	Figure 9-37a—Per STA Info subfield format.....	19
14	Figure 9-37b—Per AID TID Info subfield format	19
15		
16	Figure 9-51a—Trigger frame.....	20
17	Figure 9-51b—Common Info field(#2134)	21
18	Figure 9-51c—User Info(#1520) field.....	22
19	Figure 9-51d—Trigger Dependent Common Info field for MU-BAR variant(#614)	23
20	Figure 9-51e—Trigger Dependent User Info field for MU-BAR variant(#2700).....	23
21		
22	Figure 9-577ax—Control field format.....	27
23	Figure 9-577ay—Request Type field format.....	28
24	Figure 9-ax1—HE Capabilities element format	31
25	Figure 9-ax2—HE Capabilities Information field format	32
26	Figure 9-ax3—PPE Thresholds field format	33
27	Figure 9-ax4—PPE Thresholds Info field format.....	33
28		
29	Figure 9-ax5—HE Operation element format	35
30	Figure 9-ax6—HE Operation Parameters(#1350) field format	35
31	Figure 10-ax1—Example of MU-RTS/CTS/DL MU PPDU/Acknowledgement Response and NAV set-	
32	ting(#2224).....	40
33		
34	Figure 10-ax2—Example of MU-RTS/CTS/Trigger/HE trigger-based PPDU/Multi-STA BlockAck and	
35	NAV setting(#2224)	40
36	Figure 10-ax3—An example of an MU-RTS frame soliciting CTS frame(#Ed,#1396) responses on the prima-	
37	ry 40 MHz channel(#2224).....	42
38	Figure 10-ax4—An example of a TXOP containing an HE MU PPDU transmission with an immediate UL	
39	OFDMA acknowledgement.....	43
40	Figure 10-ax5—An example of a TXOP containing an UL MU transmission with an immediate DL MU trans-	
41	mission containing individually addressed(#1512) BlockAck frames acknowledging the frames received	
42	from the respective STAs	44
43	Figure 10-ax6—An example of a TXOP containing UL MU transmissions with an immediate Multi-STA	
44	BlockAck frame(#1407) acknowledging the MPDUs that were correctly received from each STA. The UL	
45	MU transmission may be OFDMA or MU-MIMO	44
46	Figure 10-ax7—An example of a TXOP containing UL MU transmissions with an immediate DL non-HT	
47	duplicate PPDU containing the Multi-STA BlockAck frame. The UL MU transmissions may be OFDMA or	
48	MU-MIMO	44
49	Figure 10-ax8—An example of a TXOP containing UL MU transmissions with an immediate OFDMA HE	
50	MU PPDU containing Multi-STA BlockAck frames. The UL MU transmissions may be OFDMA or MU-	
51	MIMO	45
52	Figure 10-ax9—Example of a frame exchange with GCR block ack retransmission policy	47
53	Figure 10-ax10—Example of broadcast TWT operation	50
54		
55	Figure 25-1—Illustration of the UL OFDMA-based random access procedure	60
56	Figure 25-2—An example of cascading sequence of MU PDUs.....	61
57	Figure 25-3—An example of the HE sounding protocol using MU operation	61
58	Figure 25-4—Trigger frame (TF) start time in the Beacon frame for power save operation with random access	
59	operation(#2852).....	67
60		
61	Figure 26-1—HE SU PPDU format	73
62		
63		
64		
65		

1	Figure 26-2—HE MU PPDU format	74
2	Figure 26-3—HE extended range SU PPDU format	74
3	Figure 26-4—HE trigger-based PPDU format	74
4	Figure 26-5—Transmitter block diagram for the L-SIG, RL-SIG and HE-SIG-A fields when the Beam	
5	Change field is 1	76
6	Figure 26-6—Transmitter block diagram for the L-SIG, RL-SIG and HE-SIG-A fields when the Beam	
7	Change field is 0(#2360).....	77
8	Figure 26-7—Transmitter block diagram for the HE-SIG-B field	77
9	Figure 26-8—Transmitter block diagram for the Data field of an HE SU transmission in a 26-, 52-, 106- or	
10	242-tone RU(#838) with BCC encoding	78
11	Figure 26-9—Transmitter block diagram for the Data field of an HE SU transmission in 26-, 52-, 106-, 242-	
12	, 484- or 996-tone(#838) RU with LDPC encoding	79
13	Figure 26-10—Transmitter block diagram for the Data field of an HE downlink MU-MIMO transmission in	
14	106-, 242-, 484- or 996-tone(#838) RU with LDPC encoding(#277)	80
15	Figure 26-11—Transmitter block diagram for the Data field of an HE SU PPDU in 160 MHz with LDPC en-	
16	coding.....	81
17	Figure 26-12—Transmitter block diagram for the Data field of an HE SU PPDU in 80+80 MHz with LDPC	
18	encoding.....	82
19	Figure 26-13—Illustration of OFDM and OFDMA concepts	88
20	Figure 26-14—RU locations in a 20 MHz HE PPDU	92
21	Figure 26-15—RU locations in a 40 MHz HE PPDU	93
22	Figure 26-16—RU locations in an 80 MHz HE PPDU	93
23	Figure 26-17—Timing boundaries for HE PPDU fields(#899).....	97
24	Figure 26-18—Data tone constellation of HE-SIG-A symbols.....	113
25	Figure 26-19—HE-SIG-B field encoding structure in each 20 MHz	114
26	Figure 26-20—HE-SIG-B content channel for a 20 MHz PPDU	114
27	Figure 26-21—HE-SIG-B content channel for a 40 MHz PPDU	114
28	Figure 26-22—Default mapping of the two HE-SIG-B channels and their duplication in an 80 MHz PPDU .	
29	115	
30	Figure 26-23—Default mapping of the two HE-SIG-B channels and their duplication in a 160 MHz PPDU .	
31	115	
32	Figure 26-24—Illustration for the mapping of the 8-bit RU allocation subfield and the position of the user-	
33	field to the STA's assignment	119
34	Figure 26-25—Generation of HE-LTF symbols per frequency segment in an HE SU PPDU, HE MU PPDU,	
35	HE extended range SU PPDU, and HE trigger-based PPDU using single stream pilots	133
36	Figure 26-26—Generation of 1x HE-LTF symbols per frequency segment	133
37	Figure 26-27—Generation of 2x HE-LTF symbols per frequency segment	134
38	Figure 26-28—HE PPDU padding process in the last OFDM symbol (non STBC) when a = 1	136
39	Figure 26-29—HE PPDU padding process in the last OFDM symbol (STBC) when a = 1	136
40	Figure 26-30—PE field when maximum PE duration is 8 μ s (non STBC).....	156
41	Figure 26-31—PE field when maximum PE duration is 16 μ s (non STBC).....	156
42		
43		
44		
45		
46		
47		
48		
49		
50		
51		
52		
53		
54		
55		
56		
57		
58		
59		
60		
61		
62		
63		
64		
65		

List of tables

1		
2		
3		
4	Table 1—Draft Status	2
5	Table 9-1—Valid type and subtype combinations	11
6	Table 9-9a—HT Control field	12
7	Table 9-18a—Control ID subfield values	13
8	Table 9-24—BlockAck frame variant encoding(11ak)	17
9	Table 9-ax1—GI And LTF Type subfield(#1420)(#1300) encoding	21
10	Table 9-ax2—Trigger Type subfield encoding	22
11	Table 9-27—Beacon frame body	24
12	Table 9-29—Association Request frame body	24
13	Table 9-30—Association Response frame body	25
14	Table 9-31—Reassociation Request frame body	25
15	Table 9-32—Reassociation Response frame body	25
16	Table 9-33—Probe Request frame body	26
17	Table 9-34—Probe Response frame body	26
18	Table 9-74—Element IDs	27
19	Table 9-24811—TWT Flow Identifier field for a broadcast TWT element	28
20	Table 9-2481—TWT Setup Command field values	30
21	Table 9-ax13—Fragmentation Support field encoding	32
22	Table 9-ax14—Constellation index	34
23	Table 9-ax15—PPET8 and PPET16 encoding	34
24	Table 9-ax16—RU Allocation Index encoding	35
25	Table 9-420—A-MPDU Contexts	36
26	Table 9-426a—Multiple TID A-MPDU contents in the data enabled immediate response context	37
27	Table 9-426b—Multiple TID A-MPDU contents in the data enabled no immediate response context	38
28	Table 9-426c—A-MPDU content in the UL MU context	38
29	Table 26-1—TXVECTOR and RXVECTOR parameters	72
30	Table 26-2—HE PPDU fields(#2343)	74
31	Table 26-3— Timing-related constants	83
32	Table 26-4—Tone allocation related constants for Data field in a non-OFDMA HE PPDU	85
33	Table 26-5—Tone allocation related constants for RUs in an OFDMA HE PPDU	85
34	Table 26-6—Frequently used parameters(#282)	86
35	Table 26-7—Maximum number of RUs for each channel width(#1850)	89
36	Table 26-8—Subcarrier indices for RUs in a 20 MHz HE PPDU	89
37	Table 26-9—Subcarrier indices for RUs in a 40 MHz HE PPDU	90
38	Table 26-10—Subcarrier indices for RUs in an 80 MHz HE PPDU	90
39	Table 26-11— Null subcarrier indices	95
40	Table 26-12— Pilot tone indices	95
41	Table 26-13—Tone scaling factor and guard interval duration values for HE PPDU fields	99
42	Table 26-14—CH_BANDWIDTH and for pre-HE modulated fields	101
43	Table 26-15—Fields in the HE-SIG-A for an HE SU PPDU and HE extended range SU PPDU	106
44	Table 26-16—Fields in the HE-SIG-A for an HE MU PPDU	108
45	Table 26-17—Fields in the HE-SIG-A for an HE trigger-based PPDU	110
46	Table 26-18—RU allocation signaling: Arrangement and number of MU-MIMO allocations	117
47	Table 26-19—Fields of the HE-SIG-B user field for an(#916) non-MU-MIMO(#1101) allocation	120
48	Table 26-20—Fields of the HE-SIG-B user field for an(#2817) MU-MIMO allocation	120
49	Table 26-21—Spatial Configuration subfield encoding	121
50	Table 26-22—NSD,SHORT values	137
51	Table 26-23—SERVICE field	139
52	Table 26-24—BCC interleaver parameters	145
53	Table 26-25—LDPC tone mapping distance for each RU size	146
54	Table 26-26—Pilot indices for a 26-tone RU	149
55		
56		
57		
58		
59		
60		
61		
62		
63		
64		
65		

1	Table 26-27—The 2 pilot values for a 26-tone RU(#347)	149
2	Table 26-28—Pilot indices for 52-tone RU transmission	150
3	Table 26-29—The 4 pilot values in a 52- and 106-tone RU(#347).....	150
4	Table 26-30—Pilot indices for 106-tone RU transmission	150
5	Table 26-31—Pilot indices for 242-tone RU transmission	151
6	Table 26-32—The 8 pilot values in a 242-tone RU(#347).....	152
7	Table 26-33—Pilot indices for 484-tone RU transmission	152
8	Table 26-34—Pilot indices for 996-tone RU transmission	153
9	Table 26-35—Packet Extension field in HE-SIG-A.....	157
10	Table 26-36—a-factor subfield encoding	157
11	Table 26-37—Transmit power and RSSI measurement accuracy	161
12	Table 26-38—HE PHY characteristics	164
13	Table 26-39—HE-MCSs for TBD mandatory/optional 26-tone RU, NSS = 1	165
14	Table 26-40—HE-MCSs for TBD mandatory/optional 26-tone RU, NSS = 2	165
15	Table 26-41—HE-MCSs for TBD mandatory/optional 26-tone RU, NSS = 3	166
16	Table 26-42—HE-MCSs for TBD mandatory/optional 26-tone RU, NSS = 4	167
17	Table 26-43—HE-MCSs for TBD mandatory/optional 26-tone RU, NSS = 5	167
18	Table 26-44—HE-MCSs for TBD mandatory/optional 26-tone RU, NSS = 6	168
19	Table 26-45—HE-MCSs for TBD mandatory/optional 26-tone RU, NSS = 7	169
20	Table 26-46—HE-MCSs for TBD mandatory/optional 26-tone RU, NSS = 8	169
21	Table 26-47—HE-MCSs for TBD mandatory/optional 52-tone RU, NSS = 1	170
22	Table 26-48—HE-MCSs for TBD mandatory/optional 52-tone RU, NSS = 2	171
23	Table 26-49—HE-MCSs for TBD mandatory/optional 52-tone RU, NSS = 3	171
24	Table 26-50—HE-MCSs for TBD mandatory/optional 52-tone RU, NSS = 4	172
25	Table 26-51—HE-MCSs for TBD mandatory/optional 52-tone RU, NSS = 5	172
26	Table 26-52—HE-MCSs for TBD mandatory/optional 52-tone RU, NSS = 6	173
27	Table 26-53—HE-MCSs for TBD mandatory/optional 52-tone RU, NSS = 7	173
28	Table 26-54—HE-MCSs for TBD mandatory/optional 52-tone RU, NSS = 8	174
29	Table 26-55—HE-MCSs for TBD mandatory/optional 106-tone RU, NSS = 1	174
30	Table 26-56—HE-MCSs for TBD mandatory/optional 106-tone RU, NSS = 2	175
31	Table 26-57—HE-MCSs for TBD mandatory/optional 106-tone RU, NSS = 3	175
32	Table 26-58—HE-MCSs for TBD mandatory/optional 106-tone RU, NSS = 4	176
33	Table 26-59—HE-MCSs for TBD mandatory/optional 106-tone RU, NSS = 5	176
34	Table 26-60—HE-MCSs for TBD mandatory/optional 106-tone RU, NSS = 6	177
35	Table 26-61—HE-MCSs for TBD mandatory/optional 106-tone RU, NSS = 7	177
36	Table 26-62—HE-MCSs for TBD mandatory/optional 106-tone RU, NSS = 8	178
37	Table 26-63—HE-MCSs for TBD mandatory/optional 242-tone RU and mandatory non-OFDMA 20 MHz, NSS = 1	178
38	Table 26-64—HE-MCSs for TBD mandatory/optional 242-tone RU and mandatory non-OFDMA 20 MHz, NSS = 2	179
39	Table 26-65—HE-MCSs for TBD mandatory/optional 242-tone RU and mandatory non-OFDMA 20 MHz, NSS = 3	180
40	Table 26-66—HE-MCSs for TBD mandatory/optional 242-tone RU and mandatory non-OFDMA 20 MHz, NSS = 4	181
41	Table 26-67—HE-MCSs for TBD mandatory/optional 242-tone RU and mandatory non-OFDMA 20 MHz, NSS = 5	182
42	Table 26-68—HE-MCSs for TBD mandatory/optional 242-tone RU and mandatory non-OFDMA 20 MHz, NSS = 6	183
43	Table 26-69—HE-MCSs for TBD mandatory/optional 242-tone RU and mandatory non-OFDMA 20 MHz, NSS = 7	184
44	Table 26-70—HE-MCSs for TBD mandatory/optional 242-tone RU and mandatory non-OFDMA 20 MHz, NSS = 8	185
45	Table 26-71—HE-MCSs for TBD mandatory/optional 484-tone RU and mandatory non-OFDMA 40 MHz, NSS = 1	186

1	Table 26-72—HE-MCSs for TBD mandatory/optional 484-tone RU and mandatory non-OFDMA 40 MHz,	
2	NSS = 2.....	187
3	Table 26-73—HE-MCSs for TBD mandatory/optional 484-tone RU and mandatory non-OFDMA 40 MHz,	
4	NSS = 3.....	188
5	Table 26-74—HE-MCSs for TBD mandatory/optional 484-tone RU and mandatory non-OFDMA 40 MHz,	
6	NSS = 4.....	189
7	Table 26-75—HE-MCSs for TBD mandatory/optional 484-tone RU and mandatory non-OFDMA 40 MHz,	
8	NSS = 5.....	190
9	Table 26-76—HE-MCSs for TBD mandatory/optional 484-tone RU and mandatory non-OFDMA 40 MHz,	
10	NSS = 6.....	191
11	Table 26-77—HE-MCSs for TBD mandatory/optional 484-tone RU and mandatory non-OFDMA 40 MHz,	
12	NSS = 7.....	192
13	Table 26-78—HE-MCSs for TBD mandatory/optional 484-tone RU and mandatory non-OFDMA 40 MHz,	
14	NSS = 8.....	193
15	Table 26-79—HE-MCSs for TBD mandatory/optional 996-tone RU and mandatory non-OFDMA 80 MHz,	
16	NSS = 1.....	194
17	Table 26-80—HE-MCSs for TBD mandatory/optional 996-tone RU and mandatory non-OFDMA 80 MHz,	
18	NSS = 2.....	195
19	Table 26-81—HE-MCSs for TBD mandatory/optional 996-tone RU and mandatory non-OFDMA 80 MHz,	
20	NSS = 3.....	196
21	Table 26-82—HE-MCSs for TBD mandatory/optional 996-tone RU and mandatory non-OFDMA 80 MHz,	
22	NSS = 4.....	197
23	Table 26-83—HE-MCSs for TBD mandatory/optional 996-tone RU and mandatory non-OFDMA 80 MHz,	
24	NSS = 5.....	198
25	Table 26-84—HE-MCSs for TBD mandatory/optional 996-tone RU and mandatory non-OFDMA 80 MHz,	
26	NSS = 6.....	199
27	Table 26-85—HE-MCSs for TBD mandatory/optional 996-tone RU and mandatory non-OFDMA 80 MHz,	
28	NSS = 7.....	200
29	Table 26-86—HE-MCSs for TBD mandatory/optional 996-tone RU and mandatory non-OFDMA 80 MHz,	
30	NSS = 8.....	201
31	Table 26-87—HE-MCSs for optional non-OFDMA 160 MHz and 80+80 MHz, NSS = 1.....	201
32	Table 26-88—HE-MCSs for optional non-OFDMA 160 MHz and 80+80 MHz, NSS = 2.....	202
33	Table 26-89—HE-MCSs for optional non-OFDMA 160 MHz and 80+80 MHz, NSS = 3.....	202
34	Table 26-90—HE-MCSs for optional non-OFDMA 160 MHz and 80+80 MHz, NSS = 4.....	203
35	Table 26-91—HE-MCSs for optional non-OFDMA 160 MHz and 80+80 MHz, NSS = 5.....	203
36	Table 26-92—HE-MCSs for optional non-OFDMA 160 MHz and 80+80 MHz, NSS = 6.....	204
37	Table 26-93—HE-MCSs for optional non-OFDMA 160 MHz and 80+80 MHz, NSS = 7.....	204
38	Table 26-94—HE-MCSs for optional non-OFDMA 160 MHz and 80+80 MHz, NSS = 8.....	205
39		
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IEEE P802.11ax™/D0.2

Draft 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 6: Enhancements for high efficiency in frequency bands between 1 GHz and 6 GHz

[This amendment is based on IEEE P802.11REVmc D5.0 amended by IEEE P802.11ai/D4.0, IEEE P802.11ah/D5.0, IEEE P802.11aq/D3.0, IEEE P802.11ak/D1.0 and IEEE P802.11aj/D1.0]

NOTE—The editing instructions contained in this amendment define how to merge the material contained therein into the existing base standard and its amendments to form the comprehensive standard.

The editing instructions are shown in ***bold italic***. Four editing instructions are used: change, delete, insert, and replace. ***Change*** is used to make corrections in existing text or tables. The editing instruction specifies the location of the change and describes what is being changed by using ~~strikethrough~~ (to remove old material) and underscore (to add new material). ***Delete*** removes existing material. ***Insert*** adds new material without disturbing the existing material. Insertions may require renumbering. If so, renumbering instructions are given in the editing instruction. ***Replace*** is used to make changes in figures or equations by removing the existing figure or equation and replacing it with a new one. Editorial instructions, change markings and this NOTE will not be carried over into future editions because the changes will be incorporated into the base standard.

Editorial Notes

Editor's Note: Editorial Notes in the body of the standard appear like this. They will be removed before publication. They may highlight some issue that the editor has had to address during the implementation of a change. Where there may be any technical impact from an editing issue, the editor will raise a technical letter ballot comment. There is no need for voters to comment on such issues unless they have a specific resolution they wish to present.

Editor's Note: Headings with empty content or Headings preceding editing instructions that modify the contents of the referenced subclause are there to provide context to the reader of this document, they have no other significance.

1 *Editor's Note: The default IEEE-SA style for tables is to "float". This means that they be repositioned*
 2 *later, usually at the head of the next page, to avoid splitting the table and reduce the amount of blank*
 3 *space. The table can appear to move out of the subclause it is referenced first from, and can even split a*
 4 *paragraph. This is the intended IEEE-SA behavior, please do not report it as a defect in the draft. In*
 5 *many cases, additional line feeds have been inserted to force tables to follow text, rather than float beyond*
 6 *sequential text. The additional line feeds will be removed before publication, please do not report them as*
 7 *a defect in the text.*

8
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 10 *Editor's Note: Line numbering is only approximate. This is a limitation of the FrameMaker tool.*
 11 *Whitespace between paragraphs is part of the IEEE-SA style, as defined in their templates. The combina-*
 12 *tion of these two facts leads to the appearance of blank lines in the draft between every paragraph. Please*
 13 *do not report this as an editorial defect as it is the unavoidable behavior.*

14 Tags:

15
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 19 Tags are placed in this draft near changes to identify the source of the change. Changes resulting from incor-
 20 poration of an approved proposal are shown like this: (#<number>), where <number> identifies the submis-
 21 sion/revision that introduced that change.

22
 23 These tags will be hidden in versions of the draft sent out to letter ballot - i.e., they are present only to assist
 24 the editorial review panel in checking that changes have been properly applied.

25
 26 Tags are shown close to the point of change. When a whole subclause is new, the heading is tagged.

27
 28 Otherwise, when a whole paragraph is new, the paragraph is tagged. Otherwise tags are placed after a section
 29 of changes within a paragraph or at the end of the paragraph if the changes are substantial.

30
 31 New tables are tagged in the table caption (if there is one), or in the introductory paragraph. Otherwise, new
 32 rows in existing tables are tagged only in the first column, to avoid distraction. Otherwise, a modified cell is
 33 tagged.

34
 35 Finally, any other changes made by the editor (e.g., for grammar, language, style & consistency with other
 36 comment resolutions, baseline, etc.) are tagged (#Ed).

37
 38
 39 *Editor's Note: A cumulative status of the versions of this draft is shown below.*

40
 41
 42 **Table 1—Draft Status**

Draft	Date	Status
D0.1	2016-03-03	Converted to FrameMaker from 16/0024r1 Proposed draft specification

3. Definitions, acronyms, and abbreviations

3.2 Definitions specific to IEEE 802.11

3.4 Abbreviations and acronyms

Insert the following acronym definitions (maintaining alphabetical order):

DCM	Dual carrier modulation(#2567)
DL	Downlink(#2401)
DL MU	Downlink multi-user
HE	High efficiency
OBO	Orthogonal frequency division multiple access (OFDMA) backoff(#1747)
OCW	Orthogonal frequency division multiple access (OFDMA) contention window(#1747)
OFDMA	Orthogonal frequency-division multiple access
MU-RTS	Multi-user request to send
UL	Uplink
UL MU	Uplink multi-user(#545)

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4. General description

4.3 Components of the IEEE Std 802.11 architecture

Insert a new subclause after subclause 4.3.12 as follows:

4.3.12a High efficiency (HE) STA

The IEEE 802.11 HE STA operates in frequency bands between 1 GHz and 6 GHz.

An HE STA is VHT STA that, in addition to the features supported as a VHT STA, supports the MAC features defined in Clause 25 and the PHY features defined in Clause 26.

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6. Layer management

6.1 Overview of management model

6.2 Generic management primitives

6.3 MLME SAP interface

6.3.7 Associate

6.3.7.2 MLME-ASSOCIATE.request

6.3.7.2.2 Semantics of the service primitive

Change the primitive parameters as follows (note that not all existing parameters in the baseline are shown):

The primitive parameters are as follows:

```
MLME-ASSOCIATE.request(
    ...,
    HE Capabilities,
    VendorSpecificInfo
)
```

Insert the following entry to the unnumbered table in this subclause:

Name	Type	Valid range	Description
HE Capabilities	As defined in HE Capabilities element.(#1122)	As defined in 9.4.2.213 (HE Capabilities element)	Specifies the parameters within the HE Capabilities element that are supported by the MAC entity. The parameter is optionally present if dot11HighEfficiencyOptionImplemented is true; otherwise, this parameter is not present.

6.3.7.3 MLME-ASSOCIATE.confirm

6.3.7.3.2 Semantics of the service primitive

Change the primitive parameters as follows (note that not all existing parameters in the baseline are shown):

The primitive parameters are as follows:

```
MLME-ASSOCIATE.confirm(
    ...,
    HE Capabilities,
    VendorSpecificInfo
)
```


VendorSpecificInfo
)

Insert the following entry to the unnumbered table in this subclause:

Name	Type	Valid range	Description
HE Capabilities	As defined in HE Capabilities element.(#1122)	As defined in 9.4.2.213 (HE Capabilities element)	Specifies the parameters within the HE Capabilities element that are supported by the MAC entity. The parameter is optionally present if dot11HighEfficiencyOptonImplemented is true; otherwise, this parameter is not present.

6.3.11 Start

6.3.11.2 MLME-START.request

6.3.11.2.2 Semantics of the service primitive

Change the primitive parameters as follows (note that not all existing parameters in the baseline are shown):

```
MLME-START.request(
    ....
    HE Capabilities,
    HE Operation,
    VendorSpecificInfo
)
```

Insert the following entry to the unnumbered table in this subclause:

Name	Type	Valid range	Description
HE Capabilities	As defined in HE Capabilities element.(#1122)	As defined in 9.4.2.213 (HE Capabilities element)	Specifies the parameters within the HE Capabilities element that are supported by the MAC entity. The parameter is optionally present if dot11HighEfficiencyOptonImplemented is true; otherwise, this parameter is not present.
HE Operation	As defined in HE Operation element.(#1122)	As defined in 9.4.2.214 (HE Operation element)	The additional HE capabilities to be advertised for the BSS. The parameter is present if BSSType = INFRASTRUCTURE and dot11HighEfficiencyOptonImplemented is true; otherwise, this parameter is not present.

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9. Frame formats

9.2 MAC frame formats

9.2.4 Frame fields

9.2.4.1 Frame Control field

9.2.4.1.3 Type and Subtype fields

Change the row below and insert a new row immediately after it in Table 9-1 (Valid type and subtype combinations) as follows:

Table 9-1—Valid type and subtype combinations

Type value B3 B2	Type description	Subtype value B7 B6 B5 B4	Subtype description
01	Control	0000-0011<ANA>	Reserved
<u>01</u>	<u>Control</u>	<u><ANA></u>	<u>Trigger</u>

9.2.4.1.10 Order field

Change this subclause as follows:

The Order field is 1 bit in length. The setting of the Order field is as follows:

- It is set to 1 in a non-QoS Data frame transmitted by a non-QoS STA to indicate that the frame contains an MSDU, or fragment thereof, that is being transferred using the StrictlyOrdered service class.
- It is set to 1 in a QoS Data or Management frame transmitted with a value of HT_GF, HT_MF, VHT, HE or S1G for the FORMAT parameter of the TXVECTOR to indicate that the frame contains an HT Control field.
- It is set to 1 in an S1G RTS frame to indicate that the intended recipient of the frame has permission to extend the TXOP as described in 10.51.5.4 (Relay-shared TXOP protection mechanisms).

Otherwise, the Order field is set to 0.

NOTE—The Order field is always set to 0 for frames transmitted by a DMG STA.

9.2.4.6 HT Control field

9.2.4.6.1 General

Remove Figure 9-7 (HT Control field).

1 *Insert Table 9-9a(#2373) as follows:*
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4 **Table 9-9a—HT Control field**

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Variant	Bit 0 (value)	Bit 1 (value)	Bit 2-29	Bit 30	Bit 31
HT variant	VHT (0)	HT Control Middle		AC Constraint	RDG/More PPDU
VHT variant	VHT (1)	HE (0)	VHT Control Middle(#548)	AC Constraint	RDG/More PPDU
HE variant	VHT (1)	HE (1)	Aggregated Control		

17
18 *Change the paragraphs below of 9.2.4.6.1 as follows:*
19

20
21 The HT Control field has ~~two different forms:~~(#359) the HT variant, ~~and~~(#1879) the VHT variant, ~~and the~~
 22 HE variant. These forms differ in the values of the VHT and(#711) HE subfields and in their formats, which
 23 are shown in Table 9-9a (HT Control field). The two forms differ in the format of the HT Control Middle
 24 subfield, described in 9.2.4.6.2 (HT variant) for the HT variant and in 9.2.4.6.3 (VHT variant) for the VHT
 25 variant and in the value of the VHT subfield.
 26

27
28 The VHT subfield is set to 0 to indicate an(#2829) HT variant HT Control field. The VHT subfield is set to
 29 1 and the HE subfield is set to 0 to indicate a VHT variant HT Control field. The VHT subfield is set to 1 and
 30 the HE subfield is set to 1 to indicate an(#2829) HE variant HT Control field(#960).
 31

32
33 The HT Control Middle subfield is defined in 9.2.4.6.2 (HT variant)(#2203) and the VHT Control Middle
 34 subfield is defined in 9.2.4.6.3 (VHT variant).
 35

36
37 The Aggregated Control subfield is defined in 9.2.4.6.4 (HE variant)(#2203).
 38

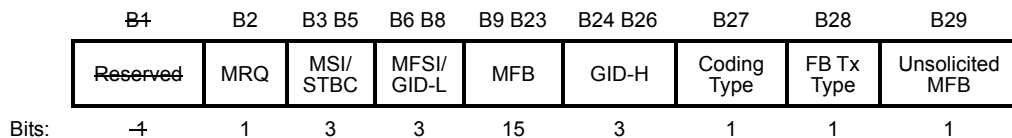
39
40 ~~The VHT subfield of the HT Control field indicates whether the HT Control Middle subfield is the VHT~~
 41 ~~Variant or the HT Variant. The VHT subfield is set to 1 to indicate that the HT Control Middle subfield is~~
 42 ~~the VHT Variant and is set to 0 to indicate that the HT Control Middle subfield is the HT Variant.~~
 43

44
45 **9.2.4.6.3 VHT variant**

46
47 *Change the paragraph below as follows:*
48

49
50 The format of the VHT Control Middle subfield of the VHT variant HT Control field is shown in Figure 9-
 51 12 (VHT Control Middle subfield of the VHT variant HT Control field).(#550)
 52

53
54 *Change Figure 9-12 as follows (remove Reserved field and change title):*
55



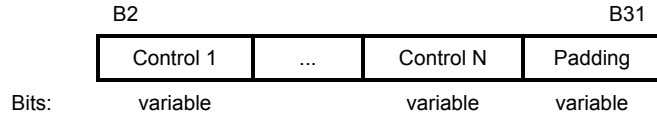
60
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65 **Figure 9-12—VHT Control Middle subfield of the VHT variant HT Control field**

1 *Insert a new subclause 9.2.4.6.4 following 9.2.4.6.3:*
 2
 3

4 **9.2.4.6.4 HE variant**
 5
 6

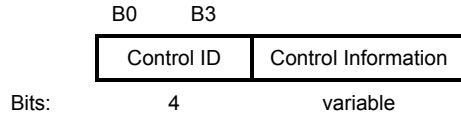
7 **9.2.4.6.4.1 General**
 8
 9

10 The format of the Aggregated Control (A-Control) subfield of the HE variant HT Control field(#1132) is
 11 shown in Figure 9-14a (A-Control subfield of the HE variant HT Control field(#360)).
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 21 **Figure 9-14a—A-Control subfield of the HE variant HT Control field(#360)**
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 23
 24

25 The A-Control subfield contains a sequence of one or more Control subfields. The format of each Control
 26 subfield is defined in Figure 9-14b (Control subfield format). The Control subfield with Control ID subfield
 27 equal to 0, if present, is the first subfield of the sequence.
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 29
 30
 31



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 38 **Figure 9-14b—Control subfield format**
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 40
 41

42 The Control ID subfield indicates the type of information carried in the Control Information subfield. The
 43 length of the Control Information subfield is fixed for each value of the Control ID subfield that is not
 44 reserved.(#1251) The values of the Control ID subfield and the associated length of the Control Information
 45 subfield are defined in Table 9-18a (Control ID subfield values).
 46
 47
 48
 49
 50

51 **Table 9-18a—Control ID subfield values**

Control ID value	Meaning	Length of the Control Information subfield (bits)	Content of the Control Information subfield
0	UL MU response scheduling	TBD	
1	Receive operating mode(#2209)	TBD	
2	HE link adaptation	TBD	
TBD	...		
8-15	Reserved		

52
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(#1252) The Padding subfield follows the last Control subfield and is set to a sequence of zeros so that the length of the A-Control subfield is 30 bits.

9.2.4.6.4.2 UL MU response scheduling

If the Control ID subfield is 0, the Control Information subfield contains (#1257) scheduling information for an HE trigger-based PPDU that carries an immediate acknowledgment, which is sent as a response to the soliciting A-MPDU (see 25.5.2 (UL MU operation)).

The format of the Control Information subfield is defined in Figure 9-14c (Control Information subfield format when Control ID subfield is 0).

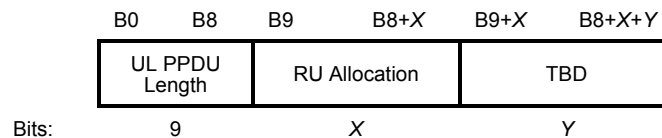


Figure 9-14c—Control Information subfield format when Control ID subfield is 0

The UL PPDU Length subfield indicates the length of the HE trigger-based PPDU response and is set to a nonzero value that is TBD.

The RU Allocation subfield indicates the resource unit (RU) assigned for transmitting the HE trigger-based PPDU response and is set to TBD.

9.2.4.6.4.3 Receive operating mode (#2209)

If the Control ID subfield is 1, the Control Information subfield contains (#1257) information related to the receive operating mode (#2209) of the STA transmitting the frame containing this information (see 25.8 (Receive operating mode)).

The format of the Control Information subfield is defined in Figure 9-14d (Control Information subfield format when Control ID subfield is 1).

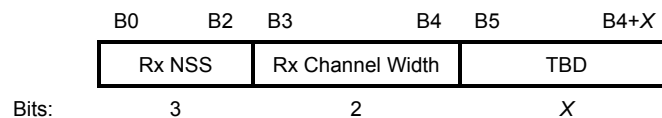


Figure 9-14d—Control Information subfield format when Control ID subfield is 1

The RX NSS subfield indicates the maximum number of spatial streams, N_{SS} , that the STA can receive (#1258) and is set to $N_{SS} - 1$.

The RX Channel Width subfield indicates the operating channel width supported by the STA in reception, and is set to 0 for 20 MHz, 1 for 40 MHz, 2 for 80 MHz, and 3 for 160 MHz.

9.2.4.6.4 HE link adaptation

If the Control ID subfield is 2, the Control Information subfield contains (#1257) information related to the HE link adaptation procedure (see 9.3.1.4 (Link adaptation using the HE variant HT Control field)).

The format of the Control Information subfield is defined in Figure 9-14e (Control Information subfield format when Control ID subfield is 2).

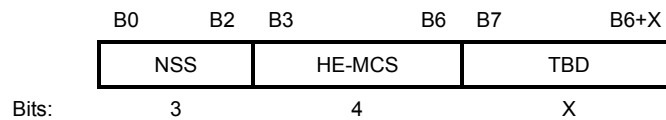


Figure 9-14e—Control Information subfield format when Control ID subfield is 2

The NSS subfield indicates the recommended number of spatial streams, N_{SS} , and is set to $N_{SS} - 1$.

The HE-MCS subfield indicates the recommended HE-MCS, and is set to the HE-MCS Index value (defined in 26.5 (Parameters for HE-MCSs)).

9.2.5 Duration/ID field (QoS STA)

9.2.5.2 Setting for single and multiple protection under enhanced distributed channel access (EDCA)

Change item a) of the 2nd paragraph as follows:

The Duration/ID field is determined as follows:

- a) Single protection settings.
 - 1) For an RTS frame that is not part of a dual clear-to-send (CTS) exchange and is not part of a BDT exchange(11ah), the Duration/ID field is set to the estimated time, in microseconds, required to transmit the pending frame, plus one CTS frame, plus one Ack or BlockAck frame if required, plus any NDPs required, plus explicit feedback if required, plus applicable IFSs.
 - 1a) In an MU-RTS frame, the Duration/ID field is set to the estimated time, in microseconds, required for the pending transmission.

Change item b) of the 2nd paragraph as follows:(#366)

- b) Multiple protection settings. The Duration/ID field is set to a value D as follows:

- 4) Else $T_{END-NAV} - T_{PPDU} \leq D \leq T_{TXOP-REMAINING} - T_{PPDU}$

where

$T_{SINGLE-MSDU}$ is the estimated time required for the transmission of the allowed frame exchange sequence defined in 10.22.2.8 (TXOP limits) (for a TXOP limit of 0), including applicable IFS durations

$T_{PENDING}$ is the estimated time required for the transmission of

- Pending MPDUs of the same AC
- Any associated immediate response frames
- Any HT NDP, VHT NDP, or Beamforming Report Poll frame transmissions and explicit feedback response frames

- 1 —Applicable IFSs
- 2 —Any RDG
- 3 —Any pending QoS Null frame exchanges by paged STAs(11ah)
- 4 —Any pending PS-Poll or NDP PS-Poll frame exchanges by paged
- 5 STAs(11ah)
- 6 —Any DL MU PPDU
- 7 —Any HE trigger-based PPDU
- 8 —Any Trigger frames to solicit HE trigger-based PPDU
- 9
- 10
- 11
- 12 T_{TXOP} is the duration given by dot11EDCATableTXOPLimit (dot11QAPEDCATableTXO-
- 13 PLimit for the AP) for that AC
- 14 $T_{TXOP-REMAINING}$ is T_{TXOP} less the time already used time within the TXOP
- 15 $T_{END-NAV}$ is the remaining duration of any NAV set by the TXOP holder, or 0 if no NAV has
- 16 been established
- 17
- 18
- 19 T_{PPDU} is the time required for transmission of the current PPDU
- 20
- 21

22 **9.2.5.7 Setting for control response frames**

23 *Insert a new paragraph after the 2nd paragraph of this subclause:*

24 In a CTS frame that is transmitted in response to an MU-RTS frame, the Duration/ID field is set to the value

25 obtained from the Duration/ID field of the MU-RTS frame that elicited the CTS frame minus the time, in

26 microseconds, between the end of the PPDU carrying the MU-RTS frame and the end of the PPDU carrying

27 the CTS frame.

32 **9.3 Format of individual frame types**

33 **9.3.1 Control frames**

34 **9.3.1.3 CTS frame format**

35 *Change the 2nd paragraph of this subclause as follows:*

36 When the CTS frame is a response to an RTS frame, the value of the RA field of the CTS frame is set to the

37 address from the TA field of the RTS frame with the Individual/Group bit forced to the value 0. When the

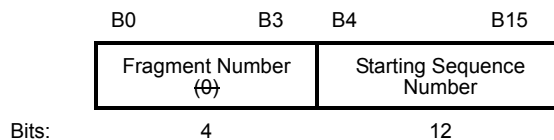
38 CTS frame is a response to an MU-RTS frame, the value of the RA field of the CTS frame is set to the

39 address from the TA field of the MU-RTS frame with the Individual/Group bit forced to the value 0.

40 **9.3.1.8 BlockAckReq frame format**

41 **9.3.1.8.2 Basic BlockAckReq variant**

42 *Change Figure 9-27 as follows:*



43 **Figure 9-27—Block Ack Starting Sequence Control subfield(#515)**

