IEEE P802.11
Wireless LANs

|  |
| --- |
| Technical Change – 64-QAM rate 1/2 |
| Date: 2018-03-01 |
| Author(s): |
| Name | Affiliation | Address | Phone | email |
| Alecsander Eitan | Qualcomm |  |  | eitana@qti.qualcomm.com |
| Assaf Kasher | Qualcomm |  |  | akasher@qti.qualcomm.com |
| Artyom Lomayev | Intel |  |  | artyom.lomayev@intel.com |
|  |  |  |  |  |
|  |  |  |  |  |

Abstract

This document proposes to add 64QAM modulation with code-rate 1/2 to the SC and OFDM.

# Technical Reason

In 802.11ay Draft 1.0 the MCS tables are:

Table 66—EDMG-MCSs for the EDMG SC mode

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| EDMG-MCS index | Modulation | NCBPS | Repetition | Code Rate | Data rate per spatial stream (Mbps)  |
| Normal GI | Short GI | Long GI |
| 1 | π/2-BPSK | 1 | 2 | 1/2  | *NCB*×385.00 | *NCB*×412.50 | *NCB*×330.00 |
| 2 | π/2-BPSK | 1 | 1 | 1/2  | *NCB*×770.00 | *NCB*×825.00 | *NCB*×660.00 |
| 3 | π/2-BPSK | 1 | 1 | 5/8  | *NCB*×962.50 | *NCB*×1031.25 | *NCB*×825.00 |
| 4 | π/2-BPSK | 1 | 1 | 3/4  | *NCB*×1155.00 | *NCB*×1237.50 | *NCB*×990.00 |
| 5 | π/2-BPSK | 1 | 1 | 13/16 | *NCB*×1251.25 | *NCB*×1340.63 | *NCB*×1072.50 |
| 6 | π/2-BPSK | 1 | 1 | 7/8  | *NCB*×1347.50 | *NCB*×1443.75 | *NCB*×1155.00 |
| 7 | π/2-QPSK | 2 | 1 | 1/2  | *NCB*×1540.00 | *NCB*×1650.00 | *NCB*×1320.00 |
| 8 | π/2-QPSK | 2 | 1 | 5/8  | *NCB*×1925.00 | *NCB*×2062.50 | *NCB*×1650.00 |
| 9 | π/2-QPSK | 2 | 1 | 3/4  | *NCB*×2310.00 | *NCB*×2475.00 | *NCB*×1980.00 |
| 10 | π/2-QPSK | 2 | 1 | 13/16 | *NCB*×2502.50 | *NCB*×2681.25 | *NCB*×2145.00 |
| 11 | π/2-QPSK | 2 | 1 | 7/8  | *NCB*×2695.00 | *NCB*×2887.50 | *NCB*×2310.00 |
| 12 | π/2-16-QAM | 4 | 1 | 1/2  | *NCB*×3080.00 | *NCB*×3300.00 | *NCB*×2640.00 |
| 13 | π/2-16-QAM | 4 | 1 | 5/8  | *NCB*×3850.00 | *NCB*×4125.00 | *NCB*×3300.00 |
| 14 | π/2-16-QAM | 4 | 1 | 3/4  | *NCB*×4620.00 | *NCB*×4950.00 | *NCB*×3960.00 |
| 15 | π/2-16-QAM | 4 | 1 | 13/16 | *NCB*×5005.00 | *NCB*×5362.50 | *NCB*×4290.00 |
| 16 | π/2-16-QAM | 4 | 1 | 7/8  | *NCB*×5390.00 | *NCB*×5775.00 | *NCB*×4620.00 |
| 17 | π/2-64-QAM | 6 | 1 | 5/8  | *NCB*×5775.00 | *NCB*×6187.50 | *NCB*×4950.00 |
| 18 | π/2-64-QAM | 6 | 1 | 3/4  | *NCB*×6930.00 | *NCB*×7425.00 | *NCB*×5940.00 |
| 19 | π/2-64-QAM | 6 | 1 | 13/16 | *NCB*×7507.50 | *NCB*×8043.75 | *NCB*×6435.00 |
| 20 | π/2-64-QAM | 6 | 1 | 7/8  | *NCB*×8085.00 | *NCB*×8662.50 | *NCB*×6930.00 |

Table 86— EDMG-MCSs for the EDMG OFDM mode

|  |  |  |  |
| --- | --- | --- | --- |
| EDMG-MCS index | Modulation | *NCBPS* | Code Rate |
| 1 | SQPSK | 1 | ½ |
| 2 | SQPSK | 1 | 5/8 |
| 3 | SQPSK | 1 | ¾ |
| 4 | SQPSK | 1 | 13/16 |
| 5 | SQPSK | 1 | 7/8 |
| 6 | QPSK | 2 | ½ |
| 7 | QPSK | 2 | 5/8 |
| 8 | QPSK | 2 | ¾ |
| 9 | QPSK | 2 | 13/16 |
| 10 | QPSK | 2 | 7/8 |
| 11 | 16-QAM | 4 | ½ |
| 12 | 16-QAM | 4 | 5/8 |
| 13 | 16-QAM | 4 | ¾ |
| 14 | 16-QAM | 4 | 13/16 |
| 15 | 16-QAM | 4 | 7/8 |
| 16 | 64-QAM | 6 | 5/8 |
| 17 | 64-QAM | 6 | ¾ |
| 18 | 64-QAM | 6 | 13/16 |
| 19 | 64-QAM | 6 | 7/8 |

It can be seen that for each modulation there are 5 Code-Rates (1/2, 5/8, 3/4, 13/16 and 7/8) with two exceptions: MCS1 in SC which is a special case and there is no ***64QAM rate 1/2***.

The reason why ***64QAM rate 1/2*** was not added is that it has the same data rate as ***16QAM rate 3/4*** but requires higher SNR than the later, hence it is less efficient.

The reasons to add the ***64QAM rate 1/2***, both for SC and OFDM are:

1. In cases where the Tx or Rx or both have high frequency response variation due to RF and channel, OFDM modulation can have better performance at ***64QAM rate 1/2*** than in ***16QAM rate 3/4***.
In ***64QAM rate 1/2*** more “damaged” subcarriers can be tolerated due to the coding.
2. In SU and MU MIMO, for both SC and OFDM, the MCSs used per stream in the same PPDU share the same coding rate and ***Base MCS***. However, if coding rate of 1/2 is used, the ***Differential EDMG-MCS*** cannot point to 64QAM, even if the SNR is appropriate. This applies a limit which in some cases can limit the throughput.

It should be noted that for MIMO case when OFDM is used, the first reason (above) is added to this one.

1. The fact that ***64QAM rate 1/2*** is excluded, impacts algorithms and implementation by adding arguably non-necessary rules and limitations.
Since the mandatory MCSs include rate 1/2, there is no implementation reason why devices supporting 64QAM cannot support ***64QAM rate 1/2***.

# Proposed change:

Add ***64QAM rate 1/2*** to SC and OFDM MCS tables and remove the limiting text regarding its use.

Based on Draft 1.1

Table 42—EDMG-MCS field definition

|  |  |  |  |
| --- | --- | --- | --- |
| Subfield | Number of bits | Start bit | Description |
| Base MCS | 5 | 0 | Indicates the lowest index of the modulation and coding scheme that is used to define the modulation and coding scheme of the spatial streams. |
| Differential EDMG-MCS1 | 2 | 5 | Each of these differential MCS subfields is set as follows:* 0: indicates the same MCS as the Base MCS subfield
* 1: indicates one higher order modulation than the Base MCS subfield with the same code rate
* 2: indicates two higher order modulation than the Base MCS subfield with the same code rate
* 3: indicates three higher order modulation than the Base MCS subfield with the same code rate

If the Number of SS field is greater than 0, then the NUC Applied and π/2-8-PSK Applied fields shall be set to 0. |
| Differential EDMG-MCS2 | 2 | 7 |
| Differential EDMG-MCS3 | 2 | 9 |
| Differential EDMG-MCS4 | 2 | 11 |
| Differential EDMG-MCS5 | 2 | 13 |
| Differential EDMG-MCS6 | 2 | 15 |
| Differential EDMG-MCS7 | 2 | 17 |
| Differential EDMG-MCS8 | 2 | 19 |

Table 45—EDMG-Header-B field structure and definition

|  |  |  |  |
| --- | --- | --- | --- |
| **Field** | **Number of bits** | **Start bit** | **Description** |
| Scrambler Seed | 7 | 0 |  |
| PSDU Length | 22 | 7 | Length of the PSDU field in octets. |
| Base MCS | 5 | 29 | Generated from TXVECTOR parameter EDMG\_MCS. Indicates the lowest index of the modulation and coding scheme that is used to define the modulation and coding scheme of the spatial streams. |
| DifferentialEDMG-MCS1 | 2 | 34 | Generated from TXVECTOR parameter EDMG\_MCS. Each of the differential MCS subfields is set as follows:* 0: indicates the same MCS as the Base MCS subfield
* 1: indicates one higher order modulation than the Base MCS subfield with the same code rate
* 2: indicates two higher order modulation than the Base MCS subfield with the same code rate
* 3: indicates three higher order modulation than the Base MCS subfield with the same code rate

If the Number of SS field is greater than 0, then the NUC Applied and π/2-8-PSK Applied fields shall be set to 0. |
| DifferentialEDMG-MCS2 | 2 | 36 |
| Superimposed Code Applied | 1 | 38 | Corresponds to TXVECTOR parameter LDPC\_SUPERIMPOSED. If the LDPC code rate is 7/8 and this field is set to zero, it indicates puncturing code with codeword length 624 or 1248 is applied.If the LDPC code rate is 7/8 and this field is set to one, it indicates that superimposed code with codeword length 672 or 1344 is applied.In all other cases, this field is reserved. |
| NUC Applied | 1 | 39 | Corresponds to the TXVECTOR parameter NUC\_MOD. If this field is set to 1, NUC is applied at the transmitter for the MCSs indicated by the EDMG-MCS1 field or the EDMG-MCS2 field, if supported. If an indicated MCS does not support NUC, uniform constellation is applied for this particular MCS.If set to 0, uniform constellation is applied for MCSs signalled in the EDMG-MCS1 field and the EDMG-MCS2 field.  |
| Spoofing Error Length Indicator | 1 | 40 | If set to 0 in an EDMG OFDM PPDU, indicates that the spoofing error, defined as the difference between the PPDU duration calculated based on L-Header and the actual PPDU duration, is smaller than TOFDM-SYM, where TOFDM-SYM = TDFT + TGI, TDFT is the OFDM IDFT/DFT period and TGI is the guard interval duration, which is determined by bits B2 and B3 of the Last RSSI field within the L-Header of the PPDU. Otherwise, if set to 1 in an EDMG OFDM PPDU, indicates that the spoofing error is greater than or equal to TOFDM-SYM. For an EDMG SC PPDU, this field is reserved. |
| Reserved | 7 | 41 |  |
| CRC | 16 | 48 | Header Check sequence. Calculation of the header check sequence is defined in 20.3.7.  |

Table 66—EDMG-MCSs for the EDMG SC mode

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| EDMG-MCS index | Modulation | NCBPS | Repetition | Code Rate | Data rate per spatial stream (Mbps)  |
| Normal GI | Short GI | Long GI |
| 1 | π/2-BPSK | 1 | 2 | 1/2  | *NCB*×385.00 | *NCB*×412.50 | *NCB*×330.00 |
| 2 | π/2-BPSK | 1 | 1 | 1/2  | *NCB*×770.00 | *NCB*×825.00 | *NCB*×660.00 |
| 3 | π/2-BPSK | 1 | 1 | 5/8  | *NCB*×962.50 | *NCB*×1031.25 | *NCB*×825.00 |
| 4 | π/2-BPSK | 1 | 1 | 3/4  | *NCB*×1155.00 | *NCB*×1237.50 | *NCB*×990.00 |
| 5 | π/2-BPSK | 1 | 1 | 13/16 | *NCB*×1251.25 | *NCB*×1340.63 | *NCB*×1072.50 |
| 6 | π/2-BPSK | 1 | 1 | 7/8  | *NCB*×1347.50 | *NCB*×1443.75 | *NCB*×1155.00 |
| 7 | π/2-QPSK | 2 | 1 | 1/2  | *NCB*×1540.00 | *NCB*×1650.00 | *NCB*×1320.00 |
| 8 | π/2-QPSK | 2 | 1 | 5/8  | *NCB*×1925.00 | *NCB*×2062.50 | *NCB*×1650.00 |
| 9 | π/2-QPSK | 2 | 1 | 3/4  | *NCB*×2310.00 | *NCB*×2475.00 | *NCB*×1980.00 |
| 10 | π/2-QPSK | 2 | 1 | 13/16 | *NCB*×2502.50 | *NCB*×2681.25 | *NCB*×2145.00 |
| 11 | π/2-QPSK | 2 | 1 | 7/8  | *NCB*×2695.00 | *NCB*×2887.50 | *NCB*×2310.00 |
| 12 | π/2-16-QAM | 4 | 1 | 1/2  | *NCB*×3080.00 | *NCB*×3300.00 | *NCB*×2640.00 |
| 13 | π/2-16-QAM | 4 | 1 | 5/8  | *NCB*×3850.00 | *NCB*×4125.00 | *NCB*×3300.00 |
| 14 | π/2-16-QAM | 4 | 1 | 3/4  | *NCB*×4620.00 | *NCB*×4950.00 | *NCB*×3960.00 |
| 15 | π/2-16-QAM | 4 | 1 | 13/16 | *NCB*×5005.00 | *NCB*×5362.50 | *NCB*×4290.00 |
| 16 | π/2-16-QAM | 4 | 1 | 7/8  | *NCB*×5390.00 | *NCB*×5775.00 | *NCB*×4620.00 |
| 17 | π/2-64-QAM | 6 | 1 | 1/2  | *NCB*×4620.00 | *NCB*×4950.00 | *NCB*×3960.00 |
| 18 | π/2-64-QAM | 6 | 1 | 5/8  | *NCB*×5775.00 | *NCB*×6187.50 | *NCB*×4950.00 |
| 19 | π/2-64-QAM | 6 | 1 | 3/4  | *NCB*×6930.00 | *NCB*×7425.00 | *NCB*×5940.00 |
| 20 | π/2-64-QAM | 6 | 1 | 13/16 | *NCB*×7507.50 | *NCB*×8043.75 | *NCB*×6435.00 |
| 21 | π/2-64-QAM | 6 | 1 | 7/8  | *NCB*×8085.00 | *NCB*×8662.50 | *NCB*×6930.00 |

Table 68—EDMG-MCSs 17 – 21 for the EDMG SC mode if the π/2-64-NUC Applied field is 1

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| EDMG-MCS index | Modulation | NCBPS | Repetition | Code Rate | Data rate per spatial stream (Mbps)  |
| Normal GI | Short GI | Long GI |
| 17 | π/2-64-NUC | 6 | 1 | 1/2  | *NCB*×4620.00 | *NCB*×4950.00 | *NCB*×3960.00 |
| 18 | π/2-64-NUC | 6 | 1 | 5/8  | *NCB*×5775.00 | *NCB*×6187.50 | *NCB*×4950.00 |
| 19 | π/2-64-NUC | 6 | 1 | 3/4  | *NCB*×6930.00 | *NCB*×7425.00 | *NCB*×5940.00 |
| 20 | π/2-64-NUC | 6 | 1 | 13/16 | *NCB*×7507.50 | *NCB*×8043.75 | *NCB*×6435.00 |
| 21 | π/2-64-NUC | 6 | 1 | 7/8  | *NCB*×8085.00 | *NCB*×8662.50 | *NCB*×6930.00 |

Table 86— EDMG-MCSs for the EDMG OFDM mode

|  |  |  |  |
| --- | --- | --- | --- |
| EDMG-MCS index | Modulation | *NCBPS* | Code Rate |
| 1 | SQPSK | 1 | ½ |
| 2 | SQPSK | 1 | 5/8 |
| 3 | SQPSK | 1 | ¾ |
| 4 | SQPSK | 1 | 13/16 |
| 5 | SQPSK | 1 | 7/8 |
| 6 | QPSK | 2 | ½ |
| 7 | QPSK | 2 | 5/8 |
| 8 | QPSK | 2 | ¾ |
| 9 | QPSK | 2 | 13/16 |
| 10 | QPSK | 2 | 7/8 |
| 11 | 16-QAM | 4 | ½ |
| 12 | 16-QAM | 4 | 5/8 |
| 13 | 16-QAM | 4 | ¾ |
| 14 | 16-QAM | 4 | 13/16 |
| 15 | 16-QAM | 4 | 7/8 |
| 16 | 64-QAM | 6 | ½ |
| 17 | 64-QAM | 6 | 5/8 |
| 18 | 64-QAM | 6 | ¾ |
| 19 | 64-QAM | 6 | 13/16 |
| 20 | 64-QAM | 6 | 7/8 |

Table 87— Data rate for the EDMG OFDM mode with NSD = 336, 734

|  |  |
| --- | --- |
| MCS | Data rate per spatial stream (Mbps) |
| *NSD* = 336 | *NSD* = 734 |
| Normal GI | Short GI | Long GI | Normal GI | Short GI | Long GI |
| 1 | 729.47 | 792.00 | 630.00 | 1593.55 | 1730.14 | 1376.25 |
| 2 | 911.84 | 990.00 | 787.50 | 1991.94 | 2162.68 | 1720.31 |
| 3 | 1094.21 | 1188.00 | 945.00 | 2390.33 | 2595.21 | 2064.38 |
| 4 | 1185.39 | 1287.00 | 1023.75 | 2589.52 | 2811.48 | 2236.41 |
| 5 | 1276.58 | 1386.00 | 1102.50 | 2788.72 | 3027.75 | 2408.44 |
| 6 | 1458.95 | 1584.00 | 1260.00 | 3187.11 | 3460.29 | 2752.50 |
| 7 | 1823.68 | 1980.00 | 1575.00 | 3983.88 | 4325.36 | 3440.63 |
| 8 | 2188.42 | 2376.00 | 1890.00 | 4780.66 | 5190.43 | 4128.75 |
| 9 | 2370.79 | 2574.00 | 2047.50 | 5179.05 | 5622.96 | 4472.81 |
| 10 | 2553.16 | 2772.00 | 2205.00 | 5577.43 | 6055.50 | 4816.88 |
| 11 | 2917.89 | 3168.00 | 2520.00 | 6374.21 | 6920.57 | 5505.00 |
| 12 | 3647.37 | 3960.00 | 3150.00 | 7967.76 | 8650.71 | 6881.25 |
| 13 | 4376.84 | 4752.00 | 3780.00 | 9561.32 | 10380.86 | 8257.50 |
| 14 | 4741.58 | 5148.00 | 4095.00 | 10358.09 | 11245.93 | 8945.63 |
| 15 | 5106.32 | 5544.00 | 4410.00 | 11154.87 | 12111.00 | 9633.75 |
| 16 | 4376.84 | 4752.00 | 3780.00 | 9561.32 | 10380.86 | 8257.50 |
| 17 | 5471.05 | 5940.00 | 4725.00 | 11951.64 | 12976.07 | 10321.88 |
| 18 | 6565.26 | 7128.00 | 5670.00 | 14341.97 | 15571.29 | 12386.25 |
| 19 | 7112.37 | 7722.00 | 6142.50 | 15537.14 | 16868.89 | 13418.44 |
| 20 | 7659.47 | 8316.00 | 6615.00 | 16732.30 | 18166.50 | 14450.63 |

Table 88— Data rate for the EDMG OFDM mode with NSD = 1134, 1532

|  |  |
| --- | --- |
| MCS | Data rate per spatial stream (Mbps) |
| *NSD* = 1134 | *NSD* = 1532 |
| Normal GI | Short GI | Long GI | Normal GI | Short GI | Long GI |
| 1 | 2461.97 | 2673.00 | 2126.25 | 3326.05 | 3611.14 | 2872.50 |
| 2 | 3077.47 | 3341.25 | 2657.81 | 4157.57 | 4513.93 | 3590.63 |
| 3 | 3692.96 | 4009.50 | 3189.38 | 4989.08 | 5416.71 | 4308.75 |
| 4 | 4000.71 | 4343.63 | 3455.16 | 5404.84 | 5868.11 | 4667.81 |
| 5 | 4308.45 | 4677.75 | 3720.94 | 5820.59 | 6319.50 | 5026.88 |
| 6 | 4923.95 | 5346.00 | 4252.50 | 6652.11 | 7222.29 | 5745.00 |
| 7 | 6154.93 | 6682.50 | 5315.63 | 8315.13 | 9027.86 | 7181.25 |
| 8 | 7385.92 | 8019.00 | 6378.75 | 9978.16 | 10833.43 | 8617.50 |
| 9 | 8001.41 | 8687.25 | 6910.31 | 10809.67 | 11736.21 | 9335.63 |
| 10 | 8616.91 | 9355.50 | 7441.88 | 11641.18 | 12639.00 | 10053.75 |
| 11 | 9847.89 | 10692.00 | 8505.00 | 13304.21 | 14444.57 | 11490.00 |
| 12 | 12309.87 | 13365.00 | 10631.25 | 16630.26 | 18055.71 | 14362.50 |
| 13 | 14771.84 | 16038.00 | 12757.50 | 19956.32 | 21666.86 | 17235.00 |
| 14 | 16002.83 | 17374.50 | 13820.63 | 21619.34 | 23472.43 | 18671.25 |
| 15 | 17233.82 | 18711.00 | 14883.75 | 23282.37 | 25278.00 | 20107.50 |
| 16 | 14771.84 | 16038.00 | 12757.50 | 19956.32 | 21666.86 | 17235.00 |
| 17 | 18464.80 | 20047.50 | 15946.88 | 24945.39 | 27083.57 | 21543.75 |
| 18 | 22157.76 | 24057.00 | 19136.25 | 29934.47 | 32500.29 | 25852.50 |
| 19 | 24004.24 | 26061.75 | 20730.94 | 32429.01 | 35208.64 | 28006.88 |
| 20 | 25850.72 | 28066.50 | 22325.63 | 34923.55 | 37917.00 | 30161.25 |