IEEE P802.11
Wireless LANs

|  |
| --- |
| CID Resolution for DCM Modulation |
| Date: 2018-03-25 |
| Author(s): |
| Name | Affiliation | Address | Phone | email |
| Artyom Lomayev | Intel | Turgeneva 30, Nizhny Novgorod 603024, Russia | +7 (831) 2969444 | artyom.lomayev@intel.com |
| Alexander Maltsev | Intel  |  |  | alexander.maltsev@intel.com |
| Claudio da Silva | Intel |  |  | claudio.da.silva@intel.com |
| Carlos Cordeiro | Intel  |  |  | carlos.cordeiro@intel.com |
|  |  |  |  |  |

Abstract

This document proposes resolutions for CIDs 2095, 2096, 1624, 2033, 2097, (5), all related to DCM modulation, [1].

**List of DCM modulation related CIDs**

|  |  |  |
| --- | --- | --- |
| **CID #** | **Comment** | **Proposed change** |
| 2095 | Change notation of SQPSK | SQPSK is the incorrect terminology. The original constellation is BPSK which is then spread to generate QPSK. Hence this modulation technique should be referred to as SBPSK. Update throughout draft |
| 2096 | Change notation of DCM SQPSK | DCM SQPSK is the incorrect terminology. The original constellation is QPSK which is then mapped onto two (dual) carriers. Hence this modulation technique should be referred to as DCM QPSK. Update throughout draft |
| 1624 | QPSK modulation is actually DCM QPSK | Rename section to DCM QPSK or DCM 16-QAM or similar. It is not QPSK |
| 2033 | should better be DCM QPSK rather than QPSK | correct title as suggested |
| 2097 | Change notation of QPSK | QPSK is the incorrect terminology. The original constellation is QPSK which is then spread to generate 16QAM. Hence this modulation technique should be referred to as SQPSK. Update throughout draft |

*Proposed change:*

Rename the modulations as follows:

OFDM mode:

1. SQPSK rename to DCM BPSK
2. QPSK rename to DCM QPSK
3. DCM SQPSK rename to Dual Stream DCM BPSK

SC mode:

1. DCM π/2-SQPSK rename to DCM π/2-BPSK

*Resolution:*

Revised.

*Editor, introduce changes on page 76, line 24 as below, [1]:*

9.4.2.146 Dynamic Tone Pairing (DTP) Report element

*Replace Table 9-245 with the following table*

|  |  |  |
| --- | --- | --- |
| Field | Length | Meaning |
| Element ID | 8 |  |
| Length | 8 |  |
| GroupPairIndex(0) | 8 | Index of DTP group pair *n* in the range 0 to NG – 1, for *n* = 0, 1, …, NG – 1. |
| GroupPairIndex(1) | 8 |
| … | … |
| GroupPairIndex(NG – 1) | 8 |

*Replace the third paragraph the following*

GroupPairIndex(n) subfields for *n* = 0, 1,.., NG – 1 indicate DTP groups, which in turn determines how pairs of DCM BPSK and DCM QPSK symbols are mapped to OFDM tones when DTP is enabled, as described in 30.6.8.3.8.3. Valid values of GroupPairIndex(n) are in the range 0 to NG – 1. The NG value is dependent on the total number of data subcarriers which for a 2.16 GHz, 4.32 GHz, 6.48 GHz, and 8.64 GHz channel is equal to 42, 92, 142, and 192, respectively. The valid values of GroupPairIndex(0), GroupPairIndex(1),…, GroupPairIndex(NG – 1) are distinct and therefore represent a permutation of integers 0 to NG – 1. For NG = 92, 142, and 192, GroupPairIndex(NG – 1) shall be equal to NG – 1.

9.4.2.250.4 PHY Capability field

The PHY Capability field is defined in Figure 38.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | B0 | B1 | B2 | B3 | B4 | B5 | B6 | B7 B9 |
|  | Phase Hopping Supported | Open Loop Precoding Supported | DCM π/2-BPSK Supported | Short CW Punctured Supported | Short CW Superimposed Supported | Long CW Punctured Supported | Long CW Superimposed Supported | SC Maximum Number of SU-MIMO Spatial Streams Supported |
| Bits: | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | B10 B12 | B13 | B14 | B15 | B16 B18 | B19 | B20 B23 |
|  | OFDM Maximum Number of SU-MIMO Spatial Streams Supported | NUC TX Supported | NUC RX Supported | π/2-8-PSK Supported | Number of Concurrent RF Chains | STBC Supported | Reserved |
| Bits: | 3 | 1 | 1 | 1 | 3 | 1 | 4 |

1. —PHY Capability field format

If the Phase Hopping Supported subfield is set to 1, the STA supports phase hopping as specified in 30.6.8.3. Otherwise, the STA does not support phase hopping.

If the Open Loop Precoding Supported subfield is set to 1, the STA supports open loop precoding as specified in 30.6.8.3. Otherwise, the STA does not support open loop precoding.

If the DCM π/2-BPSK Supported subfield is set to 1, the STA supports DCM π/2-BPSK as specified in 30.5.9.5.2. Otherwise, the STA does not support DCM π/2-BPSK.

The Short CW Punctured Supported, Short CW Superimposed Supported, Long CW Punctured Supported and Long CW Superimposed Supported subfields indicate the support by an EDMG STA for LDPC code rate 7/8 with codeword length equal to 624, 672, 1248, and 1344 bits as follows:

*Editor, introduce changes on page 266, line 1 as below, [1]:*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| DCM\_BPSK | FORMAT is EDMG | Indicates whether DCM BPSK modulation is applied. Enumerated type:DCM\_BPSK\_NotApplied:For EDMG SC mode, indicates that DCM π/2-BPSK is not applied, for EDMG OFDM mode, indicates that Dual Stream DCM BPSK is not appliedDCM\_BPSK\_Applied:For EDMG SC mode, indicates that DCM π/2-BPSK is applied, for EDMG OFDM mode, indicates that Dual Stream DCM BPSK is applied | Y | Y |

*Editor, introduce changes on page 294, line 1 as below, [1]:*

|  |  |  |  |
| --- | --- | --- | --- |
| STBC Applied | 1 | 15 | Corresponds to the TXVECTOR parameter STBC. If set to 1, indicates that STBC was applied at the transmitter. Otherwise, set to 0.If set to 1, the DCM BPSK Applied and the Phase Hopping fields shall be set to 0.  |

|  |  |  |  |
| --- | --- | --- | --- |
| DCM BPSK Applied | 1 | 62 | Corresponds to the TXVECTOR parameter DCM\_BPSK. If set to 1 and the PSDU is encoded using the EDMG SC mode, it indicates that DCM π/2-BPSK modulation defined in 30.5.9.5.2 was applied at the transmitter.If set to 1 and the PSDU is encoded using the EDMG OFDM mode with two spatial streams, it indicates that Dual Stream DCM BPSK modulation defined in 30.6.8.3.4 was applied at the transmitter.If set to 1, the STBC Applied and the Phase Hopping fields shall be set to 0.In all other cases, this field is set to 0. |

*Editor, introduce changes on page 296, line 1 as below, [1]:*

|  |  |  |  |
| --- | --- | --- | --- |
| Phase Hopping | 1 | 93 | Corresponds to TXVECTOR parameter PHASE\_HOPPING. If set to 1 in an EDMG OFDM mode PPDU, this field indicates that phase hopping modulation is used. Otherwise this field is set to 0. If set to 1, the STBC Applied and the DCM BPSK Applied fields shall be set to 0. This field is reserved in an EDMG SC mode PPDU, or if the transmitter or receiver do not support phase hopping. |

*Editor, introduce changes on page 338, line 18 as below, [1]:*

The set of MCSs for an EDMG SC mode PPDU are defined in Table 66, where *NCB* is as defined above. If the π/2-8-PSK Applied field in the EDMG-Header-A of an SU PPDU is 1, then MCS 12 and 13 shall use π/2-8-PSK modulation as indicated in Table 67. If the π/2-64-NUC Applied field in the EDMG-Header-A or in the EDMG-Header-B is 1, then MCS 17 through 20 shall use π/2-64-NUC modulation as indicated in Table 68. If the DCM BPSK Applied field in the EDMG-Header-A of an SU PPDU is 1, then MCS 2 through 6 shall use DCM BPSK modulation as indicated in Table 69.

*Editor, introduce changes on page 339, line 7 as below, [1]:*

1. —EDMG-MCSs 2 – 6 for the EDMG SC mode if the DCM BPSK Applied field is 1

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| EDMG-MCS index | Modulation | NCBPS | Repetition | Code Rate | Data rate per spatial stream (Mbps)  |
| Normal GI | Short GI | Long GI |
| 2 | DCM π/2-BPSK | 1 | 1 | 1/2  | *NCB*×770.00 | *NCB*×825.00 | *NCB*×660.00 |
| 3 | DCM π/2-BPSK | 1 | 1 | 5/8  | *NCB*×962.50 | *NCB*×1031.25 | *NCB*×825.00 |
| 4 | DCM π/2-BPSK | 1 | 1 | 3/4  | *NCB*×1155.00 | *NCB*×1237.50 | *NCB*×990.00 |
| 5 | DCM π/2-BPSK | 1 | 1 | 13/16 | *NCB*×1251.25 | *NCB*×1340.63 | *NCB*×1072.50 |
| 6 | DCM π/2-BPSK | 1 | 1 | 7/8  | *NCB*×1347.50 | *NCB*×1443.75 | *NCB*×1155.00 |

*Editor, introduce changes on page 356, line 8 as below, [1]:*

* + - * 1. Dual carrier modulation (DCM) π/2-BPSK

A frequency domain diversity scheme based on DCM π/2-BPSK may be applied to an EDMG PPDU transmission over 2.16+2.16 GHz or 4.32+4.32 GHz channels. An EDMG STA shall only apply DCM π/2-BPSK to an EDMG PPDU transmitted to a peer EDMG STA if the DCM π/2-BPSK Supported field in the peer STA’s EDMG Capabilities element is one.

The DCM π/2-BPSK modulation is applied to an EDMG PPDU if, in the EDMG-Header-A, the BW field indicates a bandwidth configuration 2.16+2.16 GHz or 4.32+4.32 GHz, the Channel Aggregation field is set to one, the Number of SS field indicates 2 spatial streams, and the DCM BPSK Applied field is set to one. The value of the EDMG-MCS1 and EDMG-MCS2 fields in the EDMG-Header-A shall be the same and in the range from 2 to 6.

The DCM π/2-BPSK modulation is defined as follows:

* After LDPC encoding, the bit stream of the first space-time stream (*iSTS* = 1) and the second space-time stream (*iSTS* = 2) is broken into two groups of N*CBPB*×NCB bits as  and  respectively, where q denotes the SC symbol block number and *q* =0,1,…N*BLKS* – 1. NCBPB is defined as in Table 77 for the π/2-BPSK case, NCB = 1 for a 2.16+2.16 GHz channel and NCB = 2 for a 4.32+4.32 GHz channel.
* Each pair of bits  of the qth SC data block, k=0,1,NCBPB×NCB – 1, is converted into a pair of constellation points  and .
* Finally, the qth SC data block of the first space-time stream , k = 0, 1, …, NCBPB×NCB – 1, is assigned to the channel containing the primary 2.16 GHz channel and the second space-time stream , k = 0, 1, …, NCBPB×NCB – 1, is assigned to the channel that does not contain the primary channel.

The DCM π/2-BPSK modulation uses the same symbol blocking structure as for a SU PPDU defined in 30.5.9.2.2.3.

*Editor, introduce changes on page 394, line 1 as below, [1]:*

Table 86 — EDMG-MCSs for the EDMG OFDM mode

|  |  |  |  |
| --- | --- | --- | --- |
| EDMG-MCS index | Modulation | *NCBPS* | Code Rate |
| 1 | DCM BPSK | 1 | ½ |
| 2 | DCM BPSK | 1 | 5/8 |
| 3 | DCM BPSK | 1 | ¾ |
| 4 | DCM BPSK | 1 | 13/16 |
| 5 | DCM BPSK | 1 | 7/8 |
| 6 | DCM QPSK | 2 | ½ |
| 7 | DCM QPSK | 2 | 5/8 |
| 8 | DCM QPSK | 2 | ¾ |
| 9 | DCM QPSK | 2 | 13/16 |
| 10 | DCM 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 |

*Editor, introduce changes on page 401, line 21 as below, [1]:*

The coded and padded bit stream is converted into a stream of complex constellation points, following the rules defined in this subclause for DCM BPSK, Dual Stream DCM BPSK, DCM QPSK, 16-QAM, and 64-QAM modulations.

The DCM BPSK, Dual Stream DCM BPSK, and DCM QPSK modulations use tone pairing mechanisms to extract channel frequency diversity as defined in 30.6.8.3.8. The 16-QAM and 64-QAM modulations use the interleaver defined in 30.6.8.3.9.

*Editor, introduce changes on page 402, line 18 as below, [1]:*

30.6.8.3.3 DCM BPSK modulation

*Editor, introduce changes on page 403, line 2 as below, [1]:*

* + - * 1. Dual Stream DCM BPSK modulation

Dual Stream DCM BPSK modulation is applied if the number of spatial streams, NSS, is equal to 2 and the DCM BPSK Applied field in EDMG-Header-A is set to 1.

*Editor, introduce changes on page 404, line 1 as below, [1]:*

* + - * 1. DCM QPSK modulation

*Editor, introduce changes on page 405, line 5 as below, [1]:*

* + - * 1. Tone pairing for DCM BPSK and DCM QPSK

30.6.8.3.8.1 General

The DCM BPSK and DCM QPSK modulations perform mapping of pair of symbols  to OFDM subcarriers with indexes 0 ≤ k ≤ NSD/2 – 1 and NSD/2 ≤ P(k) ≤ NSD – 1 to exploit channel frequency diversity.

*Editor, introduce changes on page 408, line 25 as below, [1]:*

For DCM BPSK and DCM QPSK modulations, STBC shall apply static tone pairing (STP) subcarriers mapping.

* + - * 1. Phase hopping modulation

The phase hopping modulation is applied in a received PPDU if the number of spatial streams is equal to two (i.e., NSS = 2) and the Phase Hopping field in the EDMG-Header-A is equal to 1.

The phase hopping modulation shall use the (BPSK, BPSK), (QPSK, QPSK), (QPSK, 16-QAM), (16-QAM, QPSK), (16-QAM, 16-QAM), or (64-QAM, 64-QAM) modulations for the first and the second spatial streams accordingly.

For each modulation type, the encoded bits of iSSth spatial stream are broken into groups of  bits, , where q denotes the group number.

For (BPSK, BPSK) configuration, the modulation is performed in two steps:

* First, BPSK points are modulated as , k = 0, 1, …, NSD – 1

*Editor, introduce changes on page 415, line 28 as below, [1]:*

* The first path is selected if the FORMAT parameter is EDMG. In this case, the modulation is defined by EDMG\_MODULATION parameter. If EDMG\_MODULATION parameter is set to EDMG\_C\_MODE, EDMG\_SC\_MODE, or EDMG\_OFDM\_MODE, then it indicates EDMG control mode, EDMG SC mode, or EDMG OFDM mode defined in 30.4, 30.5, and 30.6, respectively. An example of the EDMG PHY transmit procedure provided in this subclause does not include optional features like EDMG A-PPDU, SU with multiple space-time streams, STBC, Dual Stream DCM BPSK, DCM π/2-BPSK and MU transmission.

*Editor, introduce changes on page 418, line 4 as below, [1]:*

NOTE— This procedure does not describe the operation of optional features, such as A-PPDU, SU multiple space-time streams, STBC, Dual Stream DCM BPSK, DCM π/2-BPSK, and MU transmission.

*Editor, introduce changes on page 422, line 6 as below, [1]:*

NOTE— This procedure does not describe the operation of optional features, such as A-PPDU, SU multiple space-time streams, STBC, DCM BPSK, DCM π/2-BPSK, and MU reception.

*Editor, introduce changes on page 392, line 10 as below, [1]:*

The data blocks shall be modulated using DCM QPSK modulation with Static Tone Pairing (STP). The EDMG-Header-B shall use the OFDM modulation as defined for the Data field of the PPDU (see 30.6.8.3).

*Editor, introduce changes on page 393, line 16 as below, [1]:*

The data blocks shall be modulated using DCM QPSK modulation with Static Tone Paring (STP). The EDMG-Header-A field shall use an OFDM modulation as defined for the Data field of the PPDU in 30.6.8.3.

*Editor, introduce changes on page 398, line 1 as below, [1]:*

Table 91 — Values of NCBPS for different modulation types and number of data subcarriers

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Symbol mapping | NSD = 336 | NSD = 734 | NSD = 1134 | NSD = 1532 |
| DCM BPSK | 336 | 734 | 1134 | 1532 |
| DCM QPSK | 672 | 1468 | 2268 | 3064 |
| 16-QAM | 1344 | 2936 | 4536 | 6128 |
| 64-QAM | 2016 | 4404 | 6804 | 9192 |

**SP:**

Do you agree to accept the proposed resolutions for CIDs 2095, 2096, 1624, 2033, 2097 in (11-18-0331-02-00ay CID Resolution for DCM Modulation)?

**References:**

1. Draft P802.11ay\_D1.1