IEEE P802.11
Wireless LANs

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| CID Resolution – Part XIV |
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|  |  |  |  |  |

Abstract

This document proposes resolutions for CID 4466, [1], [2].

**CID 4466**

*Comment, p 505, line 12*

there are several spatial mapping methods specified for SC PPDU transmission. Indication for the receiver on which spatial mapping method is used at the transmitter is missing. The receiver would have such information for combining.

*Proposed change:*

Clarify the transmission of indication on spatial mapping methods.

*Resolution:*

Revised.

*Editor: add row in Table 46 as specified below*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| BEAMFORMED | FORMAT is EDMG orFORMAT is NON\_EDMG and NON\_EDMG\_MODULATION is NON\_EDMG\_DUP\_SC\_MODE | Enumerated Type:BeamformedNot\_BeamformedIf set to Beamformed, indicates that digital beamforming is applied. Set to Not\_Beamformed otherwise.  | Y | Y |
| CSD\_APPLIED | BEAMFORMED is Not\_Beamformed | Enumerated Type:CSD\_AppliedCSD\_Not\_AppliedIf set to CSD\_Applied, indicates that CSD is applied over different transmit chains. Set to CSD\_Not\_Applied otherwise. |  |  |

*Editor: add section 29.5.9.5.2 titled as Transmission in EDMG format as proposed below*

* + - * 1. Transmission in EDMG format

The EDMG data transmit waveform for *iTX*th transmit chain in time domain shall be defined at the EDMG SC chip rate *Fc EDMG* as follows:



where:

 is the total number of chips

 is the total number of space-time streams

 is a spatial mapping matrix independent of the *nth* chip time index that is described in 29.5.10.2

 is a matrix element from *mth* row and *nth* column

 is the data sequence, it includes data payload symbols as well as the Guard Interval (GI) symbols

 is the delta function, which is equal to 1, if *n* = *q*, and 0, otherwise

 is a time sample index

*Editor: introduce changes on p 478, line 5 as specified below*

29.5.4.2 Definition

The EDMG-STF field transmit waveform in time domain shall be defined at the EDMG SC chip rate *Fc EDMG* and chip time duration *Tc EDMG*. The EDMG-STF field for the *iTXth* transmit chain is defined as follows:



where:

*NSTS* is a total number of space-time streams

 is the short training field definition for *iSTSth* space-time stream

 is a spatial mapping matrix

 is a matrix element from *mth* row and *nth* column

In case of spatial expansion, *NSTS* = 1 ≤ *NTX*, the spatial mapping matrix  is defined as the column vector composed of all ones of size *NTX* by 1. The spatial expansion is performed by application of CSD over different transmit chains as defined in 29.5.10.

The EDMG-STF field is composed of 18 repetitions of  followed by one with inverse sign . The waveform for the EDMG-STF field, , is defined as . Note that sequence  is defined for 0 ≤ *n* ≤ 128×*NCB* – 1. For other values of *n*,  is set to 0.

*Editor: introduce changes on p 479, line 5 as specified below*

The EDMG-CEF field transmit waveform in time domain shall be defined at the EDMG SC chip rate *Fc EDMG* and chip time duration *Tc EDMG*. The EDMG-CEF field is composed of  subfields for the *iTXth* transmit chain is defined as follows:



where:

 is the total number of EDMG-CEF subfields, where index *n* defines a subfield number

*NSTS* is a total number of space-time streams

 is a channel estimation field definition for the *iSTSth* space-time stream, where *m* = 1 for *n* = 1 and *m* = 2 for *n* > 1

 is the EDMG-CEF subfield duration

 is an EDMG-CEF mapping matrix

 is a spatial mapping matrix

 is a matrix element from *mth* row and *nth* column

In case of spatial expansion, *NSTS* = 1 ≤ *NTX*, the spatial mapping matrix  is defined as the column vector composed of all ones of size *NTX* by 1. The spatial expansion is performed by application of CSD over different transmit chains as defined in 29.5.10.

The waveform for the channel estimation subfield, , is defined as .

*Editor: p 482, line 1, add clarification text as below*

The SC data blocks shall be modulated using π/2-BPSK modulation as defined in 20.6.3.2.4. Each SC data block is prepended with a guard interval as defined in 29.5.9.2.

The EDMG-Header-B field is transmitted applying EDMG transmission format defined in 29.5.9.5.2.

*Editor: p 483, line 1, add clarification text as below*

The data blocks shall be modulated using π/2-BPSK modulation as defined in 20.6.3.2.4. Each of the modulated data blocks *cb1* and *cb2* is prepended with 64 × *NCB* guard symbols, and the data block *cb2* is appended with approproate number of guard symbols as described in 29.5.9.2.3.

The EDMG-Header-A field for *iPPDU* > 1 is transmitted applying EDMG transmission format defined in 29.5.9.5.2.

*Editor: introduce changes on p 409, line 1 in Table 47 as specified below*

|  |  |
| --- | --- |
|  | Spatial mapping matrix of size *NTX* by *NSTS*, independent of subcarrier index |
|  | Spatial mapping matrix of size *NTX* by *NSTS*, applied for non-EDMG PPDU transmission and independent of subcarrier index |
|  | Spatial mapping matrix of size *NTX* by *NSTS*, applied for pre-EDMG fields of EDMG PPDU transmission and independent of subcarrier index |
|  | Spatial mapping matrix of size *NTX* by *NSTS*, applied for EDMG fields of EDMG PPDU transmission and independent of subcarrier index |
|  | Spatial mapping matrix of size *NTX* by *NSTS*, defined for *k*th subcarrier |
|  | Spatial mapping matrix of size *NTX* by *NSTS*, applied for EDMG fields of EDMG PPDU transmission and defined for *k*th subcarrier |

*Editor: introduce changes on p 505, line 12 as specified below*

* + - 1. Spatial mapping

Spatial mapping defines the method of *NSTS* space-time streams to *NTX* transmit chains mapping, where *NSTS* ≤ *NTX*, which may be implemented by means of a spatial mapping matrix *Q* of size *NTX* by *NSTS* and by cyclic shift diversity (CSD), if applied. The spatial mapping matrix *Q* is independent of the chip time index or subcarrier index and is constant in time.

This standard defines four basic mappings for the EDMG PHY, namely, direct mapping, indirect mapping, digital beamforming and spatial expansion. Provided below are examples of spatial mapping methods and *Q* matrices that might be used in different cases.

* Direct mapping, *NSTS* = *NTX*: the spatial mapping matrix *Q* is a square diagonal complex values matrix of size *NTX* that might be defined as follows:
* , the identity matrix
* , exponential matrix
* Indirect mapping, *NSTS* = *NTX*: the spatial mapping matrix *Q* is a square matrix of size *NTX* composed of complex values that might be defined as follows:
* Normalized discrete Fourier matrix
* Normalized Hadamard matrix
* Normalized direct mapping diagonal matrix with permutated rows and/or columns
* Digital beamforming, *NSTS* ≤ *NTX*: the spatial mapping matrix *Q* is a rectangular matrix of size *NTX* by *NSTS* composed of complex values that might be defined based on some knowledge of the channel.
* Spatial expansion, *NSTS* = 1 < *NTX*: the spatial expansion is performed by multiplication by matrix *Q*, which is defined as a column vector of size *NTX* by 1 and composed of all ones and application of CSD over different transmit chains. The CSD is applied to the fields of PPDU with the exception of the TRN field. This enables duplication of the transmission of PPDU fields over the *NTX* transmit chains and avoids unintentional beamforming that exists with a coherent signal transmission. The spatial expansion technique is not applied to the TRN field, which is transmitted using an orthogonal sequence set.
* Channel aggregation, in this case *NTX* is an even number: the transmit chains 1 through *NTX*/2 are assigned to the primary or primary and secondary channels and transmit chains *NTX*/2 + 1 are assigned to the secondary or scondary1 and secondary2 channels. The mapping of space-time streams to the transmit chains is defined by the spatial mapping matrix *Q*, which is implementation specific.

The spatial mapping matrix Q may be different for the pre-EDMG and EDMG modulated fields, except for the case of an EDMG SU PPDU transmitted over a 2.16 GHz or 2.16 + 2.16 GHz channel with single space-time stream (*iSTS* = 1). The spatial mapping matrix Q shall be normalized to have the same average power per transmit chain for pre-EDMG and EDMG modulated fields.

*Editor: introduce changes on p 507, line 6 as specified below*

The non-EDMG PPDU waveform for the *iTXth* transmit chain shall be defined as:



where:

 is a spatial mapping matrix

 is a matrix element from *mth* row and *nth* column

In case of spatial expansion, the non-EDMG waveform for the *iTXth* transmit chain includes a cyclic shift, , dependent on the particular transmit chain number. The cyclic shift, , is defined in SC chip units as (*iTX* – 1)×*Nc*×*Tc*, where *Nc* is equal to 4 chips and *Tc* is a chip time duration.



where:

*N* is the total number of chips in the non-EDMG PPDU waveform

*Editor: introduce changes on p 511, line 1 as specified below*

The PPDU waveform of the pre-EDMG and Data fields for the *iTXth* transmit chain shall be defined as:



where:

 is a spatial mapping matrix

 is a matrix element from *mth* row and *nth* column

In case of spatial expansion, the PPDU waveform of the pre-EDMG and Data fields for the *iTXth* transmit chain includes a cyclic shift, , dependent on the particular transmit chain number. The cyclic shift, , is defined in SC chip units as (*iTX* – 1)×*Nc*×*Tc*, where *Nc* is equal to 4 chips and *Tc* is a chip time duration.



where:

*N* is the total number of chips in the pre-EDMG and Data fields of the EDMG PPDU

*Editor: introduce changes on p 514, line 2 as specified below*

The EDMG PPDU waveform for the *iTXth* transmit chain shall be defined as:



where:

 is a spatial mapping matrix

 is a matrix element from *mth* row and *nth* column

In case of spatial expansion, the EDMG PPDU waveform for the *iTXth* transmit chain includes a cyclic shift, , dependent on the particular transmit chain number. The cyclic shift, , is defined in SC chip units as (*iTX* – 1)×*Nc*×*Tc*, where *Nc* is equal to 4 chips and *Tc* is a chip time duration:



where:

*N* is the total number of chips in the pre-EDMG, Data, AGC and TRN fields

*Editor: introduce changes on p 515, line 24 as specified below*

The PPDU waveform of the pre-EDMG fields for the *iTXth* transmit chain shall be defined as:



where:

 is a spatial mapping matrix

 is a matrix element from *mth* row and *nth* column

In case of spatial expansion, the PPDU waveform of the pre-EDMG fields for the *iTXth* transmit chain includes a cyclic shift, , dependent on the particular transmit chain number. The cyclic shift, , is defined in SC chip units as (*iTX* – 1)×*Nc*×*Tc*, where *Nc* is equal to 4 chips and *Tc* is a chip time duration.



where:

*N* is the total number of chips in the pre-EDMG field of the EDMG PPDU waveform

*Editor: introduce changes on p 518, line 8 as specified below*

EDMG preamble and Data field transmission

For a single PPDU transmission, the EDMG modulated field of the EDMG preamble and Data field of an SU PPDU is defined for the *iTXth* transmit chain at the *Fc EDMG* chip rate and includes the following modulated fields:



where:

 is the duration of the EDMG-STF field of the PPDU

 is the total duration of the EDMG-STF and EDMG-CEF fields of the PPDU

The EDMG-STF, EDMG-CEF, and Data field transmission is defined in 29.5.4, 29.5.5, and 29.5.9.5.2 accordingly.

For an EDMG A-PPDU transmission of NPPDU PPDUs, the EDMG modulated field of the EDMG preamble and Data field of an SU PPDU is defined for *iTXth* transmit chain at the *Fc EDMG* and includes the following modulated fields:



where:

 is the duration of EDMG-STF field of the PPDU

 is the total duration of EDMG-STF and EDMG-CEF fields of the PPDU

 is the total duration of EDMG-STF, EDMG-CEF, and Data1 fields of the PPDU

 is the total duration of EDMG-STF, EDMG-CEF, Data1, and EDMG-Header-A2 fields of the PPDU

…

 is the total duration of EDMG-STF, EDMG-CEF, Data1, EDMG-Header-A2, Data2, …, and DataNPPDU – 1 fields of the PPDU

 is the total duration of EDMG-STF, EDMG-CEF, Data1, EDMG-Header-A2, Data2, …, DataNPPDU – 1, and EDMG-Header-ANPPDU fields of the PPDU

The EDMG-STF, EDMG-CEF, Data, and EDMG-Header-A field transmission is defined in 29.5.4, 29.5.5, 29.5.9.5.2, and 29.5.7 accordingly.

In case of spatial expansion, the PPDU waveform of the EDMG preamble and Data field for the *iTXth* transmit chain includes a cyclic shift, , dependent on the particular transmit chain number. The cyclic shift, , is defined in SC chip units as (*iTX* – 1)×*Nc*×*Tc*, where *Nc* is equal to 4 chips and *Tc* is a chip time duration.



where:

*N* is the total number of chips in the EDMG preamble and Data fields of the EDMG PPDU

*Editor: introduce changes on p 522, line 3 as specified below*

* + - * 1. EDMG preamble, EDMG-Header-B and Data field transmission

The EDMG preamble, EDMG-Header-B and Data field of an EDMG MU PPDU is defined for *iTXth* transmit chain at the *Fc EDMG* chip rate and includes the following modulated fields:



where:

is the duration of the EDMG-STF field of the PPDU

 is the total duration of the EDMG-STF and EDMG-CEF fields of the PPDU

 is the total duration of the EDMG-STF, EDMG-CEF and EDMG-Header-B fields of the PPDU

The EDMG-STF, EDMG-CEF, Data, and EDMG-Header-A field transmission is defined in 29.5.4, 29.5.5, 29.5.9.5.2, and 29.5.6 accordingly.

*Editor: introduce changes on p 541, line 14 as specified below*

The EDMG-STF field transmit waveform in time domain shall be defined at the OFDM sampling rate *Fs* and sample time duration *Ts* as follows:



where:

 is 88, 192, 296 and 400 for *NCB* = 1, 2, 3 and 4 respectively

*NSTS* is the total number of space-time streams

 is the spatial mapping matrix per *kth* subcarrier

 is a matrix element from *mth* row and *nth* column

 is a window function applied to smooth the transitions between consecutive OFDM symbols, whose definition is implementation dependent

*q* is the time sample index, 

*Editor: introduce changes on p 542, line 20 as specified below*

The EDMG-CEF field transmit waveform in time domain shall be defined at the OFDM sampling rate *Fs* and sample time duration *Ts* as follows:



where:

 is the total number of active tones

*NSTS* is the total number of space-time streams

 is the OFDM symbol duration in time domain

 is the long guard interval time duration

 is the spatial mapping matrix per *kth* subcarrier

 is the EDMG-CEF mapping matrix defined below

 is the number of OFDM symbols in the EDMG-CEF for a given total number of space-time streams *NSTS* defined below

 is a matrix element from *mth* row and *nth* column

 is the window function applied to smooth the transitions between consecutive OFDM symbols. Its definition is implementation dependent

*q* is the time sample index, 

*Editor: introduce changes on p 553, line 30 as specified below*

The EDMG data transmit waveform for *iTX*th transmit chain in time domain shall be defined at the OFDM sampling rate *Fs* as follows:



where:

 is the total number of active tones

 is the total number of space-time streams

 is the OFDM symbol duration in time domain

 is the guard interval duration

 is the spatial mapping matrix per *kth* subcarrier

 is a matrix element from *mth* row and *nth* column

 is a window function applied to smooth the transitions between consecutive OFDM symbols and its definition is implementation specific

 is the data sequence, it is defined by inserting zeros from –*NSR* to *NSR*, and then inserting data at the *Md(k)* tones defined in 29.6.2.5, *D(iSTS, n, Md(k))* = *d(iSTS, n, k)*, for *k* = 0, 1, …, *NSD* – 1

 is the pilot sequence defined in 29.6.2.6

 is a time sample index

*Editor: introduce changes on p 562, line 7 as specified below*

* + - 1. Spatial mapping

Spatial mapping defines the method of *NSTS* space-time streams to *NTX* transmit chains mapping, where *NSTS* ≤ *NTX*. This may be implemented by means of spatial mapping matrix *Qk* of size *NTX* by *NSTS* defined per subcarrier basis and cyclic shift diversity (CSD), if applied.

The standard defines four basic mappings, including direct mapping, indirect mapping, digital beamforming, and spatial expansion. Examples of spatial mapping methods and *Qk* matrices that might be used in different cases are as follows:

* Direct mapping, *NSTS* = *NTX*: spatial mapping matrix *Qk* is a square diagonal complex values matrix of size *NTX* that might be defined as follows:
* , the identity matrix
* , the exponential matrix
* Indirect mapping, *NSTS* = *NTX*: spatial mapping matrix *Qk* is a square matrix of size *NTX* composed of complex values that might be defined as follows:
* Normalized discrete Fourier matrix
* Normalized Hadamard matrix
* Normalized direct mapping diagonal matrix with permuted rows and/or columns
* Digital beamforming, *NSTS* ≤ *NTX*: spatial mapping matrix *Qk* is a rectangular matrix of size *NTX* by *NSTS* composed of complex values that might be defined based on the knowledge of the channel.
* Spatial expansion, *NSTS* = 1 < *NTX*: spatial expansion that might be applied to the pre-EDMG fields is performed by multiplication by matrix *Q*, which is defined as a column vector of size *NTX* by 1 and composed of all ones and application of CSD over different transmit chains. The cyclic shift is applied to the number of consecutive fields in the PPDU. This allows duplication of the PPDU fields transmission over the *NTX* transmit chains and avoids unintentional beamforming existing with a coherent signal transmission.
* Channel aggregation, in this case *NTX* is an even number: the transmit chains 1 through *NTX*/2 are assigned to the primary or primary and secondary channels and transmit chains *NTX*/2 + 1 are assigned to the secondary or scondary1 and secondary2 channels. The mapping of space-time streams to the transmit chains is defined by the spatial mapping matrix *Qk*, which is implementation specific.

**SP:**

Do you agree to accept the proposed resolutions for CID 4466 in (11-19-0667-01-00ay CID Resolution - Part XIV)?

**References:**

1. Draft P802.11ay\_D3.0
2. 11-19-0297-03-00ay-comments-on-11ay-d3-0