IEEE P802.11  
Wireless LANs

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| CR on Hybrid Beamforming feedback | | | | |
| Date: 2018-05-07 | | | | |
| Author(s): | | | | |
| Name | Affiliation | Address | Phone | email |
| Sunwoong Yun | LG Electronics | Seocho LG R&D Lab, Korea |  | sunwoong.yun@lge.com |
| Kome Oteri | InterDigital | 9710 Scranton Road, #250, San Diego, CA, 92121 |  | Kome.oteri@interidigital.com |
| Dana Ciochina | Sony Europe Ltd |  |  | dana.ciochina@sony.com |
| Thomas Handte | Sony Europe Ltd |  |  | thomas.handte@sony.com |
| SungJin Park | LG Electronics |  |  | allen.park@lge.com |
| Saehee Bang | LG Electronics |  |  | saehee.bang@lge.com |
| Jinmin Kim | LG Electronics |  |  | jinmin1230.kim@lge.com |
| Jinsoo Choi | LG Electronics |  |  | js.choi@lge.com |
| Sanggook Kim | LG Electronics | San Diego/California/US |  | sanggook.kim@lge.com |
| Chris Hansen | Peraso |  |  | chris@covariantcorp.com |
| Nelson Costa | Peraso |  |  | nelson@perasotech.com |

Abstract

The document provides resolution to CIDs 1375, 1579, 1580, 1581, 1905, and 2026.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **CID** | **Clause Number(C)** | **Page** | **Comment** | **Proposed Change** | **Resolution** |
| 1375 | 10.38.9.2.4.4 | 179.17 | The feedback phase is not defined, not in terms of protocol and not in terms of which frames are used | Define the feedback phase | Revised  TGay editor to make the changes shown in 11-18/441r1 under all headings that include CID 1375 |
| 1579 | 10.38.9.2.4.4 | 174.16 | Currently, there is no spec text for HBF grouping element Ng.  If details for HBF feedback are defined, the value of Ng shall be defined. | Define HBF feedback grouping element Ng | See resolution to CID 1375 |
| 1580 | 10.38.9.2.4.4 | 174.16 | If the values of HBF grouping element Ng are defined, subcarrier indices for compressed beamforming matrix shall be defined for each channel bonding case | Define subcarrier indices for compressed beamforming matrix | See resolution to CID 1375 |
| 1581 | 10.38.9.2.4.4 | 174.16 | Currently, there is no spec text for compressed beamforming report information.  If defined, quantization bit of psi and phi for compressed beamforming shall be defined | Define quantization bit of psi and phi | See resolution to CID 1375 |
| 1905 | 10.38.9.2.4.4 | 179.16 | Feedback for Hybrid BF needs to be finalized | finalize feedback | See resolution to CID 1375 |
| 2026 | 10.38.9.2.4.4 | 179.16 | The actual feedback format for the digital beamforming matrix is not defined. | Please define feedback format for SC and OFDM digital beamforming matrix. | See resolution to CID 1375 |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

***TGay Editor: Please make the following change on Pg 97 ln 19 (#1375, #1887, #1579, #1580, #1581, #1905, #1994, and #2026):***

* + - 1. MIMO BF Feedback frame format

The MIMO BF Feedback frame is an Action No Ack frame. The format of a MIMO BF Feedback frame Action field is shown in Table 17.

1. —MIMO BF Feedback frame Action field format

|  |  |
| --- | --- |
| Order | Information |
| 1 | Category |
| 2 | Unprotected DMG Action |
| 3 | Dialog Token |
| 4 | MIMO Feedback Control element |
| 5 | One or more Channel Measurement Feedback elements |
| 6 | Zero or more EDMG Channel Measurement Feedback elements |
| 7 | Zero or more Digital BF Feedback Elements |

The Category field is defined in 9.4.1.11 (Action field).

The Unprotected DMG Action field is defined in 9.6.22.1

The Dialog Token field is set to a value chosen by the STA sending the frame to uniquely identify the transaction.

The MIMO Feedback Control element is defined in 9.4.2.261

The Channel Measurement Feedback element is defined in 9.4.2.136

The EDMG Channel Measurement Feedback element is defined in 9.4.2.253

The Digital BF Feedback element is defined in 9.4.2.x

9.4.2.261.MIMO Feedback Control element

The MIMO Feedback Control element, as shown in Table 9-xxx (MIMO Feedback Control element format), is used to carry configuration information for accompanying Channel Measurement Feedback element and EDMG Channel Measurement Feedback element.

|  |  |  |
| --- | --- | --- |
| Table 9-xxx MIMO Feedback Control element format | | |
| Field | Size | Meaning |
| Element ID | 8 bits |  |
| Length | 8 bits |  |
| Element ID Extension | 8 bits |  |
| SU/MU | 1 bit | Sets to 1 to indicate SU-MIMO beamforming and sets to 0 to indicate MU-MIMO beamforming. |
| Link Type | 1 bit | Sets to 1 to indicate initiator link and sets to 0 otherwise. This field shall be set to 1 when the SU/MU field is set to 0. |
| MIMO FBCK-TYPE | 12bits |  |
| Digital Fbck Control Field | 22bits | Defines the requirements for the digital feedback type. |

The Element ID, Length and Element ID Extension fields are defined in 9.4.2.1 (General).

The MIMO FBCK-TYPE field is defined in Figure 61.

The Digital Fbck Control field is defined in Figure 9-x and is described in Figure 9-xxxx.

**Figure 9-x- Digital Fbck Control Field**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Index | *Nr* Index |  | Grouping | Codebook  Information | Feedback Type | Number of feedback matrices |
| Bits: | 3 | 3 | 2 | 2 | 1 | 1 | 10 |

The subfields of the MIMO Feedback Control field are defined in Table 9-xx (Subfield of MIMO Feedback Control field)

Table 9-xxxx-Subfield of Digital Feedback Control field

|  |  |
| --- | --- |
| ***Subfield*** | ***Meaning*** |
| Nc Index | Indicates the number of columns, Nc, in the beamforming feedback matrix minus one :  Set to 0 for Nc = 1  Set to 1 for Nc = 2  Set to 2 for Nc = 3  Set to 3 for Nc = 4  Set to 4 for Nc = 5  Set to 5 for Nc = 6  Set to 6 for Nc = 7  Set to 7 for Nc = 8 |
| Nr Index | Indicated the number of rows, Nr, in a beamforming feedback matrix minus one:  Set to 0 for Nr = 1  Set to 1 for Nr = 2  Set to 2 for Nr = 3  Set to 3 for Nr = 4  Set to 4 for Nr = 5  Set to 5 for Nr = 6  Set to 6 for Nr = 7  Set to 7 for Nr = 8 |
|  | Indicates the number of contiguous 2.16 GHz channels, the measurement was made for minus one:  Set to 0 for 2.16 GHz  Set to 1 for 4.32 GHz  Set to 2 for 6.48 GHz  Set to 3 for 8.64 GHz |
| Grouping | Indicates the subcarrier grouping, Ng, used for beamforming feedback matrix  Set to 0 for  Set to 1 for  Set to 2 for  Set to 3 for dynamic grouping; Reserved if dynamic grouping is not supported |
| Codebook  Information | Indicates the size of codebook entries:  If SU/MU field in MIMO Feedback control element is 1:  Set to 0 for 6 bits for , 4 bits for  Set to 1 reserved  If SU/MU field in MIMO Feedback control element is 0:  Set to 0 for 9 bits for , 7 bits for  Set to 1 reserved |
| Feedback Type | The Feedback Type Field indicates which type of feedback is provided  Set to 0 for uncompressed beamforming feedback in time domain (SC)  Set to 1 for compressed using Givens-Rotation in frequency domain (OFDM) |
| Number of feedback matrices or feedback taps | If FeedbackType is set to 0, = the number of feedback taps per element of the SC feedback matrix.  If FeedbackType is set to 1 and Grouping subfield is set to less than 3, is determined by Table 9-xx (Subcarriers for which a Compressed Beamforming Feedback Matrix subfield is sent back)  If FeedbackType is set to 1 and Grouping subfield is set to 3, specifies the number of subcarriers present in the Digital Beamforming Feedback Information minus one. |

***TGay Editor: Please make the following change on Pg 69 ln 19 (#1375, #1887, #1579, #1580, #1581, #1905, #1994, and #2026): Possible renumber as 9.4.2.254***

9.4.2.x Digital BF Feedback Element

The Digital BF Feedback Element is used by the MIMO BF Feedback (see 9.6.22.7 (MIMO BF Feedback frame format)) to carry explicit feedback information in the form of beamforming feedback matrices. The feedback information can be used by a transmit beamformer to determine digital beamforming steering matrices Q. This process is described in 10.38.9.2.4 (Hybrid beamforming for SU-MIMO and MU-MIMO). When Digital BF Feedback Report is part of the MIMO Feedback Frame, the SNR fields within the Channel Measurement Feedback are interpreted as average SNR per stream, as defined in Section 9.4.2.136 in Table 9-240.

The size of the Digital BF Feedback Element depends on the values in the Digital Feedback Control field. Digital BF Feedback information is always included in the Digital BF Feedback element.

When Feedback Type is set to 0 (for SC transmission), the digital BF Feedback Information contains Nsc digital beamforming matrices. When Nsc>1 a Tap Delay Field, indicating the tap to which each digital beamforming matrix corresponds is additionally present. The digital beamforming information in time domain can be represented as a matrix function V given by

where *n1=0,* Tc/NCB is defined in Table 67, is the digital beamforming matrix per tap, is the delay of the kth tap and .

The elements of the digital beamforming matrix per tap are contained in the field Digital Beamforming Feedback Matrix k, in uncompressed form, indexed such that the (i,j)th element of is the (j-1)Nr+(i-1) –th entry of the k-th Digital Beamforming Feedback Matrix Field, shown in Table (Description of the Beamforming Feedback matrix field for one tap) and i=1..Nr, j=1,..Nc. Each digital feedback component is represented as 8bit real part, followed by the 8 bit imaginary part. The taps *nk>0* for which each of the beamforming feedback matrices are computed are indicated in the field Tap Delay*.*

Table .. Description of the “Digital Beamforming Feedback Matrix k” subfield in SC mode.

|  |  |  |  |
| --- | --- | --- | --- |
| Digital Beamforming Feedback Matrix k | Digital Feedback Component 1 | 16 | Digital beamforming coefficient(s) for stream 1 to TX transmit chain 1 |
| Digital Feedback Component 2 | 16 | Digital beamforming coefficient(s) for stream 1 to TX transmit chain 2 |
| … | … | … |
| Digital Feedback Component 1 Nr x Nc | 16 | Digital beamforming coefficient for stream Nr to TX transmit chain Nc. |

When Feedback Type is set to 1 (for OFDM transmission), the Digital BF Feedback information contains the digital beamforming feedback matrices, in compressed form with elements indexed, first, by matrix angles in the order shown in Table 9-xx (Order of angles in the Digital BF Feedback element) and, second, by data subcarrier index from lowest frequency to highest frequency. The explanation on how these angles are generated from the beamforming feedback matrix V is given in 19.3.12.3.6 (Compressed beamforming feedback matrix). In case of channel aggregation, in which the total number of spatial streams is evenly divided between the primary and secondary channels (see 30.3.3.3.2.3 Definition of EDMG SC mode and EDMG OFDM mode PPDUs), the number of rows and columns in beamforming feedback matrix shall be an even number. The number of rows in each aggregated channel’s beamforming feedback matrix shall be Nr/2 and the number of columns in each aggregated channel’s beamforming feedback matrix shall be Nc/2.

The Digital BF Feedback element has the structure and order defined in Table 9-xx (Digital BF Feedback element), where the value of is defined in Table 9.xx.

In case of channel aggregation, the value of is composed of feedback bits for each aggregated channel.

For SC, Grouping is not used, so the Grouping subfield is set to 0 when the Feedback Type is set to 0.

For OFDM, Grouping can be employed in the feedback. When the Feedback Type is set to 1, the Grouping subfield in the Digital Feedback Control Field may take on values from 0 to 3. When the Grouping subfield is set to 0-2, the subcarrier indices for which the beamforming matrices are computed is defined in in Table 9-xx (Subcarriers for which a Compressed Beamforming Feedback Matrix subfield is sent back).

When Grouping subfield in Digital Feedback Control field is set to 3, the Digital BF Feedback Element contains a differential subcarrier index field, marking the number subcarriers between each two adjacent subcarriers within the feedback report. And the subcarrier index set shall be constructed such that:

It is a subset of the subcarrier index set defined for Ng=2 and the corresponding NCB in Table 9-xx . (Subcarriers for which a Compressed Beamforming Feedback Matrix subfield is sent back) such that the edge subcarriers and the subcarriers with indices -2 and 2 are present within the feedback report and the distance between subcarriers within the feedback report is one of the values in {1,2,4, 8, 16, 32}.

Table 9.xx Digital BF Feedback element

|  |  |  |  |
| --- | --- | --- | --- |
| **Field** | **Size** | | **Meaning** |
| Element ID | 8 bits | |  |
| Length | 8 bits | |  |
| Digital Beamforming Feedback Information | Digital Beamforming Feedback Matrix 1 | bits,  (The value is defined in Table 9.xx Definition of ) | If Feedback Type is set to 0, represents the beamforming matrix in the time domain for SC for the 1st tap as described above.  If Feedback Type is set to 1, represents the beamforming matrix for the 1st subcarrier, indexed by matrix angles in the order shown in Table 9.67 |
|  |  |  |
| Digital Beamforming Feedback Matrix | bits  (The value is defined in Table 9.xx Definition of ) | If Feedback Type is set to 0, represents the beamforming matrix in the time domain for SC for the Nscth tap as described above.  If Feedback Type is set to 1, represents the beamforming matrix for the Nscth subcarrier, indexed by matrix angles in the order shown in Table 9.67 |
| Differential Subcarrier Index | Differential subcarrier index scidx(0)-scidx(1) | 3 | When Grouping field is set to 3, this field represents the number of subcarriers between scidx(0) and scidx(1). Otherwise it is not present.  It is set to j to indicate the distance between the scidx(0) and scidx(1) is 2^j  Set to 0 to indicate 1  Set to 1 to indicate 2  Set to 2 to indicate 4  Set to 3 to indicate 8  Set to 4 to indicate 16  Set to 5 to indicate 32  Values 6 and 7 are reserved. |
|  |  |  |
| Differential subcarrier index scidx() - scidx() | 3 | When Grouping field is set to 3, this field represents the number of subcarriers between scidx() and scidx(). Otherwise it is not present.  It is set to *j* to indicate the distance between the scidx()and scidx() is 2^j |
| Tap Delay | Relative Tap Delay 2 | 12 | When Feedback Type is set to 0 and , this field represents the delay of tap #2 in units of TC/NCB relative to Tap 1. Otherwise it is not present. |
| … | ... | … |
| Relative Tap Delay Nsc | 12 | When Feedback Type is set to 0 and , this field represents the delay of tap #Nsc in units of TC/NCB relative to Tap 1. Otherwise it is not present. |

The value of is defined according to the value of the feedback type as defined in Table 9.xx

Table 9.xx Definition of

|  |  |  |  |
| --- | --- | --- | --- |
| **Feedback Type** | **Size (bits)** | | |
| Single channel/Channel bonding | Channel aggregation | |
|  |  |  | 2.16GHz or 4.32GHz channel which contains primary channel |
|  | 2.16GHz or 4.32GHz channel which does not contain primary channel |
|  | ,  with and | with and | 2.16GHz or 4.32GHz channel which contains primary channel |
|  | 2.16GHz or 4.32GHz channel which does not contain primary channel |

In Table 9-67 (Order of angles in the Digital BF feedback report field),

Nc is the number of columns in a compressed beamforming feedback matrix determined by the Nc Index field of the MIMO Feedback Control field,

Nr is the number of rows in a compressed beamforming feedback matrix determined by the Nr Index field of the MIMO Feedback Control field.

Table 9-67. Order of angles in the Digital BF Feedback Information when Feedback Type=1

|  |  |  |
| --- | --- | --- |
| Size of V  (Nr × Nc) | Number of  angles (Na) | The order of angles in the Digital BF Feedback Matrix  Subfield |
| 2×1 | 2 | 11, ψ 21 |
| 2×2 | 2 | 11, ψ 21 |
| 3×1 | 4 | 11, 21, ψ1, ψ1 |
| 3×2 | 6 | , ψ |
| 3×3 | 6 | , ψ |
| 4×1 | 6 |  |
| 4×2 | 10 | , ψ, ψ |
| 4×3 | 12 | ,, ψ, ψ, ψ |
| 4×4 | 12 | ,, ψ, ψ, ψ |
| 5×1 | 8 | 11, 21, 31, 41, ψ21, ψ31, ψ41, ψ51 |
| 5×2 | 14 | 11, 1, 31, Ф41, ψ21, ψ31, ψ41, ψ51, 22, 32, 42, ψ32, ψ42, ψ52 |
| 5×3 | 18 | 11, 21, 31, 41, ψ21, ψ31, ψ41, ψ51, 22, 32, 42, ψ32, ψ42, ψ52, 33, 43, ψ43, ψ53 |
| 5×4 | 20 | 11, 21, 31, 41, ψ21, ψ31, ψ41, ψ51, 22, 32, 42, ψ32, ψ42, ψ52, 33, 43, ψ43, ψ53, 44, ψ54 |
| 5×5 | 20 | 11, 21, 31, 41, ψ21, ψ31, ψ41, ψ51, 22, 32, 42, ψ32, ψ42, ψ52, 33, 43, ψ43, ψ53, 44, ψ54 |
| 6×1 | 10 | 11, 21, 31, 41, 51, ψ21, ψ31, ψ41, ψ51, ψ61 |
| 6×2 | 18 | 11, 21, 31, 41, 51, ψ21, ψ31, ψ41, ψ51, ψ61, 22, 32, 42, 52, ψ32, ψ42, ψ52, ψ62 |
| 6×3 | 24 | 11, 21, 31, 41, 51, ψ21, ψ31, ψ41, ψ51, ψ61, 22, 32, 42, 52, ψ32, ψ42, ψ52, ψ62, 33, 43, 53, ψ43, ψ53, ψ63 |
| 6×4 | 28 | 11, 21, 31, 41, 51, ψ21, ψ31, ψ41, ψ51, ψ61, 22, 32, 42, 52, ψ32, ψ42, ψ52, ψ62, 33, 43, 53, ψ43, ψ53, ψ63, 44, 54, ψ54, ψ64 |
| 6×5 | 30 | 11, 21, 31, 41, 51, ψ21, ψ31, ψ41, ψ51, ψ61, 22, 32, 42, 52, ψ32, ψ42, ψ52, ψ62, 33, 43, 53, ψ43, ψ53, ψ63, 44, 54, ψ54, ψ64, 55, ψ65 |
| 6×6 | 30 | 11, 21, 31, 41, 51, ψ21, ψ31, ψ41, ψ51, ψ61, 22, 32, 42, 52, ψ32, ψ42, ψ52, ψ62, 33, 43, 53, ψ43, ψ53, ψ63, 44, 54, ψ54, ψ64, 55, ψ65 |
| 7×1 | 12 | 11, 21, 31, 41, 51, 61, ψ21, ψ31, ψ41, ψ51, ψ61, ψ71 |
| 7×2 | 22 | 11, 21, 31, 41, 51, 61, ψ21, ψ31, ψ41, ψ51, ψ61, ψ71, 22, 32, 42, 52, 62, ψ32, ψ42, ψ52, ψ62, ψ72 |
| 7×3 | 30 | 11, 21, 31, 41, 51, 61, ψ21, ψ31, ψ41, ψ51, ψ61, ψ71, 22, 32, 42, 52, 62, ψ32, ψ42, ψ52, ψ62, ψ72, 33, 43, 53, 63, ψ43, ψ53, ψ63, ψ73 |
| 7×4 | 36 | 11, 21, 31, 41, 51, 61, ψ21, ψ31, ψ41, ψ51, ψ61, ψ71, 22, 32, 42, 52, 62, ψ32, ψ42, ψ52, ψ62, ψ72, 33, 43, 53, 63, ψ43, ψ53, ψ63, ψ73, 44, 54, 64, ψ54, ψ64, ψ74 |
| 7×5 | 40 | 11, 21, 31, 41, 51, 61, ψ21, ψ31, ψ41, ψ51, ψ61, ψ71, 22, 32, 42, 52, 62, ψ32, ψ42, ψ52, ψ62, ψ72, 33, 43, 53, 63, ψ43, ψ53, ψ63, ψ73, 44, 54, 64, ψ54, ψ64, ψ74, 55, 65, ψ65, ψ75 |
| 7×6 | 42 | 11, 21, 31, 41, 51, 61, ψ21, ψ31, ψ41, ψ51, ψ61, ψ71, 22, 32, 42, 52, 62, ψ32, ψ42, ψ52, ψ62, ψ72, 33, 43, 53, 63, ψ43, ψ53, ψ63, ψ73, 44, 54, 64, ψ54, ψ64, ψ74, 55, 65, ψ65, ψ75, 66, ψ76 |
| 7×7 | 42 | 11, 21, 31, 41, 51, 61, ψ21, ψ31, ψ41, ψ51, ψ61, ψ71, 22, 32, 42, 52, 62, ψ32, ψ42, ψ52, ψ62, ψ72, 33, 43, 53, 63, ψ43, ψ53, ψ63, ψ73, 44, 54, 64, ψ54, ψ64, ψ74, 55, 65, ψ65, ψ75, 66, ψ76 |
| 8×1 | 14 | 11, 21, 31, 41, 51, 61, 71, ψ21, ψ31, ψ41, ψ51, ψ61, ψ71, ψ81 |
| 8×2 | 26 | 11, 21, 31, 41, 51, 61, 71, ψ21, ψ31, ψ41, ψ51, ψ61, ψ71, ψ81, 22, 32, 42, 52, 62, 72, ψ32, ψ42, ψ52, ψ62, ψ72, ψ82 |
| 8×3 | 36 | 11, 21, 31, 41, 51, 61, 71, ψ21, ψ31, ψ41, ψ51, ψ61, ψ71, ψ81, 22, 32, 42, 52, 62, 72, ψ32, ψ42, ψ52, ψ62, ψ72, ψ82, 33, 43, 53, φ63, 73, ψ43, ψ53, ψ63, ψ73, ψ83 |
| 8×4 | 44 | 11, 21, 31, 41, 51, 61, 71, ψ21, ψ31, ψ41, ψ51, ψ61, ψ71, ψ81, 22, 32, 42, 52, 62, 72, ψ32, ψ42, ψ52, ψ62, ψ72, ψ82, 33, 43, 53, 63, 73, ψ43, ψ53, ψ63, ψ73, ψ83, 44, 54, 64, 74, ψ54, ψ64, ψ74, ψ84 |
| 8×5 | 50 | 11, 21, 31, 41, 51, 61, 71, ψ21, ψ31, ψ41, ψ51, ψ61, ψ71, ψ81, 22, 32, 42, 52, 62, 72, ψ32, ψ42, ψ52, ψ62, ψ72, ψ82, 33, 43, 53, 63, 73, ψ43, ψ53, ψ63, ψ73, ψ83, 44, 54, 64, 74, ψ54, ψ64, ψ74, ψ84, 55, 65, 75, ψ65, ψ75, ψ85 |
| 8×6 | 54 | 11, 21, 31, 41, 51, 61, 71, ψ21, ψ31, ψ41, ψ51, ψ61, ψ71, ψ81, 22, 32, 42, 52, 62, 72, ψ32, ψ42, ψ52, ψ62, ψ72, ψ82, 33, 43, 53, 63, 73, ψ43, ψ53, ψ63, ψ73, ψ83, 44, 54, 64, 74, ψ54, ψ64, ψ74, ψ84, 55, 65, 75, ψ65, ψ75, ψ85, 66, 76, ψ76, ψ86 |
| 8×7 | 56 | 11, 21, 31, 41, 51, 61, 71, ψ21, ψ31, ψ41, ψ51, ψ61, ψ71, ψ81, 22, 32, 42, 52, 62, 72, ψ32, ψ42, ψ52, ψ62, ψ72, ψ82, 33, 43, 53, 63, 73, ψ43, ψ53, ψ63, ψ73, ψ83, 44, 54, 64, 74, ψ54, ψ64, ψ74, ψ84, 55, 65, 75, ψ65, ψ75, ψ85, 66, 76, ψ76, ψ86, 77, ψ87 |
| 8×8 | 56 | 11, 21, 31, 41, 51, 61, 71, ψ21, ψ31, ψ41, ψ51, ψ61, ψ71, ψ81, 22, 32, 42, 52, 62, 72, ψ32, ψ42, ψ52, ψ62, ψ72, ψ82, 33, 43, 53, 63, 73, ψ43, ψ53, ψ63, ψ73, ψ83, 44, 54, 64, 74, ψ54, ψ64, ψ74, ψ84, 55, 65,  75, ψ65, ψ75, ψ85, 66, 76, ψ76, ψ86, 77, ψ87 |

The angles are quantized as defined in Table 9-68 (Quantization of angles).

Table 9-68 (Quantization of angles).

|  |  |
| --- | --- |
| Quantized | Quantized |
| radians  where  is the number of bits used to quantize (defined by the Codebook Information field of the MIMO Feedback Control field ) | radians  where  is the number of bits used to quantize (defined by the Codebook Information field of the MIMO Feedback Control field) |

Table 9-xx . Subcarriers for which a Compressed Beamforming Feedback Matrix subfield is sent back

|  |  |  |  |
| --- | --- | --- | --- |
| NCB | Ng | Nsc | Subcarriers for which Compressed Feedback Beamforming Matrix subfield  is sent: scidx(0), scidx(1), …, scidx(Nsc-1)  Note: DC subcarriers (0, ±1) are skipped. |
| 1 | 2 | 178 | -177,-176,-174,-172,-170,-168,-166,-164,-162,-160,-158,-156,-154,-152,-150,-148,-146,-144,-142,-140,-138,-136,-134,-132,-130,-128,-126,-124,-122,-120,-118,-116,-114,-112,-110,-108,-106,-104,-102,-100,-98,-96,-94,-92,-90,-88,-86,-84,-82,-80,-78,-76,-74,-72,-70,-68,-66,-64,-62,-60,-58,-56,-54,-52,-50,-48,-46,-44,-42,-40,-38,-36,-34,-32,-30,-28,-26,-24,-22,-20,-18,-16,-14,-12,-10,-8,-6,-4,-2,2,4,6,8,10,12,14,16, 18,20, 22,24,26,28,30,32,34,36,38,40,42,44,46,48,50,52,54,56,58,60,62,64,66,68,70,72,74,76,78,80,82,84,86,88,90,92,94,96,98,100,102,104,106,108,110,112,114,116,118,120,122,124,126,128,130,132,134,136,138,140,142,144,146,148,150,152,154,156,158,160,162,164,166,168,170,172,174,176,177 |
| 4 | 90 | -177, -174,-170,-166,-162,-158,-154,-150,-146,-142,-138,-134,-130,-126,-122,-118,-114,-110,-106,-102,-98,-94,-90,-86,-82,-78,-74,-70,-66,-62,-58,-54,-50,-46,-42,-38,-34,-30,-26,-22,-18,-14,-10,-6,-2,2,6,10,14,18,22,26, 30,34, 38,42, 46,50,54, 58, 62, 66, 70,74,78,82, 86,90,94,98,102,106,110,114,118,122,126, 130,134,138,142,146, 150, 154,158,162,166,170,174,177 |
| 8 | 46 | -177,-170,-162,-154,-146,-138,-130,-122,-114,-106,-98,-90,-82,-74,-66,-58,-50,-42,-34,-26,-18,-10,-2,2,10,18,26, 34, 42, 50,58,66,74,82, 90,98,106,114,122, 130, 138, 146, 154, 162, 170, 177 |
| 2 | 2 | 388 | -386,-385,-383,-381,-379,-377,-375,-373,-371,-369,-367,-365,-363,-361,-359,-357,-355,-353,-351,-349,-347,-345,-343,-341,-339,-337,-335,-333,-331,-329,-327,-325,-323,-321,-319,-317,-315,-313,-311,-309,-307,-305,-303,-301,-299,-297,-295,-293,-291,-289,-287,-285,-283,-281,-279,-277,-275,-273,-271,-269,-267,-265,-263,-261,-259,-257,-255,-253,-251,-249,-247,-245,-243,-241,-239,-237,-235,-233,-231,-229,-227,-225,-223,-221,-219,-217,-215,-213,-211,-209,-207,-205,-203,-201,-199,-197,-195,-193,-191,-189,-187,-185,-183,-181,-179,-177,-176,-174,-172,-170,-168,-166,-164,-162,-160,-158,-156,-154,-152,-150,-148,-146,-144,-142,-140,-138,-136,-134,-132,-130,-128,-126,-124,-122,-120,-118,-116,-114,-112,-110,-108,-106,-104,-102,-100,-98,-96,-94,-92,-90,-88,-86,-84,-82,-80,-78,-76,-74,-72,-70,-68,-66,-64,-62,-60,-58,-56,-54,-52,-50,-48,-46,-44,-42,-40,-38,-36,-34,-32,-30,-28,-26,-24,-22,-20,-18,-16,-14,-12,-10,-8,-6,-4,-2,2,4,6,8,10,12,14,16,18,20,22,24,26,28,30, 32,34,36, 38,40,42, 44,46,48,50,52,54,56,58,60,62,64,66,68,70,72,74,76,78,80,82,84,86,88,90,92,94,96,98,100,102,104,106,108,110,112,114,116,118,120,122,124,126,128,130,132,134,136,138,140,142,144,146,148,150,152,154,156,158,160,162,164,166,168,170,172,174,176,177,179,181,183,185,187,189,191,193,195,197,199,201,203,205,207,209,211,213,215,217,219,221,223,225,227,229,231,233,235,237,239,241,243,245,247,249,251,253,255,257,259,261,263,265,267,269,271,273,275,277,279,281,283,285,287,289,291,293,295,297,299,301,303,305,307,309,311,313,315,317,319,321,323,325,327,329,331,333,335,337,339,341,343,345,347,349,351,353,355,357,359,361,363,365,367,369,371,373,375,377,379,381,383,385,386 |
| 4 | 196 | -386,-385,-381,-377,-373,-369,-365,-361,-357,-353,-349,-345,-341,-337,-333,-329,-325,-321,-317,-313,-309,-305,-301,-297,-293,-289,-285,-281,-277,-273,-269,-265,-261,-257,-253,-249,-245,-241,-237,-233,-229,-225,-221,-217,-213,-209,-205,-201,-197,-193,-189,-185,-181,-177,-174,-170,-166,-162,-158,-154,-150,-146,-142,-138,-134,-130,-126,-122,-118,-114,-110,-106,-102,-98,-94,-90,-86,-82,-78,-74,-70,-66,-62,-58,-54,-50,-46,-42,-38,-34,-30,-26,-22,-18,-14,-10,-6,-2,2,6,10,14,18,22,26, 30,34, 38, 42,46,50,54,58,62,66,70,74,78,82,86,90,94,98,102,106,110,114,118,122,126,130,134,138,142,146,150,154,158,162,166,170,174,177,181,185,189,193,197,201,205,209,213,217,221,225,229,233,237,241,245,249,253,257,261,265,269,273,277,281,285,289,293,297,301,305,309,313,317,321,325,329,333,337,341,345,349,353,357,361,365,369,373,377,381,385,386 |
| 8 | 101 | -386, -385,-377,-369,-361,-353,-345,-337,-329,-321,-313,-305, -297,-289,-281,-273,-265,-257,-249,-241,-233,-225,-217, -209,-201,-193,-185, -177,-170,-162, -154,-146,-138,-130, -122,-114,-106,-98,-90,-82,-74,-66,-58,-50,-42,-34,-26, -18, -10,-2,2,10,18, 26,34, 42, 50,58,62, 70,78,86, 94,102, 110, 118, 126, 134,142,150,158,166,174, 177, 185, 193,201,209,217, 225, 233,241,249,257,265, 273,281,289,297,305, 313,321,329, 337,345,353,361, 369,377,385, 386 |
| 3 | 2 | 598 | -596,-594,-592,-590,-588,-586,-584,-582,-580,-578,-576,-574,-572,-570,-568,-566,-564,-562,-560,-558,-556,-554,-552,-550,-548,-546,-544,-542,-540,-538,-536,-534,-532,-530,-528,-526,-524,-522,-520,-518,-516,-514,-512,-510,-508,-506,-504,-502,-500,-498,-496,-494,-492,-490,-488,-486,-484,-482,-480,-478,-476,-474,-472,-470,-468,-466,-464,-462,-460,-458,-456,-454,-452,-450,-448,-446,-444,-442,-440,-438,-436,-434,-432,-430,-428,-426,-424,-422,-420,-418,-416,-414,-412,-410,-408,-406,-404,-402,-400,-398,-396,-394,-392,-390,-388,-386,-385,-383,-381,-379,-377,-375,-373,-371,-369,-367,-365,-363,-361,-359,-357,-355,-353,-351,-349,-347,-345,-343,-341,-339,-337,-335,-333,-331,-329,-327,-325,-323,-321,-319,-317,-315,-313,-311,-309,-307,-305,-303,-301,-299,-297,-295,-293,-291,-289,-287,-285,-283,-281,-279,-277,-275,-273,-271,-269,-267,-265,-263,-261,-259,-257,-255,-253,-251,-249,-247,-245,-243,-241,-239,-237,-235,-233,-231,-229,-227,-225,-223,-221,-219,-217,-215,-213,-211,-209,-207,-205,-203,-201,-199,-197,-195,-193,-191,-189,-187,-185,-183,-181,-179,-177,-176,-174,-172,-170,-168,-166,-164,-162,-160,-158,-156,-154,-152,-150,-148,-146,-144,-142,-140,-138,-136,-134,-132,-130,-128,-126,-124,-122,-120,-118,-116,-114,-112,-110,-108,-106,-104,-102,-100,-98,-96,-94,-92,-90,-88,-86,-84,-82,-80,-78,-76,-74,-72,-70,-68,-66,-64,-62,-60,-58,-56,-54,-52,-50,-48,-46,-44,-42,-40,-38,-36,-34,-32,-30,-28,-26,-24,-22,-20,-18,-16,-14,-12,-10,-8,-6,-4,-2,2,4,6,8,10,12,14, 16,18,20,22,24,26,28,30,32,34,36,38,40,42,44,46,48,50,52,54,56,58,60,62,64,66,68,70,72,74,76,78,80,82,84,86,88,90,92,94,96,98,100,102,104,106,108,110,112,114,116,118,120,122,124,126,128,130,132,134,136,138,140,142,144,146,148,150,152,154,156,158,160,162,164,166,168,170,172,174,176,177,179,181,183,185,187,189,191,193,195,197,199,201,203,205,207,209,211,213,215,217,219,221,223,225,227,229,231,233,235,237,239,241,243,245,247,249,251,253,255,257,259,261,263,265,267,269,271,273,275,277,279,281,283,285,287,289,291,293,295,297,299,301,303,305,307,309,311,313,315,317,319,321,323,325,327,329,331,333,335,337,339,341,343,345,347,349,351,353,355,357,359,361,363,365,367,369,371,373,375,377,379,381,383,385,386,388,390,392,394,396,398,400,402,404,406,408,410,412,414,416,418,420,422,424,426,428,430,432,434,436,438,440,442,444,446,448,450,452,454,456,458,460,462,464,466,468,470,472,474,476,478,480,482,484,486,488,490,492,494,496,498,500,502,504,506,508,510,512,514,516,518,520,522,524,526,528,530,532,534,536,538,540,542,544,546,548,550,552,554,556,558,560,562,564,566,568,570,572,574,576,578,580,582,584,586,588,590,592,594,596 |
| 4 | 302 | -596,-594,-590,-586,-582,-578,-574,-570,-566,-562,-558,-554,-550,-546,-542,-538,-534,-530,-526,-522,-518,-514,-510,-506,-502,-498,-494,-490,-486,-482,-478,-474,-470,-466,-462,-458,-454,-450,-446,-442,-438,-434,-430,-426,-422,-418,-414,-410,-406,-402,-398,-394,-390, -386, -385,-381,-377,-373,-369,-365,-361,-357,-353,-349,-345,-341,-337,-333,-329,-325,-321,-317,-313,-309,-305, -301, -297,-293,-289,-285,-281, -277,-273,-269,-265,-261,-257,-253,-249,-245,-241,-237,-233,-229,-225,-221,-217, -213, -209,-205,-201,-197,-193,-189,-185,-181,-177,-174, -170,-166,-162, -158,-154,-150,-146,-142,-138,-134,-130, -126, -122,-118,-114,-110,-106,-102,-98,-94,-90,-86,-82,-78,-74,-70,-66,-62,-58,-54,-50,-46,-42,-38,-34,-30,-26,-22, -18,-14, -10,-6,-2,2,6,10,14,18,22, 26,30,34,38, 42, 46,50,54,58,62,66, 70,74,78,82,86,90, 94,98,102, 106, 110,114, 118, 122,126, 130, 134,138,142,146,150,154,158,162,166,170,174, 177, 181,185,189,193,197,201,205, 209,213, 217, 221, 225,229, 233,237,241, 245,249, 253, 257,261,265,269, 273,277,281, 285,289,293,297,301,305,309, 313,317,321, 325, 329, 333, 337,341,345,349, 353, 357,361,365,369,373,377,381,385, 386, 390,394,398, 402,406,410,414, 418,422, 426,430,434,438,442,446, 450,454,458, 462, 466,470, 474, 478, 482,486, 490,494,498,502,506,510,514,518,522,526, 530,534,538,542, 546,550, 554, 558,562,566,570,574, 578,582,586,590,594, 596 |
| 8 | 155 | -596,-594,-586,-578,-570,-562,-554,-546,-538,-530,-522,-514,-506,-498,-490,-482,-474,-466,-458,-450,-442,-434,-426,-418,-410,-402,-394, -386, -385,-377,-369,-361,-353,-345,-337,-329,-321,-313,-305, -297,-289,-281,-273,-265,-257,-249,-241,-233,-225,-217, -209,-201,-193,-185, -177,-170,-162, -154,-146,-138,-130, -122,-114,-106,-98,-90,-82,-74,-66,-58,-50,-42,-34,-26, -18, -10,-2,2,10,18, 26,34, 42, 50,58,62, 70,78, 86, 94,102, 110, 118, 126, 134,142,150,158,166,174, 177, 185, 193,201, 209,217, 225, 233,241,249,257,265, 273,281,289,297,305, 313,321,329, 337,345,353, 361,369,377, 385, 386,394,402,410, 418, 426,434,442, 450, 458, 466, 474, 482, 490,498,506, 514, 522,530,538,546,554, 562,570, 578,586,594, 596 |
| 4 | 2 | 808 | -805,-804,-802,-800,-798,-796,-794,-792,-790,-788,-786,-784,-782,-780,-778,-776,-774,-772,-770,-768,-766,-764,-762,-760,-758,-756,-754,-752,-750,-748,-746,-744,-742,-740,-738,-736,-734,-732,-730,-728,-726,-724,-722,-720,-718,-716,-714,-712,-710,-708,-706,-704,-702,-700,-698,-696,-694,-692,-690,-688,-686,-684,-682,-680,-678,-676,-674,-672,-670,-668,-666,-664,-662,-660,-658,-656,-654,-652,-650,-648,-646,-644,-642,-640,-638,-636,-634,-632,-630,-628,-626,-624,-622,-620,-618,-616,-614,-612,-610,-608,-606,-604,-602,-600,-598,-596,-594,-592,-590,-588,-586,-584,-582,-580,-578,-576,-574,-572,-570,-568,-566,-564,-562,-560,-558,-556,-554,-552,-550,-548,-546,-544,-542,-540,-538,-536,-534,-532,-530,-528,-526,-524,-522,-520,-518,-516,-514,-512,-510,-508,-506,-504,-502,-500,-498,-496,-494,-492,-490,-488,-486,-484,-482,-480,-478,-476,-474,-472,-470,-468,-466,-464,-462,-460,-458,-456,-454,-452,-450,-448,-446,-444,-442,-440,-438,-436,-434,-432,-430,-428,-426,-424,-422,-420,-418,-416,-414,-412,-410,-408,-406,-404,-402,-400,-398,-396,-394,-392,-390,-388,-386,-385,-383,-381,-379,-377,-375,-373,-371,-369,-367,-365,-363,-361,-359,-357,-355,-353,-351,-349,-347,-345,-343,-341,-339,-337,-335,-333,-331,-329,-327,-325,-323,-321,-319,-317,-315,-313,-311,-309,-307,-305,-303,-301,-299,-297,-295,-293,-291,-289,-287,-285,-283,-281,-279,-277,-275,-273,-271,-269,-267,-265,-263,-261,-259,-257,-255,-253,-251,-249,-247,-245,-243,-241,-239,-237,-235,-233,-231,-229,-227,-225,-223,-221,-219,-217,-215,-213,-211,-209,-207,-205,-203,-201,-199,-197,-195,-193,-191,-189,-187,-185,-183,-181,-179,-177,-176,-174,-172,-170,-168,-166,-164,-162,-160,-158,-156,-154,-152,-150,-148,-146,-144,-142,-140,-138,-136,-134,-132,-130,-128,-126,-124,-122,-120,-118,-116,-114,-112,-110,-108,-106,-104,-102,-100,-98,-96,-94,-92,-90,-88,-86,-84,-82,-80,-78,-76,-74,-72,-70,-68,-66,-64,-62,-60,-58,-56,-54,-52,-50,-48,-46,-44,-42,-40,-38,-36,-34,-32,-30,-28,-26,-24,-22,-20,-18,-16,-14,-12,-10,-8,-6,-4,-2,2,4,6,8,10,12,14,16,18,20,22,24,26, 28,30,32,34,36, 38, 40,42,44,46,48,50,52,54,56,58,60,62,64,66,68,70,72,74,76,78,80,82,84,86,88,90,92,94,96,98,100,102,104,106,108,110,112,114,116,118,120,122,124,126,128,130,132,134,136,138,140,142,144,146,148,150,152,154,156,158,160,162,164,166,168,170,172,174,176,177,179,181,183,185,187,189,191,193,195,197,199,201,203,205,207,209,211,213,215,217,219,221,223,225,227,229,231,233,235,237,239,241,243,245,247,249,251,253,255,257,259,261,263,265,267,269,271,273,275,277,279,281,283,285,287,289,291,293,295,297,299,301,303,305,307,309,311,313,315,317,319,321,323,325,327,329,331,333,335,337,339,341,343,345,347,349,351,353,355,357,359,361,363,365,367,369,371,373,375,377,379,381,383,385,386,388,390,392,394,396,398,400,402,404,406,408,410,412,414,416,418,420,422,424,426,428,430,432,434,436,438,440,442,444,446,448,450,452,454,456,458,460,462,464,466,468,470,472,474,476,478,480,482,484,486,488,490,492,494,496,498,500,502,504,506,508,510,512,514,516,518,520,522,524,526,528,530,532,534,536,538,540,542,544,546,548,550,552,554,556,558,560,562,564,566,568,570,572,574,576,578,580,582,584,586,588,590,592,594,596,598,600,602,604,606,608,610,612,614,616,618,620,622,624,626,628,630,632,634,636,638,640,642,644,646,648,650,652,654,656,658,660,662,664,666,668,670,672,674,676,678,680,682,684,686,688,690,692,694,696,698,700,702,704,706,708,710,712,714,716,718,720,722,724,726,728,730,732,734,736,738,740,742,744,746,748,750,752,754,756,758,760,762,764,766,768,770,772,774,776,778,780,782,784,786,788,790,792,794,796,798,800,802,804,805 |
| 4 | 409 | -805, -804,-800,-796,-792,-788,-784,-780,-776,-772,-768,-764,-760,-756,-752,-748,-744,-740,-736,-732,-728,-724,-720,-716,-712,-708,-704,-700,-696,-692,-688,-684,-680,-676,-672,-668,-664,-660,-656,-652,-648,-644,-640,-636,-632,-628,-624,-620,-616,-612,-608,-604,-600,-596,-594,-590,-586,-582,-578,-574,-570,-566,-562,-558,-554,-550,-546,-542,-538,-534,-530,-526,-522,-518,-514,-510,-506,-502,-498,-494,-490,-486,-482,-478,-474,-470,-466,-462,-458,-454,-450,-446,-442,-438,-434,-430,-426,-422,-418,-414,-410,-406,-402,-398,-394,-390, -386, -385,-381,-377,-373,-369,-365,-361,-357,-353,-349,-345,-341,-337,-333,-329,-325,-321,-317,-313,-309,-305, -301, -297,-293,-289,-285,-281,-277,-273,-269,-265,-261,-257,-253,-249,-245,-241,-237,-233,-229,-225,-221,-217, -213, -209,-205,-201,-197,-193,-189,-185,-181, -177,-174,-170,-166,-162, -158,-154,-150,-146,-142,-138,-134,-130, -126, -122,-118,-114,-110,-106,-102,-98,-94,-90,-86,-82,-78,-74,-70,-66,-62,-58,-54,-50,-46,-42,-38,-34,-30,-26,-22, -18,-14, -10,-6,-2,2,6,10,14,18,22, 26,30,34,38, 42, 46,50,54,58,62,66, 70,74,78,82,86,90, 94,98,102,106, 110,114, 118, 122,126, 130, 134,138,142,146,150, 154,158,162,166,170,174, 177, 181,185,189,193, 197,201,205, 209,213, 217, 221, 225,229, 233,237,241, 245,249,253,257,261,265,269, 273,277,281, 285,289,293, 297,301,305,309, 313, 317,321, 325,329, 333, 337,341,345,349, 353, 357,361,365, 369,373,377,381,385, 386, 390,394,398,402,406,410,414, 418,422, 426,430, 434,438, 442,446, 450,454,458, 462, 466,470, 474,478, 482,486, 490,494,498,502, 506,510, 514, 518,522,526,530,534,538,542,546,550, 554, 558,562,566,570,574, 578,582,586, 590,594, 596, 596,600,604,608,612,616,620,624,628,632,636,640,644,648, 652, 656, 660,664,668, 672,676,680,684,688,692,696,700,704,708, 712,716,720,724,728, 732, 736,740,744,748, 752,756,760,764, 768, 772,776,780,784,788,792, 796,800,804, 805 |
| 8 | 209 | -805, -804,-796,-788,-780,-772,-764,-756,-748,-740,-732,-724,-716,-708,-700,-692,-684,-676,-668,-660,-652,-644,-636,-628,-620,-612,-604, 596,-594,-586,-578,-570,-562,-554,-546,-538,-530,-522,-514,-506,-498,-490,-482,-474,-466,-458,-450,-442,-434,-426,-418,-410,-402,-394, -386, -385,-377,-369,-361,-353,-345,-337,-329,-321,-313,-305, -297,-289,-281,-273,-265,-257,-249,-241,-233,-225,-217, -209,-201,-193,-185, -177,-170,-162, -154,-146,-138,-130, -122,-114,-106,-98,-90,-82,-74,-66,-58,-50,-42,-34,-26, -18, -10,-2,2,10,18, 26,34, 42, 50,58,62, 70,78,86, 94,102, 110, 118, 126, 134,142,150,158,166,174, 177, 185, 193,201,209,217, 225, 233,241,249,257,265, 273,281,289,297,305, 313,321,329, 337,345,353,361,369,377,385, 386,394,402,410, 418, 426,434,442, 450, 458, 466, 474, 482, 490,498,506,514,522,530,538,546,554, 562,570, 578,586,594, 596,604,612,620,628,636,644, 652, 660,668, 676,684,692, 700,708, 716,724,732,740,748, 756,764, 772,780,788, 796, 804, 805 |

**9.4.2.250.2 Beamforming field**

The Beamforming Capability field is defined in Figure 29.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | B0 B4 | B5 | B6 | B7 | B8 |
|  | Requested BRP SC Blocks | MU-MIMO Supported | MU-MIMO Supported | SU-MIMO Supported | Grant Required |
| Bits | 5 | 1 | 1 | 1 | 1 |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | B9 | B10 | B11 | B12 | B13 B14 | B15 | B16 B23 |
|  | DMG TRN RX Only Capable | First Path Training Supported | Hybrid Beamforming and MU-MIMO Supported | Hybrid Beamforming and SU-MIMO Supported | Largest Ng supported | Dynamic Grouping Supported | Reserved |
| Bits | 1 | 1 | 1 | 1 | 2 | 1 | 8 |

The Largest Ng supported subfield indicates largest Ng that the EDMG STA supports for the beamforming feedback matrix. Set to 00 for ; Set to 01 for ; Set to 10 for ; 11 is reserved

The Dynamic Grouping Supported subfield is set to 1 to indicate that the EDMG STA supports dynamic grouping.

**10.39.9.2.4.4 Feedback phase**

The feedback phase is used by the hybrid beamforming protocol to feed back the hybrid beamforming information to the transmitter for use in a subsequent hybrid beamforming transmission. The feedback is contained in the MIMO feedback frame and the content is as follows.

In the SC mode, when the BRP frame used during the sounding phase (10.39.9.2.4.3) had the DBF FBCK Req bit set to 1 within the DMG Refinement element, the MIMO Feedback Frame contains the Digital BF Element, as described in 9.4.2.x, carrying digital beamforming matrix information. When DBF FBCK Req =0, the MIMO feedback frame constains DMG and EDMG channel measurement.

In the OFDM mode, the MIMO Feedback frame contains the Digital BF Element, as described in 9.4.2.x, carrying digital beamforming matrix information.

**Straw Poll:**

* **Do you agree to accept comment resolutions as proposed in doc 11-18/0441r1?**