**3GPP TSG RAN WG1#100bis R1-2002717**

**e-Meeting, April 20th – 30th, 2020**

**Agenda item:** 7.2.6.1

**Source:** Moderator (Samsung)

**Title:** Feature lead summary#2 for MU-MIMO CSI

**Document for:** Discussion and Decision

# Introduction

The FL summary of the proposals in the submitted contributions ([1]-[12]) for Rel.16 NR\_eMIMO MU-CSI maintenance is given below and categorized under the following sections:

* *H*igh priority (essential)
* *E*ditorial
* *L*ow priority (non-essential)
* *U*E feature/capability related: This will be discussion as a part of UE feature session

Proposals on Rel.16 draft shadow CRs are not summarized here since they are to be discussed as a part of Rel.15 maintenance.

1. Summary

In reference to the categorization given in this section (2.1, 2.2, 2.3, and 2.4), it is **proposed** that:

1. The following offline agreement and conclusion outlined in issue H.0 be endorsed

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| **Offline agreement**: On the support of CSI reporting for BWP size < 24 PRBs, only wideband CSI reporting is supported with Rel.15 Type I single-panel codebook* Note: a draft CR has been submitted to Rel.15 maintenance session for MIMO

**Offline conclusion**: On the support of CSI reporting for BWP size < 24 PRBs, there is no consensus in supporting Rel.15 Type-I multi-panel, Rel.15 Type-II, and Rel.16 eType-II codebooks for wideband CSI reporting |

1. The combined TP in section 3 from issues H.1, H.2, E.1, E.2, and E.3, to be endorsed
	1. High priority (essential)

The following issues pertain to some ambiguity in the current description of the specs and may have some significant impact on spec completeness and/or UE implementation. Some of these issues, however, are still subject to further assessment.

**Table 1 High-priority (essential)**

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| --- | --- | --- |
| **Issue** | **Description/Proposal** | **Companies**  |
| H.0: SB size is undefined when NPRB < 24 PRBs | Note: This item needs *no further discussion* since offline agreement has been reached. **Action**: Endorse offline agreement [1]: * The resulting draft CRs (Rel.15 and Rel.16 shadow) will be endorsed in Rel.15 maintenance session for MIMO
 | Moderator  |
| H.1: For R=2, when the last sub-band size equals  | **TP for TS 38.214 for section 5.2.2.2.5****5.2.2.2.5 Enhanced Type II Codebook****<**Unchanged text is omitted>- If ~~,~~ ,one precoding matrix is indicated by the PMI corresponding to the last subband. If ~~,~~ , two precoding matrices are indicated by the PMI corresponding to the last subband: the first precoding matrix corresponds to the first PRBs of the last subband and the second precoding matrix corresponds to the last PRBs of the last subband.**<**Unchanged text is omitted> | vivo |
| -             If, one precoding matrix is indicated by the PMI corresponding to the last subband. If, two precoding matrices are indicated by the PMI corresponding to the last subband: the first precoding matrix corresponds to the first PRBs of the last subband and the second precoding matrix corresponds to the last  PRBs of the last subband. | Apple, Nokia/NSB, Samsung, CATT, OPPO, ZTE/Sanechips, Qualcomm, vivo |
| H.2: FD basis indicator is not reported for  | **TP for TS 38.214 section 5.2.2.2.5****5.2.2.2.5 Enhanced Type II Codebook****<**Unchanged text is omitted> vectors, , , are identified by (for ) and wherewhich are indicated by means of the indices (for ) and ( and ), where

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|  |
| . |

**<**Unchanged text is omitted>For all values of , for . If , the nonzero elements of , identified by are found from for , and from and , for , using as defined in Table 5.2.2.2.5-4 and the algorithm:  **<**Unchanged text is omitted>When and are known, and are found as follows:- If , and is not reported. If , , for , and is not reported. If , , where is given in Table 5.2.2.2.5-4 and where the indices are assigned such that increases as increases.<Unchanged text is omitted> | CATT, Nokia/NSB, Apple, Samsung, OPPO, ZTE/Sanechips, Qualcomm, vivo, Huawei/HiSi |

* 1. Editorial

The following issues pertain to relative simple editorial corrections which are valid and not expected to be contentious. Some textual refinement may be fitting and can be discussed.

**Table 2 Editorial**

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| **Issue #** | **Description/Proposal** | **Companies** |
| E.1: typographical correction  | **Table 5.2.2.2.5-5 and Table 5.2.2.2.6-2 of TS 38.214**Where ,and the mappings from to , , , , , , , , and from to , , , , , and , , , and are as described above, including the ranges of the constituent indices of and . | Huawei/HiSi, Apple, Nokia/NSB, Samsung, CATT, OPPO, ZTE/Sanechips, Qualcomm, vivo |
| E.2: TP to improve readability | **TS 38.214 V16.1.0****5.2.2.2.5 Enhanced Type II Codebook**<omitted text>The codebooks for 1-4 layers are given in Table 5.2.2.2.5-5, where , , for are obtained as in clause 5.2.2.2.3, and the quantities and are given by | OPPO, Apple, Nokia/NSB, Samsung, CATT, OPPO, ZTE/Sanechips, Qualcomm, vivo |
| E.3: typographical correction  | **Table 5.2.2.2.6-2 of TS 38.214**Where, and the mappings from to, , , , , , , and , and from to , , , , , and are as described above, including the ranges of the constituent indices of and . | LGE, Apple, Nokia/NSB, Samsung, CATT, OPPO, ZTE/Sanechips, Qualcomm, vivo |

* 1. Non-essential

The following issues pertain to non-essential proposals with some potential specification impact which are not intended to address incomplete or faulty functions. Therefore, they will not be discussed during the eMeeting.

**Table 3 Low-priority (non-essential)**

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| **Issue #** | **Proposal(s)** | **Companies** |
| N.1: support of eT2 and eT2 PS for BWP size < 24 PRBs | Support wideband CSI reporting with the following restrictions * R=1
* Discuss any additional restriction (such as rank, number of ports, L values etc.)
 | Samsung |
| N.2: Additional restriction on parameter combinations (L,p,beta) or K0 | Modify the definition of , by introducing a minimum value, , from one of the following alternatives1a. , to ensure that a UE can report one NZC per polarisation for rank 1b. , to ensure that a UE can report one NZC per polarisation for rank 2a. , to ensure that a UE can report one NZC for each selected beam for rank 2b. , to ensure that a UE can report one NZC for each selected beam for rank for  | Nokia/NSB |
| The UE is not expected to be configured with the number of CSI subbands less than the minimum number of subbands as the following, where the number of CSI subbands is the number of 1’s in *csi-ReportingBand*.* When *paramCombination-r16 = 1*, the minimum number of CSI subbands is 5 for up to rank 2 CSI reporting, and 9 for rank 3 CSI reporting, and 13 for rank 4 CSI reporting
* When *paramCombination-r16 = 2,* the minimum number of CSI subbands is 5 for rank 3 and rank 4 CSI reporting
* When *paramCombination-r16 = 3,* the minimum number of CSI subbands is 5 for rank 3 and rank 4 CSI reporting
 | Apple |
| For eType II and eType II port-selection, support if  | Qualcomm  |
| No need to have explicit restriction the parameter combination (L,p,beta) in the specification (can be handled by UE implementation) | ZTE/Sanechips, OPPO |
| N.3: Optimization on amplitude restriction inequality | **Proposal (TP)**:for , and . is the set of indices of the selected beams that are not associated with any of the sets of group indices g(k) for *k*=0,1,2,3 described in 5.2.2.3. | MotM/Lenovo |
| Not needed since this addresses case(s) that can be handled via UE implementation  | Samsung, Fraunhofer/HHI, Nokia/NSB |
| N.4: Optimization for IntS  | Replace the intermediate set size from to , i.e. when , the size of the intermediate set is give by for RI={1,2,3,4}, where is the number of FD bases selected for RI={1,2}.Reason: Agreement does not seem to address rank 3-4 with two independent M values: Agreement:1. For *N3*>19, IntS is window-based and fully parameterized with *Minitial*, indicating that the intermediate set consists of FD bases mod(*Minitial* *+ n, N3*), *n*=0,1, …, cid:image011.png@01D61247.26989480
	1. The value cid:image012.png@01D61247.26989480 where a is higher-layer configured from two possible values
 | Qualcomm |
| Current spec with the intermediate set size of is sufficient for rank 1-4 | Samsung, CATT, Fraunhofer/HHI, Nokia/NSB |
| N.5: Optimization for NNZC indication |  bits are used to indicate the strongest coefficients for RI=1, in which | CATT |

* 1. UE feature/capability related

The following issues pertain to remaining issues on UE features which include UE capability signaling aspect and revision on UE feature group description.

A summary for UE capability related proposals is given in the following table.

**Table 4 UE capability signaling**

|  |  |  |
| --- | --- | --- |
| **Issue #** | **Proposal(s)** | **Companies** |
| U.1: FD compression unit | On the number of PMI subbands, UE signals the maximum N3 value, which shall be larger than 19. Support to report it jointly with the maximum number of CSI-RS ports per resource, the maximum number of active CSI-RS resources per band and the maximum number of active CSI-RS ports per band. | ZTE/Sanechips |
| R = 2 and N3<=19 is an optional capability with a separate indication | vivo, Samsung |
| R=1 is mandatory and R=2 is optional | OPPO, Qualcomm  |
| U.2: Max # A-CSI settings | For FR2, the maximum number of configured aperiodic CSI reporting settings a UE can report is same as Rel-15* note: max = 4 in Rel.15
 | Vivo |
| No need for additional capability signalling in relation to eType-II and eType-II-PS (should be applicable to Rel.16 in general) | Samsung |
| U.3: L=6 for eType-II | Introduce additional capability signaling | Samsung |
| U.4: Rank 3-4 | Introduce additional capability signaling | Samsung |
| U.5: Amplitude restriction: reuse Rel.15 parameter amplitudeSubsetRestriction | Introduce additional capability signaling | Samsung |
| U.5: CPU occupation rule for R=2  | For R=2, support one of the following for CSI-RS resource and ports occupation* AltA: When R=2, the number of active resources and the number of active ports within the resources should be counted twice in both CSI-RS account and codebook capability accounting;
* AltB: In UE capability signalling, include whether supporting R=2 in each SupportedCSI-RS-Resource, i.e., SupportedCSI-RS-Resource contains {max number of ports per resource, max number of resources, max number of total ports, max number of PMIs per subband CQI}.
 | Qualcomm |
| Not supported | Samsung |
| U.6: Support for concurrent codebooks | In Rel-16, for UE capability of supporting concurrent codebooks with mixed types, support the following solution:* Report {codebook1, codebook2, max number of ports per resource, max number of resources, max number of ports} for concurrent codebook with mixed types
	+ Codebook1 is restricted to Type I (SP/MP), and codebook2 is restricted to Type II (any type, Rel-15/16, regular/port-selection)
	+ Limit the total number of current capabilities to 4
* For other concurrent codebooks types, the combined capability of the concurrent codebooks shall be within the capability of each codebook;
	+ For concurrent codebook 1 with and codebook 2 with , where and denote the number of ports per resource and the number of resources for codebook triggered by the gNB, the UE expects is within the capability report of both codebook 1 and codebook 2.
	+ Combination of 3 codebooks is not allowed.
	+ Any combination of type II codebooks is not allowed.

Intel proposes to introduce one of the following:* The list of supported combinations of the maximum number of CSI-RS ports, the maximum number of resources, the total number of Tx ports active per band across all the supported codebook types
* The maximum number of CSI-RS resources and maximum number CSI-RS ports active for each band combination and for each codebook type
 | Qualcomm, Intel |
| Not supported | Samsung |

In addition, the following proposals on the description and categorization of MU-CSI-related UE features are summarized below:

**Table 5 View on UE feature group list**

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| --- | --- |
| **Companies** | **Proposal(s)** |
| ZTE/Sanechips | Update FG description as follows

|  |  |  |  |
| --- | --- | --- | --- |
| 16-3a | Regular eType-II | 1. Support of codebook parameter combinations 1-6
2. Support of PMI sub-bands with value N3<=19
3. Rank 1 and 2
4. UCI omission
 | TBD |
| 16-3a-1 | CSI-RS and number of PMI subbands for eType-II | For regular eType-II: A list of supported combinations, each combination is {Max # of Tx ports in one resource, Max # of resources across all CCs simultaneously, total # of Tx ports across all CCs simultaneously, Max # of PMI subbands N3}, where N3>=19  | 16-3a, TBD |
| 16-3a-2 | Rank for eType-II | Support of rank 3,4 for regular eType-II | 16-3a, TBD |
| 16-3a-3 | CBSR for eType-II | Support of CBSR for eType II | 16-3a, TBD |
| 16-3a-4 | Codebook parameter combination 7-8 for eType II | Support of codebook parameter combinations 7-8 | 16-3a, TBD |
| 16-3b | Port selection eType-II | 1. 6 parameter combinations (combos with L=6 don’t apply)
2. Support of PMI sub-bands with value N3<=19
3. Rank 1 and 2
4. UCI omission
 | TBD |
| 16-3b-1 | CSI-RS and number of PMI subbands for port selection eType-II | For port selection eType-II: A list of supported combinations, each combination is {Max # of Tx ports in one resource, Max # of resources across all CCs simultaneously, total # of Tx ports across all CCs simultaneously, Max # of PMI subbands N3}, where N3>=19 | 16-3b, TBD |
| 16-3b-2 | Rank for port selection eType-II | Support of rank 3,4 for port selection eType-II | 16-3b, TBD |
| 16-3c | Number of AP-CSI report settings per BWP  | Support up to 8 configured aperiodic CSI report setting per BWP  | TBD |

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| Apple | **FG 16-3a: Regular eType-II**Basic components* We can add another component “Support of rank 1,2”
* Component 5, “UCI omission”, we prefer this to be moved to “Optional components”

Optional components* Component 3, “CBSR”. There are 2 mode of CBSR, one is just on and off, i.e. only 2 amplitude restrictions, the other is choice from 4 amplitude restrictions. The second mode is agreed to be optional even for UE supports CBSR. Therefore, we suggest the change "(1) Whether UE supports CBSR (2) If UE supports CBSR, whether UE supports 4 values of restriction, i.e. amplitudeSubsetRestriction as in 38.214"

**FG 16-3b: Port selection eType-II**Basic components* We can add another component “Support of rank 1,2”
* Component 5, “UCI omission”, we prefer this to be moved to “Optional components”
 |
| Qualcomm | Support following UE feature list for MUCSI enhancement.

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| --- | --- | --- |
| 16-3a | Regular eType-II | 1. CSI-RS capability: A list of supported combinations, each combination is of {Max # of Tx ports in one resource, max # of resources and total # of Tx ports} to support regular eType II
2. Support of parameter combinations {support L=6, not support L=6}
3. Number of PMI subbands {R=1, R=1-2}
	1. Jointly reported with component 1, i.e., a list of supported combinations, each combination is of { Max # of Tx ports in one resource, max # of resources and total # of Tx ports, R=1 or R=1-2}
4. Supported rank: {1-2, 1-4}
5. Support amplitude subset restriction level {no amplitude subset restriction, support amplitude subset restriction}
 |
| 16-3b | Port selection eType-II | 1. CSI-RS capability: A list of supported combinations, each combination is of {Max # of Tx ports in one resource, max # of resources and total # of Tx ports} to support eType II port-selection
2. Number of PMI subbands {R=1, R=1-2}
	1. Jointly reported with component 1, i.e., a list of supported combinations, each combination is of { Max # of Tx ports in one resource, max # of resources and total # of Tx ports, R=1 or R=1-2}
3. Supported rank: {1-2, 1-4}
 |
| 16-3c | CSI-RS capabilities for concurrent codebooks with mixed types | A list of supported combinations, each combination is of {Codebook A, Codebook B, Max # of Tx ports in one resource, max # of resources and total # of Tx ports} to support codebook combinations of codebook A and codebook B. |

 |
| Nokia/NSB | * 16-3a:
	+ Component 1: reuse same numbers as in R15.
	+ Component 2: Only the first 6 combinations are mandatory. The last 2 are optional and can be moved to the optional components with 1-bit capability (L=6).
	+ Component 3: This should read: Support of PMI sub-bands with value R=1 [FFS: and, for , with value R=2]
	+ Optional component 2: Support of PMI sub-bands with R=2 [FFS: and]
	+ Optional component 3: Distinction is needed between support of “amplitude subset restriction” and “no amplitude subset restriction”
* 16-3b:
	+ Component 1: reuse same numbers as in R15.
	+ Component 3: This should read: Support of PMI sub-bands with value R=1 [FFS: and, for , with value R=2]
	+ Optional component 1: Support of PMI sub-bands with R=2 [FFS: and]
 |

1. Combined TP for TS 38.214 V16.1.0

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| --- | --- | --- |
| 5.2.2.2.5 Enhanced Type II Codebook**<**Unchanged text is omitted>- When :- For each subband in *csi-ReportingBand* that is not the first or last subband of a BWP, two precoding matrices are indicated by the PMI: the first precoding matrix corresponds to the first PRBs of the subband and the second precoding matrix corresponds to the last PRBs of the subband.- For each subband in *csi-ReportingBand* that is the first or last subband of a BWP- If , one precoding matrix is indicated by the PMI corresponding to the first subband. If , two precoding matrices are indicated by the PMI corresponding to the first subband: the first precoding matrix corresponds to the first PRBs of the first subband and the second precoding matrix corresponds to the last PRBs of the first subband.- If , one precoding matrix is indicated by the PMI corresponding to the last subband. If , two precoding matrices are indicated by the PMI corresponding to the last subband: the first precoding matrix corresponds to the first PRBs of the last subband and the second precoding matrix corresponds to the last PRBs of the last subband.**<**Unchanged text is omitted> vectors, , , are identified by (for ) and wherewhich are indicated by means of the indices (for ) and ( and ), , where**<**Unchanged text is omitted>For all values of , for . If , the nonzero elements of , identified by are found from , for , and from and , for , using as defined in Table 5.2.2.2.5-4 and the algorithm:**<**Unchanged text is omitted>When and are known, and are found as follows:- If , and is not reported. If , , for , and is not reported. If , , where is given in Table 5.2.2.2.5-4 and where the indices are assigned such that increases as increases.**<**Unchanged text is omitted>The codebooks for 1-4 layers are given in Table 5.2.2.2.5-5, where , , for are obtained as in clause 5.2.2.2.3, and the quantities and are given by**<**Unchanged text is omitted>**Table 5.2.2.2.5-5: Codebook for 1-layer. 2-layer, 3-layer and 4-layer CSI reporting using antenna ports 3000 to 2999+*P*CSI‑RS****<**Unchanged text is omitted>

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| Where and the mappings from to , , , , , , , , and from to , , , , , and , , , and are as described above, including the ranges of the constituent indices of and .  |

**<**Unchanged text is omitted>5.2.2.2.6 Enhanced Type II Port Selection Codebook**<**Unchanged text is omitted>**Table 5.2.2.2.6-2: Codebook for 1-layer. 2-layer, 3-layer and 4-layer CSI reporting using antenna ports 3000 to 2999+*P*CSI‑RS****<**Unchanged text is omitted>

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| Where ,and the mappings from to, , , , , and from to , , , , , and , , , and are as described above, including the ranges of the constituent indices of and .  |

**<**Unchanged text is omitted> |

# References

1. R1-2002137 Summary of offline email discussion on [100e-NR-eMIMO-MUCSI-01] follow up Moderator (Samsung)
2. R1-2001562 Remaining issues on MU-CSI in R16 Huawei, HiSilicon
3. R1-2001595 Maintenance of CSI enhancement for MU-MIMO ZTE
4. R1-2001677 Discussion on remaining issues on MU CSI vivo
5. R1-2001725 Text proposals for CSI enhancements for MU-MIMO support OPPO
6. R1-2001912 Correction on enhanced Type II port selection codebook LG Electronics
7. R1-2002089 Remaining issues on CSI Enhancement for MU-MIMO CATT
8. R1-2002136 On maintenance of Rel.16 MU CSI enhancements Samsung
9. R1-2002293 Maintenance on Rel-16 CSI enhancements Nokia, Nokia Shanghai Bell
10. R1-2002336 Remaining issues for Rel-16 Type II CSI enhancement Apple
11. R1-2002410 Remaining issues on MU-CSI Enhancements Motorola Mobility, Lenovo
12. R1-2002550 Remaining issues on CSI enhancement for MU-MIMO support Qualcomm Incorporated