**3GPP TSG RAN WG1 #112bis-e R1-2303885**

**e-Meeting, April 17th – April 26th, 2023**

**Source: Moderator (NTT DOCOMO)**

**Title: FL summary on DMRS#2**

**Agenda item: 9.1.3.1**

**Document for: Discussion and Decision**

# Introduction

In RAN#94-e meeting, a new Rel-18 WID on MIMO [1] was agreed. From 7 objectives, there are two objectives for DMRS enhancements, as shown below.

|  |
| --- |
| 1. Study, and if justified, specify larger number of orthogonal DMRS ports for downlink and uplink MU-MIMO (without increasing the DM-RS overhead), only for CP-OFDM,  * Striving for a common design between DL and UL DMRS * Up to 24 orthogonal DM-RS ports, where for each applicable DMRS type, the maximum number of orthogonal ports is doubled for both single- and double-symbol DMRS   […]   1. Study, and if justified, specify UL DMRS, SRS, SRI, and TPMI (including codebook) enhancements to enable 8 Tx UL operation to support 4 and more layers per UE in UL targeting CPE/FWA/vehicle/Industrial devices  * Note: Potential restrictions on the scope of this objective (including coherence assumption, full/non-full power modes) will be identified as part of the study. |

This document contains summary of the company’s tdocs and FL proposals.

# Objective #3 (increasing DMRS ports)

## Antenna ports table for PDSCH

### 2.1.1 eType1, maxLength1

In previous RAN1 meetings, we have made agreements or working assumption for the following rows in the table for Rel.18 eType1 DMRS ports with *maxLength* = 1 for PDSCH. We discuss the remaining issue in this section.

**Table 7.3.1.2.2-1-X: Antenna port(s) (1000 + DMRS port), *dmrs-Type*=eType1, *maxLength*=1**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **One Codeword:**  **Codeword 0 enabled,**  **Codeword 1 disabled** | | | | **Two Codewords:**  **Codeword 0 enabled,**  **Codeword 1 enabled** | | | |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | **Notes** | **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | Notes |
| 0 | 1 | 0 | Cat. 1 | 0 | 2 | 0,1,2,3,8 | Rank 5-8 with one DMRS symbol  (Working assumption) |
| 1 | 1 | 1 | 1 | 2 | 0,1,2,3,8,10 |
| 2 | 1 | 0,1 | 2 | 2 | 0,1,2,3,8,9,10 |
| 3 | 2 | 0 | 3 | 2 | 0,1,2,3,8,9,10,11 |
| 4 | 2 | 1 |  |  |  |  |
| 5 | 2 | 2 |  |  |  |  |
| 6 | 2 | 3 |  |  |  |  |
| 7 | 2 | 0,1 |  |  |  |  |
| 8 | 2 | 2,3 |  |  |  |  |
| 9 | 2 | 0-2 |  |  |  |  |
| 10 | 2 | 0-3 |  |  |  |  |
| 11 | 2 | 0,2 |  |  |  |  |
| 12 | 1 | 8 | Cat.2 |  |  |  |  |
| 13 | 1 | 9 |  |  |  |  |
| 14 | 1 | 8,9 |  |  |  |  |
| 15 | 2 | 8 |  |  |  |  |
| 16 | 2 | 9 |  |  |  |  |
| 17 | 2 | 10 |  |  |  |  |
| 18 | 2 | 11 |  |  |  |  |
| 19 | 2 | 8,9 |  |  |  |  |
| 20 | 2 | 10,11 |  |  |  |  |
| 21 | [2] | [8-10] |  |  |  |  |
| 22 | [2] | [8-11] |  |  |  |  |
| 23 | [2] | [8, 10],  [9, 11] |  |  |  |  |
| 24 | 1 | 0,1,8 | Cat.3 |  |  |  |  |
| 25 | 1 | 0,1,8,9 |  |  |  |  |
| 26 | 2 | 0,1,8 |  |  |  |  |
| 27 | 2 | 0,1,8,9 |  |  |  |  |
| 28 | 2 | 2,3,10 |  |  |  |  |
| 29 | 2 | 2,3,10,11 |  |  |  |  |

**Row 21-22 (1CW)**

The benefit of supporting the row 21-22 is that it can be multiplexed with row 9-10, so that 2 UEs can share DMRS ports in two CDM groups. However, such MU-MIMO is precluded. Hence, FL suggestion is to remove the row 21-22.

**Row 23 (1CW)**

Huawei/HiSilicon[3] and Xiaomi[14] propose to support row 23 of {9,11}. On the other hand, ZTE/China Telecom[4], Qualcomm[23], Docomo[25] propose to remove the row 23. Considering we have discussed in several meetings, and we could not have consensus to support the row 23, FL suggestion is to remove row 23.

Huawei/HiSilicon[3]:

|  |
| --- |
| Unlike other layer combinations that can be achieved by different compositions of DMRS port combinations, {3+3+2} can only be enabled by composition {#28 + #26 + #23}, which means entry #23 is irreplaceable for supporting all layer combinations.  The system-level simulation is conducted to reflect the probability of different layer combinations, where the maximum number of MU pairing layer is limited to 8. Other detailed simulation assumptions can be found in Appendix A The PDF of layer combinations is shown in Figure 1, from which it can be clearly observed that layer combination {3+3+2} has a relatively high probability to be scheduled. By further concentrating on the cases with 8 MU pairing layers, the probability of layer combination {3+3+2} can reach more than 1/3. Considering that replacing {3+3+2} by {3+3+1+1} (or other layer combinations corresponding to more than 3 paired UEs) subjects to practical MU traffic, while replacing {3+3+2} by {4+3+1} (or other layer combinations corresponding to at least one 4-layer UE) may bring MU performance degradation, layer combination {3+3+2} plays an important role to achieve the maximum number of MU pairing layer under this DMRS configuration. To enable this particular layer combination, entry#23 in Table 1, DMRS port combination {9, 11}, should undoubtedly be supported.    **Figure.1 The PDF of layer combinations** |

Qualcomm [23]:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Regarding the proposal to use DMRS ports [9,11] with row 23, the intention of the proponent is for MU enhancements, i.e., allow a particular MU scheduling scenario with 3 users with rank 3+3+2. However, we don’t see DMRS ports [9,11] is suitable for MU, based on the following reasons.   * Channel estimation performance of the UE with port [9,11] will be quite bad as it sees channel interference from both CDM groups. * This is not aligned with MU design principle since Rel-15, which is allocate DMRS ports of a same UE into a same CDM group. * It creates serious trouble for UE implementation, as UE is assigned with DMRS ports [9,11] will have to effectively estimate 8 DMRS ports (for MU detection and noise estimation), which is not doable on a UE which only supports 1 CW PDSCH.   The justification from the proponent of the proposal to support DMRS ports [9,11] is that it can support 3 users with rank 3+3+2, i.e., [0,1,8]+[2,3,10]+[9,11], to fully utilize the potential of rank 8 DL MU-MIMO capability for 1 symbol type-1 DMRS. However, we believe this case of rank 3+3+2 is just one corner case of MU scheduling, because of the following reasons.   * MU scheduling fully utilize 8 layers is rare, given mutual interference between MU layers. More reasonable gNB should schedule MU with less than 8 layers. * Even in rank 8 MU scheduling, we listed all possible scheduling cases as in the following table. As there are in total 21 cases, the case of rank 3+3+2 is just one out of 21 cases. * Even if rank 3+3+2 is not supported without DMRS ports [9, 11], gNB can switch to 4 UEs MU with [0,1,8]+[2,3,10]+[9]+[11], or 3 UEs MU with [0,1,8]+[2,3,10]+[9]. There is no devastating outcome because of not supporting DMRS ports [9, 11].  |  |  |  | | --- | --- | --- | | **Case number** | **Rank combination** | **Row indices to support the rank combination** | | Case 1 | 2 UEs with 1+7 layer | row 2 (two CWs) + row 18 (1CW) | | Case 2 | 2 UEs with 2+6 layer | Not supported with current agreed table | | Case 3 | 2 UEs with 3+5 layer | Not supported with current agreed table | | Case 4 | 2 UEs with 4+4 layer | row 27 (1 CW) + row 29 (1CW) | | Case 5 | 3 UEs with 1+1+6 layers | row 1 (2 CWs)+ row 16 & 18 (1CW) | | Case 6 | 3 UEs with 1+2+5 layers | row 0 (2 CWs)+ row 16 & 20 (1CW) | | Case 7 | 3 UEs with 2+2+4 layers | row 27+ 8 + 20 (1CW) | | Case 8 | 3 UEs with 1+3+4 layers | row 27 + 28 + 18 (1CW) | | Case 9 | 3 UEs with 2+3+3 layers | Not supported with current agreed table | | Case 10 | 4 UEs with 1+1+1+5 layers | row 0 (2CWs) + row 16+17+18(1CW) | | Case 11 | 4 UEs with 1+1+2+4 layers | 27 + 8 + 17 +18 (1CW) | | Case 12 | 4 UEs with 1+2+2+3 layers | row 26+16+8+20 (1CW) | | Case 13 | 4 UEs with 1+1+3+3 layers | row 26+28+16+18 (1CW) | | Case 14 | 4 UEs with 2+2+2+2 layers | row 7+8+19+20 (1CW) | | Case 15 | 5 UEs with 1+1+1+1+4 layers | row 27+5+6+17+18(1CW) | | Case 16 | 5 UEs with 1+1+1+2+3 layers | row 26+8+16+17+18(1CW) | | Case 17 | 5 UEs with 1+1+2+2+2 layers | row 7+8+19+17+18 (1CW) | | Case 18 | 6 UEs with 1+1+1+1+1+3 layers | row 26+16+5+6+17+18(1CW) | | Case 19 | 6 UEs with 1+1+1+1+2+2 layers | row 19+20+3+4+5+6(1CW) | | Case 20 | 7 UEs with 1+1+1+1+1+1+2 layers | row 7+5+6+15+16+17+18 (1CW) | | Case 21 | 8 UEs each with 1 layer | row 3+4+5+6+15+16+17+18 (1CW) | |

**2 CWs**

Huawei/HiSilicon, ZTE/China Telcom, vivo, Spreadtrum, Intel, Xiaomi (can live), LGE, NEC propose to confirm the WA (Alt.1), and Qualcomm and MediaTek propose to add new rows so that different CW is mapped to different CDM group (Alt.2). Nokia/NSB propose to add new rank5 DMRS combinations of {0,2,3,8,9} to Alt.1. FL suggestion is to discuss and down select in this meeting.

**For at least for S-TRP**

**FL Proposal 2.1.1A**

* **For RAN1#111 agreement of the antenna ports indication in Rel.18 eType1** **DMRS ports with *maxLength* = 1 for PDSCH, at least for S-TRP case,**
  + **For 1 CW,**
    - **Do not support row 21-22**
    - **Do not support row 23**

|  |  |  |
| --- | --- | --- |
| **One Codeword:**  **Codeword 0 enabled,**  **Codeword 1 disabled** | | |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** |
| ~~21~~ | ~~[2]~~ | ~~[8-10]~~ |
| ~~22~~ | ~~[2]~~ | ~~[8-11]~~ |
| ~~23~~ | ~~[2]~~ | ~~[8, 10],~~  ~~[9, 11]~~ |

* + **For 2 CWs,**
    - * **Alt.1: Confirm the working assumption in RAN1#112 without modification.**
        + **Alt.3-1: Support at least row 0-3 for 2 CWs in Table 4-0.**

**Table 4-0: DMRS ports for 2CWs.**

|  |  |  |
| --- | --- | --- |
| **Two Codewords:**  **Codeword 0 enabled,**  **Codeword 1 enabled** | | |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** |
| 0 | 2 | 0,1,2,3,8 |
| 1 | 2 | 0,1,2,3,8,10 |
| 2 | 2 | 0,1,2,3,8,9,10 |
| 3 | 2 | 0,1,2,3,8,9,10,11 |

* + - * **Alt.2: Confirm the working assumption in RAN1#112 with the following modification.**
        + **~~Alt.3-1:~~ Support at least row 0-~~3~~7 for 2 CWs in Table 4-0.**

**Subject to UE capability, UE can indicate supporting values {4,5,6,7} only, or values {0,1,2,3,4,5,6,7[,8,9]}.**

**Table 4-0: DMRS ports for 2CWs.**

|  |  |  |
| --- | --- | --- |
| **Two Codewords:**  **Codeword 0 enabled,**  **Codeword 1 enabled** | | |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** |
| 0 | 2 | 0,1,2,3,8 |
| 1 | 2 | 0,1,2,3,8,10 |
| 2 | 2 | 0,1,2,3,8,9,10 |
| 3 | 2 | 0,1,2,3,8,9,10,11 |
| 4 | 2 | 0,1,2,3,10 |
| 5 | 2 | 0,1,8,2,3,10 |
| 6 | 2 | 0,1,8,2,3,10,11 |
| 7 | 2 | 0,1,8,9,2,3,10,11 |
| [8 | 2 | 0,2,3,8,9] |
| [9 | 2 | 0,1,2,3,8,9] |

* + - * **Alt.3: Confirm the working assumption in RAN1#112 with the following modification.**
        + **~~Alt.3-1:~~ Support at least row 0-~~3~~4 for 2 CWs in Table 4-0.**

**Table 4-0: DMRS ports for 2CWs.**

|  |  |  |
| --- | --- | --- |
| **Two Codewords:**  **Codeword 0 enabled,**  **Codeword 1 enabled** | | |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** |
| 0 | 2 | 0,1,2,3,8 |
| 1 | 2 | 0,1,2,3,8,10 |
| 2 | 2 | 0,1,2,3,8,9,10 |
| 3 | 2 | 0,1,2,3,8,9,10,11 |
| 4 | 2 | 0,2,3,8,9 |

**Summary of companies’ view**

|  |  |  |
| --- | --- | --- |
|  | **Support/fine** | **Concern** |
| **Delete row 21-22** | **Docomo, Google, OPPO, Nokia/NSB, Huawei/HiSilicon, Lenovo (can live), Sharp, Apple, New H3C, China Telcom, Samsung, Spreadtrum** | **CATT (slightly prefer), Ericsson** |
| **Delete row 23** | **Docomo, Google, OPPO, Nokia/NSB, Lenovo (can live) , Sharp, Apple, New H3C, China Telcom, Samsung, Spreadtrum** | **CATT (slightly prefer), Huawei/Hisilicon, Ericsson, Xiaomi, CMCC** |
| **Alt.1** | **Docomo, Nokia/NSB (Add FFS: {0,2,3,8,9} for rank 5) , Huawei/HiSilicon, Lenovo, Intel, ZTE, Ericsson, China Telcom, Samsung, Spreadtrum, CMCC** | **QC (UE complexity), MTK** |
| **Alt.2** | **CATT, QC, MTK,** **Xiaomi, Ericsson, Docomo, Nokia/NSB (w/ row8 ), Apple (can live)**  **Comment: UE complexity of row 4-7 is smaller. No real UE has implemented R15 DMRS ports with 2 CWs so far.** | **Intel, ZTE (out of scope), OPPO, vivo**  **Comment: R15 DMRS ports with 2 CWs specified row 0-3 (there should be no issue).** |
| **Alt.3** | **Nokia/NSB** |  |

**FL: If we remove “values {0,1,2,3} only” from Alt.2, the concern from Docomo/Ericsson/China Telcom can be solved.**

**For S-DCI M-TRP**

In RAN1#112 online, LGE pointed out that we have not agreed to reuse all rows of DMRS ports table of S-TRP to S-DCI based M-TRP.

Google[16] mentions Cat.3 is useful for TDM/FDM/SFN based sDCI mTRP operation and Cat.1-2 are useful for SDM based sDCI mTRP operation. In the following proposal, gNB can select any of Cat.1-3 for sDCI mTRP operation. Hence we don’t need to discuss separate handling between TDM/FDM/SFN based sDCI mTRP operation and SDM based sDCI mTRP operation.

**FL Proposal 2.1.1B**

* **For RAN1#111 agreement of the antenna ports indication in Rel.18 eType1** **DMRS ports with *maxLength* = 1 for PDSCH, for S-DCI based M-TRP,**
  + **Support all rows of DMRS port combinations and Number of DMRS CDM group(s) without data for Rel.18 eType1 DMRS ports with *maxLength* = 1 for PDSCH for S-TRP, in addition to row 30 for 1CW in RAN1#112 agreement.**

Please provide your views.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Docomo | **FL Proposal 2.1.1A:** Support.  For 2 CWs, support Alt.1. We have concern on Alt.2, if UE can report either “values {0,1,2,3} only” or “values {4,5,6,7} only”, because it causes market fragmentation. Hence, either “values {0,1,2,3} only” or “values {4,5,6,7} only” should be removed in Alt.2.  **FL Proposal 2.1.1B:** Support. |
| Google | 2.1.1A: Support in principle, but the UE capability part can be decided later.  2.1.1B: Support |
| OPPO | FL Proposal 2.1.1A: Support.  FL Proposal 2.1.1B: Support. |
| Nokia/NSB | FL Proposal 2.1.1A: Support.  For 2CWs, we are fine with Alt 1, also we propose to add FFS: {0,2,3,8,9} for rank 5. We will provide the evaluation result by May meeting, so please add it for last checking.  **FL: Alt.1 says “at least” and it does not preclude to add another combination.**  FL Proposal 2.1.1B: Support. |
| CATT | Proposal 2.1.1A: For 1 CW, we slightly prefer to keep row 21-23, since the size of antenna port(s) field is not increased due to these 3 rows. For 2 CWs, Alt.2 is preferred and UE capability part is for further study.  Proposal 2.1.1A: Support. |
| Huawei, HiSilicon | **FL Proposal 2.1.1A:** Not support. For 1CW, row 23 should be supported.  Thanks to FL, the analysis and simulation in our contribution are attached above, which shows the important role of layer combination 3+3+2, especially under 8 layers scenario.  Thanks QC’s great effort in detailed analyzing. In terms of each specific reason, following are the corresponding response:   1. The DMRS channel estimation is performed per port, we haven’t observe any special channel estimation degradation that [9, 11] will suffer. 2. Please see row 20, 21 for “Type2, maxLength1” DMRS in current spec., which crosses multiple CDM groups without any MU restriction. 3. Leave the different possible implementation alone, even if following QC’s implementation logic, [9, 11] is doable for UE supporting 2CW. 4. The whole WID is targeting higher-layer MU-MIMO, which we think should be a consensus among companies. 5. Among all scheduling cases listed by QC, except Case 2&3, which cannot be utilized for MU-MIMO according to the Rel.15 restriction and the performance requirement of MU scheduling, {3+3+2} is the only layer combination that hasn’t been supported by current spec. yet, which for completeness and realistic value attached above should be supported. 6. As discussed in our contribution, replacing {3+3+2} by {3+3+1+1} (or other layer combinations corresponding to more than 3 paired UEs) subjects to practical MU traffic, replacing {3+3+2} by {4+3+1} (or other layer combinations corresponding to at least one 4-layer UE) may bring MU performance degradation, furthermore, replacing {3+3+2} by {3+3+1} (or other layer combinations corresponding to less total layers) will obviously incur spectrum efficiency decrease. Now that {3+3+2} can bring performance benefit and scheduling flexibility for gNB side without incurring any devastating outcome, [9, 11] or other possible DMRS port combination facilitating {3+3+2} should be supported.   Based on our analysis and simulation, we suggest to modify the 1CW part of **FL Proposal 2.1.1A** as below:  **FL Proposal 2.1.1A**   * **For RAN1#111 agreement of the antenna ports indication in Rel.18 eType1** **DMRS ports with *maxLength* = 1 for PDSCH, at least for S-TRP case,**   + **For 1 CW,**     - **Do not support row 21-22**     - **Support row 23**   For 2CW, support Alt.1.  **FL Proposal 2.1.1B:** Support. |
| Lenovo | FL Proposal 2.1.1A: For 1 CW, we prefer to include them to increase scheduling flexibility but can live up with the proposal on account of progress if it is the majority view.  For 2 CW, support Alt.1 since for Alt.2 it will increase the UE complexity and the performance benefit by introduced rows is not a common view.  FL Proposal 2.1.1B: Support. |
| Intel | **Proposal 2.1.1A:** For 2 CWs, do not support Alt-2. We have already concluded this discussion in the last meeting and similar behavior exists in legacy case as well. We only agree with Alt-1 and propose to confirm the WA. There is no major technical issue to support Alt-1. We also agree with DOCOMO that current formulation of Alt-2 may lead to unnecessary fragmentation.  **Proposal 2.1.1B:** OK |
| QC | **FL Proposal 2.1.1A:** We support the proposal.  For 2 CW, we support Alt 2. Functionality-wise, “values {0,1,2,3}” is the same as “values {4,5,6,7}”. We don’t see if a UE can report either “values {0,1,2,3} only” or “values {4,5,6,7} only” will cause market fragmentation. From UE implementation point of view, implementing “values {4,5,6,7}” is much easier than “values {0,1,2,3}”, which is why we introduce UE capability for “values {4,5,6,7} only” to accelerate the deployment of future Rel-18 UE supporting 8-layer DL MIMO.  @Intel: Given Rel-15 8L DL-MIMO feature is not implemented/deployed in field yet. There is no backward compatibility issue if one just choosing to implement Rel-18 2 CWs PDSCH with Alt 2 and not implementing Rel-15 2 CWs PDSCH. Again, there is major implementation issue to support Alt-1 as we indicated in R1-2303576. Alt 2 is easier to implement on UE side, which will accelerate deployment 8L DL MIMO.  **FL Proposal 2.1.1B:** If I understand the intention of this FL proposal correct, this proposal means the DMRS port table for S-TRP is reused for M-TRP (of course, with one additional row in M-TRP table, as agreed before). If that is the case, we can support the spirit of this proposal. But the wording of the proposal might need some clarification. |
| MediaTek | **FL Proposal 2.1.1A:** Support  **FL Proposal 2.1.1B:** Support |
| ZTE | **FL Proposal 2.1.1A:** Support.  For 2CWs case, we support Alt 1 but do NOT support Alt 2. We fail to see the logic that the legacy rule from Rel-15 (i.e., DMRS ports 0-4 for rank = 5 or DMRS ports 0-6 for rank 7 when Type 1+ double-symbol) cannot be reused in Rel-18. In other words, the added values in Alt 2 is the restriction over the legacy, which is out of scope from our perspective.  **FL Proposal 2.1.1B:** Support.  Given that DMRS ports {0, 2, 3} has already agreed in the last meeting, either to capture it repeatedly herein or not is fine. |
| Ericsson | **FL Proposal 2.1.1A:**  **For 1 CW**, we prefer to keep row 21-23. For the antenna port combination of row 23 we are fine to support [9,11].  **For 2 CWs,** support Alt.1. For Alt.2we are fine with adding the new values 4-7, but we have concern on different UE capabilities. We can support Alt2 if there’s consensus on basic UE capability for 2 CWs, either 0-3 or 4-7 can be considered as basic UE capability for 2 CWs.  **FL Proposal 2.1.1B:** Support |
| Sharp | FL Proposal 2.1.1A: Support.  FL Proposal 2.1.1B: Support. |
| Xiaomi | **FL Proposal 2.1.1A:**  For 1 CW. As mentioned by Huawei, the intention to introduce larger number of orthogonal DMRS ports is to support more layers/UEs in MU-MIMO. Hence, we slightly prefer to support row 23.  For 2 CWs, support Alt.-2. It is a good compromise if we can not reach an agreement on the working assumption.  **FL Proposal 2.1.1B:** Support |
| Apple | FL Proposal 2.1.1A: Support  FL Proposal 2.1.1B: Support |
| New H3C | FL Proposal 2.1.1A: Support.  FL Proposal 2.1.1B: Support. |
| China Telecom | **FL Proposal 2.1.1A:** Support.  **For 2CWs case**, we don’t support Alt2. The values row 0-3 should be considered first and be supported, which is align with the current Rel-15 in principle. Therefore, the new values row 4-7 are unnecessary and will cause the UE capabilities fragmentation if UE can only support the row [4-7]. Therefore, to avoid such fragmentation and values 0-3 must be supported, the values 4-7 are not needed.  **FL Proposal 2.1.1B:** Support. |
| Samsung | FL Proposal 2.1.1A: Support, and for 2CWs, we support Alt1.  FL Proposal 2.1.1B: We can live with the proposal. |
| Spreadtrum | FL Proposal 2.1.1A: Support. For 2CW case, we prefer to confirm the WA without modification.  FL Proposal 2.1.1B: Support. |
| CMCC | FL Proposal 2.1.1A:  For 1 CW, we are fine to support row 23 to keep the rank combination of {3+3+2} and left the scheduling flexibility to network.  For 2 CWs, support Alt.1.  FL Proposal 2.1.1B: Support. |
| LGE | **FL Proposal 2.1.1A:** Support.  For 1 CW, do not support row 21-23.  For 2 CW, support Alt.1.  **FL Proposal 2.1.1B:** Support. |
| vivo | **FL Proposal 2.1.1A:**  For 1 CW, we support.  For 2 CWs, we support Alt 1. Firstly, there is no need to support redundant entries for the same target for rank=5~8. Secondly, in our understanding, channel estimation of DMRS ports and equalizer can be performed for all scheduled layers together, instead of being performed per CW. We fail to see the complexity of UE for this when using value {0,1,2,3}. Thirdly, association between CDM group and CW is not required for R15 DMRS for Rank=5~8, the legacy principle can be reused.  **FL Proposal 2.1.1B:** Support. |
| **FL** | **FL Proposal 2.1.1B is moved to [112bis-e-R18-MIMO-04] DMRS - EMAIL ENDORSEMENT 1.** |
| Nokia/NSB2 | For 2CW, there is big performance difference in channel estimation when two ports or 3 ports are multiplexed into one CDM group. So, having worse 2 ports for CW0 of rank 5 (0,1/,2,3,8) should be avoided. (0,1,8 from CDM group 0, and two ports 0,1 are used for demodulation of CW0). We propose to mix them for each CW. With (0,2/3,8,9), each CW has at lease one port from CDM group 1 where only two ports are multiplexed.  So, we propose to support (0,2,3,8,9) for rank 5. |
| QC | We thank FL very much for updating the UE capability proposal for 2 CWs. We fully support that update as it addresses companies concern on market fragmentation issue.  @VIVO and all, please check the following figure which illustrate the UE complexity issue. Mapping in entries 4-7 are much more friendly to UE processing pipeline. As shown in following figure, for a UE does not have two channel estimation nor two demodulation modules (due to hardware limitation), using entries 0-3 cannot start demodulation for a CW until the channel estimation for CDM group 2 is completed, which causes additional delay to UE processing time. While entries 4-7 can start demodulation for CW 1 right away, after channel estimation for CDM group 1.  If RAN1 as a community care about acceleration the deployment of 8L/2CWs DL MIMO, easier UE implementation of 2 CWs should be allowed.  Regarding Rel-15 2CWs already mapped CW across two CDM groups, it is true. But given no one has implemented/deployed Rel-15 2CW feature, we don’t think there is backward compatible issue if one chooses to implement 2CW starting from Rel-18 spec. |
| **FL(v41)** | **For 2CW, please check QC’s comment above, if you have concern on Alt.2.**  **For Nokia’s proposal of (0,2,3,8,9) for rank 5, I bring back “at least” for Alt.2, so that the proposal is not precluded by FL Proposal 2.1.1A. Also, I added Alt.3 to explicitly support Nokia’s proposal.** |
| ZTE3 | Do not agree with Alt. 2 of 2 CW case. I do believe our previous view is clear and sufficient.  “*We fail to see the logic that the legacy rule from Rel-15 (i.e., DMRS ports 0-4 for rank = 5 or DMRS ports 0-6 for rank 7 when Type 1+ double-symbol) cannot be reused in Rel-18. In other words, the added values in Alt 2 is the restriction over the legacy, which is out of scope from our perspective.*” |
| Apple2 | We are fine with updated FL proposal 2.1.1A. Regarding the alternatives for 2 CWs, we support Alt 1, but could live with Alt 2 as well, if majority agrees. |
| OPPO | We can understand the concern from QC for 2CW case. However, for a UE supporting two CWs transmission, the port combinations in Rel-15 are mandated to be supported regardless whether new combinations are introduced or not. Hence, we can be fine with Alt.2 if the legacy combinations are also included without capability. |
| Ericsson1 | We are fine with Alt2 for 2 CW. |
| Nokia/NSB | Thanks for FL’s effort and formulating Alt 3. We are also fine with Alt 2 with addition of (0,2,3,8,9). NW perspective, more scheduling options should not be a problem, and because it is subject to UE capability. I want to ask if QC is fine with combine Alt 2 and 3 together with single UE capability. (Copied from v43 missing due to overlap) |
| vivo | Thanks QC’s clarification for the UE processing pipeline. We still have some confusion about that of UE can’t support performing two estimations for two CDM groups of 8 ports at the same time. In our understanding, even 3 CDM group of 6 ports with maxLength=1 should be already supported in R15 UE. Moreover, up to 32 CSI-RS ports are estimated at the same time in R15. Therefore, we wonder it is really an issue to support 2 CDM group of 8 ports in R18? Could you please further clarify it? Thanks. |
| QC | @Nokia, thanks for your flexibility. On our side, we are fine to add the row (denotes by value 8) you proposed, with the following capability.   * **Subject to UE capability, UE can indicate supporting values {4,5,6,7} only, or values {0,1,2,3,4,5,6,7,8}.**   @VIVO @OPPO, there is a difference between “supported in Rel-15” and “implemented and deployed in field”. As far as I know, no one has implemented 2CW PDSCH so far. Therefore, there is no backward compatibility issue in terms of implementation. As a UE vendor, we could choose to build and support 2 CW PDSCH based on Rel-18 spec. Regarding VIVO’s question on Rel-15 UE support 3 CDM group of 6 ports. Again, no one build such a UE supporting rank 6 DL-MIMO yet. Similar for CSI-RS, I believe there is UE capability to indicate how many CSI-RS a UE can support, and UE can always report less than 32. On # CSI ports, I don’t know what is max number UEs (from different vendors) report, but even for a UE can do 32 CSI-RS port channel estimation, CSI-RS and DMRS channel estimation are two totally different components in UE modem. The algorithm, hardware, cost are entirely different. We cannot compare apple with orange. |
| QC | @ZTE, we don’t know why ZTE keeps calling added row {4,5,6,7} as a restriction. These are additional rows on top of agreed rows in last meeting. Aren’t they offer more flexibility to NW? Why they are restriction? Furthermore, there are two ways of mapping, 1) mapping 2 CW to 2 CDM groups with cross mapping. 2) mapping 2 CW to 2 CDM groups without cross mapping. They are just two different ways to do mapping, we fail to see why one is more restrictive than the other.  We are discussing different options to support 2 CW PDSCH with Rel-18 DMRS, we are not sure which part of out of scope? What scope ZTE is referring to?  @all, with our clarification in last round of discussion, I hope it is clear now that rows {4,5,6,7} is easier to implement than other rows {0,1,2,3,8} for a UE. It is very reasonable to let UE implement easier rows as baseline and introduce UE capability for more difficult rows. From NW perspective, the functionality of {4,5,6,7} is the same as {0,1,2,3,8}. I really don’t see any negative impact to take Alt 2 (with the new row Nokia added). For NW, adding more rows offers more flexibility which is beneficial. I do think Alt 2 is a good way forward. |
| Ericsson2 | We would like to add combination (0,1,2,3,8,9) to the 2CW table for Alt2, if that is fine with Nokia and QC. Both new rows provide better per CW orthogonality and more robust for large delay spread. |

### **ROUND-2**

In Wed. GTW, we made the following agreement. We need to resolve the yellow highlighted part within this meeting. Please check Huawei/HiSilicon’s comment of benefit of supporting 3+3+2 layers by row 23 {9,11}, and please prove your views.

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| **FL Proposal 2.1.1A1 (1CW)**  **For RAN1#111 agreement of the antenna ports indication in Rel.18 eType1** **DMRS ports with *maxLength* = 1 for PDSCH, at least for S-TRP case,**   * + **For 1 CW,**     - **Do not support row 21-22**     - **Do not support row 23**  |  |  |  | | --- | --- | --- | | **One Codeword:**  **Codeword 0 enabled,**  **Codeword 1 disabled** | | | | **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | | ~~21~~ | ~~[2]~~ | ~~[8-10]~~ | | ~~22~~ | ~~[2]~~ | ~~[8-11]~~ | | ~~23~~ | ~~[2]~~ | ~~[8, 10],~~  ~~[9, 11]~~ | |

**FL Proposal 2.1.1C**

* **For RAN1#111 agreement of the antenna ports indication in Rel.18 eType1** **DMRS ports with *maxLength* = 1 for PDSCH, at least for S-TRP case,**
  + **For 1 CW,**
    - **Support row 23.**

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| **One Codeword:**  **Codeword 0 enabled,**  **Codeword 1 disabled** | | |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** |
| 23 | 2 | ~~[8, 10],~~  9, 11 |

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| **Company** | **Comment** |
| QC | We object this proposal.  Like we commented already, gNB schedule full 8 layers for MU is not typical. Even for 8-layer MU, {3+3+2} is just one out of 21 cases. Furthermore {3+3+2} can be replaced by {3+3+1+1} or {4+3+1} or {3+3+1}. We really don’t see it is critical to support {3+3+2} on NW side. However, on UE side {9,11} creates huge issue for UE implementation.  From performance point of view, {9,11} is across two CDM group, which should be used for SU performance optimization. At least in Type 1 DMRS, that is the rule since Rel-15 (we do think that is the universal principle for both type 1 and type 2 DMRS). |
| OPPO | We also think the row is not needed. In Rel-15, port combination across multiple CDM groups are designed for SU-MIMO. For MU-MIMO, it can be easily replaced by other combinations via gNB scheduling without performance loss. |
| vivo | Don’t support.  We don’t prefer entries across two CDM groups for DL MU-MIMO. |
| New H3C | We slightly prefer supporting this proposal because this easy way to support {3+3+2} MU-MIMO case |
| Apple | We don’t support the proposal. As we have raised concerns on DMRS ports across multiple CDM groups, we don’t think row 23 should be included. |
| Nokia, NSB | We are fine with the proposal. |
| Ericsson | We prefer to support this proposal. |
| ZTE | We can be fine with this proposal. |
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## DCI size of antenna ports field for PDSCH/PUSCH

For the size of antenna ports field, since the number of rows in DMRS ports table is increased, it is inevitable to increase the size of DCI field for the antenna ports indication. Ericsson proposes to use RRC configuration to select the actual needed row indexes in the antenna ports table. Some companies propose to introduce new DCI field of “offset indicator” to assist DMRS port indication by the antenna ports field, while other companies think “offset indicator” is not suitable to indicate DMRS ports of Cat.3 and just increasing 1-bit of antenna ports field is better.

Let’s discuss the following proposals for PDSCH and PUSCH.

**FL Proposal 2.2A (for PDSCH)**

* **For Rel.18 eType1/eType2** **DMRS ports with *maxLength*=1/2 for PDSCH, if Rel.18 eType1/eType2** **DMRS ports is configured by RRC, the size of DCI field for antenna ports indication in DCI format 1\_1/1\_2 is down-selected from the following:**
  + **Alt.1: The DCI size of DMRS port indication is increased by 1-bit from Rel.17.**
    - **FFS: Whether existing antenna ports field is increased by 1-bit or new 1-bit DCI field is added.**
  + **Alt.2: The DCI size of DMRS port indication is increased by M (M = {0, 1}) bit, and M is configured by RRC.**
    - **RRC signaling can configure the actual rows in the antenna ports table, which can be indicated by the DCI of antenna port indication.**
    - **Note: antenna ports field can be increased by M-bit, or new M-bit DCI field (e.g. [DMRS port(s) offset indicator]) can be introduced to assist DMRS port indication by the existing antenna ports field.**

**FL Proposal 2.2B (for PUSCH)**

* **For Rel.18 eType1/eType2** **DMRS ports with *maxLength*=1/2 for PUSCH, if Rel.18 eType1/eType2** **DMRS ports is configured by RRC, the size of DCI field for antenna ports indication in DCI format 0\_1/0\_2 is down-selected from the following:**
  + **Alt.1: The DCI size of DMRS port indication is increased by 1-bit from Rel.17.**
    - **FFS: Whether existing antenna ports field is increased by 1-bit or new 1-bit DCI field is added.**
  + **Alt.2: The DCI size of DMRS port indication is increased by M (M = {0, 1}) bit, and M is configured by RRC.**
    - **RRC signaling can configure the actual rows in the antenna ports table, which can be indicated by the DCI of antenna port indication.**
    - **Note: antenna ports field can be increased by M-bit, or new M-bit DCI field (e.g. [DMRS port(s) offset indicator]) can be introduced to assist DMRS port indication by the existing antenna ports field.**

Summary of companies’ inputs for PDSCH (after round1)

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|  | **Support/fine** | **Concern** |
| **Alt.1** | Fraunhofer IIS/HHI (1st pref.), NEC, Intel, CMCC, Apple (no new field), Docomo, ZTE, CATT, Lenovo, Sharp, Huawei/HiSilicon, Nokia/NSB, Futurewei, Samsung, QC, MTK, China Telecom, Spreadtrum, vivo, OPPO, New H3C, Xiaomi, LGE, CMCC | ZTE (remove restriction of 1-bit) |
| **Alt.2** | Google, Docomo, Ericsson, ZTE, CMCC, Xiaomi, Fraunhofer IIS/HHI (2nd pref.), LGE, China Telecom (can live), Intel (can live without note) | QC (UE complexity), OPPO, Nokia/NSB (support only M=0, but not alt 2), ZTE (remove restriction of 1-bit) |

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| **Company** | **Comment** |
| Docomo | FL Proposal 2.2A: Since the size of antenna ports table is larger than that in Rel.17, it is natural to increase the DCI size of antenna ports field. Hence, we support Alt.1, and we are also file with Alt.2.  FL Proposal 2.2B: We prefer the same rule is applied to both PDSCH and PUSCH. |
| Google | Support Alt2 for both proposals. We can consider negative value for M as well for further overhead reduction. This could be something similar to codebook subset restriction. |
| Futurewei | **FL Proposal 2.2A:** We prefer Alt. 1 which is simple and straightforward to accommodate a larger antenna ports table.  **FL Proposal 2.2B:** We prefer Alt. 1, same reason as for FL Proposal 2.2A. |
| OPPO | FL Proposal 2.2A: Alt.1.  FL Proposal 2.2B: Alt.1. |
| Nokia/NSB | Proposal 2.2A: either Alt 1 or Alt2 (M=0 only, RRC configuration is mandatory)  Proposal 2.2B Alt.1 |
| CATT | FL Proposal 2.2A: Support and Alt.1 is preferred.  FL Proposal 2.2B: Support and Alt.1 is preferred. |
| Huawei,  HiSilicon | **FL Proposal 2.1.4A:** Prefer Alt.1.  **FL Proposal 2.1.4B:** Prefer Alt.1. |
| Lenovo | FL Proposal 2.2A and FL Proposal 2.2B: Support Alt.1. For Alt.2, we think it is complicated for defining two cases for M=0 and 1. Also, we have the similar view with FL to have the same rule for both PDSCH and PUSCH. |
| Intel | **Proposal 2.1.4A/B:** Prefer Alt-1. Can also live with Alt-2 but without the note. We do not support the idea of complicating DM-RS antenna port indication by further introducing port offset indication. |
| QC | FL Proposal 2.2A: support Alt 1. We don’t support Alt 2. We don’t think adding 1 bit in DCI will be showstopper for Rel-18 DMRS. Alt 2 is unnecessarily complicated.  FL Proposal 2.2B: support Alt 1. We don’t support Alt 2. We don’t think adding 1 bit in DCI will be showstopper for Rel-18 DMRS. Alt 2 is unnecessarily complicated. |
| MediaTek | FL Proposal 2.2A: We believe Alt 1 is much simpler and cleaner solution and hence our preference is Alt 1.  FL Proposal 2.2A: We believe Alt 1 is much simpler and cleaner solution and hence our preference is Alt 1. |
| ZTE | To our understanding, it is natural to increase DCI size in terms of DMRS indication due to the increased DMRS ports in Rel-18, DMRS indication field should be increased as it is due to the enhancement in Rel-18. To guarantee the completeness and flexibility of gNB scheduling is the most significant thing rather than DCI size saving. We think this issue is invalid, but if deemed necessary, our standpoint is:  **FL Proposal 2.2A (for PDSCH):** Support Alt. 1 by following updates.   * + **Conclusion: Alt.1: The DCI size of DMRS port indication is increased in Rel-18 ~~by 1-bit from Rel.17~~.**   **FL Proposal 2.2A (for PUSCH):** Support Alt. 1 by following updates.   * + **Conclusion: Alt.1: The DCI size of DMRS port indication is increased in Rel-18 ~~by 1-bit from Rel.17~~.** |
| Ericsson | Support Alt2 for both proposals. |
| Sharp | FL Proposal 2.2A: Support Alt 1.  FL Proposal 2.2B: Support Alt 1. |
| Xiaomi | FL Proposal 2.2A and FL Proposal 2.2B: Support Alt.1. Increase the size of antenna ports field DCI is a more appropriate way to indicate R18 DMRS port(s). |
| Apple | FL Proposal 2.2A: Support Alt 1 as it is much simpler  FL Proposal 2.2A: Support Alt 1 as it is much simpler |
| New H3C | FL Proposal 2.2A: Alt.1.  FL Proposal 2.2B: Alt.1. |
| China Telecom | Support Alt1 for both proposals since they are the much more simpler solutions. |
| Samsung | Support Alt1 for both proposals. It is natural to increase 1-bit if more entries are supported. |
| Spreadtrum | FL Proposal 2.2A: We prefer Alt.1 to avoid complicated design. Increasing 1 bit should be enough.  FL Proposal 2.2B: We prefer the same solution as for PDSCH, i.e. Alt1. |
| CMCC | Support Alt1 for both PDSCH and PUSCH. |
| LGE | FL Proposal 2.2A: We slightly prefer Alt.2 and we are also fine with Alt.1 if it is the majority view.  FL Proposal 2.2B: We prefer the same rule is applied to both PDSCH and PUSCH. |
| vivo | FL Proposal 2.2A: Support Alt.1. There is no doubt that we need an extended table for R18 DMRS. A direct way is to indicate using legacy table or R18 table by gNB.  FL Proposal 2.2B: Support Alt.1. |
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### **ROUND-2**

In round1, all companies preferred the same option between PUSCH and PDSCH. Hence, the two proposals are mixed.

There are following comments in the 1st round:

* QC/Lenovo: Alt.2 is unnecessary complicated
* ZTE: flexibility of gNB scheduling is the most significant thing rather than DCI size saving. Remove upper bound of 1-bit.
* Intel: introducing offset indicator makes more complicated.
* Google: M can be negative value in Alt.2.

My goal in this meeting on this issue is to make agreement of “to down select”, so that we can down select in later meetings. Hence, I have some the following questions

**FL Questions (for PDSCH/PUSCH)**

* **Q1: Do you think we must limit the max number of increased bits is “1”? If so, please comment why.**
* **Q2: Do you have concern to specify “increase antenna ports field” in the proposal? (i.e. another option of introducing new DCI field of “offset indicator” is not supported) If you have concern, please comment why.** 
  + **(From FL perspective, “increase antenna ports field” is simpler and has no drawback compared to “offset indicator”)**
* **Q3: Are you ok to include negative value of M in Alt.2? If not, please comment why.**
* **Q4: Proponents of Alt.2, please comment why you think Alt.2 is beneficial.**

**FL Proposal 2.2C (for PDSCH/PUSCH)**

* **For Rel.18 eType1/eType2** **DMRS ports with *maxLength*=1/2 for PDSCH/PUSCH, if Rel.18 eType1/eType2** **DMRS ports is configured by RRC, the DCI size of antenna ports field in DCI format 1\_1/1\_2/1\_1/1\_2 is down-selected from the following:**
  + **Alt.1: Increased by 1-bit from Rel.17.**
  + **Alt.2: Increased by M (M = {0, 1}) bit, and M is configured by RRC.**
    - **RRC signaling can configure the actual rows in the antenna ports table, which can be indicated by the DCI of antenna port indication.**
    - **FFS: Additional support of negative value of M.**

FL: If Q1’s answer is no, I’ll suggest the following.

**FL Proposal 2.2D (for PDSCH/PUSCH)**

* **For Rel.18 eType1/eType2** **DMRS ports with *maxLength*=1/2 for PDSCH/PUSCH, if Rel.18 eType1/eType2** **DMRS ports is configured by RRC, the DCI size of antenna ports field in DCI format 1\_1/1\_2/1\_1/1\_2 is down-selected from the following:**
  + **Alt.1: Increased by X-bit from Rel.17, and X is pre-determined in spec. per each case of eType1, eType2, maxLength=1, maxLength=2, PDSCH, and PUSCH.**
    - **At least X=1 is supported for all cases of eType1, eType2, maxLength=1, maxLength=2, PDSCH, and PUSCH.**
  + **Alt.2: Increased by M (M = {0, …,X}) bit, and M is configured by RRC.**
    - **At least X=1 is supported for all cases of eType1, eType2, maxLength=1, maxLength=2, PDSCH, and PUSCH.**
    - **RRC signaling can configure the actual rows in the antenna ports table, which can be indicated by the DCI of antenna port indication.**
    - **FFS: Additional support of negative value of M.**

Please comment to the above FL questions and FL proposal 2.2C/2.2D.

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| **Company** | **Comment** |
| QC | Answer to Q1: no, we don’t think adding 1 bit in DCI is a big deal.  Answer to Q2: increase antenna ports field by 1 bit is the natural solution.  Answer to Q3: We are not OK to include negative value of M. Like many companies commented, the purpose of this WI is increasing MU scheduling capacity/flexibility, including negative value of M reduce the DMRS table size which is opposite to the purpose of this WI.  We really don’t see the point to spend so much effort/time to discuss this issue over and over again. There are much more important issues to discuss rather than arguing about adding 1 bit in DCI is a big problem.  We support Proposal 2.2D, Alt 1. Just a quick question for clarification about “at least X=1…”: for PUSCH, do we have to add 1 bit in DCI? It seems not to me, because in many cases, the UL DMRS tables can keep the same size as in Rel-15. |
| OPPO | Q1: Yes, we think 1 bit is sufficient for Rel-18 DMRS enhancement, according to the DMRS table design with different DMRS configurations.  Q2: increase antenna ports field is a natural way.  Q3: No. The performance of Rel-18 DMRS should not be worse than legacy.  Support FL Proposal 2.2C. Based on the discussion in Round-1, Alt-1 has majority support. Why not down select Alt1 directly? |
| vivo | Q1: Adding 1 bit is enough.  Q2: We support increase the size of antenna ports field, which is a direct way. We don’t think indicator offset can still work at this stage, since many entries supported before can’t be obtained based on direct add one offset.  Q3: Don’t support.  Besides, we prefer Alt 1, legacy DMRS with FD-OOC2 and R18 DMRS with FD-OCC4 can be switched based on the switching between R15 DMRS antenna ports table (short) and R18 DMRS antenna ports table (long). |
| New H3C | Q1: Yes.  Q2: No.  Q3: No. share the similar view with QC. Negative value of M reduce the DMRS table size is opposite to the purpose of this WI  Support proposal 2.2c Alt.-1 |
| Apple | Q1: We don’t think adding 1 bit should be an issue  Q2: We support increasing the size of antenna port files. This is quite straightforward way  Q3: No, we don’t support negative value for M as we don’t see the logic to support worse performance compared to legacy  Support FL proposal 2.2C and prefer Alt 1 |
| **FL** | **Sorry that Q1 is not clear. ZTE wants to keep door open to increase more than 1 bits. Q1 is asking whether we should strictly limit the max number of increased bit as 1 or not.**  **Also, if all companies are ok to select Alt.1, I will propose to down select in this meeting.** |
| Nokia, NSB | Q1: Yes. We have to limit the DCI overhead.  Q2: Yes, we have concern on M. Configuring M is not efficient. Though we prefer fixed size, if reduction is needed, we prefer to use similar scheme as TDRA table, and implicit deriving of DCI bit size.  Q3: No  Support FL proposal 2.2C and prefer Alt 1 |
| Ericsson | Q1: No. Increasing 1 bit in DCI is not an critical issue.  Q2: No.  Q3: OK to support negative M.  Q4:  Due to different implementation scenarios, only a few antenna port combinations are needed once the UE capability is known to the network and the network configuration get decided. We think the UE implementation effort can be reduced if UE get to know the used combinations during RRC configuration and using only subset of the antenna port table. Therefore, it is beneficial to configure only needed rows to the UE to reducing DCI size and UE memory usage after RRC configuration.  **Support FL Proposal 2.2D Alt.2** |
| ZTE | Q1: No.  Q2: No.  Q3: No, it deviates from the objective of this WI as companies commented so far.  **Support Alt. 1 in Proposal 2.2D.**  Basically, our assessment has NOT been changed, we do believe Rel-18 DMRS indication field size should be naturally increased with X-bit from Rel-17 and without any limitation.  Even though as per FL’s comment “**ZTE wants to keep door open to increase more than 1 bits**”, our focus is “**We think this issue is invalid**”. In other words, we think there is no spec impact of this issue, such as what we commented in the last round. Hope it can be clarified. |
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## Antenna ports field for PUSCH (rank 1-4)

### 2.3.1 eType1, maxLength1

We made the following agreement in RAN1#112. Remaining issue for eType1 maxLentgh1 is whether to support the rows with [].

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| **Agreement**  For the antenna ports indication in Rel.18 eType1 DMRS ports with maxLength = 1 for PUSCH, following Table 7.3.1.1.2-8-X, Table 7.3.1.1.2-9-X, Table 7.3.1.1.2-10-X, and Table 7.3.1.1.2-11-X are supported.   * FFS: Whether to increase the size of antenna ports field in DCI format 0\_1/0\_2 or not.   Table 7.3.1.1.2-8-X: Antenna port(s), transform precoder is disabled, *dmrs-Type*=eType1, *maxLength*=1, rank = 1   |  |  |  | | --- | --- | --- | | **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | | 0 | 1 | 0 | | 1 | 1 | 1 | | 2 | 2 | 0 | | 3 | 2 | 1 | | 4 | 2 | 2 | | 5 | 2 | 3 | | 6 | 1 | 8 | | 7 | 1 | 9 | | 8 | 2 | 8 | | 9 | 2 | 9 | | 10 | 2 | 10 | | 11 | 2 | 11 | | 12-15 | Reserved | Reserved |   Table 7.3.1.1.2-9-X: Antenna port(s), transform precoder is disabled, *dmrs-Type*= eType1, *maxLength*=1, rank = 2   |  |  |  | | --- | --- | --- | | **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | | 0 | 1 | 0,1 | | 1 | 2 | 0,1 | | 2 | 2 | 2,3 | | 3 | 2 | 0,2 | | 4 | 1 | 8,9 | | 5 | 2 | 8,9 | | 6 | 2 | 10,11 | | [7] | [2] | [8,10] | | 8-15 | Reserved | Reserved |   Table 7.3.1.1.2-10-X: Antenna port(s), transform precoder is disabled, *dmrs-Type*= eType1, *maxLength*=1, rank = 3   |  |  |  | | --- | --- | --- | | **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | | 0 | 2 | 0-2 | | [1] | [2] | [8-10] | | 2 | 1 | 0,1,8 | | 3 | 2 | 0,1,8 | | 4 | 2 | 2,3,10 | | 5-15 | Reserved | Reserved |   Table 7.3.1.1.2-11-X: Antenna port(s), transform precoder is disabled, *dmrs-Type*= eType1, *maxLength*=1, rank = 4   |  |  |  | | --- | --- | --- | | **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | | 0 | 2 | 0-3 | | [1] | [2] | [8-11] | | 2 | 1 | 0,1,8,9 | | 3 | 2 | 0,1,8,9 | | 4 | 2 | 2,3,10,11 | | 5-15 | Reserved | Reserved | |

Multiple companies propose to remove the rows with [ ], considering these rows would be not supported for PDSCH.

**FL Proposal 2.3.1A**

* **For RAN1#112 agreement of the antenna ports indication in Rel.18 eType1** **DMRS ports with *maxLength* = 1 for PUSCH,** 
  + **Do not support row 7 for rank2, row1 for rank3, row 1 for rank4.**

**FL Proposal 2.3.1B (Opposite proposal)**

* **For RAN1#112 agreement of the antenna ports indication in Rel.18 eType1** **DMRS ports with *maxLength* = 1 for PUSCH,** 
  + **Support row 7 for rank2, row1 for rank3, row 1 for rank4.**

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| --- | --- |
| **Company** | **Comment** |
| Docomo | Support. For row 1 of rank 3 and row 1 of rank 4, we don’t see any use-case, because DMRS ports of Cat.3 is more useful in terms of DMRS overhead. For row 7 of rank 2, although MU MIMO restriction is not applied to PUSCH, we don’t think row 7 of rank 2 is useful. |
| Google | OK |
| Ericsson | Do not support FL proposal. These rows don’t use legacy ports are very useful for increasing the MU-MIMO capacity in uplink. Network can schedule Rel-18 UE using new ports and keep the legacy ports to schedule Rel-15 UE. |
| OPPO | Support. If the use case is MU-MIMO, the ports within the same CDM group should be used. |
| Nokia/NSB | Support the proposal. But, we can live with the rows with brace. |
| CATT | Do not support the proposal. The same port combination(s) as that for PDSCH is used. |
| Huawei, HiSilicon | Agree with Ericsson’s assessment. |
| Lenovo | We prefer to align the DMRS design for PDSCH and PUSCH. So we can live up with the proposal. |
| Intel | We think the rows may be beneficial for increasing UL MU-MIMO capacity |
| QC | We don’t have strong opinion on this proposal. If gNB vendors don’t see issues to implement receiver to support those rows, we can support keeping them. |
| MediaTek | Fine |
| ZTE | Do not support.  We share similar view to E/// that rows with [] are needed for MU-MIMO scenario, which is in line with the motivation as stated in WID. |
| Sharp | We are fine with the proposal. |
| Xiaomi | Fine. |
| Apple | Fine |
| New H3C | OK |
| China Telecom | Not support. The rows with brackets are needed. |
| LGE | Support. We think the rows may be beneficial for increasing UL MU-MIMO capacity within the same CDM group. |
| vivo | Support FL Proposal 2.3.1A. |
| ZTE2 | Support **FL Proposal 2.3.1B**. |
| **FL(v40)** | **Multiple companies suggested to support the rows. Since there is no MU-MIMO restriction for PUSCH, and there should be no technical concern at UE vendors to support the new rows (because receiver of PUSCH is gNB), and multiple gNB vendors/operator think the new row are beneficial, my suggestion is to consider FL Proposal 2.3.1B.** |
| Apple | We prefer FL proposal 2.3.1A |
| Ericsson1 | Support **FL Proposal 2.3.1B** |
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### **ROUND-2**

There is no update, but if you have any **concern** for either option, please comment what is your concern.

If there is no concern, I’ll suggest to take FL Proposal 2.3.1B

**FL Proposal 2.3.1A (delete the rows with [])**

* **For RAN1#112 agreement of the antenna ports indication in Rel.18 eType1** **DMRS ports with *maxLength* = 1 for PUSCH.**
  + **Do not support row 7 for rank2, row1 for rank3, row 1 for rank4.**

**FL Proposal 2.3.1B (support the rows with [])**

* **For RAN1#112 agreement of the antenna ports indication in Rel.18 eType1** **DMRS ports with *maxLength* = 1 for PUSCH.**
  + **Support row 7 for rank2, row1 for rank3, row 1 for rank4.**

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| --- | --- |
| **Company** | **Comment** |
| QC | We echo FL’s point: “**Multiple companies suggested to support the rows. Since there is no MU-MIMO restriction for PUSCH, and there should be no technical concern at UE vendors to support the new rows (because receiver of PUSCH is gNB), and multiple gNB vendors/operator think the new row are beneficial, my suggestion is to consider FL Proposal 2.3.1B.**”  We want to point out that, on UE side, although the effort is not large, but there is still effort to support additional rows. But we can support this proposal because we see gNB vendors’ request for more scheduling flexibility on UL.  On the other hand, on DL 2CWs, we unfortunately see some gNB vendors object proposals from UE vendors which has nearly zero impact to gNB implementation and performance, while can significantly benefit UE with reduced implementation complexity. We hope those gNB vendors can reconsider their position, because the concern from both UE/gNB needs to be considered to design Rel-18 DMRS. |
| OPPO | Our preference is FL Proposal 2.3.1A. However, we can live with FL Proposal 2.3.1B if gNB needs. |
| vivo | In the current spec, for uplink, only {0,2} is supported. In other words, there is no {1,3} in the uplink DMRS table for MU-MIMO with {0,2}. Therefore, as we have agreed that {0,2} is supported in R18, we don’t prefer other entries across CDM groups to be supported. The legacy principle can be followed. Besides, we would like to mention that the entries of uplink are the same as downlink for each rank in R15. |
| New H3C | Support Proposal 2.3.1A |
| Apple | We prefer FL Proposal 2.3.1A, but considering network vendors position, we can also accept FL Proposal 2.3.1B. |
| Nokia, NSB | We are fine with either proposal. As long as no increase of DCI bit, having multiple options may provide the flexibility. For rank 2, can we support [9,11] instead of [8,10] as we discussed in DL. |
| Ericsson | Support FL Proposal 2.3.1B. And we don’t support 2.3.1A. |
| ZTE | Support FL Proposal 2.3.1B, we agree with FL’s assessment that “**and multiple gNB vendors/operator think the new row are beneficial, my suggestion is to consider FL Proposal 2.3.1B**”.  We also completely agree with FL’s assessment that “**Since there is no MU-MIMO restriction for PUSCH, and there should be no technical concern at UE vendors to support the new rows (because receiver of PUSCH is gNB),**”. We are very wondering in what’s **the specific technical concern** of the rows with [] to some UE vendors? From the perspective of UE complexity/implementation/pipeline/cost-effectiveness/etc, is there any differentiation between {8, 10} and {0, 2} for rank 2, {8-10} and {0-2} for rank 3, {8-11} and {0-3} for rank 4? We are very interested in the answers from the companies that mentioned this point before. |
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## Signaling of Rel.18 DMRS ports

In RAN1#112, we made the following conclusion.

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| --- |
| **Conclusion**  Dynamic switching between R15 DMRS port and R18 DMRS port by a scheduling DCI is not supported in Rel-18 |

In this meeting, Huawei/HiSilicon[3], ZTE/China Telcom[4], Samsung[18] propose MAC CE based switching between Rel.15 DMRS ports and Rel.18 DMRS ports. The benefit is it can avoid RRC re-configuration, and it enables faster switching. Nokia/NSB[15] proposes DMRS type configuration per search space so that DCI-based dynamic switching between Rel.15 DMRS ports and Rel.18 for PDSCH is allowed by selecting search space of the scheduling DCI.

These proposals are not explicitly precluded by the conclusion, and it is good to discuss.

**FL Proposal 2.4A (MAC CE based switching)**

* **Support MAC CE based switching between Rel.15 DMRS ports and Rel.18 DMRS ports for PDSCH**

**FL Proposal 2.4B (Search-space based switching)**

* **Support configuration of Rel-18 DMRS per search space to indicate what DMRS type is supported for PDSCH/PUSCH scheduling in the search space.**

Google [16] proposes dynamic indication of co-scheduled UE in the same CDM group to handle the similar issue.

**FL Proposal 2.4C (dynamic indication of co-scheduled UE)**

* **Support dynamic indication of information of co-scheduled UE in the indicated CDM group(s)** **to facilitate the FD-OCC length selection in UE side**
  + **The information is whether new port index(es) (eType 1: p=8~15, eType 2: p=12~23) is/are used for co-scheduled UE in the same indicated CDM group for the scheduled UE.**

**Proposal 2.4D: (Proposed by ZTE)**

**Rel-18 PDSCH/PUSCH DMRS ports can be dynamically generated with length 2/4 FD-OCC to guarantee the performance especially in large delay spread scenario.**

* **Note: It is common understanding in RAN1 that dynamic switching between length 2/4 FD-OCC can be performed dynamically by UE implementation.**

|  |  |  |
| --- | --- | --- |
| **Company** | | **Comment** |
| Docomo | | FL proposal 2.4A: We are fine.  FL proposal 2.4B: In Rel.15-17, *DMRS-DownlinkConfig* is configured in *PDSCH-Config* and *DMRS-UplinkConfig* is configured in *PUSCH-Config*. PDSCH DMRS configuration per Search Space is new concept and its impact to TS38.331 is not small. Even if it enables indication of the dynamic switching of FD-OCC, from gNB perspective, we cannot ensure UE switches FD-OCC length for de-spreading (because not testable), and the benefit is not clear. Hence, we don’t support FL proposal 2.4B.  FL proposal 2.4C: Support. |
| Google | | In our view, we do not need to dynamically switch between R15 DMRS and R18 DMRS. But the NW only needs to provide some information for the UE to determine the FD-OCC despreading length. We suggest the following proposal:  **Support to indicate the maximum number of co-scheduled DMRS ports per CDM group in the scheduling DCI when R18 DL DMRS is configured.** |
| Futurewei | | **FL Proposal 2.4A:** Support.  **FL Proposal 2.4B:** It is not clear to us the benefit of this proposal.  **FL Proposal 2.4C:** We don’t see this proposal is necessary. |
| OPPO | | FL proposal 2.4A: Not support. We think RRC based switching is sufficient.  FL proposal 2.4B: Not support. It would increase the UE complexity to dynamically switch the OCC length.  FL proposal 2.4C: As discussed in previous meetings, we don’t think it is needed. |
| Nokia/NSB | | FL proposal 2.4A: Not support. MAC-CE based has little flexibility.  FL proposal 2.4B: Support. Rel-18 DMRS configuration should be additional indiation to Rel-15 DMRS configuration. So, just simple indication of whether to use Rel-18 DMRS or not is enough. Rel-18 DMRS is more useful for low data rate IoT service.  FL proposal 2.4C: The proposal is including dynamic switching of FD-OCC2/4. Overhead is almost similar, but less flexible. Dynamic switching is simpler and better. |
| CATT | Support Proposal 2.4A. | |
| Huawei, HiSilicon | | **FL Proposal 2.4A:** Support.  **FL Proposal 2.4B:** Not support. The benefit is not clear.  **FL Proposal 2.4C:** Fine with the principle. Details can be further discussed. |
| Lenovo | | FL proposal 2.4A: Support. From our previous simulation results, Rel-15 DMRS ports can provide better performance than Rel-18 DMRS ports; and Rel-18 DMRS ports may occupy less resources when the transmission rank is higher since only one CDM group may be enough. We think faster DMRS port type switching than RRC is beneficial and should be supported.  FL Proposal 2.4B: Not support since it will increase UE realization complexity.  FL Proposal 2.4C: Not support. |
| Intel | | **Proposal 2.4A:** Do not support dynamic switching of Rel-15 and Rel-18 ports. This issue was discussed at length and concluded in the last meeting. No need to further revisit again.  **Proposal 2.4B:** Do not support this proposal. This has major specification impact without major benefits. As we commented there is no fundamental performance issue with length-4 OCC.  **Proposal 2.4C:** The issue is not simply about new ports. Same issue exists in legacy DM-RS where the UE does not know if there are other co-scheduled UEs within a CDM group. In Rel-15, this indication was not agreed. From our perspective, if we want to make this useful, we should indicate whether there are co-scheduled ports within the same CDM group which can potentially help UEs with appropriate receivers. |
| QC | | We don’t see much need to introduce 1 bit signaling to switch Rel-15 and Rel-18 DMRS, because of the same reasons we gave in previous meetings.   * There is no much performance difference between Rel-15 and Rel-18 DMRS (see simulation), if UE implement channel estimation properly. Someone not implementing channel estimation properly does not justify the need to introduce this signaling. * Dynamic switching between Rel-15 and Rel-18 DMRS would significant increase UE implementation complexity.   Chart, line chart  Description automatically generated  We are open to discuss MAC-CE. However, we still don’t support this proposal, because it is a bad design, due to the following reasons.   * If MAC-CE based switch is introduced, it is clearly a waste of a whole MAC-CE to deliver just 1-bit (to switch between Rel-15 and Rel-18), consider the header of MAC-CE. Since this switching is essentially some MU scheduling information (to tell a Rel-18 UE with Rel-15 DMRS ports whether other MU exist or not), it is natural to include more MU scheduling information in the MAC-CE, such as the following Modified FL Proposal 2.4A. By the way, there is a RAN4 WI (RP-222300) on NW assisted advance UE canceling inter-user interference for MU-MIMO. It can be seen that the following list of MU information in Modified FL Proposal 2.4A are proposed by many companies in RAN4 as well. * Even if we just introduce 1 bit in MAC-CE, using this bit to indicate switch between Rel-15 and Rel-18 DMRS is a bad design. A better design is using this bit indicate whether there is co-scheduled MU with this target UE or not. The following are the reasons.   + (The original proposal) Indicating switch between Rel-15 and Rel-18 DMRS only help channel estimation of target UE 1 in one scenario (Scenario 1). It does not work for scenario 2 and 3. While (the modified proposal) using 1 bit to indicate MU exist or not can help channel estimation in all three scenarios.   + The modified proposal has more benefits. Functionalities 2 and 3 are not even achievable by the original proposal.     In summary, we still object include only 1-bit to switch Rel-15 and Rel-18 in MAC CE. We are open to discuss the following Modified FL Proposal 2.4A.  By the way, for PUSCH, we don’t see the need to introduce this 1-bit switch at all, even with MAC-CE based switch. As the switch is providing MU information to help receiver channel estimation, which is not needed for PUSCH.  **Modified FL Proposal 2.4A**  **Support using MAC CE to indicate at least the following MU scheduling related information to a target UE for PDSCH. ~~based switching between Rel.15 DMRS ports and Rel.18 DMRS ports for PDSCH/PUSCH~~**   * **1 bit to indicate if co-scheduled UE exist or not.** * **1 bit to indicate whether PRG of co-scheduled UEs (if exist) are aligned with target UE.** * **1 bit to indicate whether PDSCH staring and symbol of co-scheduled UEs (if exist) are aligned with target UE.** * **1 bit to indicate whether DMRS sequences of co-scheduled UEs (if exist) are aligned with the target UE.** * **DMRS to PDSCH power ratio of co-scheduled UEs, if exist. FFS number of bits.** * **Supported Max QAM (i.e., 64QAM, 256QAM, or 1024QAM) of co-scheduled UEs, if exist. FFS number of bits.**   **FFS: including other MU scheduling information in the MAC-CE.** |
| MediaTek | | **Proposal 2.4A: N**ot support. This was discussed earlier and decided RRC switching is sufficient.  **FL Proposal 2.4B:** Not Support. This introduced UE complexity. Any DCI/PDCCH based DRMS type selection should be excluded based on the previous discussions, this proposal is basically introducing the same concept but with different mechanism.  **FL proposal 2.4C:** Fine to discuss further on the details. |
| ZTE | | **Proposal 2.4A:** Support.  In general, this switching is to compensate the performance loss issue caused by length 4 FD-OCC in large delay spread scenario as captured in the WA in RAN1#110 meeting.   |  | | --- | | **Working Assumption**  To increase the number of DMRS ports for PDSCH/PUSCH, support at least Opt.1 (introduce larger FD-OCC length than Rel.15 (e.g. 4 or 6)).   * FFS: FD-OCC length for Rel.18 DMRS type 1 and type 2. * FFS: Whether it is needed to handle potential performance issues of Opt 1. For example, study if there is performance loss in case of large delay spread scenario. If needed, how (e.g. additionally support other options). |   Basically, we do believe indication of the switching between length 2/4 FD-OCC is very essential for both UE side and gNB side.   * For UE side, Rel-18 DMRS ports will be more sensitive to delay spread variation than the Rel-15 DMRS ports due to the sparser allocation of length 4 FD-OCC basis in frequency domain. Besides, companies (at least including vivo, Ericssion, Huawei, Lenovo and ZTE) provided simulation results in the previous meeting have already proved that performance loss is indeed existing for length 4 FD-OCC when compared with length 2 FD-OCC large delay spread scenario (DS = 1000ns). The only reason used by opponents is that UE can be implemented based on the special but also fancy assumption of transmitter in gNB side (e.g., power scaling of path/cluster with larger delays by precoder, in [R1-2209970](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_110b-e/Docs/R1-2209970.zip) from QC in RAN1#110b-e). Apparently, we do believe this assumption is over-demanded and also unfair to gNB implementation. * For gNB side, this switching is very essential for optimizing system performance via guaranteeing transmission scheduling in SU-MIMO and MU-MIMO scenarios as we elaborated in in our tdoc ([R1-2302419)](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_112b-e/Docs/R1-2302419.zip).   In particular, if some companies insist the switching can be performed dynamically based on their UE implementation with the “advanced” processing, it should allow that gNB can generate Rel-18 DMRS ports (at least for Cat. 1) with length 2/4 FD-OCC in the same sense. This point should be common understanding to RAN1 and also be captured in Rel-18. We proposed:  **Proposal 2.4D:**  **Rel-18 PDSCH/PUSCH DMRS ports can be dynamically generated with length 2/4 FD-OCC to guarantee the performance especially in large delay spread scenario.**   * **Note: It is common understanding in RAN1 that dynamic switching between length 2/4 FD-OCC can be performed dynamically by UE implementation.**   **Proposal 2.4B:** Do not support. We share similar view with companies, it will lead to UE complexity of SS monitoring in addition.  **Proposal 2.4C:** Fine to further study, but we do believe it is not irrelevant to the selection of FD-OCC length. More precisely, it is to indicate the interference from co-scheduled UE with different FD-OCC length, whether this kind of scheduling can be supported should be discussed at first. On the other hand, this issue is the very similar to co-existence between Rel-15 and Rel-18 DMRS in MU-MIMO, which should be discussed in case 3) in section 2.5 instead. |
| Ericsson | | Proposal 2.4A: Fine with this proposal.  Proposal 2.4B: Fine with the proposal.  Proposal 2.4C: Fine with the proposal. |
| Sharp | | FL Proposal 2.4A: Support.  FL Proposal 2.4B: We are open to discuss.  FL Proposal 2.4C: We are fine with the proposal. |
| Xiaomi | | Proposal 2.4A: Not support. Our first choice is RRC based switching.  Proposal 2.4B: Not support.  Proposal 2.4C: Ok to further discuss. But we don’t get the intention of proposal 2.4C. |
| Apple | | **FL Proposal 2.4A:** We do Not support and as discussed earlier, RRC switching is sufficient.  **FL Proposal 2.4B:** We do not Support. Share similar view as QC and Mediatek that this introduced UE complexity.  **FL proposal 2.4C:** Fine to discuss further |
| New H3C | | OK for proposal 2.4A |
| China Telecom | | **Proposal 2.4A**: Support the proposal. From the simulation before, we think most of us agree that the FD-OCC 4 will bring an extra performance loss. The reason why indication of dynamic switching with DCI was not supported in the last meeting is that some companies thought that the capability can be supported by the UE according to the implement. But the question is, we don’t think all the UEs will have the capability to avoid such performance degradation by themselves. If so, we think Proposal 2.4D by ZTE should also be supported to ensure the performance. Even the problem can be solved by UEs, the increase of complexity can be even larger than that brought by the indication. And if the MAC CE is not flexible, why RRC based switching can be a good solution? And it is interesting that why adding 1 bit for DMRS switching is a bad design and unnecessary, but and more bits for indicating the information about UE co-existence is needed. Since DCI based solution is precluded in the last meeting, we think the best solution currently is to support the MAC CE based switching solution.  **Proposal 2.4B**: Not support.  **Proposal 2.4C**: We are fine to further discuss, but we don’t understand the motivation of discussing it here, we think the proposal is actually about the co-existence of Rel-15 and Rel-18 DMRS.. |
| Samsung | | Proposal 2.4A: We have similar view with ZTE and China Telecom. Not all UEs cannot have a capability freely switching between length-2/4 FD-OCC based on UE’s own decision. If a UE does not have such implementation and a capability, then as mentioned by many companies, the channel estimation performance would be degraded. So, for such UEs, such switching indication at least via MAC-CE would be beneficial.  Proposal 2.4B: Do not support.  Proposal 2.4C: Similar view with Nokia and ZTE, this issue is not exactly related to switching between FD-OCC length. |
| Fraunhofer | | FL proposal 2.4A: No support. We also think that RRC-based switching is sufficient.  FL proposal 2.4B: No support.  FL proposal 2.4C: We don’t think it is needed. |
| Spreadtrum | | Proposal 2.4A: We prefer RRC based switching.  Proposal 2.4B: This feature will change the way of DMRS type determination of current spec. However, we think it’s not worthy since the benefit is not clear.  Proposal 2.4C: If our memory is correct, this proposal was originally brought for MU-MIMO between Rel.15 DMRS ports and Rel.18 DMRS ports. We are OK to further discuss either in this section or in section 2.5. |
| CMCC | | FL proposal 2.4A: Support. Length-4 FD-OCC is more sensitive to the frequency selectivity fading, it is better to use length-2 FD-OCC for channel estimation under large delay spread scenario. While for higher layers MU-MIMO, length-4 FD-OCC is needed. So, MAC CE based switching of length 2 and length 4 FD-OCC is benefit for SU and MU-MIMO switching. For MU-MIMO scheduling, if the layers of MU-MIMO is less than 8 or 12 layers, then length-2 FD-OCC can be used with better performance. While when network schedules higher layers MU-MIMO, then length-4 FD-OCC is needed. So, MAC CE based switching of length 2 and length 4 FD-OCC is benefit for MU-MIMO scheduling.  FL Proposal 2.4B: Not support. Configuration of DMRS type per search space will reduce the flexibility of search space.  FL Proposal 2.4C: Fine with the proposal. |
| LGE | | Agree with Google, we do not need to dynamically switch between R15 DMRS and R18 DMRS because semi-static switching is sufficient. |
| vivo | | FL proposal 2.4A: No support, and RRC is fine. Since there is no consensus to support dynamic switching, we think RRC-based switching is fine. If MAC CE is used, which table is used and which FD-OCC length is assumed would be more complex than direct RRC configuration.  FL proposal 2.4B: No support.  FL proposal 2.4C: Since there is no consensus to support dynamic switching, we don’t understand the motivation of this proposal at this stage. |
| ZTE2 | | @FL, we think it is critical to reach the common understanding as in the above Proposal 2.4D. Could it be treated for discussion/clarification?  **FL: I captured it. Companies, please check FL proposal 2.4D.** |
| QC3 | | Regarding the following proposal by ZTE, we don’t know what it means by “Rel-18 PDSCH/PUSCH DMRS ports can be dynamically generated with length 2/4 FD-OCC”. Can ZTE please clarify?  Also, about the note, as we commented multiple times, UE can choose not to perform any dynamic switch. We don’t know what is the intention of the note and don’t agree with it.  Last but not least, what is the spec impact of this proposal? Can ZTE please clarify? |
| ZTE3 | | @QC:   1. It literally is Rel-18 DMRS sequence can be generated by FD-OCC 2 (the legacy) or FD-OCC 4 (Rel-18) depends on the channel estimation of delay spread from the perspective of gNB implementation, if your assumption of this feature is common understanding of all UE vendors. Consequently/Obviously/Alternatively, one spec impact is that Rel-18 DMRS ports can be generated by FD-OCC 2. 2. BTW, could you please answer my previous question (provided at least 48hrs ago) that do you believe the processing assumption in your tdoc that “power scaling of path/cluster with larger delays by precoder” in transmitter side is common and acceptable to gNB vendors? Fyi, our answer is **NO**. |
| Apple2 | | In our view, we are somewhat repeating the discussions from previous meeting and don’t see the need to consider again additional methods to switching between FD-OCC2 and FD-OCC4 other that semi-statically via RRC. From this point of view, we cannot support the proposal from ZTE or the FL proposal 2.4A and 2.4B |
| Nokia/NSB2 | | Regarding to ZTE proposal (2.4D), we don’t understand the consequence of the proposal.  With the current companies view, we think only RRC configuration is enough. We think only one RRC parameter if Rel-18 DMRS is supported or not is required on top of the Rel-15 DMRS config. QC’s proposal (2.4A) doesn’t make sense. Because MAC-CE is used for switching of mode but for providing dynamic scheduling information. (copied from v43) |
| vivo | | We can understand the motivation of ZTE for proposal 2.4D. But we would like to mention that we have agreed in the previous meeting that R18 DMRS is with FD-OOC4 and R15 DMRS is with FD-OCC2 for the spec perspective, and how to perform channel estimation is up to UE implementation.  In our mind, the direct way is to use RRC to semi-switch the legacy indication tables and R18 indication tables with extended entries, as different type of DMRS is configured by RRC in R15. But we are also ok with MAC-CE, if MAC-CE is also used for switching of the legacy indication tables and R18 indication tables, rather the length switching of FD-OCC for R18 DMRS. |

### **ROUND-2**

In Wed. online, the following proposal was discussed. However, there was no consensus. Opponents comments the following:

* This repeats the same discussion of dynamic switching in RAN1#112.
* Using MAC CE to indicate just 1-bit is even worse than DCI based.

Please continue the discussion to find any chance to make consensus for this proposal. However, please don’t suggest to discuss other proposals (FL Proposal 2.4B/2.4C/2.4D), because they are far from consensus.

**FL Proposal 2.4A (MAC CE based switching)**

* **Support MAC CE based switching between Rel.15 DMRS ports and Rel.18 DMRS ports for PDSCH**

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| **Company** | **Comment** |
| QC | We object this proposal, based on the same reasons we mentioned in last round (copied below). By the way, we raised many technical concerns about this proposal, but it seems none of them were addressed by proponents of this proposal.  We are open to discuss MAC-CE. However, we still don’t support this proposal, because it is a bad design, due to the following reasons.   * If MAC-CE based switch is introduced, it is clearly a waste of a whole MAC-CE to deliver just 1-bit (to switch between Rel-15 and Rel-18), consider the header of MAC-CE. Since this switching is essentially some MU scheduling information (to tell a Rel-18 UE with Rel-15 DMRS ports whether other MU exist or not), it is natural to include more MU scheduling information in the MAC-CE, such as the following Modified FL Proposal 2.4A. By the way, there is a RAN4 WI (RP-222300) on NW assisted advance UE canceling inter-user interference for MU-MIMO. It can be seen that the following list of MU information in Modified FL Proposal 2.4A are proposed by many companies in RAN4 as well. * Even if we just introduce 1 bit in MAC-CE, using this bit to indicate switch between Rel-15 and Rel-18 DMRS is a bad design. A better design is using this bit indicate whether there is co-scheduled MU with this target UE or not. The following are the reasons.   + (The original proposal) Indicating switch between Rel-15 and Rel-18 DMRS only help channel estimation of target UE 1 in one scenario (Scenario 1). It does not work for scenario 2 and 3. While (the modified proposal) using 1 bit to indicate MU exist or not can help channel estimation in all three scenarios.   + The modified proposal has more benefits. Functionalities 2 and 3 are not even achievable by the original proposal.     In summary, we still object include only 1-bit to switch Rel-15 and Rel-18 in MAC CE. We are open to discuss the following Modified FL Proposal 2.4A.  **Modified FL Proposal 2.4A**  **Support using MAC CE to indicate at least the following MU scheduling related information to a target UE for PDSCH. ~~based switching between Rel.15 DMRS ports and Rel.18 DMRS ports for PDSCH/PUSCH~~**   * **1 bit to indicate if co-scheduled UE exist or not.** * **1 bit to indicate whether PRG of co-scheduled UEs (if exist) are aligned with target UE.** * **1 bit to indicate whether PDSCH staring and symbol of co-scheduled UEs (if exist) are aligned with target UE.** * **1 bit to indicate whether DMRS sequences of co-scheduled UEs (if exist) are aligned with the target UE.** * **DMRS to PDSCH power ratio of co-scheduled UEs, if exist. FFS number of bits.** * **Supported Max QAM (i.e., 64QAM, 256QAM, or 1024QAM) of co-scheduled UEs, if exist. FFS number of bits.**   **FFS: including other MU scheduling information in the MAC-CE.**  @ZTE, to answer your question on precoding, we did not use any “fancy” precoding in our simulation. What we used is nothing but per PRG based precoding. Channel delay is reduced after precoding is a natural outcome of precoding. Because the whole purpose of per PRG based precoding is find the strongest direction of the channel for each PRG and amplify that direction via beamforming which will effectively suppress other directions of the channel. Then if you translate this frequency selective channel amplifying and suppression into delay domain, the strong paths (which are normally closer to the DC tap of the channel) are amplified, while the weaker path (which are normally further away to the DCI tap of the channel) are suppressed. So you will see the PDP of the channel gets shortened, which means the channel delay after precoding is shortened. |
| OPPO | We don’t need to repeat the discussion again. There would not be consensus among companies, as in previous meetings. |
| New H3C | Support Proposal 2.4A |
| Apple | We strongly object this proposal and it seems not reasonable to repeat similar discussion with slightly different approach. In our view, this will likely have similar conclusion as for DCI based indication from previous meeting. |
| Nokia, NSB | Not support. MAC-CE doesn’t provide benefit over RRC signaling. The use case of MAC-CE is switching mode when the number of active UE increase, but this is not dynamic behavior but semi-static option. If we don’t support simultaneous support of Rel-15/Rel-18, we don’t see the gain. This may impact to DCI size, but it is ambiguous from when the DCI size is valid. |
| Ericsson | Support FL Proposal 2.4A |
| ZTE | Support FL Proposal 2.4A.  According to my tons of elaborations so far, I do believe almost all companies understand the necessity/advantage/practical use case of the indication of FD-OCC 2/4 switching for both UE side and gNB side. |
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## MU-MIMO between Rel.15 DMRS ports and Rel.18 DMRS ports

In RAN1#110, we agreed to study MU-MIMO between Rel.15 DMRS ports and Rel.18 DMRS ports within a CDM group for PDSCH. Note that for PUSCH, there should be no restriction. For PDSCH, some companies claims that there is no need to make an agreement of “*UE does not expect such MU-MIMO in a CDM group*”, because the current specification already allows MU-MIMO by allocating different PN sequence, TCI state, etc. between different UEs by gNB implementation, and it does not make sense to preclude such existing gNB implementation by RAN1 spec. Hence, for 3) and 4), unless Alt.2 in 4) is agreed, we may not need any agreement (i.e. it is up to gNB responsible to avoid such MU operation).

Nevertheless, if we remove whole 3) and 4), some companies may have concern, because it looks like UE should handle such MU operation. Hence, slight wording change is suggested for 3) and 4).

**FL Proposal 2.5A**

* **For MU-MIMO within a CDM group between Rel.15 DMRS ports and Rel.18 DMRS ports,**
  + **1) For PUSCH, there is no restriction.**
  + **2) For PDSCH, there is no additional restriction between Rel.18 UE1 indicated with Rel-18 Legacy ports (eType1: ports 1000-1007, eType2: ports 1000-1011) and Rel.15/18 UE2 indicated with Rel.15 DMRS ports in a CDM group from Rel.17 spec.**
    - **Note: MU-MIMO restriction in Rel.17 is applied.**
  + **3) For PDSCH, between Rel.18 UE1 indicated with Rel-18 New ports (eType1: ports 1008-1015, eType2: ports 1012-1023) and Rel.15 UE2 indicated with Rel.15 DMRS ports in a CDM group,**
    - **UE is not required to handle such MU-MIMO in a CDM group (No spec. impact).**
  + **4) For PDSCH, between Rel.18 UE1 indicated with Rel-18 New ports (eType1: ports 1008-1015, eType2: ports 1012-1023) and Rel.18 UE2 indicated with Rel.15 DMRS ports in a CDM group, down select from the following.**
    - **Alt.1: UE is not required to handle such MU-MIMO in a CDM group (No spec. impact).**
    - **Alt.2: Rel.18 UE2 configured with Rel.15 DMRS ports can be signaled, to indicate that there may be another Rel.18 UE1 with Rel.18 New ports (eType1: ports 1008-1015, eType2: ports 1012-1023) in the same CDM group, so that the Rel.18 UE2 can assume FD-OCC length 4 for channel estimation of Rel.15 DMRS ports.**
      * **Dedicated UE capability is introduced.**
      * **The signaling is at least by RRC (FFS: whether to support DCI based signaling).**

**Objected by QC/Huawei/HiSilicon**

**FL Proposal 2.5B (Proposal from QC/HW)**

* **For MU-MIMO within a CDM group between Rel.15 DMRS ports and Rel.18 DMRS ports,**
  + **1) For PUSCH, there is no restriction.**
  + **2) For PDSCH, there is no additional restriction between Rel.18 UE1 indicated with Rel-18 Legacy ports (eType1: ports 1000-1007, eType2: ports 1000-1011) and Rel.15/18 UE2 indicated with Rel.15 DMRS ports in a CDM group from Rel.17 spec.**
    - **Note: MU-MIMO restriction in Rel.17 is applied.**
  + **3) For PDSCH, between Rel.18 UE1 indicated with Rel-18 New ports (eType1: ports 1008-1015, eType2: ports 1012-1023) and Rel.15 UE2 indicated with Rel.15 DMRS ports in a CDM group,**
    - **UE does not expect such MU-MIMO within a CDM group .**
  + **4) For PDSCH, between Rel.18 UE1 indicated with Rel-18 New ports (eType1: ports 1008-1015, eType2: ports 1012-1023) and Rel.18 UE2 indicated with Rel.15 DMRS ports in a CDM group, down select from the following.**
    - **Alt.1: UE does not expect such MU-MIMO within a CDM group .**
    - **Alt.2: Rel.18 UE2 configured with Rel.15 DMRS ports can be signaled, to indicate that there may be another Rel.18 UE1 with Rel.18 New ports (eType1: ports 1008-1015, eType2: ports 1012-1023) in the same CDM group, so that the Rel.18 UE2 can assume FD-OCC length 4 for channel estimation of Rel.15 DMRS ports.**
      * **Dedicated UE capability is introduced.**
      * **The signaling is at least by RRC (FFS: whether to support DCI based signaling).**

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| **Company** | **Comment** |
| Docomo | Support. For 4), we support Alt.2 because UE configured with R15 can receive DMRS with FD-OCC length 4 to handle MU operation. If Alt.2 (RRC can configure increased M = {0,1} bits of antenna ports field) is supported in FL Proposal 2.2A, Alt.2 in the above proposal may be not beneficial. However, if not, Alt.2 in the above proposal is beneficial because we don’t need to increase the size of antenna ports field for some UEs for MU-MIMO. |
| Google | Support |
| Futurewei | On 4), we prefer Alt. 1. It is up to gNB implementation whether to schedule such MU-MIMO in a CDM group. |
| OPPO | Support the proposal and prefer Alt.1 for 4). It is up to gNB implementation to schedule such case and gNB should ensure the orthogonality among co-scheduled DMRS ports. |
| Nokia/NSB | Fine without specification impact. |
| CATT | Support.  Alt.1 is preferred for 4). |
| Huawei, HiSilicon | For **3)**, the current version seems confusing. The original version aims to guarantee the performance of Rel.15 UE is not affected by explicitly adding scheduling restriction, the effect of which cannot be achieved by the current version.  To address some companies’ concern that “the current specification already allows MU-MIMO by allocating different PN sequence between different UEs by gNB implementation”, similar to the MU MIMO restriction in current spec. which consists of wording “orthogonal”, we can introduce some wording meaning that aforementioned limitation between Rel.18 UE and Rel.15 UE applies to DMRS ports with same PN sequence (corresponds to the “orthogonal” in current MU restriction). The detailed capture way can be left to editor.  **FL: Thanks, but for non-orthogonal case (e.g. different PN sequence), it is up to gNB implementation that “orthogonal” DMRS ports may or may not be used to other UEs. Majority companies think there is no need to specify such thing. Also, when we make an agreement, we should clarify whether it has spec impact or not, so that spec editors can correctly capture the agreements.**  For **4)**, ensuring the orthogonality of length-2 FD-OCC between co-scheduled Rel.18 new DMRS ports and Rel.15 DMRS ports by introducing a restriction can also be treated as candidate direction. In this way the channel estimation performance of Rel.15 DMRS port can be guaranteed to the most extent. As a result we suggest to add an alternative for 4) as below:  **FL Proposal 2.5A**   * **For MU-MIMO within a CDM group between Rel.15 DMRS ports and Rel.18 DMRS ports,**   + **4) For PDSCH, between Rel.18 UE1 indicated with Rel-18 New ports (eType1: ports 1008-1015, eType2: ports 1012-1023) and Rel.18 UE2 indicated with Rel.15 DMRS ports in a CDM group, down select from the following.**   **Alt.3: Introduce restriction that the UE indicated with Rel.15 DMRS ports is not expected to be co-scheduled with a UE indicated with Rel.18 DMRS ports if the orthogonality of length-2 FD-OCC between the co-scheduled DMRS ports cannot be satisfied.** |
| Lenovo | Support. For item 4, we support Alt.1 since for Alt.2 it may increase DCI bit. The application scenario for item 4 is not common and the motivation for introducing additional DCI signalling is not so strong. |
| Intel | For 4) we are OK with Alt-1 |
| QC | ~~For 1)-3) in the FL Proposal 2.5A, we support.~~  For 4), we suggest discussing it after MU restriction (in section 2.6) is settled. If MU restriction is agreed, we think Alt 2 is acceptable with MU restriction on certain rows; Otherwise, taking Alt 1 is more reasonable from our perspective. Furthermore, Alt 2 needs clarification. The signaling whether is based on DCI (**This should be MAC-CE, as DCI based signaling is excluded in last meeting**) or RRC is related to the discussion in section 2.4. Again, our view is that using 1 bit just to deliver Rel-18 UE 1 is with Rel-18 new ports is a not a design, based on the reasons we gave in previous section.  In summary, we think 4) will be automatically settled after discussion in 2.4 and 2.6 are concluded. |
| MediaTek | Support.  For item 4, we prefer Alt 1. |
| ZTE | Support.  For item 4), Alt 3 raised by HW is also valid to in our views. |
| Ericsson | Support. For 4) we support Alt-2. |
| Sharp | For 4), we prefer Alt 2. |
| Xiaomi | Fine with proposal 2.5A. |
| Apple | Support 1,2,3 and for 4), our first preference is Alt.1, but would also be fine with Alt.2 as long as Alt-2 is the default UE capability. |
| New H3C | Support.  For item 4, we prefer Alt 1. |
| China Telecom | Support. We prefer Alt.2 for 4). |
| Samsung | Support in principle, and support Alt1 for 4). |
| Fraunhofer | Support and we prefer ALT1 for item 4. |
| Spreadtrum | Support. For 4) we support Alt.1. If such case is scheduled, gNB should guarantee the orthogonality of all the DMRS ports. |
| CMCC | Support 1), 2) and 3).  For 4), if MAC CE or DCI based switching between Rel.15 DMRS ports and Rel.18 DMRS ports is supported in FL proposal 2.4A, then Alt2 is not needed. |
| LGE | Support the proposal and prefer Alt.1 for 4). |
| vivo | Support no spec impact.  We would like to mention again that even in Rel-15, there is no spec restriction that two co-scheduled UE should use the orthogonal ports in MU-MIMO. Please note that the different DMRS scrambling IDs can be configured for different UEs in MU-MIMO. Therefore, it’s up to gNB implementation. |
| QC4 | Sorry for a late comment on 3). We missed the wording change of 3) comparing to previous meeting.  Regarding this wording, “**UE is not required to handle such MU-MIMO in a CDM group (No spec. impact)”,** we think the wording in previous meeting “UE does not expect such MU-MIMO in a CDM group” is better. With current wording, the two phrases in red actually conflict with each other. If there is no spec impact, gNB can schedule MU in that way, Rel-15 UE2’s performance will degrade. This is very against the design principle of 3GPP where a newly added feature should not degrade the performance of existing legacy feature. Of course, Rel-15 does not exclude implicit MU via different DMRS sequences, when gNB are confident the correlation of the two sequences are small, thus expecting small interference between them. But case 3 is same DMRS sequence with non-orthgonal FD-OCC code, these two ports would see large cross-correlation and Rel-15 UE2 performance will surely be degraded. Therefore, we think current wording is very problematic. We will object current wording. |
| **FL** | **I added FL Proposal 2.5B. The restriction from HW/QC means “Rel.15 UE2 may assume that the [orthogonal] Rel-18 New ports in the CDM group are not associated with transmission of PDSCH to another UE”. However, RAN1 Rel.18 can only discuss impact of Rel.18 RAN1 spec. The suggestion from HW/QC does not impact to Rel.18 RAN1 spec., because Rel.15 UE does not read Rel.18 spec. I think HW/QC’s intention is to restrict gNB implementation, but RAN1 cannot explicitly restrict gNB behavior. I think this is why most of companies think there should be no spec. impact on this issue.**  **Any wording suggestion to Proposal 2.5B would be appreciated.** |
| Apple2 | Similar to QC/HW, we also have concern on the wording change in proposal 2.5A , i.e. UE is not required to handle. Sorry for missing that out earlier. This can have serious implication on Rel-15 UE’s performance. Thanks to FL for alternative proposal 2.5B. However, we still think the wording from the previous meeting is much clear, i.e. “UE does not expect such MU-MIMO within a CDM group” |
| OPPO | What we are discussing is about MU-MIMO within one CDM group, which means that the sequences are the same but ports are different among the multiplexed UEs. There would be significant interference if the OCC codes are not orthogonal among multiplexed UEs. Since only the UE behavior of Rel-18 UE can be specified here, the impact/interference to Rel-15 UE should be considered. In this case, we agree with QC that the previous wording “UE does not expect such MU-MIMO in a CDM group” is better to restrict the Rel-18 gNB behavior. If we rely on gNB to schedule orthogonal OCC codes for Rel-15 UEs and Rel-18 UEs, without any restriction in spec., the performance cannot be guaranteed. |
| vivo | We believe that companies have the common understanding that MU-MIMO can be scheduled based on non-orthogonal ports with different DMRS scrambling ID, which means orthogonal ports are not always required for MU-MIMO.  One more scenario is that MU-MIMO can also be scheduled with different analog beams in FR2, if two UEs are far apart. In this case, even with the same scrambling ID, non-orthogonal ports can still be used for different UEs in MU-MIMO.  Therefore, we don’t think any restriction is needed in spec. We believe gNB can schedule UE in MU-MIMO well to ensure the performance of UEs in different scenarios. |
| MediaTek | We also Agree with Apple/HW/QC, we find the original wording more suitable, i.e., “UE does not expect such MU-MIMO within a CDM group”, and propose to change back to original wording. |

### **ROUND-2**

Based on the 1st round, both 1) and 2) are stable.

FL proposal 2.5A was intended for no spec. impact. The reason is the current specification already allows MU-MIMO by allocating different PN sequence, TCI state, etc. between different UEs by gNB implementation, and it does not make sense to preclude such existing gNB implementation by RAN1 spec.

However, Huawei/HiSilicon, QC, Apple, MTK, OPPO suggest to have explicit agreement to restrict Rel.18 gNB not operate such MU-MIMO.

On the other hand, vivo/ZTE/etc. already mentioned MU-MIMO by non-orthogonal sequence (e.g. different DMRS scrambling IDs) should not be precluded. Hence, I added yellow highlighted part. If you have concern to the yellow part, please check and reply to vivo/ZTE’s comments.

**FL Proposal 2.5B (Proposal from QC/HW)**

* **For MU-MIMO within a CDM group between Rel.15 DMRS ports and Rel.18 DMRS ports,**
  + **1) For PUSCH, there is no restriction.**
  + **2) For PDSCH, there is no additional restriction between Rel.18 UE1 indicated with Rel-18 Legacy ports (eType1: ports 1000-1007, eType2: ports 1000-1011) and Rel.15/18 UE2 indicated with Rel.15 DMRS ports in a CDM group from Rel.17 spec.**
    - **Note: MU-MIMO restriction in Rel.17 is applied.**
  + **3) For PDSCH, between Rel.18 UE1 indicated with Rel-18 New ports (eType1: ports 1008-1015, eType2: ports 1012-1023) and Rel.15 UE2 indicated with Rel.15 DMRS ports in a CDM group,**
    - **UE does not expect such MU-MIMO within a CDM group [if DMRS scrambling IDs are the same between UEs].**
  + **4) For PDSCH, between Rel.18 UE1 indicated with Rel-18 New ports (eType1: ports 1008-1015, eType2: ports 1012-1023) and Rel.18 UE2 indicated with Rel.15 DMRS ports in a CDM group, down select from the following.**
    - **Alt.1: UE does not expect such MU-MIMO within a CDM group [if DMRS scrambling IDs are the same between UEs].**
    - **Alt.2: Rel.18 UE2 configured with Rel.15 DMRS ports can be signaled, to indicate that there may be another Rel.18 UE1 with Rel.18 New ports (eType1: ports 1008-1015, eType2: ports 1012-1023) in the same CDM group, so that the Rel.18 UE2 can assume FD-OCC length 4 for channel estimation of Rel.15 DMRS ports.**
      * **Dedicated UE capability is introduced.**
      * **The signaling is at least by RRC (FFS: whether to support DCI based signaling).**
    - **Alt.3: Introduce restriction that the UE indicated with Rel.15 DMRS ports is not expected to be co-scheduled with a UE indicated with Rel.18 DMRS ports if the orthogonality of length-2 FD-OCC between the co-scheduled DMRS ports cannot be satisfied.**

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| **Company** | **Comment** |
| OPPO | We are fine with the update. In Our understanding, in a CDM groups means the ports are orthogonal via the same based sequence.  Furthermore, in current 38.214, we use “the UE may assume that all the remaining orthogonal antenna ports are not associated with transmission of PDSCH to another UE”, which does preclude different sequences. Accordingly, as another solution, we can replace “in a CDM group” with “with orthogonal antenna portsin a CDM group” |
| vivo | Don’t support.  Mention again, in addition to using different DMRS scrambling IDs, MU-MIMO can also be scheduled with different analog beams in FR2, if two UEs are far apart. In this case, even with the same scrambling ID, non-orthogonal ports can still be used for different UEs in MU-MIMO. We can’t restrict the method for MU-MIMO at the gNB side.  That’s the reason why there is no any restriction for this MU-MIMO issue in the current spec, since there are many MU-MIMO implementation, not just based on orthogonal ports. |
| Apple | 1. and 2) are fine   For 3), since the impact is to legacy UEs, we cannot support the yellow part. Even with different scrambling IDs if MU-MIMO is allowed within same CDM group between legacy UE and Rel-18 UE, legacy UE would be impacted because it may still require estimating the interference on the others ports scheduled for other UE.  For 4), it can be acceptable to add yellow part to Alt 1. However, then we would rather prefer Alt 2. |
| Nokia, NSB | We don’t support. 1) and 2) are fine, but we don’t see need for the other part. Up to NW scheduling. |
| Ericsson | Support 1), 2).  For 3), are we sure this would work for all Rel-18 and Rel-15 UEs? We prefer to not include the yellow highlight part.  For 4), for Alt1, does this mean this [**if DMRS scrambling IDs are the same between UEs]** also apply to those SU-MIMO rows? Our preference is Alt2. But we can consider support Alt1. as UE capability. |
| ZTE | For clarification at first, we have no comment that “**vivo/ZTE/etc. already mentioned MU-MIMO by non-orthogonal sequence (e.g. different DMRS scrambling IDs) should not be precluded.**” as FL mentioned above.  We also think the newly added yellow parts are not needed. Based on that, we support 1), 2), 3) and Alt 2 in 4). |
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## MU-MIMO scheduling restriction within a CDM group

In section 5.1.6 in TS38.214, MU-MIMO scheduling restriction is specified as following.

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| For DM-RS configuration type 1,  - if a UE is scheduled with one codeword and assigned with the antenna port mapping with indices of {2, 9, 10, 11 or 30} in Table 7.3.1.2.2-1 and Table 7.3.1.2.2-2 of Clause 7.3.1.2 of [5, TS 38.212], or  - if a UE is scheduled with one codeword and assigned with the antenna port mapping with indices of {2, 9, 10, 11 or 12} in Table 7.3.1.2.2-1A and {2, 9, 10, 11, 30 or 31} in Table 7.3.1.2.2-2A of Clause 7.3.1.2 of [5, TS 38.212], or  - if a UE is scheduled with two codewords,  the UE may assume that all the remaining orthogonal antenna ports are not associated with transmission of PDSCH to another UE.  For DM-RS configuration type 2,  - if a UE is scheduled with one codeword and assigned with the antenna port mapping with indices of {2, 10 or 23} in Table 7.3.1.2.2-3 and Table 7.3.1.2.2-4 of Clause 7.3.1.2 of [5, TS38.212], or  - if a UE is scheduled with one codeword and assigned with the antenna port mapping with indices of {2, 10, 23 or 24} in Table 7.3.1.2.2-3A and {2, 10, 23 or 58} in Table 7.3.1.2.2-4A of Clause 7.3.1.2 of [5, TS 38.212], or  - if a UE is scheduled with two codewords,  the UE may assume that all the remaining orthogonal antenna ports are not associated with transmission of PDSCH to another UE. |

After Rel.18 eType1/eType2 DMRS ports tables are defined, which row of DMRS port combination requires MU-MIMO restriction will be specified. It is not proper to just reuse the indexes of rows which require MU-restriction in current Rel.17 spec. For example, for Rel.15 Type 1, if row 2 (i.e. {0,1} with number of CDM group without data = 1) is indicated, remaining DMRS ports are not used to another UE. This is because there is no remaining orthogonal DMRS ports in Rel.15 Type 1. However, in Rel.18 eType 1, if row 2 (i.e. {0,1} with number of CDM group without data = 1) is indicated, there are remaining DMRS ports of {8,9}, and it is straightforward to allow DMRS ports combination of {8,9} with number of CDM group without data = 1 to another UE. Hence, we cannot reuse the indexes of rows which require MU-restriction in current Rel.17 spec.

Qualcomm [23] etc. proposes the following principle.

**FL Proposal 2.6A**

* **Adopt the following MU scheduling restriction for Rel.18 DMRS ports for PDSCH:**
  + **If the DMRS ports of a UE are in more than one CDM groups, the UE does not expect DMRS ports from a co-scheduled UE in a same CDM group as the UE.**
    - **The above applies to both single symbol and dual symbol DMRS.**
  + **Furthermore, for dual symbol DMRS, if the DMRS ports of a UE are associated with more than one TD-OCC codes in one CDM group, the UE does not expect DMRS ports from a co-scheduled UE in a same CDM group as the UE.**

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| **Company** | **Comment** |
| Docomo | Not support. For Type1 in R15, if two CDM groups are used for a UE, there is MU-MIMO restriction. However, for Type2 in R15, even if more than one CDM groups are used for a UE, there is no MU-MIMO restriction for some cases. Hence, the above proposal looks too restrictive compared to Rel.15, and we prefer to discuss which row requires MU-MIMO restriction row by row, after antenna ports table for PDSCH is agreed. |
| Google | We failed to see the benefit for the proposal |
| Futurewei | Not support. In our view, this restriction is unnecessary and will reduce the MU scheduling flexibility and degrade MU-MIMO performance, which this agenda item is intended to enhance. |
| OPPO` | Support. We think similar restriction as in Rel-15 should be extended to Rel-18 to ensure the channel estimation performance. We can further discuss which Row needs such restriction in the next step. |
| Nokia/NSB | We are fine with the first bullet. |
| CATT | Not support. The number of orthogonal ports in one CDM is doubled in Rel.18 and the restriction is not needed. |
| Huawei, HiSilicon | Not support. Considering the whole WID is targeting higher-layer MU-MIMO and there does exist some DMRS port combinations crossing multiple CDM groups without any MU restriction already as discussed in section 2.1.1, aforementioned MU scheduling restriction is not needed. |
| Lenovo | Not support. It is too restrictive. We agree with FL to discuss together with antenna port indication table. |
| Intel | Such restriction is not needed. |
| QC | We support the proposal.  It does not change the technical fact of the problem, whether we discussed row by row in DMRS port table or we discuss it here as a general principle. **The key point is that a UE with capability of decoding 1 CW PDSCH cannot estimate more than 4 DMRS ports. While some of the rows in the DMRS ports table for 1 CW require UE to estimate more than 4 ports, if MU exist. That is the fundamental reason the above MU restriction is needed for those rows.** Those rows are listed as below.   * DMRS ports distributed into two CDM groups, for both single symbol and dual symbol DMRS * DMRS ports distributed into two TD-OCC codes, for dual symbol DMRS.   To DCM: whether DMRS is with type 1 or type 2, it does not change the technical problem. If we agree with the MU restriction for type 1 DMRS due to the technical reason we mentioned above, we should agree the same MU restriction for type 2 DMRS. |
| MediaTek | Support |
| ZTE | Do NOT support.  This proposal does not accurately reflect the legacy MU-MIMO restriction as mentioned by companies. Several rows in the legacy are in line with the first and second bullets but not restricted in MU-MIMO scenario, i.e.:   * For the first bullet, * Rows 9 and 20-22 when Type2 + maxlength1 in Table 7.3.1.2.2-3 and Table 7.3.1.2.2-3A of TS 38.212. * Rows 9 and 20-22 when Type2 + maxlength2 in Table 7.3.1.2.2-4 and Table 7.3.1.2.2-4A of TS 38.212. * For the second bullet, * Rows 26-29 when Type2 + maxlength1 in Table 7.3.1.2.2-3 and Table 7.3.1.2.2-3A of TS 38.212. * Rows 26-29 when Type2 + maxlength2 in Table 7.3.1.2.2-4 and Table 7.3.1.2.2-4A of TS 38.212.   If it is to make the legacy MU-MIMO restriction of Rel-18 DMRS ports corresponding to the Rel-15 DMRS ports with same rules of combination, it only needs to list those rows of each case as the current specification. Besides, note that Rel-18 DMRS ports indication tables are still pending, this issue should be postponed accordingly.  **TS 38.214, section 5.1.6.2**   |  | | --- | | For DM-RS configuration type 1,  - if a UE is scheduled with one codeword and assigned with the antenna port mapping with indices of {2, 9, 10, 11 or 30} in Table 7.3.1.2.2-1 and Table 7.3.1.2.2-2 of Clause 7.3.1.2 of [5, TS 38.212], or  - if a UE is scheduled with one codeword and assigned with the antenna port mapping with indices of {2, 9, 10, 11 or 12} in Table 7.3.1.2.2-1A and {2, 9, 10, 11, 30 or 31} in Table 7.3.1.2.2-2A of Clause 7.3.1.2 of [5, TS 38.212], or  - if a UE is scheduled with two codewords,  the UE may assume that all the remaining orthogonal antenna ports are not associated with transmission of PDSCH to another UE.  For DM-RS configuration type 2,  - if a UE is scheduled with one codeword and assigned with the antenna port mapping with indices of {2, 10 or 23} in Table 7.3.1.2.2-3 and Table 7.3.1.2.2-4 of Clause 7.3.1.2 of [5, TS38.212], or  - if a UE is scheduled with one codeword and assigned with the antenna port mapping with indices of {2, 10, 23 or 24} in Table 7.3.1.2.2-3A and {2, 10, 23 or 58} in Table 7.3.1.2.2-4A of Clause 7.3.1.2 of [5, TS 38.212], or  - if a UE is scheduled with two codewords,  the UE may assume that all the remaining orthogonal antenna ports are not associated with transmission of PDSCH to another UE. | |
| Ericsson | We prefer to not apply such MU restriction for Rel-18 DMRS for PDSCH. |
| QC2 | To ZTE: The MU problem on Rel-18 is more challenging than Rel-15. We understand ZTE prefer to follow Rel-15 for everything. But please look at the problem from technical perspective. On this MU issue, things change from Rel-15 to Rel-18.  Rel-15 spec only allows at most 4 DMRS ports with two CDM groups (for 1-symbol DMRS) or two TD-OCC codes in one CDM group (for 2-symbol DMRS). UE only need to estimate at most 4 MU ports for MU detection and noise/interference estimation.  In Rel-18, in the same scenarios, Rel-18 specs might allow up to 8 DMRS ports, A UE with capability of decoding 1 CW can only estimate up to 4 DMRS ports, hence cannot handle these MU scenarios, as shown in the figure below.    From gNB MU scheduling perspective, we don’t see what are the advantages of distributing <=4 ports of each UE into two CDM groups or two TD-OCCs, rather than keep one UE’s <=4 ports in a single CDM group or a single TD-OCC. Using CDM group to TD-OCC to separate UEs are natural way to minimize interference between MU. For UEs with rank<=4, can ZTE or any proponent who like MU scheduling with a UE’s DMRS ports across CDM groups or TD-OCCs please explain what are the benefits to do so, comparing to confining <=4 DMRS ports of a UE within a CDM group and a TD-OCC. |
| Xiaomi | Not support.  We get the intention of this proposal 2.6A, but it is too strict to R18 DMRS. The intention of this WI is to support more layers/UEs in MU-MIMO. This restriction put a little too much limitation on the use cases of R18 DMRS. |
| Apple | Support the first bullet and are also fine with second bullet |
| New H3C | This restriction isn’t required |
| China Telecom | Not support. We don’t understand why the restrictions are needed. |
| Samsung | We don’t support additional MU scheduling restriction within a CDM group. The purpose of this agenda item is to increase the number of MU-MIMO layer. |
| Fraunhofer | We fail to see the benefit of this proposal. |
| Spreadtrum | Support. MU scheduling restriction is important to reduce UE complexity. |
| CMCC | Not support. One of the motivations to increasing DMRS ports is for MU-MIMO, if adding MU restriction on the rows listed in the proposal, the performance of increasing DMRS ports is degraded. |
| LGE | Support. We think similar restriction as in Rel-15 should be extended to Rel-18. |
| vivo | Support in principle. We can understand that the principle in this proposal is similar with what for legacy DMRS. But it can be discussed in section 2.1 case by case, like the restriction in the previous agreements. |
| ZTE2 | To QC: Why this kind of restriction you emphasized is specially needed to Rel-18 UE but not for Rel-15 UE? Notably, the current spec does NOT have such restriction as we pointed out above. |
| QC3 | @ZTE, please read our input/comments above, which has been provided 24 hours ago. Please let us know if you have any technical question to our input. |
| ZTE3 | @QC, according to comments input so far, I do NOT see the issue you emphasized is general to Rel-15&onwards UE in the current NR network, Why is this question so special to you???  I do believe companies include us have already ventilated that it is unreasonable to make further MU-MIMO restriction beyond the legacy rules: 1) Rel-18 DMRS ports mainly aim to MU-MIMO scenario; 2) It is very confusing to see the logic that the functionality (in terms of MU-MIMO scenario) of Rel-18 UE will be worse than that of Rel-15 UE!!! |

### **ROUND-2**

Please continue the discussion.

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| **Company** | **Comment** |
| QC | @ZTE, your statement “It is very confusing to see the logic that the functionality (in terms of MU-MIMO scenario) of Rel-18 UE will be worse than that of Rel-15 UE!!!” is a wrong statement. I don’t know from where you draw such a misleading conclusion. Rel-18 functionality (even with MU restrictions on some rows in DMRS table) of course is stronger than Rel-15, because there are much more rows in the table for gNB to use.  The following is our explanation why Rel-18 needs new MU restriction on certain rows, which is essentially because Rel-18 doubling # DMRS ports per CDM group. We have provided this explanation multiple times. But for the convenience of the discussion, we copy it below.  The MU problem on Rel-18 is more challenging than Rel-15. We understand ZTE prefer to follow Rel-15 for everything. But please look at the problem from technical perspective. On this MU issue, things change from Rel-15 to Rel-18.  Rel-15 spec only allows at most 4 DMRS ports with two CDM groups (for 1-symbol DMRS) or two TD-OCC codes in one CDM group (for 2-symbol DMRS). UE only need to estimate at most 4 MU ports for MU detection and noise/interference estimation.  In Rel-18, in the same scenarios, Rel-18 specs might allow up to 8 DMRS ports, A UE with capability of decoding 1 CW can only estimate up to 4 DMRS ports, hence cannot handle these MU scenarios, as shown in the figure below.    From gNB MU scheduling perspective, we don’t see what are the advantages of distributing <=4 ports of each UE into two CDM groups or two TD-OCCs, rather than keep one UE’s <=4 ports in a single CDM group or a single TD-OCC. Using CDM group to TD-OCC to separate UEs are natural way to minimize interference between MU. For UEs with rank<=4, can ZTE or any proponent who like MU scheduling with a UE’s DMRS ports across CDM groups or TD-OCCs please explain what are the benefits to do so, comparing to confining <=4 DMRS ports of a UE within a CDM group and a TD-OCC. |
| OPPO | We share similar view as QC and we also think the MU-restriction is much more necessary in Rel-18 than in Rel-15 since more ports are introduced in one CDM group.  For DMRS ports in more than one CDM groups, or associated with more than one TD-OCC codes in one CDM group, we have the following observations:   * Case 1: If the DMRS ports are legacy ports with MU-restriction in Rel-15, the MU-restriction should be maintained in Rel-18. * Case 2: If the DMRS ports are legacy ports without MU-restriction in Rel-15, additional MU-restriction similar to Case 1 can be specified in Rel-18. * Case 3: If the DMRS ports are new DMRS ports in Rel-18, MU-restriction is also preferred. If companies have concern on the restriction on new ports, we could accept to introduce UE capability for these port combinations, since they introduce significant UE complexity. |
| Nokia, NSB | In case when [9,11] is supported, UE may assume MU-MIMO always happening. For other case, we are fine with re-using Rel-15 assumption. |
| Ericsson | One possible way out for this debate is to take the restriction as UE capability. We don’t support if such restriction being applied for all Rel-18 DMRS. |
| ZTE | Do not support FL Proposal 2.6A.  Re QC’s comment “***Rel-15 spec only allows at most 4 DMRS ports with two CDM groups (for 1-symbol DMRS) or two TD-OCC codes in one CDM group (for 2-symbol DMRS). UE only need to estimate at most 4 MU ports for MU detection and noise/interference estimation.***”, it is NOT correct. As per the legacy MU-MIMO restriction in the current TS 38.214, the following rows can be definitely used in MU-MIMO scenario but also more that 4 DMRS ports need to be detected and estimated for noise/interference in MU-MIMO.   * When type1 + maxlength2 of 1CW, rows 12-29 by two CDM groups without data and 2-symbol DMRS (up to **8** DMRS ports need to be detected and estimated). * When type2 + maxlength1 of 1CW, rows 11-22 by three CDM groups without data and 1-symbol DMRS (up to **6** DMRS ports need to be detected and estimated). * When type2 + maxlength2 of 1CW, rows 11-22 by three CDM groups without data and 1-symbol DMRS (up to **6** DMRS ports need to be detected and estimated), rows 24-57 by three CDM groups without data and 2-symbol DMRS (up to **12** DMRS ports need to be detected and estimated).   Based on my above elaboration, QC’s assessment “*In Rel-18, in the same scenarios, Rel-18 specs might allow up to 8 DMRS ports, A UE with capability of decoding 1 CW can only estimate up to 4 DMRS ports, hence cannot handle these MU scenarios, as shown in the figure below.*” is invalid.  Re QC’s comment that “***Rel-18 functionality (even with MU restrictions on some rows in DMRS table) of course is stronger than Rel-15, because there are much more rows in the table for gNB to use.*** ”, it is fortunate we are on the same page now. As per above instances of Rel-15 DMRS, it is crystal clear that the issue your keep emphasizing is NOT existing. So I think you now can share the my feeling that “*It is very confusing to see the logic that the functionality (in terms of MU-MIMO scenario) of Rel-18 UE will be worse than that of Rel-15 UE!!!*”.  Again, we do NOT agree to make any further MU-MIMO restriction of Rel-18 DMRS that beyond the legacy unless technical and also true justification can be provided. |
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## Sequence mapping

CATT [10] discuss the following issue:

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| With length 4 FD-OCC, patterns of Rel.18 eType 1 DMRS and eType 2 DMRS can be designed as same as that in Rel.15 type 1 DMRS and type 2 DMRS.  In Rel.15 DMRS, sequence is mapped to resource elements according to equation (1):  (1)  Parameter is included in , and . In , is the index of OCC weighting. In parameter , determines the frequency resources (subcarriers) used for DMRS transmission.  In Rel.18 DMRS with length 4 FD-OCC, four values of (e.g., ,, and ) are needed, and they are corresponding to four resource elements in frequency domain, respectively.  In Rel.18 eType 2 DMRS, four values of can be 0, 1, 6 and 7 to facilitate resource mapping in frequency domain. Take CDM group 0 as an example, these values can ensure that DMRS occupies the 1st, 2nd, 7th, and 8th REs in one RB. However, these values of will complicate sequence generation of . For example, UE may need to generate longer PN sequence than needed if is used in resource mapping equation, since not all values in the generated sequence are used for DMRS transmission. On the other hand, sequence orthogonality between multiple ports may be an issue due to the same reason (discontinuous values in the generated sequence are used for DMRS transmission).  Four values of can also be 0, 1, 2 and 3 to simplify sequence generation, and is used in resource mapping equation. In order to ensure that DMRS occupies the 1st, 2nd, 7th, and 8th REs in one RB for CDM group 0, parameter can be modified, and equation (2) is used in sequence mapping.  (2)  In Rel.18 eType 1 DMRS, four values of can also be 0, 1, 2 and 3, and equation (3) can be used in sequence mapping.  (3) |

**FL Proposal 2.7A**

**The following sequence mapping equations are adopted for Rel.18 eType 1 DMRS and Rel.18 eType 2 DMRS, respectively:**

* **Rel.18 eType 1 DMRS:**
* **Rel.18 eType 2 DMRS:**

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| **Company** | **Comment** |
| Docomo | Fine with the proposal. |
| Google | I am not sure whether we need to agree on this, but it looks this can be handled by editor based on our previous agreement. |
| Futurewei | Support in principle. |
| OPPO | Maybe it can be handled by editor when we finish the design. |
| Nokia/NSB | Up to editor. |
| CATT | Support. |
| Huawei, HiSilicon | Seems the detailed mapping equations can be left to editor. |
| Lenovo | Support in principle and it is up to editor. |
| Intel | Do not need an agreement probably. This is the natural outcome of current agreements and is up to the editor. |
| QC | We think it can be up to editor how to capture agreements made for Rel-18 DMRS. The proposal is not needed. |
| MediaTek | Agree with comment made by OPPO/Huawei this can be left to editor. |
| ZTE | It is sufficient to be up to editor. |
| Ericsson | Shall be up to editor to decide. |
| Sharp | Support |
| Xiaomi | Support |
| Apple | Agree that this can left up to editor |
| New H3C | OK in principal |
| China Telecom | Fine with the proposal and it can be up to editor. |
| Samsung | We are fine with the proposal but also okay to be up to editor. |
| Fraunhofer | Do not support. |
| Spreadtrum | Support in principle. Up to the editor is also fine. |
| CMCC | Support |
| LGE | Support and it is up to editor. |
| vivo | Support in principle, and it can be up to editor. |
| **FL** | **Multiple companies comment that it can be up to editors. Proponents, please comment if you have different views.** |
| **FL** | **I will not treat this proposal again. Please discuss this issue in CR.** |
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## Scheduling restrictions of PDSCH among MU-MIMO UEs

Qualcomm [23] discuss the following:

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| In Rel-15, there were some restrictions already introduced (as listed in detail below). However, in the deployment, implementation, and operating of 5G in the past a few years, a few new cases which requires more alignment among MU were identified. Given Rel-18 MIMO supporting more MU scenarios, and this WI is targeting MU enhancement, it is preferred to consider potentially aligning transmission parameters of MU in a better way.  There are three enhanced MU alignments that can be considered in Rel-18.   * Alignment 1: aligning the number of CDM groups without data among MU. * Alignment 2: aligning the PRG boundary for MU in different CDM groups * Alignment 3: aligning the staring and ending PDSCH symbol for MU   For alignment 1, one can notice that in Rel-15, there is already a paragraph in TS38.214 in this line to aligning number of CDM groups. However, the highlighted text (in yellow) is not clear. There could be two interpretations.   * Interpretation 1: the “CDM groups without data” are not used for data transmission only for this target UE. While co-scheduled UEs may still use them for data transmission. * Interpretation 2: the “CDM groups without data” are not used for data transmission for all MU.   When receiving PDSCH scheduled by DCI format 1\_1, the UE shall assume that the CDM groups indicated in the configured index from Tables 7.3.1.2.2-1, 7.3.1.2.2-2, 7.3.1.2.2-3, 7.3.1.2.2-4 of [5, TS. 38.212] contain potential co-scheduled downlink DM-RS and are not used for data transmission, where "1", "2" and "3" for the number of DM-RS CDM group(s) in Tables 7.3.1.2.2-1, 7.3.1.2.2-2, 7.3.1.2.2-3, 7.3.1.2.2-4 of [5, TS. 38.212] correspond to CDM group 0, {0,1}, {0,1,2}, respectively.  If interpretation 1 is assumed, then depends on MU using them for data or not, there could be 3dB or 4.77dB difference on interfering MU’s DMRS to data power ratio, which is unknown to target UE. Target UE will need to do blind detection to figure that out. If interpretation 2 is assume, there is no ambiguity.  With the above analysis, we have the following proposal.  **Proposal 2: A UE is expected the same “number of CDM groups without data” for co-schedule MU in Rel-18 DL DMRS.**  For alignment 2, as shown in the following, Rel-15 actual has PRG boundary (and allocation in occupied PRGs) alignment across MU UEs, but only for MU within the same CDM groups. For channel estimation of target UE, the below restriction in Rel-15 is fine, as the channel is only performed for the assigned CDM group for the target UE. However, for interference/noise estimation, Rel-15 restriction is not sufficient, as target UE need to estimate interference/noise based on all tones which includes the other CDM group. With misaligned PRG boundary, target UE’s interference estimation is not accurate, unless UE blindly detect the potential PRG boundary mis-alignment across MU.  The UE does not expect the precoding of the potential co-scheduled UE(s) in other DM-RS ports of the same CDM group to be different in the PRG-level grid configured to this UE with PRG =2 or 4.  The UE does not expect the resource allocation of the potential co-scheduled UE(s) in other DM-RS ports of the same CDM group to be misaligned in the PRG-level grid to this UE with PRG=2 or 4.  With the above analysis, we have the following proposal.  **Proposal 3: A UE is expected the same PRG boundary and the same RB assignment (in PRG-level grid) for co-schedule MU in same and different CDM groups in Rel-18 DL DMRS.**  Similar to frequency alignment as in alignment 2, alignment 3 for time domain is desired for target UE’s interference/noise estimation. Again, in Rel-15, some restriction (as cited below) along this line is made from channel estimation perspective. However, without aligned PDSCH starting and ending symbol, although DMRS symbols are aligned with can make sure a good channel estimation for target UE, but the mis-aligned PDSCH starting and ending symbol can still break the target UE’s interference/noise estimation.  To solve this issue, the following proposal is made.  **Proposal 4: A UE is expected the same staring OFDM symbol and the same ending OFDM symbol for PDSCH of co-schedule MU in Rel-18 DL DMRS.** |

Since we have not discussed scheduling restriction of PDSCH among MU-MIMO UEs, we can discuss whether such restriction should be introduced for Rel.18 DMRS. New restriction from Rel.15-17 is noted with underline in the proposal.

**FL Proposal 2.8A**

* **Adopt the following MU scheduling restriction for Rel.18 DMRS ports for PDSCH:**
  + **1) A UE is expected the same “number of CDM groups without data” for co-schedule MU in Rel-18 DL DMRS.**
  + **2) A UE is expected the same PRG boundary and the same RB assignment (in PRG-level grid) for co-schedule MU in same and different CDM groups in Rel-18 DL DMRS.**
  + **3) A UE is expected the same staring OFDM symbol and the same ending OFDM symbol for PDSCH of co-schedule MU in Rel-18 DL DMRS.**

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| **Company** | **Comment** |
| Docomo | Not support to introduce additional MU restriction from Rel.15-17.  1) Our understanding of the existing spec. is interpretation2, and co-scheduled UEs may use “CDM group without date” for the UE’s DMRS. We are fine to clarify the interpretation2, but it can be done in Rel.15-17 CR in AI7.1 or 7.2.  2) In Rel.15-17, the restriction of PRG boundary is only applied to UEs with the same CDM group, and we prefer to keep the same scheduling flexibility for Rel.18.  3) In Rel.15-17, there is no restriction that PDSCH between MU should be fully overlapped (except for mDCI mTRP in Rel.16). Although we understand the interference/noise can be different if PDSCHs are not fully overlapped, we assume UE can demodulate PDSCH as long as DMRS symbols are aligned. We prefer to keep the same scheduling flexibility for Rel.18. |
| Futurewei | We share the same view as Docomo that these additional MU scheduling restrictions are unnecessary. |
| OPPO | We think the scheduling restriction in Rel-17 is sufficient and can be extended to Rel-18. No new rule needs to be introduced. |
| Nokia/NSB | We didn’t have such restriction in Rel-15. Up to NW scheduling. |
| CATT | For 1), support to discuss.  For 2) and 3), we share the same view as Docomo and Futurewei. These additional scheduling restrictions are not necessary. |
| Huawei, HiSilicon | Share the same view with Docomo. |
| Lenovo | We think it is not necessary to introduce additional MU scheduling restrictions. |
| Intel | Share same understanding as DOCOMO. Legacy rules should be sufficient. For 3) legacy rules should already ensure DM-RS symbols are aligned even if PDSCH length may be different. |
| QC | We support the proposals.  For 1), we can see what are companies’ understandings of current spec.  For 2) and 3), we understand there were no such restriction in Rel 15-17. But the issue exists, which causes UE cannot estimate noise/interference of co-scheduled UE correctly. **DMRS alignment does not solve this issue.** Please see the following figures for 3) of misaligned PDSCH in time domain. The similar mis-alignment of PRG in freq domain motivates restriction 2).    It is not true that “UE can demodulate PDSCH as long as DMRS symbols are aligned”. Demodulation, especially for high MCS, easily fail due to in-accurate noise/interference Rnn estimation. |
| MediaTek | Support. Similar comments as QC. We believe the restriction added by 2) and 3) will allow for better UE demod performance. |
| ZTE | Do not support. It is out of scope in Rel-18. |
| Ericsson | We don’t support this proposal. The legacy MU restrictions are sufficient. However, it is good to be aware of such UE demodulation limitations on MU scheduling. |
| Apple | Support and similar view as QC and Mediatek |
| New H3C | We have the same view with Docomo. |
| ZTE | Not support just like Proposal 2.6A. |
| Samsung | We don’t see any necessity on having additional spec. based MU restriction, legacy rules are sufficient. |
| Fraunhofer | Same view than Docomo. |
| Spreadtrum | We agree with some companies view that such MU restriction can achieve better demodulation performance. |
| LGE | We have same understanding as DOCOMO. Legacy rules should be sufficient. For 3) legacy rules should already ensure DM-RS symbols are aligned. |
| vivo | Don’t support. We prefer to follow the legacy principle. |
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## Other proposals

Following proposals are also proposed.

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| **Proposals** | **Companies** |
| 1. **Study on** **OCC disabling scheme for new DMRS type (Rel.17 feature in above 52.6GHz).** | Samsung |
| 1. **Reusing** **low PAPR design for Rel.18 DMRS port(s)** | Huawei/HiSilicon |
| 1. **support eType1 DMRS for MsgA PUSCH.** | Lenovo |
| 1. **Additional scheduling restriction of orphan RE issue for eType1** | Vivo, CATT, Lenovo, Google |
| 1. **Orphan RB issue for eType2** | Qualcomm |
|  |  |
| 1. **PTRS power boosting for PDSCH with Rel-18 DMRS ports** | Lenovo |

Please provide your views on the above proposals, or other aspects which are not included in the summary, if any.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| FL | For 2), the proposal is to reuse existing specification of low PAPR sequence. From FL perspective, if we don’t make any agreement to update the spec., the existing Rel.17 spec. (in this case, both Rel.15 DMRS sequence and Rel.16 DMRS sequence) is automatically applied, if UE supports its UE capability. Hence, we don’t need to discuss proposal to “reuse existing spec.”. |
| Docomo | For 5), it seems the issue (orphan RB in PRG) also exists in Rel.15. We are not sure why we need to discuss it for Rel.18 DMRS. |
| Google | For 5), could Docomo clarify a bit how such issue exists in R15? |
| Docomo2 | Re Google’s question to 5), if we correctly understand the proposal, the issue is when PRB boundary of the scheduled PDSCH is not aligned with PRG boundary (as in figure), channel estimation performance may degrade for “eType2” DMRS, because UE may de-spread DMRS in PRG level. But, it seems this is also true for Rel.15 Type 1 or Type 2 DMRS, and this is not special issue of Rel.18 DMRS.    Orphan RB issue for eType 2 in R1- 2303576 |
| Nokia/NSB | 1. Not needed. We didn’t have it for Rel-15 2. Override existing spec is enough. 3. DMRS port 0 is always used for MsgA @Lenovo, thanks for correcting me. Confused with Msg3. Can we use Rel-15 DMRS for the case? 4. Not need. Up to network 5. Not need. Up to network |
| Huawei, HiSilicon | Thanks FL for reply. We share the same view with FL that the existing Rel.17 spec. should be automatically inherited. Given that DMRS root sequence is one of the most fundamental factors that will influence the implementation, here we only want to quickly check whether all companies share the same view and derive a conclusion. |
| Lenovo | We propose to study PTRS power boosting for PDSCH with Rel-18 DMRS ports.  For item 3, To Nokia/NSB:  For Msg-A, the mapping is defined between preambles of a PRACH slot and PUSCH occasions associated with DMRS resource, where one DMRS resource is associated one DMRS port index and/or DMRS sequence. One example is shown as follows:    Fig.x Example of the mapping between PRACH transmission and PUSCH transmission  Also, please refer to the following description in TS38.214  For MsgA PUSCH transmission, if the UE is not configured with *msgA-PUSCH-DMRS-CDM-group,* the UEshall assume that 2 DM-RS CDM groups are configured. Otherwise, *msgA-PUSCH-DMRS-CDM-group* indicates which DM-RS CDM group to use from the set of {0,1}.  For MsgA PUSCH transmission, if the UE is not configured with *msgA-PUSCH-NrofPorts,* the UEshall assume that 4 ports are configured per DM-RS CDM group for double-symbol DM-RS. Otherwise, *msgA-PUSCH-NrofPorts* with value of 0 indicates the first port per DM-RS CDM group, while a value of 1 indicates the first two ports per DM-RS CDM group. |
| QC | For 5), the issue does not exist in Rel-15. In Rel-15, because one DMRS symbol only supports 6 DMRS ports, in the orphan RB, each DMRS port can have 12/6=2 observations/looks of channel in frequency domain. It is possible to estimate slope of the channel with 2 observations. However, in Rel-18, each DMRS symbol supports 12 DMRS ports. In Orphan RB, each DMRS port only has 12/12=1 observation/look of channel in frequency domain. It is impossible to estimate slope of the channel in orphan RB. In other words, we can only estimate the DC component of the channel (i.e., assuming channel is flat in the RB). Channel estimation performance of the orphan RB will be pretty bad, which makes the orphan RB performance bottleneck for the whole PDSCH assignment, especially with high MCS. To overcome this performance issue, UE can do precoder blind detection to align orphan RB with other PRGs. But this would need extra implementation complexity which justifies a dedicated UE capability. |

# Specifying objective #5 (>4 layers PUSCH DMRS)

## Void

### 3.1.2.1 eType1, maxLength1

Since DMRS ports table for PDSCH for eType1 maxLength1 is almost agreed, I’d like to discuss the following proposal. Since DMRS ports combinations for 2 CWs for PDSCH are working assumption, the following proposal can be working assumption.

**FL Proposal 3.1.2.1A (for working assumption)**

* **For Rel.18 eType1** **DMRS ports with *maxLength* = 1 for PUSCH with rank 5-8, following Table 7.3.1.1.2-11-X-1, Table 7.3.1.1.2-11-X-2, Table 7.3.1.1.2-11-X-3, and Table 7.3.1.1.2-11-X-4 are supported.**
  + **FFS: The size of antenna ports field in DCI format 0\_1/0\_2.**

Table 7.3.1.1.2-11-X-1 Antenna port(s), transform precoder is disabled, *dmrs-Type*=eType1, *maxLength*=1, rank = 5

|  |  |  |
| --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** |
| 0 | 2 | 0,1,2,3,8 |
| [1 | 2 | 3,8,9,10,11] |
| [2 | 2 | 0,1,8,10,11] |
| 3-15 | Reserved | Reserved |

Table 7.3.1.1.2-11-X-2: Antenna port(s), transform precoder is disabled, *dmrs-Type*= eType1, *maxLength*=1, rank = 6

|  |  |  |
| --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** |
| 0 | 2 | 0,1,2,3,8,10 |
| [1 | 2 | 2,3,8,9,10,11] |
| 2-15 | Reserved | Reserved |

Table 7.3.1.1.2-11-X-3: Antenna port(s), transform precoder is disabled, *dmrs-Type*= eType1, *maxLength*=1, rank = 7

|  |  |  |
| --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** |
| 0 | 2 | 0,1,2,3,8,9,10 |
| [1 | 2 | 1,2,3,8,9,10,11] |
| 2-15 | Reserved | Reserved |

Table 7.3.1.1.2-11-X-4: Antenna port(s), transform precoder is disabled, *dmrs-Type*= eType1, *maxLength*=1, rank = 8

|  |  |  |
| --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** |
| 0 | 2 | 0,1,2,3,8,9,10,11 |
| 1-15 | Reserved | Reserved |

|  |  |  |
| --- | --- | --- |
| **Company** | **Comment** | |
| Docomo | Support. | |
| Google | Support in principle | |
| OPPO | Support. | |
| Nokia/NSB | Fine with the proposal | |
| CATT | | Support. |
| Huawei, HiSilicon | Support in principle. | |
| Lenovo | Support. | |
| Intel | OK | |
| QC | We don’t prefer the proposal, which map one CW’s layers to two CDM groups. We still prefer the other design which map one CW’s layers to one CDM group, which can simplify gNB receiver. We think we can defer the decision on this proposal after we decide whether/how to confirm the WA for 2CWs type 1 1-symbol DMRS. | |
| ZTE | | Support.  This is in line with the same rule as we elaborated in section 2.1. Again, we fail to see the logic that any restriction over the legacy is needed, which is out of scope from our perspective. |
| Ericsson | We don’t support the proposal.  For PUSCH there’s no MU-MIMO restriction as PDSCH, only reuse the PDSCH will limit the advantage of Rel-18 DMRS design with double orthogonal ports. More ports combinations for PUSCH shall be supported to increase the MU-MIMO capacity in uplink.  To allow Rel-15 UE being co-scheduled using legacy port 0,1,2,3, we propose to  **Add port combination (3,8,9,10,11) and/or (0,1,8,10,11) into the rank 5 table,**  **Add port combination (2,3,8,9,10,11) into the rank 6 table,**  **Add port combination (1,2,3,8,9,10,11) into rank 7 table.** | |
| Sharp | Support | |
| Apple | Fine | |
| New H3C | OK | |
| China Telecom | Support. | |
| Samsung | Support. | |
| Spreadtrum | Support | |
| CMCC | Support | |
| LGE | Support. | |
| vivo | Support | |
| Ericsson1 | Thanks FL to add the combinations that benefits co-scheduling of Rel-15/18 UE. We would like to swap the order of new added antenna ports combinations for rank5 and rank7.  rank5 **(3,8,9,10,11) -> (8,9,3,10,11)**  rank7 **(1,2,3,8,9,10,11) -> (1,8,9,2,3,10,11)**  The reason is that new combinations can also be added to the PUSCH table for potential optimization at gNB side. I quoted the new rows for PDSCH here to show that the combinations are following same principle to group antenna ports of 1 CW within one CDM group.   |  |  |  | | --- | --- | --- | | 4 | 2 | 0,1,2,3,10 | | 5 | 2 | 0,1,8,2,3,10 | | 6 | 2 | 0,1,8,2,3,10,11 | | 7 | 2 | 0,1,8,9,2,3,10,11 | | |
|  |  | |
|  |  | |
|  |  | |

## Max number of PTRS ports

We discussed the following proposal since RAN1#110bis-e, however, there was no consensus.

**FL proposal#3.2A:**

* **For 8Tx PUSCH, support up to 4 ports PTRS for CP-OFDM.**

Support/fine: InterDigital, CATT, Lenovo, Apple, Qualcomm, Xiaomi, LGE Docomo, MediaTek, CMCC, Ericsson

No: Samsung, OPPO, Nokia/NSB, vivo, Spreadtrum,

If the above proposal is not acceptable, following will be the consequence. It means 2-port PTRS in the current spec.is reused.

**FL proposal#3.2B: (for conclusion)**

* **For 8Tx PUSCH, no consensus to support up to 4 ports PTRS for CP-OFDM.**

Support/fine: ZTE, Spreadtrum, OPPO, vivo, Samsung, Nokia/NSB, Docomo,

Please provide your views.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Docomo | Support FL Proposal 3.2A, because Ng (antenna coherent groups) was agreed with 1, 2, 4. If different antenna groups do not share the same PA, different phase noise would be observed for different antenna groups. Hence, each DMRS port(s) should be associated with one PTRS port, and the total number of PTRS ports should be up to 4. But, considering the situation, and 8 PTRS ports will be not used for 8Tx non-coherent codebook, we can accept FL proposal#3.2B. |
| Google | Support 3.2B. Ng does not mean number of panels. Currently only 2 panels are supported for STxMP. |
| InterDigital | Support Proposal 3.2A. To properly support Ng=4, that may represent antenna units pointed to four different directions, 4 PTRS ports should be supported. |
| OPPO | Support Proposal 3.2B. We don’t think we need N PTRS ports for N antenna groups. |
| Nokia/NSB | Support the proposal. 4 PTRS require high overhead but no clear gain. (we can come back if we support simultaneous TX to 4 TRPs in FR2) |
| Lenovo | Support FL Proposal 3.2A. |
| QC | We support FL Proposal 3.2A, based on the reason as DOCOMO mentioned. And we don’t think it is feasible for antenna groups to share a same PA/Oscillator.  We don’t agree with FL Proposal 3.2B, which effectively excluding Ng=4 for 8 Tx in Rel-18. If we have to take the conclusion due to controversial views, we request to add a note to the conclusion.  **Updated FL proposal#3.2B: (for conclusion)**   * **For 8Tx PUSCH, no consensus to support up to 4 ports PTRS for CP-OFDM.**   **Note: This conclusion effectively excludes the support of Ng=4 for 8 Tx PUSCH with the use of PTRS.** |
| MediaTek | Proposal 3.2A: Support |
| ZTE | Support **FL’s proposal#3.2B**.  Note that 8Tx UL aims for PUSCH transmission in FR1, we fail to see the motivation of supporting 4 PTRS ports in Rel-18. Subsequently, we do not agree the Note suggested by QC. |
| Ericsson | Support proposal #3.2A. |
| Sharp | Support FL proposal 3.2B. |
| Xiaomi | Support FL Proposal 3.2A. |
| Apple | Proposal 3.2A: Support. As discussed earlier, if we support up to 8 Tx UL partial-coherent operation over 4 port groups (panels) with up to 8 layers, we need 4 port PTRS |
| New H3C | Support FL proposal 3.2B. |
| China Telecom | Support FL proposal 3.2B. |
| Samsung | Support FL proposal#3.2B. Supporting 4 PTRS ports may have bad effect on UL throughput which is the key motivation to have up to 8 layers. And also, up to 8-layer would be appropriate on FR1 which PTRS is optionally used. Hence, we think increasing the maximum number of PTRS ports is not needed. |
| Spreadtrum | Support proposal#3.2B. The note suggested by QC is not always true. |
| CMCC | Support FL proposal#3.2A. If four antenna groups are assumed for UE’s antenna layouts, then maximal PT-RS ports to be configured may be 4. |
| LGE | Support FL Proposal 3.2A, For 8 Tx antenna ports, there can be no coherence at all among 8 antenna ports or 4 pairs of coherent antenna ports can be considered depending on antenna implementation. In this case, 2 PT-RS ports may not be sufficient for phase noise estimation from more than two phase noise sources. |
| vivo | Support proposal#3.2B. |

## PTRS-DMRS association

**One port PTRS**

In RAN1#112, we made the following agreement.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Agreement**   * **For full-coherent PUSCH with rank 5-8 with one port PTRS, support Alt.1 in the RAN1#111 agreement with the following update**   + **Alt.1: the size of PTRS-DMRS association field is 2bit in DCI format 0\_1/0\_2.**     - **~~FFS: Association with~~ The CW with the higher MCS is selected in case of two CWs.**     - **If the MCS is the same for two CWs, the PTRS port is associated with the first CW.**   **Table 7.3.1.1.2-25~~B~~: PTRS-DMRS association for UL PTRS port 0**   |  |  | | --- | --- | | **Value** | **DMRS port** | | 0 | 1st scheduled DMRS port with the CW ~~with the higher MCS~~ | | 1 | 2nd scheduled DMRS port the CW ~~with the higher MCS~~ | | 2 | 3rd scheduled DMRS port the CW ~~with the higher MCS~~ | | 3 | 4th scheduled DMRS port the CW ~~with the higher MCS~~ | |

ZTE [4] points out there is a case that one port PTRS is configured for partial/non-coherent PUSCH. ZTE’s proposal is to use 3-bit PTRS-DMRS association for one port PTRS for partial/non-coherent PUSCH. However, considering that 2-bit PTRS-DMRS association is agreed for full coherent codebook, from FL perspective, it is more reasonable to reuse the agreement of 2-bit PTRS-DMRS association to 1 port PTRS for partial/non-coherent PUSCH as well.

FL note: However, it seems the case of one port PTRS for partial/non-coherent codebook is missing in TS38.214?

|  |
| --- |
| 6.2.3.1 UE PT-RS transmission procedure when transform precoding is not enabled (TS38.214)  The maximum number of configured PT-RS ports is given by the higher layer parameter *maxNrofPorts* in PTRS-*UplinkConfig*. The UE is not expected to be configured with a larger number of UL PT-RS ports than it has reported need for.  […]  For partial-coherent and non-coherent codebook-based UL transmission, the actual number of UL PT-RS port(s) is determined based on TPMI(s) and/or number of layers which are indicated by 'Precoding information and number of layers' field(s) in DCI format 0\_1 and DCI format 0\_2 or configured by higher layer parameter *precodingAndNumberOfLayers*:  - if the UE is configured with the higher layer parameter *maxNrofPorts* in PTRS-*UplinkConfig* set to 'n2', the actual UL PT-RS port(s) and the associated transmission layer(s) are derived from indicated TPMI(s) as:  - PUSCH antenna port 1000 and 1002 in indicated TPMI(s) share PT-RS port 0, and PUSCH antenna port 1001 and 1003 in indicated TPMI(s) share PT-RS port 1.  - UL PT-RS port 0 is associated with the UL layer 'x' of layers which are transmitted with PUSCH antenna port 1000 and PUSCH antenna port 1002 in indicated TPMI(s), and UL PT-RS port 1 is associated with the UL layer 'y' of layers which are transmitted with PUSCH antenna port 1001 and PUSCH antenna port 1003 in indicated TPMI(s), where 'x' and/or 'y' are given by DCI parameter 'PTRS-DMRS association' as shown in DCI format 0\_1 and DCI format 0\_2 described in Clause 7.3.1 of [5, TS38.212]. |

**FL proposal#3.3A: (one port PTRS for partial/non-coherent PUSCH)**

* **For partial/non-coherent PUSCH, if one PTRS ports is configured, PTRS-DMRS association for PUSCH with up to 8 layers is the following.**
  + **The size of PTRS-DMRS association field is 2-bit in DCI format 0\_1/0\_2.**
    - **The CW with the higher MCS [or SE] is selected in case of two CWs.**
    - **If the MCS [or SE] is the same for two CWs, the PTRS port is associated with the first CW.**

**Table 7.3.1.1.2-25: PTRS-DMRS association for UL PTRS port 0**

|  |  |
| --- | --- |
| **Value** | **DMRS port** |
| 0 | 1st scheduled DMRS port with the CW |
| 1 | 2nd scheduled DMRS port with the CW |
| 2 | 3rd scheduled DMRS port with the CW |
| 3 | 4th scheduled DMRS port with the CW |

**FL proposal#3.3A2: (one port PTRS for partial/non-coherent PUSCH)**

* **For partial/non-coherent PUSCH, if one PTRS ports is configured, PTRS-DMRS association for PUSCH with up to 8 layers is the following.**
  + **The size of PTRS-DMRS association field is 3-bit in DCI format 0\_1/0\_2.**

**Table 7.3.1.1.2-25B: PTRS-DMRS association for UL PTRS port 0**

|  |  |
| --- | --- |
| **Value** | **DMRS port** |
| 0 | 1st scheduled DMRS port |
| 1 | 2nd scheduled DMRS port |
| 2 | 3rd scheduled DMRS port |
| 3 | 4th scheduled DMRS port |
| 4 | 5th scheduled DMRS port |
| 5 | 6th scheduled DMRS port |
| 6 | 7th scheduled DMRS port |
| 7 | 8th scheduled DMRS port |

**Two port PTRS**

For 2 PTRS ports for partial/non-coherent PUSCH, 3 options can be discussed. For Alt.3, there are at least unused 2-bit of antenna ports field for rank 5-8 based on sect. 3.1.1 and 3.1.2.

FL note: The following is only applied to 2-port PTRS. 4-port PTRS (if supported) can be discussed separately.

**FL proposal#3.3B: (two port PTRS for partial/non-coherent PUSCH)**

* **For two PTRS ports for partial/non-coherent PUSCH, PTRS-DMRS association for PUSCH with up to 8 layers is down selected from the following.**
  + **Alt.1: The size of PTRS-DMRS association field is 4-bit in DCI format 0\_1/0\_2.**

Table 1: PTRS-DMRS association for UL PTRS ports 0 and 1

|  |  |  |  |
| --- | --- | --- | --- |
| **Value of MSB** | **DMRS port** | **Value of LSB** | **DMRS port** |
| 0 | 1st DMRS port which shares PTRS port 0 | 0 | 1st DMRS port which shares PTRS port 1 |
| 1 | 2nd DMRS port which shares PTRS port 0 | 1 | 2nd DMRS port which shares PTRS port 1 |
| 2 | 3rd DMRS port which shares PTRS port 0 | 2 | 3rd DMRS port which shares PTRS port 1 |
| 3 | 4th DMRS port which shares PTRS port 0 | 3 | 4th DMRS port which shares PTRS port 1 |

* + **Alt.2: The size of PTRS-DMRS association field is 2-bit in DCI format 0\_1/0\_2.**
    - **The CW with the higher MCS is selected in case of two CWs.**
    - **If the MCS is the same for two CWs, the PTRS port is associated with the first CW.**

Table 2: PTRS-DMRS association for UL PTRS ports 0 and 1

|  |  |  |  |
| --- | --- | --- | --- |
| **Value of MSB** | **DMRS port** | **Value of LSB** | **DMRS port** |
| 0 | 1st DMRS port which shares PTRS port 0 | 0 | 1st DMRS port which shares PTRS port 1 |
| 1 | 2nd DMRS port which shares PTRS port 0 | 1 | 2nd DMRS port which shares PTRS port 1 |

* + **Alt.3: The size of PTRS-DMRS association field is 2-bit in DCI format 0\_1/0\_2.**
    - **For PUSCH with rank 5-8, 2-bit of antenna ports field is reused in addition to 2-bit PTRS-DMRS association in DCI format 0\_1/0\_2, and total 4-bit is used for PTRS-DMRS association.**

Table 1: PTRS-DMRS association for UL PTRS ports 0 and 1

|  |  |  |  |
| --- | --- | --- | --- |
| **Value of MSB** | **DMRS port** | **Value of LSB** | **DMRS port** |
| 0 | 1st DMRS port which shares PTRS port 0 | 0 | 1st DMRS port which shares PTRS port 1 |
| 1 | 2nd DMRS port which shares PTRS port 0 | 1 | 2nd DMRS port which shares PTRS port 1 |
| 2 | 3rd DMRS port which shares PTRS port 0 | 2 | 3rd DMRS port which shares PTRS port 1 |
| 3 | 4th DMRS port which shares PTRS port 0 | 3 | 4th DMRS port which shares PTRS port 1 |

* + **Alt.4: The size of PTRS-DMRS association field is 2-bit in DCI format 0\_1/0\_2.**

Table 2: PTRS-DMRS association for UL PTRS ports 0 and 1

|  |  |  |  |
| --- | --- | --- | --- |
| **Value of MSB** | **DMRS port** | **Value of LSB** | **DMRS port** |
| 0 | 1st DMRS port which shares PTRS port 0 | 0 | 1st DMRS port which shares PTRS port 1 |
| 1 | 2nd DMRS port which shares PTRS port 0 | 1 | 2nd DMRS port which shares PTRS port 1 |

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Docomo | FL proposal#3.3A: If one port PTRS for partial/non-coherent PUSCH is supported in R17, we are fine.  FL proposal#3.3B: Support Alt.1. |
| Google | 3.3A: As we discussed in our contribution, the higher MCS does not mean higher SE, as there are some reserved MCS as follows. So, we think the “higher MCS” should be replaced by “MCS with higher SE”. For reserved MCS, the SE can be calculated based on the TB size and allocated REs.    3.3B: We suggest adding Alt4 as follows. If the DCI overhead is a concern, we can consider partial indication.   * + **Alt.4: The size of PTRS-DMRS association field is 2-bit in DCI format 0\_1/0\_2.**   Table 2: PTRS-DMRS association for UL PTRS ports 0 and 1   |  |  |  |  | | --- | --- | --- | --- | | **Value of MSB** | **DMRS port** | **Value of LSB** | **DMRS port** | | 0 | 1st DMRS port which shares PTRS port 0 | 0 | 1st DMRS port which shares PTRS port 1 | | 1 | 2nd DMRS port which shares PTRS port 0 | 1 | 2nd DMRS port which shares PTRS port 1 | |
| OPPO | FL proposal#3.3A: Support.  FL proposal#3.3B:  We support to add Alt.4 as Google proposed.  We think there would be some issues with Alt.2. Depended on the codebook design, it is possible that two CWs are mapped to different antenna groups, and associated with two different PTRS ports. In this case, “The CW with the higher MCS is selected in case of two CWs.” cannot work at all. Alt.4 is a better solution. |
| Nokia/NSB | FL proposal#3.3A: Share view with DOCOMO  FL proposal#3.3B: prefer Alt.4 but also fine with Alt 1. |
| CATT | FL proposal#3.3A: Support.  FL proposal#3.3B: Support Alt.3. For PUSCH transmission with rank = 5, 6, 7, 8, there is only one or two DMRS port combinations for each rank. Since the bitwidth of Antenna port filed in DCI format 0\_1/0\_2 is 3 to 5 bits, 2-bits of the Antenna port filed can be used to indicate the mapping of PTRS ports and DMRS ports, and the overhead of DCI would not be increased. |
| Huawei, HiSilicon | **FL Proposal 3.3A:** Support.  **FL Proposal 3.3B:** In order to harvest similar overhead reduction benefit to one-port-PTRS case, the DCI overhead of PTRS-DMRS association should remains 2 bit. Detailed design can be discussed after TPMI is decided in 9.1.4.2. |
| Lenovo | FL proposal#3.3A: Support.  FL proposal#3.3B: Support Alt.1. |
| QC | FL proposal#3.3A: We are fine with the proposal.  FL proposal#3.3B: Support Alt.1. Alt 2 does not support the scenario where one PTRS port for CW1 and another PTRS port for CW2. With Alt 2, both PTRS ports are used for a same CW, which seems a problem/restriction. By the way, Alt 3 needs some clarification. Does it mean the size of PTRS-DMRS association varies with rank? If so, it seems cause dynamic DCI size which does not work. |
| MediaTek | FL proposal#3.3A: Support.  FL proposal#3.3B: We prefer Alt.1. |
| ZTE | **FL proposal#3.3A**: Do Not support.  For partial/non-coherent codebook and also non-codebook based transmission, if the max number of PTRS port is configured as one, then one out of 8 DMRS ports is associated to this one PTRS. Taking rank = 8 as an example, if the antenna port group is configured as 2, one DMRS port is associated with only one antenna port group, the DMRS port with the CW of higher MCS may not be associated with antenna port group with heavier phase noise. To guarantee the PTRS port is associated with the DMRS port with heavier phase noise, 3-bit indication should be used when one DMRS port is used.  **FL proposal#3.3B**: Support Alt 1. |
| Sharp | FL proposal 3.3A: Support  FL proposal 3.3B: Support Alt 1. |
| Xiaomi | FL proposal#3.3A: Fine with the proposal  FL proposal#3.3B: Support Alt.1. |
| Apple | FL proposal#3.3A: Support.  FL proposal#3.3B: Prefer Alt.1. |
| New H3C | FL proposal#3.3A: Support.  FL proposal#3.3B: Prefer Alt.1. |
| China Telecom | FL proposal 3.3A: Not support. We share the similar view as ZTE that 1 more bit for indicating CW is needed to ensure the performance.  FL proposal 3.3B: Support Alt 1. |
| Samsung | FL proposal#3.3A: We are fine with the proposal.  FL proposal#3.3B: We are open to discuss and prefer Alt2 to have same DCI overhead comparing with 1-port PTRS. We are fine with discussing after finalizing TPMI design from AI 9.1.4.2. |
| Spreadtrum | FL proposal#3.3A: Support.  FL proposal#3.3B: We prefer Alt.1 to achieve full signaling flexibility. |
| CMCC | FL proposal#3.3B: Support Alt.1. For codebook-based UL transmission, the actual number of UL PT-RS port(s) is determined based on TPMI and/or number of layers as: PUSCH antenna port 1000 and 1004 in indicated TPMI share PT-RS port 0, and PUSCH antenna port 1001 and 1005 in indicated TPMI share PT-RS port 1, PUSCH antenna port 1002 and 1006 in indicated TPMI share PT-RS port 2, and PUSCH antenna port 1003 and 1007 in indicated TPMI share PT-RS port 3. Then, 4 bits of PTRS-DMRS association field is needed to indicate the association between PT-RS port and DMRS port pair. |
| LGE | FL proposal#3.3A: Support.  FL proposal#3.3B: Support Alt.1. |
| vivo | FL proposal#3.3A: Support.  FL proposal#3.3B: We prefer Alt 2 with less overhead.  This proposal is associated with the design of partial/non-coherent codebook. Since the codebook is not determined yet, we suggest postponing this proposal before the outcome of AI 9.1.4.2. |
| **FL** | **For FL proposal#3.3A, I added FL proposal#3.3A2 (3-bit PTRS-DMRS association). I’d like to ask companies whether to support FL proposal#3.3A.**  **Also, please comment to Google’s proposal of changing “higher MCS” to “MCS with higher SE”** |
| ZTE2  (one typo was revised in v47) | **In case of one port PTRS for partial/non-coherent PUSCH**  **Support FL proposal#3.3A2.**  On proposal#3.3A, it relies on the relationship between CW with higher MSC and antenna port/port group with heavier phase noise when PUSCH with rank > 4. We evaluate simulation for 6 and 8 layers transmission of two CWs (more details can be found in our tdoc [R1-2302419](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_112b-e/Docs/R1-2302419.zip)). **As a result, it proves that the PTRS ports will not always associated with the antenna port group with heavier phase noise**. Hence the principle of proposal#3.3A cannot be workable for this case. By comparison, it is very clear proposal#3,3A2 can be used anyways with very great flexibility, and it won’t cause crosstalk with the final design of 8Tx partial/non-coherent codebook in the ongoing discussion of AI 9.1.4.2. In particular, we fail to see the motivation to save 1-bit but sacrifice the schedule flexibility.    **In case of two port PTRS for partial/non-coherent PUSCH**  **Support either Alt 1 or Alt 3.**  According to our simulation result and elaboration above, there is no relationship between CW with higher MSC and antenna port/port group with heavier phase in this case noise neither. Besides, it can be noted that even though without the outcome of 8Tx partial/non-coherent codebook in AI 9.1.4.2, either Alt 1 or Alt 3 can be workable. |
| QC3 | We prefer FL proposal#3.3A2 (3-bit PTRS-DMRS association).  We think it is fine to use higher MCS, which is the behavior in current spec anyway.  For FL proposal#3.3B, besides our comment to Alt 1/2/3, for the newly added Alt 4, we don’t support it as it restricts PTRS only can be associated to 4 out of the 8 DMRS ports. |
| Apple2 | We prefer FL proposal 3.3A1, but could also live with 3.3A2  For FL proposal 3.3B, we still prefer Alt 1. |
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### 3.3.1 One port PTRS

### **ROUND-2**

**One port PTRS**

**FL proposal#3.3A: (one port PTRS for partial/non-coherent PUSCH)**

* **For partial/non-coherent PUSCH, if one PTRS ports is configured, PTRS-DMRS association for PUSCH with up to 8 layers is the following.**
  + **The size of PTRS-DMRS association field is 2-bit in DCI format 0\_1/0\_2.**
    - **The CW with the higher MCS [or SE] is selected in case of two CWs.**
    - **If the MCS [or SE] is the same for two CWs, the PTRS port is associated with the first CW.**

**Table 7.3.1.1.2-25: PTRS-DMRS association for UL PTRS port 0**

|  |  |
| --- | --- |
| **Value** | **DMRS port** |
| 0 | 1st scheduled DMRS port with the CW |
| 1 | 2nd scheduled DMRS port with the CW |
| 2 | 3rd scheduled DMRS port with the CW |
| 3 | 4th scheduled DMRS port with the CW |

**FL proposal#3.3A2: (one port PTRS for partial/non-coherent PUSCH)**

* **For partial/non-coherent PUSCH, if one PTRS ports is configured, PTRS-DMRS association for PUSCH with up to 8 layers is the following.**
  + **The size of PTRS-DMRS association field is 3-bit in DCI format 0\_1/0\_2.**

**Table 7.3.1.1.2-25B: PTRS-DMRS association for UL PTRS port 0**

|  |  |
| --- | --- |
| **Value** | **DMRS port** |
| 0 | 1st scheduled DMRS port |
| 1 | 2nd scheduled DMRS port |
| 2 | 3rd scheduled DMRS port |
| 3 | 4th scheduled DMRS port |
| 4 | 5th scheduled DMRS port |
| 5 | 6th scheduled DMRS port |
| 6 | 7th scheduled DMRS port |
| 7 | 8th scheduled DMRS port |

**FL: In the 1st round, majority companies support FL proposal#3.3A. However, ZTE is not ok with FL proposal#3.3A. Please review ZTE’s comment and input your view on FL proposal#3.3A2.**

**For [or SE] in Alt.1, please review Google’s comment and input your views.**

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| --- | --- |
| **Company** | **Comment** |
| QC | Between the two options, considering ZTE’s results, proposal#3.3A2 is better. But then should we revisit the agreement made for full coherent PUSCH?  Regarding higher MCS vs higher SE, we prefer using the wording higher MCS. If the concern is about reserved MCS for retransmission, we think it is fine by simply pick CW based on MCS rather than seek for the optimization for this retransmission scenario. The concern with “highest SE” is that UE will have to keep tracking MCS(or SE) of previous PUSCH transmissions to prepare the MCS/SE of previous PUSCH to be used in later retransmission’s PTRS, which is inconvenient for UE implementation.  By the way, following “higher MCS” is the current UE behaviour anyway for DL PTRS DMRS association. |
| OPPO | We still prefer proposal#3.3A.  Based on the result from ZTE, it is still unclear how much benefit can be brought with additional one bit overhead. The same mechanism as that for full coherent case can be reused directly. |
| vivo | Support FL proposal#3.3A with higher MSC.  In the current spec, the same DMRS-PTRS association table is used for full/partial/non-coherent PUSCH when one PTRS port is assigned. So, we prefer to reuse the same principle. If gNB really cares about the performance, two PTRS ports can be activated.  Regarding the change of higher MCS to higher Spectrum efficiency (SE), we think it’s not needed, since based on legacy principle and the previous agreement for full-coherent case, it is based on higher MCS. |
| New H3C | Support FL proposal#3.3A |
| Apple | Still prefer FL Proposal#3.3A that reuse the same principle of higher MCS. |
| Nokia, NSB | We are fine with either FL proposal #3.3A or #3.3A2. We think 2 PTRS is more practical when partial and non-coherent codebook, so there is no critical problem to accept any of them. |
| ZTE | According to our input in the last round, we do support FL Proposal#3.3A2. |
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### 3.3.2 Two port PTRS

### **ROUND-2**

**Two port PTRS**

There is no change of the proposal. In the 1st round, there are some comments with technical reason. Please check the following, and inputs your views. Vivo suggests to postpone the discussion. If other companies agree it, my suggestion will be to make agreement “to down select”.

|  |  |
| --- | --- |
| OPPO | We think there would be some issues with Alt.2. Depended on the codebook design, it is possible that two CWs are mapped to different antenna groups, and associated with two different PTRS ports. In this case, “The CW with the higher MCS is selected in case of two CWs.” cannot work at all. Alt.4 is a better solution. |
| CATT | Support Alt.3. For PUSCH transmission with rank = 5, 6, 7, 8, there is only one or two DMRS port combinations for each rank. Since the bitwidth of Antenna port filed in DCI format 0\_1/0\_2 is 3 to 5 bits, 2-bits of the Antenna port filed can be used to indicate the mapping of PTRS ports and DMRS ports, and the overhead of DCI would not be increased. |
| Huawei, HiSilicon | In order to harvest similar overhead reduction benefit to one-port-PTRS case, the DCI overhead of PTRS-DMRS association should remains 2 bit. Detailed design can be discussed after TPMI is decided in 9.1.4.2. |
| QC | Alt 2 does not support the scenario where one PTRS port for CW1 and another PTRS port for CW2. With Alt 2, both PTRS ports are used for a same CW, which seems a problem/restriction. By the way, Alt 3 needs some clarification. Does it mean the size of PTRS-DMRS association varies with rank? If so, it seems cause dynamic DCI size which does not work.  **FL: For Alt.3, I think total DCI size does not change depending on the indicated rank.**  **PTRS-DMRS association field is always 2-bit in DCI. The 2-bit is used for rank 1-4 as R15. If rank 5-8 is indicated, since many reserved bit exists in antenna ports field for rank 5-8, 2-bit of (unused) antenna ports field is jointly used in addition to 2-bit PTRS-DMRS association field (i.e. total 4-bit is used for PTRS-DMRS association for rank5-8).**  for the newly added Alt 4, we don’t support it as it restricts PTRS only can be associated to 4 out of the 8 DMRS ports. |
| CMCC | Support Alt.1. For codebook-based UL transmission, the actual number of UL PT-RS port(s) is determined based on TPMI and/or number of layers as: PUSCH antenna port 1000 and 1004 in indicated TPMI share PT-RS port 0, and PUSCH antenna port 1001 and 1005 in indicated TPMI share PT-RS port 1, PUSCH antenna port 1002 and 1006 in indicated TPMI share PT-RS port 2, and PUSCH antenna port 1003 and 1007 in indicated TPMI share PT-RS port 3. Then, 4 bits of PTRS-DMRS association field is needed to indicate the association between PT-RS port and DMRS port pair. |
| vivo | This proposal is associated with the design of partial/non-coherent codebook. Since the codebook is not determined yet, we suggest postponing this proposal before the outcome of AI 9.1.4.2. |

**FL proposal#3.3B: (two port PTRS for partial/non-coherent PUSCH)**

* **For two PTRS ports for partial/non-coherent PUSCH, PTRS-DMRS association for PUSCH with up to 8 layers is down selected from the following.**
  + **Alt.1: The size of PTRS-DMRS association field is 4-bit in DCI format 0\_1/0\_2.**

Table 1: PTRS-DMRS association for UL PTRS ports 0 and 1

|  |  |  |  |
| --- | --- | --- | --- |
| **Value of MSB** | **DMRS port** | **Value of LSB** | **DMRS port** |
| 0 | 1st DMRS port which shares PTRS port 0 | 0 | 1st DMRS port which shares PTRS port 1 |
| 1 | 2nd DMRS port which shares PTRS port 0 | 1 | 2nd DMRS port which shares PTRS port 1 |
| 2 | 3rd DMRS port which shares PTRS port 0 | 2 | 3rd DMRS port which shares PTRS port 1 |
| 3 | 4th DMRS port which shares PTRS port 0 | 3 | 4th DMRS port which shares PTRS port 1 |

* + **Alt.2: The size of PTRS-DMRS association field is 2-bit in DCI format 0\_1/0\_2.**
    - **The CW with the higher MCS is selected in case of two CWs.**
    - **If the MCS is the same for two CWs, the PTRS port is associated with the first CW.**

Table 2: PTRS-DMRS association for UL PTRS ports 0 and 1

|  |  |  |  |
| --- | --- | --- | --- |
| **Value of MSB** | **DMRS port** | **Value of LSB** | **DMRS port** |
| 0 | 1st DMRS port which shares PTRS port 0 | 0 | 1st DMRS port which shares PTRS port 1 |
| 1 | 2nd DMRS port which shares PTRS port 0 | 1 | 2nd DMRS port which shares PTRS port 1 |

* + **Alt.3: The size of PTRS-DMRS association field is 2-bit in DCI format 0\_1/0\_2.**
    - **For PUSCH with rank 5-8, 2-bit of antenna ports field is reused in addition to 2-bit PTRS-DMRS association in DCI format 0\_1/0\_2, and total 4-bit is used for PTRS-DMRS association.**

Table 1: PTRS-DMRS association for UL PTRS ports 0 and 1

|  |  |  |  |
| --- | --- | --- | --- |
| **Value of MSB** | **DMRS port** | **Value of LSB** | **DMRS port** |
| 0 | 1st DMRS port which shares PTRS port 0 | 0 | 1st DMRS port which shares PTRS port 1 |
| 1 | 2nd DMRS port which shares PTRS port 0 | 1 | 2nd DMRS port which shares PTRS port 1 |
| 2 | 3rd DMRS port which shares PTRS port 0 | 2 | 3rd DMRS port which shares PTRS port 1 |
| 3 | 4th DMRS port which shares PTRS port 0 | 3 | 4th DMRS port which shares PTRS port 1 |

* + **Alt.4: The size of PTRS-DMRS association field is 2-bit in DCI format 0\_1/0\_2.**

Table 2: PTRS-DMRS association for UL PTRS ports 0 and 1

|  |  |  |  |
| --- | --- | --- | --- |
| **Value of MSB** | **DMRS port** | **Value of LSB** | **DMRS port** |
| 0 | 1st DMRS port which shares PTRS port 0 | 0 | 1st DMRS port which shares PTRS port 1 |
| 1 | 2nd DMRS port which shares PTRS port 0 | 1 | 2nd DMRS port which shares PTRS port 1 |

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| --- | --- |
| **Company** | **Comment** |
| QC | Same view as in previous round. Alt 1 seems the most straightforward way to go. |
| OPPO | We are fine with Alt 1 and Alt 4. |
| vivo | Support to do down-selection after the outcome of AI 9.1.4.2. |
| New H3C | Slightly prefer alt.1 |
| Apple | Prefer Alt 1 |
| Nokia, NSB | We are fine with either Alt 1 or Alt 4. |
| ZTE | Support Alt 1.  We can also be fine with Alt 4. |
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## (viod) PTRS power boosting

Note: power boosting for partial coherent codebook is remaining issue.

## Other proposals

Following proposals are also proposed.

|  |  |
| --- | --- |
| **Proposals** | **Companies** |
| 1. **UE indicates the number of PTRS ports associated to Ng as part of its capability** | IDC |
| 1. **For PTRS-DMRS association, if MCS is reserved MCS, the associated DMRS port is based on the MCS with highest SE.** | Google |

Please provide your views on the above proposals, or other aspects which are not included in the summary, if any.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Nokia/NSB (RAN1#112) | One more issue we have to resolve is, for Rel-15 DMRS, we cannot use PT-RS with TD-OCC. For Rel-18, we can further discuss on the options.  **TS38.214**  If a UE transmitting PUSCH scheduled by DCI format 0\_2 is configured with the higher layer parameter *phaseTrackingRS* in *dmrs-UplinkForPUSCH-MappingTypeA-DCI-0-2* or *dmrs-UplinkForPUSCH-MappingTypeB-DCI-0-2*, or a UE transmitting PUSCH scheduled by DCI format 0\_0 or DCI format 0\_1 is configured with the higher layer parameter *phaseTrackingRS* in *dmrs-UplinkForPUSCH-MappingTypeA* or *dmrs-UplinkForPUSCH-MappingTypeB*, the UE may assume that the following configurations are not occurring simultaneously for the transmitted PUSCH  - any DM-RS ports among 4-7 or 6-11 for DM-RS configurations type 1 and type 2, respectively are scheduled for the UE and PT-RS is transmitted from the UE. |
| Google | For 2), as we mentioned previously, the higher MCS does not mean higher SE, as there are some reserved MCS as follows. So, we think the “higher MCS” should be replaced by “MCS with higher SE”. For reserved MCS, the SE can be calculated based on the TB size and allocated REs.    Based on current agreements, a worst case is that there might be no PT-RS if the gNB indicates MCS=29 for one CW, but MCS=27 for the second CW. |
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# Conclusion

Following FL proposals are made.

# References

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| --- | --- | --- | --- |
| [1] | **[R1-2302302](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2302302.zip)** | Remaining Details on DMRS Enhancements | InterDigital, Inc. |
| [2] | **[R1-2302313](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2302313.zip)** | On increasing the number of orthogonal DM-RS ports for MU-MIMO | FUTUREWEI |
| [3] | **[R1-2302373](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2302373.zip)** | Discussion on DMRS enhancements in Rel-18 | Huawei, HiSilicon |
| [4] | **[R1-2302419](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2302419.zip)** | DMRS enhancement for UL/DL MU-MIMO and 8 Tx UL SU-MIMO | ZTE, China Telecom |
| [5] | **[R1-2302428](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2302428.zip)** | Discussions on increased number of orthogonal DMRS ports | New H3C Technologies Co., Ltd. |
| [6] | **[R1-2302472](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2302472+.zip)** | Further discussion on DMRS enhancements | vivo |
| [7] | **[R1-2302535](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2302535.zip)** | DMRS enhancement for Rel-18 MIMO | OPPO |
| [8] | **[R1-2302588](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2302588.zip)** | Discussion on increased number of orthogonal DMRS ports | Spreadtrum Communications |
| [9] | **[R1-2302634](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2302634.zip)** | On increased number of orthogonal DMRS ports | Fraunhofer IIS |
| [10] | **[R1-2302683](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2302683.zip)** | DMRS enhancements in Rel-18 | CATT |
| [11] | **[R1-2302726](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2302726.zip)** | Discussion of increased number of orthogonal DMRS ports | Lenovo |
| [12] | **[R1-2302767](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2302767.zip)** | On increased number of orthogonal DMRS ports for MU-MIMO and 8 Tx UL SU-MIMO | Ericsson |
| [13] | **[R1-2302783](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2302783.zip)** | DMRS Enhancements for Rel-18 NR | Intel Corporation |
| [14] | **[R1-2302962](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2302962.zip)** | Discussion on DMRS enhancement | Xiaomi |
| [15] | **[R1-2303008](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2303008.zip)** | Rel-18 UL and DL DMRS Enhancements | Nokia, Nokia Shanghai Bell |
| [16] | **[R1-2303045](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2303045.zip)** | On DMRS Enhancement | Google |
| [17] | **[R1-2303071](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2303071.zip)** | Increased number of orthogonal DMRS ports | LG Electronics |
| [18] | **[R1-2303115](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2303115.zip)** | Views on DMRS enhancements | Samsung |
| [19] | **[R1-2303180](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2303180.zip)** | Increased number of orthogonal DMRS ports | Sharp |
| [20] | **[R1-2303219](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2303219.zip)** | Discussion on increased number of orthogonal DMRS ports | CMCC |
| [21] | **[R1-2303329](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2303329.zip)** | Increased number of orthogonal DMRS ports | MediaTek Inc. |
| [22] | **[R1-2303470](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2303470.zip)** | Views on supporting increased number of orthogonal DMRS ports | Apple |
| [23] | **[R1-2303576](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2303576.zip)** | Design for increased number of orthogonal DMRS ports | Qualcomm Incorporated |
| [24] | **[R1-2303678](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2303678.zip)** | Discussion on increased number of orthogonal DMRS ports | NEC |
| [25] | **[R1-2303700](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_112b-e/Docs/R1-2303700.zip)** | Discussion on DMRS enhancements | NTT DOCOMO, INC. |

# **Appendix**

## **RAN1#109e agreements:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| **EVM**  Agreement   * LLS is used for objective #3 (increasing DMRS ports for MU-MIMO) in Rel.18 MIMO, while SLS can be used optionally.   Agreement   * No EVM discussion is needed for objective #5 (>4 layers PUSCH DMRS) in AI 9.1.3.1 (DMRS) in Rel.18.   Agreement   * LLS for increasing DMRS ports in AI 9.1.3.1 in Rel.18:   + Evaluated channel: PDSCH as baseline (Companies can additionally submit evaluation results of PUSCH).   + Evaluation metric:     - BLER for fixed MCS and rank as baseline     - User throughput for adaptive MCS and rank as optional     - MSE or NMSE of DMRS as optional   + Evaluation baseline (i.e. compared with):     - For evaluation of enhanced single-symbol DMRS, baseline refers to Rel.15 single-symbol DMRS or Rel.15 double-symbol DMRS.     - For evaluation of enhanced double-symbol DMRS, baseline refers to Rel.15 double-symbol DMRS.   Agreement   * Following evaluation assumptions are used for LLS for increasing DMRS ports in AI 9.1.3.1 in Rel.18.  |  |  | | --- | --- | | **Parameter** | **Value** | | Duplex, Waveform | TDD, OFDM  Note: FDD, OFDM is not precluded | | Carrier Frequency | 4 GHz | | Subcarrier spacing | 30kHz | | Channel Model | CDL-B or CDL-C in TR 38.901 with 30ns or 300ns delay spread as baseline for MU-MIMO and SU-MIMO  Note: Other delay spread is not precluded.  Note: Simulation using TDL-A with 30ns or 300ns for MU-MIMO is not precluded. | | Delay spread | Baseline: 30ns, 300ns  Optional: 1000ns | | UE velocity | Baseline: 3km/h, 30km/h  Optional: 60km/h, 120km/h | | Allocation bandwidth | 20MHz  Note: Other bandwidth smaller than 20MHz is not precluded | | MIMO scheme | Baseline: MU-MIMO  Optional: SU-MIMO | | BS antenna configuration | Companies can select and need to report which option(s) are used between  - 32 ports: (M, N, P, Mg, Ng, Mp, Np) = (8,8,2,1,1,2,8), (dH,dV) = (0.5, 0.8)λ  - 16 ports: (M, N, P, Mg, Ng, Mp, Np) = (8,4,2,1,1,2,4), (dH,dV) = (0.5, 0.8)λ  Other configurations are not precluded. | | UE antenna configuration | Companies can select and need to report which option(s) are used between  4RX: (M, N, P, Mg, Ng, Mp, Np) = (1,2,2,1,1,1,2), (dH,dV) = (0.5, 0.5)λ for rank > 2  2RX: (M, N, P, Mg, Ng, Mp, Np) = (1,1,2,1,1,1,1), (dH,dV) = (0.5, 0.5)λ for (rank 1,2)  Other configuration is not precluded. | | MIMO Rank | 1, 2, or 4 per UE (rank fixed or rank adaptation) | | UE number for MU-MIMO | 1, 2, 4, 8, or 12 | | Precoding and precoding granularity | For PDSCH: Companies can select and need to report which option(s) are used between   * [ZF or SVD] based sub-band precoding (with 4PRB precoding granularity) on ideal channel knowledge * CSI codebook based sub-band precoding (with 4PRB precoding granularity) on ideal CSI feedback.   For PUSCH: Companies can select and need to report which option(s) are used between   * [ZF or SVD] based wide-band precoding on ideal channel knowledge * Codebook based wide-band precoding on ideal CSI feedback. | | Feedback delay for precoding | 5ms | | DMRS type | Type 1E and/or Type 2E, which are enhanced DMRS that are based on the legacy RE mappings of DMRS Type 1/2, where the enhanced DMRS support larger DMRS ports.  Note: The terminology of Type 1E and/or Type 2E is for discussion purpose. | | DMRS configurations | Baseline:   * Single symbol DMRS without additional DMRS symbols and 1 additional DMRS symbol * Double symbol DMRS without additional DMRS symbols.   Note: evaluation of other additional DMRS symbol(s) are not precluded. | | DMRS mapping type | Mapping type A (slot based) for PDSCH.  Mapping type A (slot based) for PUSCH. | | Link adaptation | * Fixed modulation, coding and rank for BLER evaluation as baseline. * Adaptation of both MCS and rank for throughput evaluation as optional. | | HARQ | Baseline: Off  Optional: On (HARQ with max. 4 re-transmissions) for throughput evaluation | | Channel estimation | Realistic channel estimation with ideal info of frequency sync, SNR, doppler and delay spread | | Receiver type | MMSE as baseline | | EVM | No radio impairments |   Agreement   * For LLS assumptions for increasing DMRS ports in AI 9.1.3.1 in Rel.18:   + Precoding assumption of PUSCH, “[ZF or SVD]” in RAN1#109e agreement is updated by     - Alt.2-2: SVD   Agreement  For LLS assumptions for increasing DMRS ports in AI 9.1.3.1 in Rel.18:   * Precoding assumption of PDSCH, “[ZF or SVD]” in RAN1#109e agreement is updated by SVD.   Agreement   * For MU-MIMO LLS of PDSCH, for evaluation of SVD/CSI-codebook based sub-band precoding, companies shall report the pre-coding assumption of interference of co-scheduled UEs from the following:   + Alt.1: calculated by pre-coder of channel of each co-scheduled UE.     - For precoding assumption of PDSCH, precoder of target UE and precoder of co-scheduled UE are generated independently.     - Companies can report a set of azimuth and zenith angle offset used for evaluation (For example, azimuth angle offsets from [30o, 60o, 90o] and zenith angle offset from [3o, 6o] can be considered).   + Alt.2: calculated by random pre-coder (i.e. precoder selected randomly from a predefined set of precoders) which is different from the pre-coder of target UE.     - For precoding assumption of PDSCH, only the channel of one target UE, i.e. *Hd*, needs to be modelled. Precoder is generated based on *Hd* to obtain the precoder for this UE only. The interference from co-scheduled UEs can be modelled as, cid:image002.png@01D86C43.8E5DA4E0, wherein *Wi* can be randomly selected from a predefined set of precoders       * Companies shall report how to generate the predefined set of precoders for simulation.   + Alt.3: the same pre-coder as scheduled UE.     - PDSCH interference and interfering DMRS ports are emulated using the same pre-coder as for the scheduled UE.     - Power offset of the co-scheduled UE is one value from {0dB, -3dB, -6dB} as fixed evaluation parameter. Other values are not precluded.     - For precoding assumption of PDSCH, only the channel of one target UE, i.e. *Hd*, needs to be modelled. Precoder for the target UE (denoted as *Wd*) is generated based on *Hd* only. Denote the precoding matrix/vector of the ith co-scheduled UEs as *Wi*, and *Wi*=*Wd* (*Wi* for all th co-scheduled UEs are same). Then the interference from co-scheduled UEs can be modelled as cid:image003.png@01D86C43.8E5DA4E0.​   For the above Alt.1-3, only PDSCH performance of the target UE is evaluated, while interference of both PDSCH and DMRS of co-scheduled UE(s) is simulated.  Agreement   * For SLS assumption for increasing DMRS ports in AI 9.1.3.1 in Rel.18,   + Scenario: Dense Urban (Macro only) at 4GHz is a baseline. Other scenarios (e.g. Umi, Uma) are not precluded.   + Following evaluation assumptions are used for SLS.  |  |  |  | | --- | --- | --- | | **Parameter** | | **Value** | | Scenario | | Dense Urban (macro only) | | Carrier frequency | | 4GHz | | Duplex, Waveform | | TDD, OFDM  Note: FDD, OFDM is not precluded | | Multiple access | | OFDMA | | Frequency Range | | FR1 only. | | Inter-BS distance | | 200 m | | Channel model | | According to the TR 38.901 | | Antenna setup and port layouts at gNB | | Companies need to report which option(s) are used between   * 32 ports: (M, N, P, Mg, Ng, Mp, Np) = (8,8,2,1,1,2,8), (dH,dV) = (0.5, 0.8)λ * 16 ports: (M, N, P, Mg, Ng, Mp, Np) = (8,4,2,1,1,2,4), (dH,dV) = (0.5, 0.8)λ   Other configurations are not precluded. | | Antenna setup and port layouts at UE | | 4RX: (M, N, P, Mg, Ng, Mp, Np) = (1,2,2,1,1,1,2), (dH,dV) = (0.5, 0.5)λ for rank > 2  2RX: (M, N, P, Mg, Ng, Mp, Np) = (1,1,2,1,1,1,1), (dH,dV) = (0.5, 0.5)λ for (rank 1,2)  Other configurations are not precluded. | | BS Tx power | | 41 dBm for 10MHz, 44dBm for 20MHz, 47dBm for 40MHz | | BS antenna height | | 25 m | | BS noise figure | | 5 dB | | UE noise figure | | 9 dB | | UE antenna height & gain | | Follow TR36.873 | | Modulation | | Up to 256 QAM | | Coding on PDSCH | | LDPC  Max code-block size=8448bit | | Numerology | Slot/non-slot | 14 OFDM symbols per slot | | SCS | 30 kHz | | Simulation bandwidth | | 20 MHz | | Number of RBs | | 52 for 30 kHz SCS | | Frame structure | | Slot Format 0 (all downlink) for all slots | | MIMO scheme | | SU/MU-MIMO with rank adaptation is a baseline  For low RU, SU-MIMO or SU/MU-MIMO with rank adaptation are assumed  For medium/high RU, SU/MU-MIMO with rank adaptation is assumed | | MIMO layers | | For all evaluation, companies to provide the assumption on the maximum MU layers (e.g. 8 or 12) | | CSI feedback | | Feedback assumption at least for baseline scheme  CSI feedback periodicity (full CSI feedback): 5 ms,  Scheduling delay (from CSI feedback to time to apply in scheduling): 4 ms | | Overhead | | Companies shall provide the downlink overhead assumption | | Traffic model | | Baseline: FTP1 with 50% Resource Utilization  Optional: Full buffer | | UE distribution | | [80%] indoor (3km/h),  [20%] outdoor (30km/h) | | UE receiver | | MMSE-IRC as the baseline receiver | | Feedback assumption | | Realistic | | Channel estimation | | Realistic |   **For increasing orthogonal DMRS ports**  Agreement   * Specify to increase the max. number of DMRS ports for PDSCH/PUSCH larger than Rel.15 for CP-OFDM without increasing the DMRS overhead.   + Strive to have common design of DMRS enhancement for PDSCH and PUSCH for a given DMRS Type.   Agreement   * The maximum number of enhanced DMRS ports in Rel.18 is doubled from Rel.15 DMRS ports:   + For DMRS type 1, the max. number of enhanced DMRS ports in Rel.18 for PDSCH/PUSCH is     - Single symbol DMRS: 8 DMRS ports.     - Double symbol DMRS: 16 DMRS ports.   + For DMRS type 2, the max. number of enhanced DMRS ports in Rel.18 for PDSCH/PUSCH is     - Single symbol DMRS: 12 DMRS ports.     - Double symbol DMRS: 24 DMRS ports.   Agreement   * To increase the number of DMRS ports for PDSCH/PUSCH, evaluate and, if needed, specify one or more from the following options:   + Opt.1 (enhance FD-OCC): Introduce larger FD-OCC length than Rel.15 (e.g. 4 or 6).     - Study aspect includes potential performance degradation in large delay spread, potential scheduling restriction, backward compatibility.   + Opt.2 (enhance TD-OCC): Utilize TD-OCC over non-contiguous DMRS symbols (e.g. TD-OCC across front/additional DMRS symbols)     - Study aspect includes potential performance degradation in high UE velocity, potential scheduling restriction (e.g. how to apply freq. hopping), potential DMRS configuration restriction (e.g. restriction of the number of additional DMRS), backward compatibility.   + Opt.3 (Sparser frequency allocation): increase the number of CDM groups (e.g. larger number of comb/FDM).     - Study aspect includes potential performance degradation in large delay spread, backward compatibility.   + Opt.4 (using TDMed DMRS symbol): reusing additional DMRS symbols to increase orthogonal DMRS ports     - Study aspect includes potential performance degradation in high UE velocity, potential DMRS configuration restriction (e.g. restriction of the number of additional DMRS), backward compatibility.   + Opt.5 TD-OCC over non-contiguous DMRS symbols combined with FD-OCC or FDM: reusing additional DMRS symbol(s) to improve channel estimation performance.     - Study aspect includes potential performance degradation in high UE velocity, potential scheduling restriction (e.g. how to apply freq. hopping), potential DMRS configuration restriction (e.g. restriction of the number of additional DMRS), backward compatibility.   + The same option can be applied to both single symbol DMRS and double symbol DMRS.   Agreement   * To increase the max. number of DMRS ports for PDSCH/PUSCH compared to Rel.15 DMRS for CP-OFDM without increasing the DMRS overhead,   + Study whether/how to enable MU-MIMO between Rel.15 DMRS ports and Rel.18 DMRS ports, as well as whether/how to enable MU-MIMO among Rel.18 DMRS ports, in the same or different CDM group.   Agreement   * To increase the max. number of orthogonal DMRS ports for PDSCH/PUSCH larger than Rel.15   + Study whether/how to support DCI-based dynamic antenna ports indication of Rel.18 DMRS ports and/or Rel.15 DMRS ports.   + Study whether/how to reuse the antenna port indication table in 38.212 as much as possible for both PDSCH and PUSCH   + Study the potential need for MU scheduling restrictions in the design of the enhanced antenna port indication table in 38.212 for DL PDSCH.   **For 8 Tx UL SU-MIMO**  Agreement   * Study the following potential DMRS enhancement for potential support of more than 4 layers SU-MIMO PUSCH.   + Extend DMRS port allocation table for rank 5~8     - Note: DL DMRS table can be a reference   + Enhancement for DMRS to PTRS mapping * Study whether to utilize Rel.18 DMRS ports for more than 4 layers SU-MIMO PUSCH. * Note: the above study does not imply more than 4 layers SU-MIMO PUSCH is supported. * Note: other study for potential DMRS enhancement for potential support of more than 4 layers SU-MIMO PUSCH is not precluded. |

## **RAN1#110 agreements:**

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| **For increasing orthogonal DMRS ports**  Working Assumption   * To increase the number of DMRS ports for PDSCH/PUSCH, support at least Opt.1 (introduce larger FD-OCC length than Rel.15 (e.g. 4 or 6)).   + FFS: FD-OCC length for Rel.18 DMRS type 1 and type 2.   + FFS: Whether it is needed to handle potential performance issues of Opt 1. For example, study if there is performance loss in case of large delay spread scenario. If needed, how (e.g. additionally support other options).   Agreement   * For enhanced FD-OCC length for DMRS of PDSCH/PUSCH, support the following FD-OCC length:   + For Rel.18 DMRS type 1, down select from the following in RAN1#110bis-e:     - Opt.1-1: Length 6 FD-OCC is applied to 6 REs of DMRS within a PRB within an CDM group     - Opt.1-2: Length 4 FD-OCC is applied to 4 REs of DMRS within a PRB or across consecutive PRBs within an CDM group   + For Rel.18 DMRS type 2:     - Length 4 FD-OCC is applied to 4 REs of DMRS within a PRB within an CDM group     - FFS: Support of length 6 FD-OCC   Agreement   * Support MU-MIMO between Rel.15 DMRS ports and Rel.18 DMRS ports.   + For MU-MIMO by different CDM groups, no MU-MIMO scheduling restriction of PUSCH/PDSCH (i.e. MU-MIMO between Rel.15 UE and Rel.18 UE is allowed).   + For MU-MIMO within a CDM group, study whether and how to support MU-MIMO between Rel.15 DMRS ports and Rel.18 DMRS ports for PDSCH.     - Note: the study includes MU-MIMO between Rel.15 UE and Rel.18 UE, and between Rel.18 UEs.   + Note: PUSCH above is CP-OFDM waveform.   Agreement  For increased DMRS ports for enhanced FD-OCC, study whether/how to support DCI based switching between DMRS port(s) associated with length 2 FD-OCC and DMRS port(s) associated with length M FD-OCC (where M > 2).  **For 8 Tx UL SU-MIMO**  Agreement   * For support of more than 4 layers SU-MIMO PUSCH, study the following potential enhancements for PTRS-DMRS association.   + Whether to support more than 2-port UL PTRS.   + Whether to increase the DCI size of PTRS-DMRS association field in DCI format 0\_1/0\_2.   Agreement  For > 4 layers PUSCH, support rank = 5,6,7,8 for both DMRS type 1/2, and for both single-symbol/double-symbol DMRS. |

## **RAN1#110bis-e agreements:**

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| **For increasing orthogonal DMRS ports**  Conclusion   * For discussion purpose, definition of Rel.15 DMRS ports and Rel-18 DMRS ports are:   + Rel.15 Type 1/Type 2 DMRS ports: DMRS ports with FD-OCC length =2.   + Rel.18 eType 1/eType 2 DMRS ports: DMRS ports with FD-OCC length >2. * Following figure as an example shows difference between Rel.15 Type 1 DMRS ports and Rel.18 eType 1 DMRS ports.     Agreement  Confirm the working assumption in RAN1#110 with the following update:   * To increase the number of DMRS ports for PDSCH/PUSCH, support at least Opt.1 (introduce larger FD-OCC length than Rel.15 (e.g. 4 or 6)).   + ~~FFS: FD-OCC length for Rel.18 DMRS type 1 and type 2.~~   + FFS: Whether it is needed to handle potential performance issues of Opt 1. For example, study if there is performance loss in case of large delay spread scenario. If needed, how (e.g. additionally support other options).   Agreement  For enhanced FD-OCC length for DMRS of PDSCH/PUSCH for Rel.18 eType 1 DMRS, support   * Opt.1-2: Length 4 FD-OCC is applied to 4 REs of DMRS within a PRB or across consecutive PRBs within an CDM group   Agreement  For FD-OCC length 4 for DMRS of PDSCH/PUSCH for Rel.18 eType 1/eType 2 DMRS, support one from the following FD-OCCs (to be selected in RAN1#111):   * Opt.1-1: Walsh matrix (Hadamard code):  |  |  |  |  |  | | --- | --- | --- | --- | --- | | FD-OCC index | wf(0) | wf(1) | wf(2) | wf(3) | | 0 | +1 | +1 | +1 | +1 | | 1 | +1 | -1 | +1 | -1 | | 2 | +1 | +1 | -1 | -1 | | 3 | +1 | -1 | -1 | +1 |  * Opt.1-2: Cyclic shift with {0, π, π/2, 3π/2}:  |  |  |  |  |  | | --- | --- | --- | --- | --- | | FD-OCC index | wf(0) | wf(1) | wf(2) | wf(3) | | 0 | +1 | +1 | +1 | +1 | | 1 | +1 | -1 | +1 | -1 | | 2 | +1 | +j | -1 | -j | | 3 | +1 | -j | -1 | +j |   Agreement  For Rel.18 eType 1/eType 2 DMRS ports of PDSCH/PUSCH with FD-OCC length 4, association between DMRS port indexes, CDM group index, FD-OCC index, and TD-OCC index (across consecutive DMRS symbols, if any) are determined by the following Table 1 and Table 2.   * The *p* in Table 1 and Table 2 corresponds to DMRS port index for PUSCH. * DMRS port index for PDSCH is determined by *p* +1000 in Table 1 and Table 2.   Table 1. Rel.18 eType 1 DMRS ports for PUSCH   |  |  |  |  | | --- | --- | --- | --- | | p | CDM group index | FD-OCC index | TD-OCC index | | 0 | 0 | 0 | 0 | | 1 | 0 | 1 | 0 | | 2 | 1 | 0 | 0 | | 3 | 1 | 1 | 0 | | 4 | 0 | 0 | 1 | | 5 | 0 | 1 | 1 | | 6 | 1 | 0 | 1 | | 7 | 1 | 1 | 1 | | 8 | 0 | 2 | 0 | | 9 | 0 | 3 | 0 | | 10 | 1 | 2 | 0 | | 11 | 1 | 3 | 0 | | 12 | 0 | 2 | 1 | | 13 | 0 | 3 | 1 | | 14 | 1 | 2 | 1 | | 15 | 1 | 3 | 1 |   Table 2. Rel.18 eType 2 DMRS ports for PUSCH   |  |  |  |  | | --- | --- | --- | --- | | p | CDM group index | FD-OCC index | TD-OCC index | | 0 | 0 | 0 | 0 | | 1 | 0 | 1 | 0 | | 2 | 1 | 0 | 0 | | 3 | 1 | 1 | 0 | | 4 | 2 | 0 | 0 | | 5 | 2 | 1 | 0 | | 6 | 0 | 0 | 1 | | 7 | 0 | 1 | 1 | | 8 | 1 | 0 | 1 | | 9 | 1 | 1 | 1 | | 10 | 2 | 0 | 1 | | 11 | 2 | 1 | 1 | | 12 | 0 | 2 | 0 | | 13 | 0 | 3 | 0 | | 14 | 1 | 2 | 0 | | 15 | 1 | 3 | 0 | | 16 | 2 | 2 | 0 | | 17 | 2 | 3 | 0 | | 18 | 0 | 2 | 1 | | 19 | 0 | 3 | 1 | | 20 | 1 | 2 | 1 | | 21 | 1 | 3 | 1 | | 22 | 2 | 2 | 1 | | 23 | 2 | 3 | 1 |   Agreement  For FD-OCC length 4 in Rel.18 eType 1 DMRS for PDSCH, support the following:   * Introduce UE capability to report whether UE can be scheduled PDSCH without the scheduling restriction for FD-OCC length 4 in Rel.18 eType 1 DMRS.   + If this capability is not supported by the UE, UE expects that gNB shall apply the scheduling restriction for PDSCH for FD-OCC length 4 in Rel.18 eType 1 DMRS. * The scheduling restriction above means satisfying all of the following at least for other than M-TRP PDSCH transmission with FDM 2a or FDM 2b scheme.   + The number of consecutively scheduled PRBs for PDSCH is even.   + The number of PRBs offset of scheduled PDSCH from point A (common resource block 0) is even.   + FFS: Restriction on scheduling of different UEs in case of MU-MIMO.   + FFS: Scheduling restriction for M-TRP PDSCH transmission with FDM 2a or FDM 2b scheme. * Note1: Up to UE how to implement DMRS channel estimation. * Note2: No further RAN1 specification enhancement is introduced to handle the orphan REs (e.g. if the total number of REs of DMRS in a CDM group is not multiples of 4, how to handle the remainder of REs) for UE that is scheduled PDSCH without the scheduling restriction. * Note 3: Other scheduling restrictions, if identified in future meetings, are not precluded.   Conclusion  For FD-OCC length 4 in Rel.18 eType 1 DMRS for PUSCH,   * No spec. enhancement is needed to handle orphan RE issue (e.g. if the total number of REs of DMRS in a CDM group is not multiples of 4, how to handle the remainder of REs), because gNB (receiver) can decide whether the scheduling restriction is needed or not.   **For 8 Tx UL SU-MIMO**  Agreement  For more than 4 layers SU-MIMO PUSCH, support   * Both Rel.15 Type 1/Type 2 DMRS ports and Rel.18 eType 1/eType 2 DMRS ports.   + For UE supporting Rel.18 eType 1/eType 2 DMRS ports, UE can be indicated with either of Rel.15 Type 1/Type 2 DMRS ports or Rel.18 eType 1/eType 2 DMRS ports.     - RRC based indication is supported as the baseline. FFS whether DCI based indication is further needed.   + For UE not supporting Rel.18 eType 1/eType 2 DMRS ports, UE can be indicated with Rel.15 Type 1/Type 2 DMRS ports only. |

## **RAN1#111 agreements:**

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| **For increasing orthogonal DMRS ports**  Agreement  For FD-OCC length 4 for PDSCH/PUSCH, select the following:   * Opt.1-1 (Walsh matrix) for PDSCH * Opt.1-2 (Cyclic shift) for PUSCH   Agreement   * For the antenna ports indication in Rel.18 eType1/eType2 DMRS ports with maxLength = 1/2 for PDSCH, all of the following port combinations can be indicated:   + Cat. 1) Legacy port indexes (eType 1: p=0~7, eType 2: p=0~11)   + Cat. 2) New port indexes (eType 1: p=8~15, eType 2: p=12~23)   + Cat. 3) Legacy port indexes and New port indexes at least within a CDM group at least for *maxLength*=1 (eType 1: up to 4 ports from {0, 1, 8, 9} and/or up to 4 ports from {2, 3, 10, 11}, eType 2: up to 4 ports from {0, 1, 12, 13} and/or up to 4 ports from {2, 3, 14, 15} and/or up to 4 ports from {4, 5, 16, 17}) at least for S-TRP case,     - For up to 4 ranks, only one CDM group is used per UE. For larger than 4 ranks, more than one CDM groups can be used per UE. * FFS: Whether to increase the size of antenna ports field in DCI format 1\_1/1\_2, or introduce new DCI field for antenna ports indication, or not. * FFS: Whether the new antenna port(s) table is specified or not. * FFS: MU restrictions for certain entries. e.g., DMRS ports = {0,2}, or {8,10}, etc. * FFS: Cat.3 for M-TRP case. * Note: DMRS port index for PDSCH is determined by p +1000   Agreement  For length 2 TD-OCC (across consecutive DMRS symbols, if any) for DMRS of PDSCH/PUSCH for Rel.18 eType 1/2 DMRS, support Opt.1:   * Opt.1:  |  |  |  | | --- | --- | --- | | **TD-OCC index** | **Wt(0)** | **Wt(1)** | | 0 | +1 | +1 | | 1 | +1 | -1 |   Agreement   * For the antenna ports indication in Rel.18 eType1 DMRS ports with maxLength = 1 for PDSCH, at least for S-TRP case, support the following rows of DMRS port combinations and Number of DMRS CDM group(s) without data.   + FFS: Antenna ports indication in Rel.18 eType1 DMRS ports with maxLength = 1 for PDSCH for M-TRP case.   **Table 7.3.1.2.2-1-X: Antenna port(s) (1000 + DMRS port), *dmrs-Type*=eType1, *maxLength*=1**   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | **One Codeword:**  **Codeword 0 enabled,**  **Codeword 1 disabled** | | | | **Two Codewords:**  **Codeword 0 enabled,**  **Codeword 1 enabled** | | | | | **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | **Notes** | **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | Notes | | 0 | [1] | [0] | Cat. 1 | [0] | [2] | [0,1,2,3,8] | [Rank 5-8 with one DMRS symbol] | | 1 | [1] | [1] | [1] | [2] | [0,1,2,3,8,10] | | 2 | [1] | [0,1] | [2] | [2] | [0,1,2,3,8,9,10] | | 3 | 2 | 0 | [3] | [2] | [0,1,2,3,8,9,10,11] | | 4 | 2 | 1 |  |  |  |  | | 5 | 2 | 2 |  |  |  |  | | 6 | 2 | 3 |  |  |  |  | | 7 | 2 | 0,1 |  |  |  |  | | 8 | 2 | 2,3 |  |  |  |  | | 9 | [2] | [0-2] |  |  |  |  | | 10 | [2] | [0-3] |  |  |  |  | | 11 | [2] | [0,2] |  |  |  |  | | 12 | [1] | [8] | Cat.2 |  |  |  |  | | 13 | [1] | [9] |  |  |  |  | | 14 | [1] | [8,9] |  |  |  |  | | 15 | 2 | 8 |  |  |  |  | | 16 | 2 | 9 |  |  |  |  | | 17 | 2 | 10 |  |  |  |  | | 18 | 2 | 11 |  |  |  |  | | 19 | 2 | 8,9 |  |  |  |  | | 20 | 2 | 10,11 |  |  |  |  | | 21 | [2] | [8-10] |  |  |  |  | | 22 | [2] | [8-11] |  |  |  |  | | 23 | [2] | [8, 10],  [9, 11] |  |  |  |  | | 24 | [1] | [0,1,8] | Cat.3 |  |  |  |  | | 25 | [1] | [0,1,8,9] |  |  |  |  | | 26 | 2 | 0,1,8 |  |  |  |  | | 27 | 2 | 0,1,8,9 |  |  |  |  | | 28 | 2 | 2,3,10 |  |  |  |  | | 29 | 2 | 2,3,10,11 |  |  |  |  | |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |   **For 8 Tx UL SU-MIMO**  Agreement   * For > 4 layers PUSCH, support new antenna ports tables for rank = 5,6,7,8 for both single-symbol/double-symbol DMRS.   + For Type 1/Type 2 Rel.15 DMRS ports, new antenna ports tables are the following:     - The same DMRS port combination(s) as that for rank = 5,6,7,8 for PDSCH is reused at least for full or non-coherent UL codebook.   + For Rel.18 eType1/eType2 DMRS ports,     - New antenna ports tables with new DMRS port combinations are used for rank = 5,6,7,8 (FFS: details).     - Note: Whether the DMRS port combination allows to use single symbol DMRS for rank = 5,6,7,8 should be checked.   + FFS: For partial coherent UL codebook, support layers to DMRS port mapping that layers associated to the same antenna port group are multiplexed into the same DMRS CDM group.   + FFS: One or more than one DMRS port combination(s) for each rank and TPMI   + Note: New DMRS port combinations above does not preclude the new antenna ports tables including the current DMRS port combination(s) for PDSCH for rank = 5,6,7,8 in Rel.15-17.   + FFS: Whether the antenna ports combinations for rank = 5,6,7,8 can be indicated by the reserved entries of existing antenna ports tables for rank =1,2,3,4, if the rank is indicated together with DMRS antenna ports.   Agreement   * For full-coherent PUSCH with rank 5-8, UE shall expect only one port PTRS to be configured. * Down select from the following in RAN1#112:   + Alt.1: the size of PTRS-DMRS association field is 2bit in DCI format 0\_1/0\_2.     - FFS: Association with the CW with the higher MCS.   **Table 7.3.1.1.2-25B: PTRS-DMRS association for UL PTRS port 0**   |  |  | | --- | --- | | **Value** | **DMRS port** | | 0 | 1st scheduled DMRS port with the CW with the higher MCS | | 1 | 2nd scheduled DMRS port the CW with the higher MCS | | 2 | 3rd scheduled DMRS port the CW with the higher MCS | | 3 | 4th scheduled DMRS port the CW with the higher MCS |  * + - * Alt.2: The size of PTRS-DMRS association field is 3bit in DCI format 0\_1/0\_2, and the following PTRS-DMRS association for UL PTRS port 0 is specified in TS38.212.   **Table 7.3.1.1.2-25B: PTRS-DMRS association for UL PTRS port 0**   |  |  | | --- | --- | | **Value** | **DMRS port** | | 0 | 1st scheduled DMRS port | | 1 | 2nd scheduled DMRS port | | 2 | 3rd scheduled DMRS port | | 3 | 4th scheduled DMRS port | | 4 | 5th scheduled DMRS port | | 5 | 6th scheduled DMRS port | | 6 | 7th scheduled DMRS port | | 7 | 8th scheduled DMRS port | |

## **RAN1#112 agreements:**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **For increasing orthogonal DMRS ports**  Agreement   * For RAN1#111 agreement of the antenna ports indication in Rel.18 eType1 DMRS ports with maxLength = 1 for PDSCH, at least for S-TRP case, support at least support the following rows:   + For 1 CW,     - 1) Row 0-2, 12-14, 24-25 (rows with Number of DMRS CDM group(s) without data = 1)   Agreement  For RAN1#111 agreement of the antenna ports indication in Rel.18 eType1 DMRS ports with maxLength = 1 for PDSCH, at least for S-TRP case, at least support the following rows:   * For 1 CW,   + 2) Row 9-11     - For the above rows, introduce MU-MIMO restriction (i.e. UE does not expect to be multiplexed with other DMRS ports in the same CDM group).   Working Assumption  For RAN1#111 agreement of the antenna ports indication in Rel.18 eType1 DMRS ports with maxLength = 1 for PDSCH, at least for S-TRP case, for 2 CWs,   * + - * Alt.3-1: Support at least row 0-3 for 2 CWs in Table 4-0.   Table 4-0: DMRS ports for 2CWs.   |  |  |  | | --- | --- | --- | | **Two Codewords:**  **Codeword 0 enabled,**  **Codeword 1 enabled** | | | | **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | | 0 | 2 | 0,1,2,3,8 | | 1 | 2 | 0,1,2,3,8,10 | | 2 | 2 | 0,1,2,3,8,9,10 | | 3 | 2 | 0,1,2,3,8,9,10,11 |   Agreement  For the antenna ports indication in Rel.18 eType1 DMRS ports with maxLength = 1 for PDSCH for S-DCI based M-TRP, support at least the following row(s):   * For one CW, support at least row 30 in the following table.   + For the above row, introduce MU-MIMO restriction (i.e. UE does not expect to be multiplexed with other DMRS ports in the same CDM group). * FFS: other rows are not precluded   Table 7.3.1.2.2-1A-X: Antenna port(s) (1000 + DMRS port), dmrs-Type=eType1, maxLength=1   |  |  |  | | --- | --- | --- | | **One Codeword:**  **Codeword 0 enabled,**  **Codeword 1 disabled** | | | | **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | | … | … | … | | 30 | 2 | 0,2,3 |   Agreement  For Rel.18 eType1/eType2 DMRS ports for PDSCH/PUSCH, support Alt.1 for PTRS RE mapping.   * + Alt 1: Different RE offsets set for different Rel.18 DMRS port indexes as shown in Table 4   Table 4 Different RE offsets set for different Rel.18 DMRS port indexes   |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | | **DM-RS antenna port *p***  **(*p* for PUSCH,**  ***p*+1000for PDSCH)** |  | | | | | | | | | **DM-RS Configuration type 1** | | | | **DM-RS Configuration type 2** | | | | | **resourceElementOffset** | | | | **resourceElementOffset** | | | | | offset00 | offset01 | offset10 | offset11 | offset00 | offset01 | offset10 | offset11 | | **0** | 0 | 2 | 6 | 8 | 0 | 1 | 6 | 7 | | **1** | 2 | 4 | 8 | 10 | 1 | 6 | 7 | 0 | | **2** | 1 | 3 | 7 | 9 | 2 | 3 | 8 | 9 | | **3** | 3 | 5 | 9 | 11 | 3 | 8 | 9 | 2 | | **4** | - | - | - | - | 4 | 5 | 10 | 11 | | **5** | - | - | - | - | 5 | 10 | 11 | 4 | | **8** | 4 | 6 | 10 | 0 | - | - | - | - | | **9** | 6 | 8 | 0 | 2 | - | - | - | - | | **10** | 5 | 7 | 11 | 1 | - | - | - | - | | **11** | 7 | 9 | 1 | 3 | - | - | - | - | | **12** | - | - | - | - | 6 | 7 | 0 | 1 | | **13** | - | - | - | - | 7 | 0 | 1 | 6 | | **14** | - | - | - | - | 8 | 9 | 2 | 3 | | **15** | - | - | - | - | 9 | 2 | 3 | 8 | | **16** | - | - | - | - | 10 | 11 | 4 | 5 | | **17** | - | - | - | - | 11 | 4 | 5 | 10 |   **For 8 Tx UL SU-MIMO**  Working assumption   * To support PUSCH with rank = 5-8, support the following for enhancement of DMRS port allocation tables.   + Option 1: Separate DMRS ports tables for rank 5,6,7,8 for each of eType1/eType2 and maxLength=1/2 (similar to the current UL DMRS ports table).     - FFS: whether/how to reuse the reserved field in antenna ports field for other purposes can be discussed in AI9.1.4.2 [or AI9.1.3.1].   Agreement   * For the antenna ports indication in Rel.18 eType1 DMRS ports with maxLength = 1 for PUSCH, following Table 7.3.1.1.2-8-X, Table 7.3.1.1.2-9-X, Table 7.3.1.1.2-10-X, and Table 7.3.1.1.2-11-X are supported.   + FFS: Whether to increase the size of antenna ports field in DCI format 0\_1/0\_2 or not.   + ~~Note: Antenna ports tables for Rel.18 eType2 DMRS ports with maxLength = 1/2 and eType1 DMRS ports with maxLength = 2 for PUSCH are to be discussed separately.~~   Table 7.3.1.1.2-8-X: Antenna port(s), transform precoder is disabled, *dmrs-Type*=eType1, *maxLength*=1, rank = 1   |  |  |  | | --- | --- | --- | | **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | | 0 | 1 | 0 | | 1 | 1 | 1 | | 2 | 2 | 0 | | 3 | 2 | 1 | | 4 | 2 | 2 | | 5 | 2 | 3 | | 6 | 1 | 8 | | 7 | 1 | 9 | | 8 | 2 | 8 | | 9 | 2 | 9 | | 10 | 2 | 10 | | 11 | 2 | 11 | | 12-15 | Reserved | Reserved |   Table 7.3.1.1.2-9-X: Antenna port(s), transform precoder is disabled, *dmrs-Type*= eType1, *maxLength*=1, rank = 2   |  |  |  | | --- | --- | --- | | **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | | 0 | 1 | 0,1 | | 1 | 2 | 0,1 | | 2 | 2 | 2,3 | | 3 | 2 | 0,2 | | 4 | 1 | 8,9 | | 5 | 2 | 8,9 | | 6 | 2 | 10,11 | | [7] | [2] | [8,10] | | 8-15 | Reserved | Reserved |   Table 7.3.1.1.2-10-X: Antenna port(s), transform precoder is disabled, *dmrs-Type*= eType1, *maxLength*=1, rank = 3   |  |  |  | | --- | --- | --- | | **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | | 0 | 2 | 0-2 | | [1] | [2] | [8-10] | | 2 | 1 | 0,1,8 | | 3 | 2 | 0,1,8 | | 4 | 2 | 2,3,10 | | 5-15 | Reserved | Reserved |   **Table 7.3.1.1.2-11-X: Antenna port(s), transform precoder is disabled, *dmrs-Type*= eType1, *maxLength*=1, rank = 4**   |  |  |  | | --- | --- | --- | | **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | | 0 | 2 | 0-3 | | [1] | [2] | [8-11] | | 2 | 1 | 0,1,8,9 | | 3 | 2 | 0,1,8,9 | | 4 | 2 | 2,3,10,11 | | 5-15 | Reserved | Reserved |   Agreement   * For full-coherent PUSCH with rank 5-8 with one port PTRS, support Alt.1 in the RAN1#111 agreement with the following update   + Alt.1: the size of PTRS-DMRS association field is 2bit in DCI format 0\_1/0\_2.     - ~~FFS: Association with~~ The CW with the higher MCS is selected in case of two CWs.     - If the MCS is the same for two CWs, the PTRS port is associated with the first CW.   **Table 7.3.1.1.2-25~~B~~: PTRS-DMRS association for UL PTRS port 0**   |  |  | | --- | --- | | **Value** | **DMRS port** | | 0 | 1st scheduled DMRS port with the CW ~~with the higher MCS~~ | | 1 | 2nd scheduled DMRS port the CW ~~with the higher MCS~~ | | 2 | 3rd scheduled DMRS port the CW ~~with the higher MCS~~ | | 3 | 4th scheduled DMRS port the CW ~~with the higher MCS~~ | |