**3GPP TSG RAN WG1 #112bis-e R1-2303884**

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

**Source: Moderator (NTT DOCOMO)**

**Title: FL summary on DMRS#1**

**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]:

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| 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**
  + **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 {0,1,2,3} only, or values {4,5,6,7} only, or values {0,1,2,3,4,5,6,7}.**

**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 |

**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.**

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 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. |
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### 2.1.2 eType1, maxLength2

Next step is to make an agreement of DMRS port table for eType1, maxLength2.

Based on the agreements of eType1 maxLength1, we can observe the following principle.

* All rows of Cat.1 (Rel.15 legacy ports) are agreed.
  + Rows of rank 3-4 in Cat.1 (Rel.15 legacy ports) have MU-MIMO restriction.
  + Rows of rank 3-4 in Cat.2 (Rel.18 new ports) are with [ ] (probably, these rows are not supported).
* All rows of Number of DMRS CDM group(s) without data = 1 are agreed.

Hopefully, we can follow this principle to eType1, maxLength2.

The following table is the same table as sect. 2.1.2 in FL summary#2 in RAN1#112 (R1-2301775), and [ ] of some rows are removed based on the above principle.

* For the blue highlighted rows (rows with Number of DMRS CDM group(s) without data = 1), the benefit is for dynamic switching between MU-MIMO and SU-MIMO.
* For the yellow highlighted rows (rank 3-4 in Cat.1-2), row 9-10 is beneficial for sDCI mTRP. Row 26-30 and row 57-60 are useful to be multiplexed between two UEs with rank 3-4 for double symbol DMRS.
* Cat.3 is useful for lower DMRS overhead.

In RAN1#112, multiple companies commented that the max number of rows should not exceed 64, so that the DCI size is increased up to 1-bit. By removing row 40-42 and 61, the total number of rows are 64 now. Let’s try whether the following proposal can be agreed.

For 2CWs, it is pointed out that row 4-7 and row 8-11 are equivalent from DMRS overhead perspective. Hence, I add [] to row 8-11. Considering 2 CWs for eType1 maxLength1 is working assumption, row 4-7 for 2 CW is proposal for working assumption.

**At least for S-TRP case**

**FL Proposal 2.1.2A**

* **For the antenna ports indication in Rel.18 eType1** **DMRS ports with *maxLength* = 2 for PDSCH, at least for S-TRP case, support all rows of DMRS port combinations and Number of DMRS CDM group(s) without data in Table 7.3.1.2.2-2-X.**
  + **For row 9-11 in one CW, introduce MU-MIMO restriction (i.e. UE does not expect to be multiplexed with other DMRS ports in the same CDM group).**
  + **Note: Row 4-7 for 2 CWs is proposal for working assumption.**

**Table 7.3.1.2.2-2-X: Antenna port(s) (1000 + DMRS port), *dmrs-Type*=eType1, *maxLength*=2**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **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)** | **Number of front-load symbols** | **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | **Number of front-load symbols** |
| 0 | 1 | 0 | 1 | 0 | 2 | 0-4 | 2 |
| 1 | 1 | 1 | 1 | 1 | 2 | 0,1,2,3,4,6 | 2 |
| 2 | 1 | 0,1 | 1 | 2 | 2 | 0,1,2,3,4,5,6 | 2 |
| 3 | 2 | 0 | 1 | 3 | 2 | 0,1,2,3,4,5,6,7 | 2 |
| 4 | 2 | 1 | 1 | 4 | 2 | 0,1,2,3,8 | 1 |
| 5 | 2 | 2 | 1 | 5 | 2 | 0,1,2,3,8,10 | 1 |
| 6 | 2 | 3 | 1 | 6 | 2 | 0,1,2,3,8,9,10 | 1 |
| 7 | 2 | 0,1 | 1 | 7 | 2 | 0,1,2,3,8,9,10,11 | 1 |
| 8 | 2 | 2,3 | 1 | [8 | 1 | 0,1,4,5,8 | 2] |
| 9 | 2 | 0-2 | 1 | [9 | 1 | 0,1,4,5,8,12 | 2] |
| 10 | 2 | 0-3 | 1 | [10 | 1 | 0,1,4,5,8,9,12 | 2] |
| 11 | 2 | 0,2 | 1 | [11 | 1 | 0,1,4,5,8,9,12,13 | 2] |
| 12 | 2 | 0 | 2 | 12 | 2 | 0,1,4,5,8 | 2 |
| 13 | 2 | 1 | 2 | 13 | 2 | 0,1,4,5,8,12 | 2 |
| 14 | 2 | 2 | 2 | 14 | 2 | 0,1,4,5,8,9,12 | 2 |
| 15 | 2 | 3 | 2 | 15 | 2 | 0,1,4,5,8,9,12,13 | 2 |
| 16 | 2 | 4 | 2 | 16 | 2 | 2,3,6,7,10 | 2 |
| 17 | 2 | 5 | 2 | 17 | 2 | 2,3,6,7,10,14 | 2 |
| 18 | 2 | 6 | 2 | 18 | 2 | 2,3,6,7,10,11,14 | 2 |
| 19 | 2 | 7 | 2 | 19 | 2 | 2,3,6,7,10,11,14,15 | 2 |
| 20 | 2 | 0,1 | 2 |  |  |  |  |
| 21 | 2 | 2,3 | 2 |  |  |  |  |
| 22 | 2 | 4,5 | 2 |  |  |  |  |
| 23 | 2 | 6,7 | 2 |  |  |  |  |
| 24 | 2 | 0,4 | 2 |  |  |  |  |
| 25 | 2 | 2,6 | 2 |  |  |  |  |
| 26 | 2 | 0,1,4 | 2 |  |  |  |  |
| 27 | 2 | 2,3,6 | 2 |  |  |  |  |
| 28 | 2 | 0,1,4,5 | 2 |  |  |  |  |
| 29 | 2 | 2,3,6,7 | 2 |  |  |  |  |
| 30 | 2 | 0,2,4,6 | 2 |  |  |  |  |
| 31 | 1 | 8 | 1 |  |  |  |  |
| 32 | 1 | 9 | 1 |  |  |  |  |
| 33 | 1 | 8,9 | 1 |  |  |  |  |
| 34 | 2 | 8 | 1 |  |  |  |  |
| 35 | 2 | 9 | 1 |  |  |  |  |
| 36 | 2 | 10 | 1 |  |  |  |  |
| 37 | 2 | 11 | 1 |  |  |  |  |
| 38 | 2 | 8,9 | 1 |  |  |  |  |
| 39 | 2 | 10,11 | 1 |  |  |  |  |
| ~~[40~~ | ~~2~~ | ~~8-10~~ | ~~1]~~ |  |  |  |  |
| ~~[41~~ | ~~2~~ | ~~8-11~~ | ~~1]~~ |  |  |  |  |
| ~~[42~~ | ~~2~~ | ~~8,10~~ | ~~1]~~ |  |  |  |  |
| 43 | 2 | 8 | 2 |  |  |  |  |
| 44 | 2 | 9 | 2 |  |  |  |  |
| 45 | 2 | 10 | 2 |  |  |  |  |
| 46 | 2 | 11 | 2 |  |  |  |  |
| 47 | 2 | 12 | 2 |  |  |  |  |
| 48 | 2 | 13 | 2 |  |  |  |  |
| 49 | 2 | 14 | 2 |  |  |  |  |
| 50 | 2 | 15 | 2 |  |  |  |  |
| 51 | 2 | 8,9 | 2 |  |  |  |  |
| 52 | 2 | 10,11 | 2 |  |  |  |  |
| 53 | 2 | 12,13 | 2 |  |  |  |  |
| 54 | 2 | 14,15 | 2 |  |  |  |  |
| 55 | 2 | 8,12 | 2 |  |  |  |  |
| 56 | 2 | 10,14 | 2 |  |  |  |  |
| 57 | 2 | 8,9,12 | 2 |  |  |  |  |
| 58 | 2 | 10,11,14 | 2 |  |  |  |  |
| 59 | 2 | 8,9,12,13 | 2 |  |  |  |  |
| 60 | 2 | 10,11,14,15 | 2 |  |  |  |  |
| ~~61~~ | ~~2~~ | ~~8,10,12,14~~ | ~~2~~ |  |  |  |  |
| 62 | 1 | 0,1,8 | 1 |  |  |  |  |
| 63 | 1 | 0,1,8,9 | 1 |  |  |  |  |
| 64 | 2 | 0,1,8 | 1 |  |  |  |  |
| 65 | 2 | 0,1,8,9 | 1 |  |  |  |  |
| 66 | 2 | 2,3,10 | 1 |  |  |  |  |
| 67 | 2 | 2,3,10,11 | 1 |  |  |  |  |

FL note: there is additional proposal to add the following rows for 1CW (Cat.3 with 2 symbols). MU capacity of supporting row 26-30 and row 57-60 are the same as supporting row 73-80. However, it seems row 73-80 seems to have lower UE complexity, because different CDM group is used for different UE for MU multiplexing.

|  |  |  |  |
| --- | --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | **Number of front-load symbols** |
| 69 | 1 | 0,1,8 | 2 |
| 70 | 1 | 0,1,8,9 | 2 |
| 71 | 1 | 4,5,12 | 2 |
| 72 | 1 | 4,5,12,13 | 2 |
| 73 | 2 | 0,1,8 | 2 |
| 74 | 2 | 0,1,8,9 | 2 |
| 75 | 2 | 4,5,12 | 2 |
| 76 | 2 | 4,5,12,13 | 2 |
| 77 | 2 | 2,3,10 | 2 |
| 78 | 2 | 2,3,10,11 | 2 |
| 79 | 2 | 6,7,14 | 2 |
| 80 | 2 | 6,7,14,15 | 2 |

**For M-TRP case**

**FL Proposal 2.1.2B**

* **For the antenna ports indication in Rel.18 eType1** **DMRS ports with *maxLength* = 2 for PDSCH, for S-DCI based M-TRP case, support all the following rows of DMRS port combinations and Number of DMRS CDM group(s) without data.**
  + **All rows for Rel.18 eType1 DMRS ports with *maxLength* = 2 for PDSCH for S-TRP.**
  + **For one CW, add new row 68 in Table 7.3.1.2.2-2A-X.**

**Table 7.3.1.2.2-2A-X: Antenna port(s) (1000 + DMRS port), *dmrs-Type*=eType1, *maxLength*=2**

|  |  |  |  |
| --- | --- | --- | --- |
| **One Codeword:**  **Codeword 0 enabled,**  **Codeword 1 disabled** | | | |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | **Number of front-load symbols** |
| … | … | … | … |
| 68 | 2 | 0,2,3 | 1 |

Please provide your views.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Docomo | Proposal 2.1.2A: Support.  Proposal 2.1.2B: Support. But, the total number of rows is 65 for sDCI mTRP, and at least one row can be removed in case of sDCI mTRP to keep 64 rows. For example, some rows of Cat.3 may not be useful for CDM based sDCI mTRP. However, Cat.3 is useful for TDM/FDM/SFN based sDCI mTRP operation. We believe row 30 is not useful for sDCI mTRP, and suggest to remove row 30 for sDCI mTRP to keep 64 rows. |
| Google | 2.1.2A: Support  2.1.2B: Support |
| OPPO | For proposal 2.1.2A:  1. we think Row 8-11 are not needed, which have similar overhead and performance as Row 4-7.  2. Considering a UE with two CWs is not likely to be scheduled with MU-MIMO, the use case of Row 12-19 for two CWs is also unclear to us.  3. For S-DCI based M-TRP, the number of rows would exceed 64 and would increase one more bit. It is proposed to remove row 55 and 56 to avoid the overhead. Row 55-56 is equivalent to Row 24-25, and cannot provide any additional use case.  Proposal 2.1.2B: Support. |
| Nokia/NSB | **Proposal 2.1.2A:** We don’t support for increasing DCI size by 2bits, so the additional rows should be minimized.   * Row 9,10, 30: Do not support * 2CWs, we don’t see need for the row 0-3 (2 symbol). Does this for dynamic switching of FD-OCC2 and FD-OCC4? 0-3 need double overhead. So, we propose to use the same table as “maxLength=1” for two CWs.   **Proposal 2.1.2B:** Support the proposal. |
| CATT | Proposal 2.1.2A: Support the proposal without FL note. Cat.3 port combinations with 2 symbols will increase the overhead of antenna port(s) field.  Proposal 2.1.2B: Support. |
| Huawei, HiSilicon | **FL Proposal 2.1.2A:** Generally fine. Some rows need to be deleted or discussed.   1. Remove row 55&56. The benefit of row 24 and 25 is that only TD-OCC dispreading is adopted during channel estimation, which means other co-scheduled DMRS ports with different FD-OCC are not expected to be within the same CDM group. Following this principle, entry 55 and 56 are useless. 2. Row 57~60 should be further discussed to facilitate more layer combinations. 3. For 2CW, at least row 8~11 is also needed to facilitate supporting rank>4 with only 1 symbol, which can improve the efficiency of resource utilization and scheduling flexibility.   **FL Proposal 2.1.2B:** Support. |
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### 2.1.3 eType2, maxLength1

For eType2 maxLength1, the following principle of eType1 maxLength1 can be reused.

* All rows of Cat.1 (Rel.15 legacy ports) are agreed.
* All rows of Number of DMRS CDM group(s) without data = 1 are agreed.

For MU-MIMO restriction of Type2 in Rel.15, only row 23 has MU-MIMO restriction in Rel.15. If we follow this MU-MIMO restriction, there is no point to support row 47 (12,14). Hence, FL suggestion is to remove the row 47.

For row 33-34 and row 44-46 (i.e. rank 3-4 in Cat.2), it has no use-case because Cat.3 is better in terms of DMRS overhead and MU multiplexing. Hence, these rows can be removed (For now, these rows are with [ ] in the table).

**At least for S-TRP case**

**FL Proposal 2.1.3A**

* **For the antenna ports indication in Rel.18 eType2** **DMRS ports with *maxLength* = 1 for PDSCH, at least for S-TRP case, support all rows of DMRS port combinations and Number of DMRS CDM group(s) without data in Table 7.3.1.2.2-3-X.**
  + **For row 23 in one CW, introduce MU-MIMO restriction (i.e. UE does not expect to be multiplexed with other DMRS ports in the same CDM group).**
  + **Note: Row 4-11 for 2 CWs is proposal for working assumption.**

Table 7.3.1.2.2-3-X: Antenna port(s) (1000 + DMRS port), dmrs-Type=eType2, 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)** | **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** |
| 0 | 1 | 0 | 0 | 3 | 0-4 |
| 1 | 1 | 1 | 1 | 3 | 0-5 |
| 2 | 1 | 0,1 | 2 | 3 | 12-16 |
| 3 | 2 | 0 | 3 | 3 | 12-17 |
| 4 | 2 | 1 | 4 | 2 | 0,1,2,3,12 |
| 5 | 2 | 2 | 5 | 2 | 0,1,2,3,12,14 |
| 6 | 2 | 3 | 6 | 2 | 0-3,12-14 |
| 7 | 2 | 0,1 | 7 | 2 | 0-3,12-15 |
| 8 | 2 | 2,3 | 8 | 3 | 0,1,2,3,12 |
| 9 | 2 | 0-2 | 9 | 3 | 0,1,2,3,12,14 |
| 10 | 2 | 0-3 | 10 | 3 | 0-3,12-14 |
| 11 | 3 | 0 | 11 | 3 | 0-3,12-15 |
| 12 | 3 | 1 |  |  |  |
| 13 | 3 | 2 |  |  |  |
| 14 | 3 | 3 |  |  |  |
| 15 | 3 | 4 |  |  |  |
| 16 | 3 | 5 |  |  |  |
| 17 | 3 | 0,1 |  |  |  |
| 18 | 3 | 2,3 |  |  |  |
| 19 | 3 | 4,5 |  |  |  |
| 20 | 3 | 0-2 |  |  |  |
| 21 | 3 | 3-5 |  |  |  |
| 22 | 3 | 0-3 |  |  |  |
| 23 | 2 | 0,2 |  |  |  |
| 24 | 1 | 12 |  |  |  |
| 25 | 1 | 13 |  |  |  |
| 26 | 1 | 12,13 |  |  |  |
| 27 | 2 | 12 |  |  |  |
| 28 | 2 | 13 |  |  |  |
| 29 | 2 | 14 |  |  |  |
| 30 | 2 | 15 |  |  |  |
| 31 | 2 | 12,13 |  |  |  |
| 32 | 2 | 14,15 |  |  |  |
| [33 | 2 | 12-14] |  |  |  |
| [34 | 2 | 12-15] |  |  |  |
| 35 | 3 | 12 |  |  |  |
| 36 | 3 | 13 |  |  |  |
| 37 | 3 | 14 |  |  |  |
| 38 | 3 | 15 |  |  |  |
| 39 | 3 | 16 |  |  |  |
| 40 | 3 | 17 |  |  |  |
| 41 | 3 | 12,13 |  |  |  |
| 42 | 3 | 14,15 |  |  |  |
| 43 | 3 | 16,17 |  |  |  |
| [44 | 3 | 12-14] |  |  |  |
| [45 | 3 | 15-17] |  |  |  |
| [46 | 3 | 12-15] |  |  |  |
| ~~[47~~ | ~~2~~ | ~~12,14]~~ |  |  |  |
| 48 | 1 | 0,1,12 |  |  |  |
| 49 | 1 | 0,1,12,13 |  |  |  |
| 50 | 2 | 0,1,12 |  |  |  |
| 51 | 2 | 0,1,12,13 |  |  |  |
| 52 | 2 | 2,3,14 |  |  |  |
| 53 | 2 | 2,3,14,15 |  |  |  |
| 54 | 3 | 0,1,12 |  |  |  |
| 55 | 3 | 0,1,12,13 |  |  |  |
| 56 | 3 | 2,3,14 |  |  |  |
| 57 | 3 | 2,3,14,15 |  |  |  |
| 58 | 3 | 4,5,16 |  |  |  |
| 59 | 3 | 4,5,16,17 |  |  |  |

**For M-TRP case**

**FL Proposal 2.1.3B**

* **For the antenna ports indication in Rel.18 eType2** **DMRS ports with *maxLength* = 1 for PDSCH, for S-DCI based M-TRP case, support all the following rows of DMRS port combinations and Number of DMRS CDM group(s) without data.**
  + **All rows for Rel.18 eType2 DMRS ports with *maxLength* = 1 for PDSCH for S-TRP.**
  + **For one CW, add new row 60 in Table 7.3.1.2.2-3A-X.**

**Table 7.3.1.2.2-3A-X: Antenna port(s) (1000 + DMRS port), *dmrs-Type*=eType2, *maxLength*=1**

|  |  |  |
| --- | --- | --- |
| **One Codeword:**  **Codeword 0 enabled,**  **Codeword 1 disabled** | | |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** |
| … | … | … |
| 60 | 2 | 0,2,3 |

Please provide your views.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Docomo | Proposal 2.1.3A: Support.  Proposal 2.1.3B: Support. |
| Google | Proposal 2.1.3A: Support.  Proposal 2.1.3B: Support. |
| OPPO | Proposal 2.1.3A:  1. We agree that Row 33-34,Row 44-47 are not needed.  2. Considering a UE with two CWs is not likely to be scheduled with MU-MIMO, the use case of Row 2-3 and Row 8-11 for two CWs is unclear to us.  Proposal 2.1.3B: Support. |
| Nokia/NSB | Proposal 2.1.3A:   * For 1CW, not support row 9,10,20,21,22, 33,34, 44-46 * For 2CWs,   + Not support row 2,3,8 and 9   + propose to add {0,2,3,12,13} # of CDM group without data=2. We don’t see need for  |  |  |  | | --- | --- | --- | |  | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | |  | 2 | 0,2,3,12,13 |   Proposal 2.1.3B: Support |
| CATT | Proposal 2.1.3A: Support in principle. We slightly prefer to keep rows for SU-MIMO (e.g., row 44-47) if the size of antenna port(s) field is not increased.  Proposal 2.1.3B: Support. |
| Huawei, HiSilicon | **FL Proposal 2.1.3A:**  For 1CW, support.  For 2CW, considering it is used for SU scenario, row 8~11 is not needed.  **FL Proposal 2.1.3B:** Support. |
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### 2.1.4 eType2, maxLength2

For eType2 maxLength2, the following principle of eType1 maxLength1 can be reused.

* All rows of Cat.1 (Rel.15 legacy ports) are agreed.
* All rows of Number of DMRS CDM group(s) without data = 1 are agreed.

For MU-MIMO restriction of Type2 in Rel.15, only row 23 has MU-MIMO restriction in Rel.15. If we follow this MU-MIMO restriction, there is no point to support row 81 (12,14). Hence, FL suggestion is to remove the row 81.

For row 67-68 and row 78-80 (i.e. rank 3-4 in Cat.2), it has no use-case because Cat.3 is better in terms of DMRS overhead and MU multiplexing. Hence, these rows can be removed (For now, these rows are with [ ] in the table).

**At least for S-TRP case**

**FL Proposal 2.1.4A**

* **For the antenna ports indication in Rel.18 eType2** **DMRS ports with *maxLength* = 2 for PDSCH, at least for S-TRP case, support all rows of DMRS port combinations and Number of DMRS CDM group(s) without data in Table 7.3.1.2.2-4-X.**
  + **For row 23 in one CW, introduce MU-MIMO restriction (i.e. UE does not expect to be multiplexed with other DMRS ports in the same CDM group).**
  + **Note: Row 6-13 for 2 CWs is proposal for working assumption.**

Table 7.3.1.2.2-4-X: Antenna port(s) (1000 + DMRS port), dmrs-Type=eType2, maxLength=2

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **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)** | **Number of front-load symbols** | **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | **Number of front-load symbols** |
| 0 | 1 | 0 | 1 | 0 | 3 | 0-4 | 1 |
| 1 | 1 | 1 | 1 | 1 | 3 | 0-5 | 1 |
| 2 | 1 | 0,1 | 1 | 2 | 2 | 0,1,2,3,6 | 2 |
| 3 | 2 | 0 | 1 | 3 | 2 | 0,1,2,3,6,8 | 2 |
| 4 | 2 | 1 | 1 | 4 | 2 | 0,1,2,3,6,7,8 | 2 |
| 5 | 2 | 2 | 1 | 5 | 2 | 0,1,2,3,6,7,8,9 | 2 |
| 6 | 2 | 3 | 1 | 6 | 2 | 0,1,2,3,12 | 1 |
| 7 | 2 | 0,1 | 1 | 7 | 2 | 0-3,12,14 | 1 |
| 8 | 2 | 2,3 | 1 | 8 | 2 | 0-3,12-14 | 1 |
| 9 | 2 | 0-2 | 1 | 9 | 2 | 0-3,12-15 | 1 |
| 10 | 2 | 0-3 | 1 | 10 | 3 | 0,1,2,3,12 | 1 |
| 11 | 3 | 0 | 1 | 11 | 3 | 0-3,12,14 | 1 |
| 12 | 3 | 1 | 1 | 12 | 3 | 0-3,12-14 | 1 |
| 13 | 3 | 2 | 1 | 13 | 3 | 0-3,12-15 | 1 |
| 14 | 3 | 3 | 1 | 14 | 1 | 0,1,6,7,12 | 2 |
| 15 | 3 | 4 | 1 | 15 | 1 | 0,1,6,7,12,18 | 2 |
| 16 | 3 | 5 | 1 | 16 | 1 | 0,1,6,7,12,13,18 | 2 |
| 17 | 3 | 0,1 | 1 | 17 | 1 | 0,1,6,7,12,13,18,19 | 2 |
| 18 | 3 | 2,3 | 1 | 18 | 2 | 0,1,6,7,12 | 2 |
| 19 | 3 | 4,5 | 1 | 19 | 2 | 0,1,6,7,12,18 | 2 |
| 20 | 3 | 0-2 | 1 | 20 | 2 | 0,1,6,7,12,13,18 | 2 |
| 21 | 3 | 3-5 | 1 | 21 | 2 | 0,1,6,7,12,13,18,19 | 2 |
| 22 | 3 | 0-3 | 1 | 22 | 2 | 2,3,8,9,14 | 2 |
| 23 | 2 | 0,2 | 1 | 23 | 2 | 2,3,8,9,14,20 | 2 |
| 24 | 3 | 0 | 2 | 24 | 2 | 2,3,8,9,14,15,20 | 2 |
| 25 | 3 | 1 | 2 | 25 | 2 | 2,3,8,9,14,15,20,21 | 2 |
| 26 | 3 | 2 | 2 | 26 | 3 | 0,1,6,7,12 | 2 |
| 27 | 3 | 3 | 2 | 27 | 3 | 0,1,6,7,12,18 | 2 |
| 28 | 3 | 4 | 2 | 28 | 3 | 0,1,6,7,12,13,18 | 2 |
| 29 | 3 | 5 | 2 | 29 | 3 | 0,1,6,7,12,13,18,19 | 2 |
| 30 | 3 | 6 | 2 | 30 | 3 | 2,3,8,9,14 | 2 |
| 31 | 3 | 7 | 2 | 31 | 3 | 2,3,8,9,14,20 | 2 |
| 32 | 3 | 8 | 2 | 32 | 3 | 2,3,8,9,14,15,20 | 2 |
| 33 | 3 | 9 | 2 | 33 | 3 | 2,3,8,9,14,15,20,21 | 2 |
| 34 | 3 | 10 | 2 | 34 | 3 | 4,5,10,11,16 | 2 |
| 35 | 3 | 11 | 2 | 35 | 3 | 4,5,10,11,16,22 | 2 |
| 36 | 3 | 0,1 | 2 | 36 | 3 | 4,5,10,11,16,17,22 | 2 |
| 37 | 3 | 2,3 | 2 | 37 | 3 | 4,5,10,11,16,17,22,23 | 2 |
| 38 | 3 | 4,5 | 2 |  |  |  |  |
| 39 | 3 | 6,7 | 2 |  |  |  |  |
| 40 | 3 | 8,9 | 2 |  |  |  |  |
| 41 | 3 | 10,11 | 2 |  |  |  |  |
| 42 | 3 | 0,1,6 | 2 |  |  |  |  |
| 43 | 3 | 2,3,8 | 2 |  |  |  |  |
| 44 | 3 | 4,5,10 | 2 |  |  |  |  |
| 45 | 3 | 0,1,6,7 | 2 |  |  |  |  |
| 46 | 3 | 2,3,8,9 | 2 |  |  |  |  |
| 47 | 3 | 4,5,10,11 | 2 |  |  |  |  |
| 48 | 1 | 0 | 2 |  |  |  |  |
| 49 | 1 | 1 | 2 |  |  |  |  |
| 50 | 1 | 6 | 2 |  |  |  |  |
| 51 | 1 | 7 | 2 |  |  |  |  |
| 52 | 1 | 0,1 | 2 |  |  |  |  |
| 53 | 1 | 6,7 | 2 |  |  |  |  |
| 54 | 2 | 0,1 | 2 |  |  |  |  |
| 55 | 2 | 2,3 | 2 |  |  |  |  |
| 56 | 2 | 6,7 | 2 |  |  |  |  |
| 57 | 2 | 8,9 | 2 |  |  |  |  |
| 58 | 1 | 12 | 1 |  |  |  |  |
| 59 | 1 | 13 | 1 |  |  |  |  |
| 60 | 1 | 12,13 | 1 |  |  |  |  |
| 61 | 2 | 12 | 1 |  |  |  |  |
| 62 | 2 | 13 | 1 |  |  |  |  |
| 63 | 2 | 14 | 1 |  |  |  |  |
| 64 | 2 | 15 | 1 |  |  |  |  |
| 65 | 2 | 12,13 | 1 |  |  |  |  |
| 66 | 2 | 14,15 | 1 |  |  |  |  |
| [67 | 2 | 12-14 | 1] |  |  |  |  |
| [68 | 2 | 12-15 | 1] |  |  |  |  |
| 69 | 3 | 12 | 1 |  |  |  |  |
| 70 | 3 | 13 | 1 |  |  |  |  |
| 71 | 3 | 14 | 1 |  |  |  |  |
| 72 | 3 | 15 | 1 |  |  |  |  |
| 73 | 3 | 16 | 1 |  |  |  |  |
| 74 | 3 | 17 | 1 |  |  |  |  |
| 75 | 3 | 12,13 | 1 |  |  |  |  |
| 76 | 3 | 14,15 | 1 |  |  |  |  |
| 77 | 3 | 16,17 | 1 |  |  |  |  |
| [78 | 3 | 12-14 | 1] |  |  |  |  |
| [79 | 3 | 15-17 | 1] |  |  |  |  |
| [80 | 3 | 12-15 | 1] |  |  |  |  |
| ~~[81~~ | ~~2~~ | ~~12,14~~ | ~~1]~~ |  |  |  |  |
| 82 | 3 | 12 | 2 |  |  |  |  |
| 83 | 3 | 13 | 2 |  |  |  |  |
| 84 | 3 | 14 | 2 |  |  |  |  |
| 85 | 3 | 15 | 2 |  |  |  |  |
| 86 | 3 | 16 | 2 |  |  |  |  |
| 87 | 3 | 17 | 2 |  |  |  |  |
| 88 | 3 | 18 | 2 |  |  |  |  |
| 89 | 3 | 19 | 2 |  |  |  |  |
| 90 | 3 | 20 | 2 |  |  |  |  |
| 91 | 3 | 21 | 2 |  |  |  |  |
| 92 | 3 | 22 | 2 |  |  |  |  |
| 93 | 3 | 24 | 2 |  |  |  |  |
| 94 | 3 | 12,13 | 2 |  |  |  |  |
| 95 | 3 | 14,15 | 2 |  |  |  |  |
| 96 | 3 | 16,17 | 2 |  |  |  |  |
| 97 | 3 | 18,19 | 2 |  |  |  |  |
| 98 | 3 | 20,21 | 2 |  |  |  |  |
| 99 | 3 | 22,23 | 2 |  |  |  |  |
| 100 | 3 | 12,13,18 | 2 |  |  |  |  |
| 101 | 3 | 14,15,20 | 2 |  |  |  |  |
| 102 | 3 | 16,17,22 | 2 |  |  |  |  |
| 103 | 3 | 12,13,18,19 | 2 |  |  |  |  |
| 104 | 3 | 14,15,20,21 | 2 |  |  |  |  |
| 105 | 3 | 16,17,22,23 | 2 |  |  |  |  |
| 106 | 1 | 12 | 2 |  |  |  |  |
| 107 | 1 | 13 | 2 |  |  |  |  |
| 108 | 1 | 18 | 2 |  |  |  |  |
| 109 | 1 | 19 | 2 |  |  |  |  |
| 110 | 1 | 12,13 | 2 |  |  |  |  |
| 111 | 1 | 18,19 | 2 |  |  |  |  |
| 112 | 2 | 12,13 | 2 |  |  |  |  |
| 113 | 2 | 14,15 | 2 |  |  |  |  |
| 114 | 2 | 18,19 | 2 |  |  |  |  |
| 115 | 2 | 20,21 | 2 |  |  |  |  |
| 116 | 1 | 0,1,12 | 1 |  |  |  |  |
| 117 | 1 | 0,1,12,13 | 1 |  |  |  |  |
| 118 | 2 | 0,1,12 | 1 |  |  |  |  |
| 119 | 2 | 0,1,12,13 | 1 |  |  |  |  |
| 120 | 2 | 2,3,14 | 1 |  |  |  |  |
| 121 | 2 | 2,3,14,15 | 1 |  |  |  |  |
| 122 | 3 | 0,1,12 | 1 |  |  |  |  |
| 123 | 3 | 0,1,12,13 | 1 |  |  |  |  |
| 124 | 3 | 2,3,14 | 1 |  |  |  |  |
| 125 | 3 | 2,3,14,15 | 1 |  |  |  |  |
| 126 | 3 | 4,5,16 | 1 |  |  |  |  |
| 127 | 3 | 4,5,16,17 | 1 |  |  |  |  |

FL note: there is additional proposal to add the following rows for 1CW (Cat.3 with 2 symbols). MU capacity of supporting row 42-47 and row 100-105 are the same as supporting row 141-152. However, it seems row 141-152 seems to have lower UE complexity, because different CDM group is used for different UE for MU multiplexing.

|  |  |  |  |
| --- | --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | **Number of front-load symbols** |
| 129 | 1 | 0,1,12 | 2 |
| 130 | 1 | 0,1,12,13 | 2 |
| 131 | 1 | 6,7,18 | 2 |
| 132 | 1 | 6,7,18,19 | 2 |
| 133 | 2 | 0,1,12 | 2 |
| 134 | 2 | 0,1,12,13 | 2 |
| 135 | 2 | 6,7,18 | 2 |
| 136 | 2 | 6,7,18,19 | 2 |
| 137 | 2 | 2,3,14 | 2 |
| 138 | 2 | 2,3,14,15 | 2 |
| 139 | 2 | 8,9,20 | 2 |
| 140 | 2 | 8,9,20,21 | 2 |
| 141 | 3 | 0,1,12 | 2 |
| 142 | 3 | 0,1,12,13 | 2 |
| 143 | 3 | 6,7,18 | 2 |
| 144 | 3 | 6,7,18,19 | 2 |
| 145 | 3 | 2,3,14 | 2 |
| 146 | 3 | 2,3,14,15 | 2 |
| 147 | 3 | 8,9,20 | 2 |
| 148 | 3 | 8,9,20,21 | 2 |
| 149 | 3 | 4,5,16 | 2 |
| 150 | 3 | 4,5,16,17 | 2 |
| 151 | 3 | 10,11,22 | 2 |
| 152 | 3 | 10,11,22,23 | 2 |

**For M-TRP case**

**FL Proposal 2.1.4B**

* **For the antenna ports indication in Rel.18 eType2** **DMRS ports with *maxLength* = 2 for PDSCH, for S-DCI based M-TRP case, support all the following rows of DMRS port combinations and Number of DMRS CDM group(s) without data.**
  + **All rows for Rel.18 eType2 DMRS ports with *maxLength* = 2 for PDSCH for S-TRP.**
  + **For one CW, add new row 128 in Table 7.3.1.2.2-4A-X.**

**Table 7.3.1.2.2-4A-X: Antenna port(s) (1000 + DMRS port), *dmrs-Type*=eType2, *maxLength*=2**

|  |  |  |  |
| --- | --- | --- | --- |
| **One Codeword:**  **Codeword 0 enabled,**  **Codeword 1 disabled** | | | |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | **Number of front-load symbols** |
| … | … | … | … |
| 128 | 2 | 0,2,3 | 1 |

Please provide your views.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Docomo | Proposal 2.1.4A: Support.  Proposal 2.1.4B: Support. |
| Google | Proposal 2.1.4A: Support.  Proposal 2.1.4B: Support. |
| OPPO | Proposal 2.1.4A:  1. Agree that row 67-68 and row 78-80 are not needed.  2. Row 14-17 and Row 6-9 for two CWs have similar overhead and performance (FDM vs. TDM), so we think Row 14-17 are not needed.  3. Considering a UE with two CWs is not likely to be scheduled with MU-MIMO, the use case of Row 18-37 for two CWs is unclear to us.  Proposal 2.1.4B: Support. |
| Nokia/NSB | Proposal 2.1.4A:  1. We need more reduction of the rows. .  2. We support the same table for 2CWs as in “maxLength=1”  Proposal 2.1.4B: Support. (value should be less than 128, for not increasing DCI bit size) |
| CATT | Proposal 2.1.4A: Support in principle. We slightly prefer to keep rows for SU-MIMO (e.g., row 78-81) if the size of antenna port(s) field is not increased. Besides, we suggest to remove FL note, since Cat.3 port combinations with 2 symbols will increase the overhead of antenna port(s) field.  Proposal 2.1.4B: Support. |
| Huawei, HiSilicon | **FL Proposal 2.1.4A:** Generally fine. Some rows need to be discussed.   1. Row 100~105 should be further discussed to facilitate more layer combinations. 2. For 2CW, considering it is used for SU scenario, row 10~13 is not needed. Furthermore, at least row 14~17 is also needed to facilitate supporting rank>4 with only 1 symbol, which can improve the efficiency of resource utilization and scheduling flexibility.   **FL Proposal 2.1.4B:** Support. |
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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 (in RAN1#112)

|  |  |  |
| --- | --- | --- |
|  | **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 |  |
| **Alt.2** | Google, Docomo, Ericsson, ~~OPPO,~~ ZTE, CMCC, Xiaomi, Fraunhofer IIS/HHI (2nd pref.), ~~Nokia/NSB~~, LGE, China Telecom (can live) | QC (UE complexity), OPPO, Nokia/NSB (support only M=0, but not alt 2) |

|  |  |
| --- | --- |
| **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. |
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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 [].

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **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.**

|  |  |
| --- | --- |
| **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. |
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### 2.3.2 eType1, maxLength2 (discuss later)

Based on reviewing tdocs, multiple companies propose to reuse the same DMRS ports combinations of PDSCH to PUSCH with rank 1-4. Following tables captures all DMRS port combinations of PDSCH (including rows with [ ]).

**FL: Since DMRS ports combinations for PDSCH is not decided yet, we will discuss this later.**

Table 7.3.1.1.2-12-X: Antenna port(s), transform precoder is disabled, *dmrs-Type*=eType2, *maxLength*=1, rank = 1

|  |  |  |  |
| --- | --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | **Number of front-load symbols** |
| 0 | 1 | 0 | 1 |
| 1 | 1 | 1 | 1 |
| 2 | 2 | 0 | 1 |
| 3 | 2 | 1 | 1 |
| 4 | 2 | 2 | 1 |
| 5 | 2 | 3 | 1 |
| 6 | 2 | 0 | 2 |
| 7 | 2 | 1 | 2 |
| 8 | 2 | 2 | 2 |
| 9 | 2 | 3 | 2 |
| 10 | 2 | 4 | 2 |
| 11 | 2 | 5 | 2 |
| 12 | 2 | 6 | 2 |
| 13 | 2 | 7 | 2 |
| 14 | 1 | 8 | 1 |
| 15 | 1 | 9 | 1 |
| 16 | 2 | 8 | 1 |
| 17 | 2 | 9 | 1 |
| 18 | 2 | 10 | 1 |
| 19 | 2 | 11 | 1 |
| 20 | 2 | 8 | 2 |
| 21 | 2 | 9 | 2 |
| 22 | 2 | 10 | 2 |
| 23 | 2 | 11 | 2 |
| 24 | 2 | 12 | 2 |
| 25 | 2 | 13 | 2 |
| 26 | 2 | 14 | 2 |
| 27 | 2 | 15 | 2 |
| 28-31 | Reserved | Reserved | Reserved |

Table 7.3.1.1.2-13-X: Antenna port(s), transform precoder is disabled, *dmrs-Type*= eType2, *maxLength*=1, rank = 2

|  |  |  |  |
| --- | --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | **Number of front-load symbols** |
| 0 | 1 | 0,1 | 1 |
| 1 | 2 | 0,1 | 1 |
| 2 | 2 | 2,3 | 1 |
| 3 | 2 | 0,2 | 1 |
| 4 | 2 | 0,1 | 2 |
| 5 | 2 | 2,3 | 2 |
| 6 | 2 | 4,5 | 2 |
| 7 | 2 | 6,7 | 2 |
| 8 | 2 | 0,4 | 2 |
| 9 | 2 | 2,6 | 2 |
| 10 | 1 | 8,9 | 1 |
| 11 | 2 | 8,9 | 1 |
| 12 | 2 | 10,11 | 1 |
| 13 | [2 | 8,10 | 1] |
| 14 | 2 | 8,9 | 2 |
| 15 | 2 | 10,11 | 2 |
| 16 | 2 | 12,13 | 2 |
| 17 | 2 | 14,15 | 2 |
| 18 | 2 | 8,12 | 2 |
| 19 | 2 | 10,14 | 2 |
| 20-31 | Reserved | Reserved | Reserved |

Table 7.3.1.1.2-14-X: Antenna port(s), transform precoder is disabled, *dmrs-Type*= eType2, *maxLength*=1, rank = 3

|  |  |  |  |
| --- | --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | **Number of front-load symbols** |
| 0 | 2 | 0-2 | 1 |
| 1 | 2 | 0,1,4 | 2 |
| 2 | 2 | 2,3,6 | 2 |
| 3 | 2 | 8-10 | 1 |
| 4 | 2 | 8,9,12 | 2 |
| 5 | 2 | 10,11,14 | 2 |
| 6 | 1 | 0,1,8 | 1 |
| 7 | 2 | 0,1,8 | 1 |
| 8 | 2 | 2,3,10 | 1 |
| 9-31 | Reserved | Reserved | Reserved |

Table 7.3.1.1.2-15-X: Antenna port(s), transform precoder is disabled, *dmrs-Type*= eType2, *maxLength*=1, rank = 4

|  |  |  |  |
| --- | --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | **Number of front-load symbols** |
| 0 | 2 | 0-3 | 1 |
| 1 | 2 | 0,1,4,5 | 2 |
| 2 | 2 | 2,3,6,7 | 2 |
| 3 | 2 | 0,2,4,6 | 2] |
| 4 | 2 | 8-11 | 1 |
| 5 | 2 | 8,9,12,13 | 2 |
| 6 | 2 | 10,11,14,15 | 2 |
| 7 | 2 | 8,10,12,14 | 2 |
| 8 | 1 | 0,1,8,9 | 1 |
| 9 | 2 | 0,1,8,9 | 1 |
| 10 | 2 | 2,3,10,11 | 1 |
| 11-31 | Reserved | Reserved | Reserved |

### 2.3.3 eType2, maxLength1 (discuss later)

Based on reviewing tdocs, multiple companies propose to reuse the same DMRS ports combinations of PDSCH to PUSCH with rank 1-4. Following tables captures all DMRS port combinations of PDSCH (including rows with [ ]).

**FL: Since DMRS ports combinations for PDSCH is not decided yet, we will discuss this later.**

Table 7.3.1.1.2-16-X: Antenna port(s), transform precoder is disabled, *dmrs-Type*=eType2, *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 | 3 | 0 |
| 7 | 3 | 1 |
| 8 | 3 | 2 |
| 9 | 3 | 3 |
| 10 | 3 | 4 |
| 11 | 3 | 5 |
| 12 | 1 | 12 |
| 13 | 1 | 13 |
| 14 | 2 | 12 |
| 15 | 2 | 13 |
| 16 | 2 | 14 |
| 17 | 2 | 15 |
| 18 | 3 | 12 |
| 19 | 3 | 13 |
| 20 | 3 | 14 |
| 21 | 3 | 15 |
| 22 | 3 | 16 |
| 23 | 3 | 17 |
| 24-31 | Reserved | Reserved |

Table 7.3.1.1.2-17-X: Antenna port(s), transform precoder is disabled, *dmrs-Type*= eType2, *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 | 3 | 0,1 |
| 4 | 3 | 2,3 |
| 5 | 3 | 4,5 |
| 6 | 2 | 0,2 |
| 7 | 1 | 12,13 |
| 8 | 2 | 12,13 |
| 9 | 2 | 14,15 |
| 10 | 3 | 12,13 |
| 11 | 3 | 14,15 |
| 12 | 3 | 16,17 |
| 13 | ~~2~~ | ~~12,14~~ |
| 14-31 | Reserved | Reserved |

Table 7.3.1.1.2-18-X: Antenna port(s), transform precoder is disabled, *dmrs-Type*= eType2, *maxLength*=1, rank = 3

|  |  |  |
| --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** |
| 0 | 2 | 0-2 |
| 1 | 3 | 0-2 |
| 2 | 3 | 3-5 |
| 3 | [2 | 12-14] |
| 4 | [3 | 12-14] |
| 5 | [3 | 15-17] |
| 6 | 1 | 0,1,12 |
| 7 | 2 | 0,1,12 |
| 8 | 2 | 2,3,14 |
| 9 | 3 | 0,1,12 |
| 10 | 3 | 2,3,14 |
| 11 | 3 | 4,5,16 |
| 12-31 | Reserved | Reserved |

Table 7.3.1.1.2-19-X: Antenna port(s), transform precoder is disabled, *dmrs-Type*= eType2, *maxLength*=1, rank = 4

|  |  |  |
| --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** |
| 0 | 2 | 0-3 |
| 1 | 3 | 0-3 |
| 2 | [2 | 12-15] |
| 3 | [3 | 12-15] |
| 4 | 1 | 0,1,12,13 |
| 5 | 2 | 0,1,12,13 |
| 6 | 2 | 2,3,14,15 |
| 7 | 3 | 0,1,12,13 |
| 8 | 3 | 2,3,14,15 |
| 9 | 3 | 4,5,16,17 |
| 10-31 | Reserved | Reserved |

### 2.3.4 eType2, maxLength2 (discuss later)

Based on reviewing tdocs, multiple companies propose to reuse the same DMRS ports combinations of PDSCH to PUSCH with rank 1-4. Following tables captures all DMRS port combinations of PDSCH (including rows with [ ]).

**FL: Since DMRS ports combinations for PDSCH is not decided yet, we will discuss this later.**

Table 7.3.1.1.2-20-X: Antenna port(s), transform precoder is disabled, *dmrs-Type*=eType2, *maxLength*=2, rank = 1

|  |  |  |  |
| --- | --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | **Number of front-load symbols** |
| 0 | 1 | 0 | 1 |
| 1 | 1 | 1 | 1 |
| 2 | 2 | 0 | 1 |
| 3 | 2 | 1 | 1 |
| 4 | 2 | 2 | 1 |
| 5 | 2 | 3 | 1 |
| 6 | 3 | 0 | 1 |
| 7 | 3 | 1 | 1 |
| 8 | 3 | 2 | 1 |
| 9 | 3 | 3 | 1 |
| 10 | 3 | 4 | 1 |
| 11 | 3 | 5 | 1 |
| 12 | 3 | 0 | 2 |
| 13 | 3 | 1 | 2 |
| 14 | 3 | 2 | 2 |
| 15 | 3 | 3 | 2 |
| 16 | 3 | 4 | 2 |
| 17 | 3 | 5 | 2 |
| 18 | 3 | 6 | 2 |
| 19 | 3 | 7 | 2 |
| 20 | 3 | 8 | 2 |
| 21 | 3 | 9 | 2 |
| 22 | 3 | 10 | 2 |
| 23 | 3 | 11 | 2 |
| 24 | 1 | 0 | 2 |
| 25 | 1 | 1 | 2 |
| 26 | 1 | 6 | 2 |
| 27 | 1 | 7 | 2 |
| 28 | 1 | 12 | 1 |
| 29 | 1 | 13 | 1 |
| 30 | 2 | 12 | 1 |
| 31 | 2 | 13 | 1 |
| 32 | 2 | 14 | 1 |
| 33 | 2 | 15 | 1 |
| 34 | 3 | 12 | 1 |
| 35 | 3 | 13 | 1 |
| 36 | 3 | 14 | 1 |
| 37 | 3 | 15 | 1 |
| 38 | 3 | 16 | 1 |
| 39 | 3 | 17 | 1 |
| 40 | 3 | 12 | 2 |
| 41 | 3 | 13 | 2 |
| 42 | 3 | 14 | 2 |
| 43 | 3 | 15 | 2 |
| 44 | 3 | 16 | 2 |
| 45 | 3 | 17 | 2 |
| 46 | 3 | 18 | 2 |
| 47 | 3 | 19 | 2 |
| 48 | 3 | 20 | 2 |
| 49 | 3 | 21 | 2 |
| 50 | 3 | 22 | 2 |
| 51 | 3 | 24 | 2 |
| 52 | 1 | 12 | 2 |
| 53 | 1 | 13 | 2 |
| 54 | 1 | 18 | 2 |
| 55 | 1 | 19 | 2 |
| 56-63 | Reserved | Reserved | Reserved |

Table 7.3.1.1.2-21-X: Antenna port(s), transform precoder is disabled, *dmrs-Type*= eType2, *maxLength*=2, rank = 2

|  |  |  |  |
| --- | --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | **Number of front-load symbols** |
| 0 | 1 | 0,1 | 1 |
| 1 | 2 | 0,1 | 1 |
| 2 | 2 | 2,3 | 1 |
| 3 | 3 | 0,1 | 1 |
| 4 | 3 | 2,3 | 1 |
| 5 | 3 | 4,5 | 1 |
| 6 | 2 | 0,2 | 1 |
| 7 | 3 | 0,1 | 2 |
| 8 | 3 | 2,3 | 2 |
| 9 | 3 | 4,5 | 2 |
| 10 | 3 | 6,7 | 2 |
| 11 | 3 | 8,9 | 2 |
| 12 | 3 | 10,11 | 2 |
| 13 | 1 | 0,1 | 2 |
| 14 | 1 | 6,7 | 2 |
| 15 | 2 | 0,1 | 2 |
| 16 | 2 | 2,3 | 2 |
| 17 | 2 | 6,7 | 2 |
| 18 | 2 | 8,9 | 2 |
| 19 | 1 | 12,13 | 1 |
| 20 | 2 | 12,13 | 1 |
| 21 | 2 | 14,15 | 1 |
| 22 | 3 | 12,13 | 1 |
| 23 | 3 | 14,15 | 1 |
| 24 | 3 | 16,17 | 1 |
| 25 | 2 | 12,14 | 1 |
| 26 | 3 | 12,13 | 2 |
| 27 | 3 | 14,15 | 2 |
| 28 | 3 | 16,17 | 2 |
| 29 | 3 | 18,19 | 2 |
| 30 | 3 | 20,21 | 2 |
| 31 | 3 | 22,23 | 2 |
| 32 | 1 | 12,13 | 2 |
| 33 | 1 | 18,19 | 2 |
| 34 | 2 | 12,13 | 2 |
| 35 | 2 | 14,15 | 2 |
| 36 | 2 | 18,19 | 2 |
| 37 | 2 | 20,21 | 2 |
| 38-63 | Reserved | Reserved | Reserved |

Table 7.3.1.1.2-22-X: Antenna port(s), transform precoder is disabled, *dmrs-Type*= eType2, *maxLength*=2, rank = 3

|  |  |  |  |
| --- | --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | **Number of front-load symbols** |
| 0 | 2 | 0-2 | 1 |
| 1 | 3 | 0-2 | 1 |
| 2 | 3 | 3-5 | 1 |
| 3 | 3 | 0,1,6 | 2 |
| 4 | 3 | 2,3,8 | 2 |
| 5 | 3 | 4,5,10 | 2 |
| 6 | 2 | 12-14 | 1 |
| 7 | 3 | 12-14 | 1 |
| 8 | 3 | 15-17 | 1 |
| 9 | 3 | 12,13,18 | 2 |
| 10 | 3 | 14,15,20 | 2 |
| 11 | 3 | 16,17,22 | 2 |
| 12 | 1 | 0,1,12 | 1 |
| 13 | 2 | 0,1,12 | 1 |
| 14 | 2 | 2,3,14 | 1 |
| 15 | 3 | 0,1,12 | 1 |
| 16 | 3 | 2,3,14 | 1 |
| 17 | 3 | 4,5,16 | 1 |
| 18-63 | Reserved | Reserved | Reserved |

Table 7.3.1.1.2-23-X: Antenna port(s), transform precoder is disabled, *dmrs-Type*= eType2, *maxLength*=2, rank = 4

|  |  |  |  |
| --- | --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | **Number of front-load symbols** |
| 0 | 2 | 0-3 | 1 |
| 1 | 3 | 0-3 | 1 |
| 2 | 3 | 0,1,6,7 | 2 |
| 3 | 3 | 2,3,8,9 | 2 |
| 4 | 3 | 4,5,10,11 | 2 |
| 5 | 2 | 12-15 | 1 |
| 6 | 3 | 12-15 | 1 |
| 7 | 3 | 12,13,18,19 | 2 |
| 8 | 3 | 14,15,20,21 | 2 |
| 9 | 3 | 16,17,22,23 | 2 |
| 10 | 1 | 0,1,12,13 | 1 |
| 11 | 2 | 0,1,12,13 | 1 |
| 12 | 2 | 2,3,14,15 | 1 |
| 13 | 3 | 0,1,12,13 | 1 |
| 14 | 3 | 2,3,14,15 | 1 |
| 15 | 3 | 4,5,16,17 | 1 |
| 16-63 | Reserved | Reserved | Reserved |

## Signaling of Rel.18 DMRS ports

In RAN1#112, we made the following conclusion.

|  |
| --- |
| **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/PUSCH.**

**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.**

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| **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. |
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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).**

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

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| **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 4. Not need. Upt o network 5. Not need. Upt o 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. |

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

## Antenna port(s) table for PUSCH (rank 5-8)

In RAN1#112, we made the following working assumption. In this meeting, multiple companies propose to confirm the WA. However, since joint indication or separate indication of TRI and TPMI is still not decided for CB MIMO in AI 9.1.4.2, it is safer to keep the working assumption for CB MIMO based PUSCH.

|  |
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| **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]. |

However, for NCB, it seems only joint indication of TRI and SRI is assumed in AI 9.1.4.2, and there should be no issue to confirm the WA for NCB based PUSCH. WA for CB can be confirmed after the outcome of the discussion of joint/separate indication of TRI/TPMI in AI9.1.4.2.

**FL Proposal 3.1A**

* **Confirm the following Working Assumption in RAN1#112 at least for NCB based PUSCH:**
  + *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].*
  + **Note: The above Working Assumption for CB based PUSCH may be confirmed later.**

**Whether separate DMRS ports table is needed for partial coherent UL codebook.**

In RAN1#112, the FL proposal 3.1B was discussed, and following comments were made.

|  |
| --- |
| **ZTE:** Support Alt. 2. According to the legacy rules, DMRS port combinations can be from the same or different CDM groups no matter full/partial/non-coherent UL codebook. We fail to see the reason the make the new restriction in Rel-18 specially.  **CMCC:** Support Alt 2. DMRS ports combination(s) that the same antenna group into different DMRS CDM groups is supported in Rel-15, we don’t see more restriction is needed for Rel-18.  **InterDigital:** Support Alt.1. We’re concerned with the loss of coherency if DMRS ports of the same CDM group are mapped to different antenna groups. This would lead to CHEST degradation and poor demodulation.  **Nokia/NSB:** Support Alt 1. For partial coherent case, the precoded layers may have different power according to the number antenna ports to layers mapping, and multiplexing non-coherent DMRS ports with different power causes performance degradation. |

**FL Proposal 3.1B**

* **For > 4 layers PUSCH with Rel.15 Type1/Type2 DMRS ports and Rel.18 eType 1/eType 2 DMRS ports, for partial coherent UL codebook, down select from the following:**
  + **Alt.1: DMRS ports combination(s) that the same antenna group into the same DMRS CDM group.**
  + **Alt.2: DMRS ports combination(s) for full/non-coherent UL codebook is reused.**
    - **Note: DMRS ports combination(s) that the same antenna group into the same or different DMRS CDM group.**

**Table. Summary of companies’ views for FL Proposal 3.1B (in RAN1#112)**

|  |  |
| --- | --- |
| **Support Alt.1** | **Support Alt.2** |
| IDC, Nokia/NSB, Sharp, Docomo, Lenovo, | OPPO, Xiaomi, CATT, CMCC, Google, ZTE, Huawei, HiSilicon, Fraunhofer IIS/HHI, LGE, Ericsson, vivo, Spreadtrum |

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Docomo | Proposal 3.1A: Support.  Proposal 3.1B: Support Alt.1. |
| Google | Proposal 3.1A: Support.  Proposal 3.1B: Support Alt2. Now even for STxMP, there is no restriction like Alt1. |
| InterDigital | Proposal 3.1B: Support Alt. 1. We have antenna group definition that is based on relative coherency between different antenna elements which also is driving precoder type for uplink transmission. Therefore, there is no reason not to respect the coherency of the TX chain for DMRS CDM mapping. In our view, for partial coherent UEs, each CDM group should be mapped to a different antenna group to avoid potential loss due to inaccurate channel estimation. |
| OPPO | Proposal 3.1A: Support.  Proposal 3.1B: Support Alt2. We think it can be implemented by gNB scheduling. |
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### 3.1.1 For Rel.15 DMRS ports

In RAN1#111, following was agreed.

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| --- |
| * + 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. |

Based on the agreement for R15 DMRS ports, DMRS ports combination(s) for rank = 5-8 PDSCH is simply reused for PUSCH. In RAN1#112, some companies proposed to select one row for each table. However, we have agreement of “*The same DMRS port combination(s) as that for rank = 5,6,7,8 for PDSCH*”, and it seems we should reuse exactly the same DMRS combinations.

**FL Proposal 3.1.1A**

* **Adopt Table 7.3.1.1.2-12B/13B/14B/15B/16B/17B/20B/21B/22B/23B to support signalling >4 ranks PUSCH with Rel-15 DMRS ports.**
* **FFS: Whether/how some of bits in the antenna ports field can be reused for other purpose for >4 ranks PUSCH.**

Table 7.3.1.1.2-12B: Antenna port(s), transform precoder is disabled, *dmrs-Type*=1, *maxLength*=2, rank = 5

|  |  |  |  |
| --- | --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | **Number of front-load symbols** |
| 0 | 2 | 0-4 | 2 |
| 1-15 | Reserved | Reserved | Reserved |

Table 7.3.1.1.2-13B: Antenna port(s), transform precoder is disabled, *dmrs-Type*= 1, *maxLength*=2, rank = 6

|  |  |  |  |
| --- | --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | **Number of front-load symbols** |
| 0 | 2 | 0,1,2,3,4,6 | 2 |
| 1-15 | Reserved | Reserved | Reserved |

Table 7.3.1.1.2-14B: Antenna port(s), transform precoder is disabled, *dmrs-Type*= 1, *maxLength*=2, rank = 7

|  |  |  |  |
| --- | --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | **Number of front-load symbols** |
| 0 | 2 | 0,1,2,3,4,5,6 | 2 |
| 1-15 | Reserved | Reserved | Reserved |

Table 7.3.1.1.2-15B: Antenna port(s), transform precoder is disabled, *dmrs-Type*= 1, *maxLength*=2, rank = 8

|  |  |  |  |
| --- | --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | **Number of front-load symbols** |
| 0 | 2 | 0,1,2,3,4,5,6,7 | 2 |
| 1-15 | Reserved | Reserved | Reserved |

Table 7.3.1.1.2-16B: Antenna port(s), transform precoder is disabled, *dmrs-Type*= 2, *maxLength*=1, rank=5

|  |  |  |
| --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** |
| 0 | 3 | 0-4 |
| 1-15 | Reserved | Reserved |

Table 7.3.1.1.2-17B: Antenna port(s), transform precoder is disabled, *dmrs-Type*= 2, *maxLength*=1, rank=6

|  |  |  |
| --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** |
| 0 | 3 | 0-5 |
| 1-15 | Reserved | Reserved |

Table 7.3.1.1.2-20B: Antenna port(s), transform precoder is disabled, *dmrs-Type*= 2, *maxLength*=2, rank=5

|  |  |  |  |
| --- | --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | **Number of front-load symbols** |
| 0 | 3 | 0-4 | 1 |
| 1 | 2 | 0,1,2,3,6 | 2 |
| 12-31 | Reserved | Reserved | Reserved |

Table 7.3.1.1.2-21B: Antenna port(s), transform precoder is disabled, *dmrs-Type*= 2, *maxLength*=2, rank=6

|  |  |  |  |
| --- | --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | **Number of front-load symbols** |
| 0 | 3 | 0-5 | 1 |
| 1 | 2 | 0,1,2,3,6,8 | 2 |
| 2-31 | Reserved | Reserved | Reserved |

Table 7.3.1.1.2-22B: Antenna port(s), transform precoder is disabled, *dmrs-Type*= 2, *maxLength*=2, rank=7

|  |  |  |  |
| --- | --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | **Number of front-load symbols** |
| 0 | 2 | 0,1,2,3,6,7,8 | 2 |
| 1-31 | Reserved | Reserved | Reserved |

Table 7.3.1.1.2-23B: Antenna port(s), transform precoder is disabled, *dmrs-Type*= 2, *maxLength*=2, rank=8

|  |  |  |  |
| --- | --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | **Number of front-load symbols** |
| 0 | 2 | 0,1,2,3,6,7,8,9 | 2 |
| 1-31 | Reserved | Reserved | Reserved |

Please provide your views.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Docomo | Support. Some companies may prefer to select one row for each table, but in our understanding, the one or two DMRS port combination(s) in the above tables are already agreed because of “*The same DMRS port combination(s)*” in the agreement. |
| Google | Support in principle |
| OPPO | Fine. |
| Nokia/NSB | Support in principle for full-coherent/non-coherent only. |
| CATT | Support. |
| Huawei, HiSilicon | Fine with the DMRS port combination(s).  Whether a joint table or multiple separate tables are needed depends on whether the WA in section 3.1 is confirmed for CB-based PUSCH |
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### 3.1.2 For Rel.18 DMRS ports

Vivo, CATT, CMCC, Docomo, etc. propose to reuse DMRS port combinations for PDSCH with Rel.18 DMRS ports. I’d like to check whether the following principle is agreeable.

**FL Proposal 3.1.2A**

* **For > 4 layers PUSCH with Rel.18 eType 1/eType 2 DMRS ports, reuse the same DMRS port combination(s) as that for rank = 5,6,7,8 for PDSCH with Rel.18 eType 1/eType 2 DMRS ports at least for full or non-coherent UL codebook.**

Please provide your views.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Docomo | Support. |
| Google | It seems the DMRS port indication has nothing to do with the UL precoder. We think the common design could be applicable for all types of precoders. |
| OPPO | Agree with Google. |
| Nokia/NSB | Support in principle. But, we prefer using at most two combinations per rank. |
| CATT | Support. |
| Huawei, HiSilicon | Support. |
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### 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 |
| 1-15 | 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 |
| 1-15 | 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 |
| 1-15 | 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. | |
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### 3.1.2.2 eType1, maxLength2 (discuss later)

**FL: Since DMRS ports combinations for PDSCH is not decided yet, we will discuss this later.**

Table 7.3.1.1.2-15-X-1: Antenna port(s), transform precoder is disabled, *dmrs-Type*=eType1, *maxLength*=2, rank = 5

|  |  |  |  |
| --- | --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | **Number of front-load symbols** |
| 0 | 2 | 0-4 | 2 |
| 1 | 2 | 0,1,2,3,8 | 1 |
| 2 | 1 | 0,1,4,5,8 | 2 |
| 3 | 2 | 0,1,4,5,8 | 2 |
| 4 | 2 | 2,3,6,7,10 | 2 |
| 5-31 | Reserved | Reserved | Reserved |

Table 7.3.1.1.2-15-X-2: Antenna port(s), transform precoder is disabled, *dmrs-Type*= eType1, *maxLength*=2, rank = 6

|  |  |  |  |
| --- | --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | **Number of front-load symbols** |
| 0 | 2 | 0,1,2,3,4,6 | 2 |
| 1 | 2 | 0,1,2,3,8,10 | 1 |
| 2 | 1 | 0,1,4,5,8,12 | 2 |
| 3 | 2 | 0,1,4,5,8,12 | 2 |
| 4 | 2 | 2,3,6,7,10,14 | 2 |
| 5-31 | Reserved | Reserved | Reserved |

Table 7.3.1.1.2-15-X-3: Antenna port(s), transform precoder is disabled, *dmrs-Type*= eType1, *maxLength*=2, rank = 7

|  |  |  |  |
| --- | --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | **Number of front-load symbols** |
| 0 | 2 | 0,1,2,3,4,5,6 | 2 |
| 1 | 2 | 0,1,2,3,8,9,10 | 1 |
| 2 | 1 | 0,1,4,5,8,9,12 | 2 |
| 3 | 2 | 0,1,4,5,8,9,12 | 2 |
| 4 | 2 | 2,3,6,7,10,11,14 | 2 |
| 5-31 | Reserved | Reserved | Reserved |

Table 7.3.1.1.2-15-X-4: Antenna port(s), transform precoder is disabled, *dmrs-Type*= eType1, *maxLength*=2, rank = 8

|  |  |  |  |
| --- | --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | **Number of front-load symbols** |
| 0 | 2 | 0,1,2,3,4,5,6,7 | 2 |
| 1 | 2 | 0,1,2,3,8,9,10,11 | 1 |
| 2 | 1 | 0,1,4,5,8,9,12,13 | 2 |
| 3 | 2 | 0,1,4,5,8,9,12,13 | 2 |
| 4 | 2 | 2,3,6,7,10,11,14,15 | 2 |
| 5-31 | Reserved | Reserved | Reserved |

### 3.1.2.3 eType2, maxLength1 (discuss later)

**FL: Since DMRS ports combinations for PDSCH is not decided yet, we will discuss this later.**

Table 7.3.1.1.2-19-X-1: Antenna port(s), transform precoder is disabled, *dmrs-Type*=eType2, *maxLength*=1, rank = 5

|  |  |  |
| --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** |
| 0 | 3 | 0-4 |
| 1 | 3 | 12-16 |
| 2 | 2 | 0,1,2,3,12 |
| 3 | 3 | 0,1,2,3,12 |
| 4-31 | Reserved | Reserved |

Table 7.3.1.1.2-19-X-2: Antenna port(s), transform precoder is disabled, *dmrs-Type*= eType2, *maxLength*=1, rank = 6

|  |  |  |
| --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** |
| 0 | 3 | 0-5 |
| 1 | 3 | 12-17 |
| 2 | 2 | 0,1,2,3,12,14 |
| 3 | 3 | 0,1,2,3,12,14 |
| 4-31 | Reserved | Reserved |

Table 7.3.1.1.2-19-X-3: Antenna port(s), transform precoder is disabled, *dmrs-Type*= eType2, *maxLength*=1, rank = 7

|  |  |  |
| --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** |
| 0 | 2 | 0-3,12-14 |
| 1 | 3 | 0-3,12-14 |
| 2-31 | Reserved | Reserved |

Table 7.3.1.1.2-19-X-4: Antenna port(s), transform precoder is disabled, *dmrs-Type*= eType2, *maxLength*=1, rank = 8

|  |  |  |
| --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** |
| 0 | 2 | 0-3,12-15 |
| 1 | 3 | 0-3,12-15 |
| 2-31 | Reserved | Reserved |

### 3.1.2.4 eType2, maxLength2 (discuss later)

**FL: Since DMRS ports combinations for PDSCH is not decided yet, we will discuss this later.**

Table 7.3.1.1.2-23-X-1: Antenna port(s), transform precoder is disabled, *dmrs-Type*=eType2, *maxLength*=2, rank = 5

|  |  |  |  |
| --- | --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | **Number of front-load symbols** |
| 0 | 3 | 0-4 | 1 |
| 1 | 2 | 0,1,2,3,6 | 2 |
| 2 | 2 | 0,1,2,3,12 | 1 |
| 3 | 3 | 0,1,2,3,12 | 1 |
| 4 | 1 | 0,1,6,7,12 | 2 |
| 5 | 2 | 0,1,6,7,12 | 2 |
| 6 | 2 | 2,3,8,9,14 | 2 |
| 7 | 3 | 0,1,6,7,12 | 2 |
| 8 | 3 | 2,3,8,9,14 | 2 |
| 9 | 3 | 4,5,10,11,16 | 2 |
| 10-63 | Reserved | Reserved | Reserved |

Table 7.3.1.1.2-23-X-2: Antenna port(s), transform precoder is disabled, *dmrs-Type*= eType2, *maxLength*=2, rank = 6

|  |  |  |  |
| --- | --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | **Number of front-load symbols** |
| 0 | 3 | 0-5 | 1 |
| 1 | 2 | 0,1,2,3,6,8 | 2 |
| 2 | 2 | 0-3,12,14 | 1 |
| 3 | 3 | 0-3,12,14 | 1 |
| 4 | 1 | 0,1,6,7,12,18 | 2 |
| 5 | 2 | 0,1,6,7,12,18 | 2 |
| 6 | 2 | 2,3,8,9,14,20 | 2 |
| 7 | 3 | 0,1,6,7,12,18 | 2 |
| 8 | 3 | 2,3,8,9,14,20 | 2 |
| 9 | 3 | 4,5,10,11,16,22 | 2 |
| 10-63 | Reserved | Reserved | Reserved |

Table 7.3.1.1.2-23-X-3: Antenna port(s), transform precoder is disabled, *dmrs-Type*= eType2, *maxLength*=2, rank = 7

|  |  |  |  |
| --- | --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | **Number of front-load symbols** |
| 0 | 2 | 0,1,2,3,6,7,8 | 2 |
| 1 | 2 | 0-3,12-14 | 1 |
| 2 | 3 | 0-3,12-14 | 1 |
| 3 | 1 | 0,1,6,7,12,13,18 | 2 |
| 4 | 2 | 0,1,6,7,12,13,18 | 2 |
| 5 | 2 | 2,3,8,9,14,15,20 | 2 |
| 6 | 3 | 0,1,6,7,12,13,18 | 2 |
| 7 | 3 | 2,3,8,9,14,15,20 | 2 |
| 8 | 3 | 4,5,10,11,16,17,22 | 2 |
| 9-63 | Reserved | Reserved | Reserved |

Table 7.3.1.1.2-23-X-4: Antenna port(s), transform precoder is disabled, *dmrs-Type*= eType2, *maxLength*=2, rank = 8

|  |  |  |  |
| --- | --- | --- | --- |
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | **Number of front-load symbols** |
| 0 | 2 | 0,1,2,3,6,7,8,9 | 2 |
| 1 | 2 | 0-3,12-15 | 1 |
| 2 | 3 | 0-3,12-15 | 1 |
| 3 | 1 | 0,1,6,7,12,13,18,19 | 2 |
| 4 | 2 | 0,1,6,7,12,13,18,19 | 2 |
| 5 | 2 | 2,3,8,9,14,15,20,21 | 2 |
| 6 | 3 | 0,1,6,7,12,13,18,19 | 2 |
| 7 | 3 | 2,3,8,9,14,15,20,21 | 2 |
| 8 | 3 | 4,5,10,11,16,17,22,23 | 2 |
| 9-63 | Reserved | Reserved | Reserved |

## 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.

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| --- | --- |
| **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) |
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## PTRS-DMRS association

**One port PTRS**

In RAN1#112, we made the following agreement.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **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 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: 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 |

**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 |

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| --- | --- |
| **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. |
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## PTRS power boosting

InterDigital, Huawei/HiSilicon, ZTE, vivo, OPPO, Spreadtrum, CATT, Lenovo, Ericsson, and Google discuss PTRS power boosting for PUSCH with rank>4 in their tdocs. Most of companies seems ok with FL proposal 3.4A in RAN1#112, but it was pointed out that non codebook scenario was missing. Hence, the case of con-codebook is added.

**FL proposal#3.4A:**

* **For 8Tx PUSCH, specify PUSCH to PTRS power ratio per layer per RE () based on the following principles.**
  + **Principle 1: When the *ptrs-Power* configures 01, the PTRS to PUSCH power ratio is 10log10(L), where L is the total number of PUSCH layers.**
  + **Principle 2: When the *ptrs-Power* configures 00, the PTRS to PUSCH power ratio is determined as the following**
    - **Principle 2.1: For fully coherent TPMIs, PTRS to PUSCH power ratio is 10log10(L), where L is the total number of PUSCH layers.**
    - **Principle 2.2: For non-coherent TPMIs, PTRS to PUSCH power ratio is 10log10(Qp), where Qp is the number of PTRS ports configured to the UE.**
    - **Principle 2.3: For non-codebook PUSCH, PTRS to PUSCH power ratio is 10log10(Qp), where Qp is the number of PTRS ports configured to the UE.**
    - **FFS: The PTRS to PUSCH power ratio for partial coherent TPMIs**
  + **Send LS to RAN4 to inform that RAN1 made the above agreement and ask if any impact to PAPR when PTRS RE is 12 dB boosting over the PUSCH REs for L=8.**

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| **Company** | **Comment** |
| Docomo | Support. |
| Google | We think we can make the proposal more general with regard to the upper bound. We think the EPRE ratio should not exceed 9dB with regard to the ICI similar to LTE. But we could ask for RAN4’s advice.   * **For 8Tx PUSCH, specify PUSCH to PTRS power ratio per layer per RE () based on the following principles.**   + **Principle 1: When the *ptrs-Power* configures 01, the PTRS to PUSCH power ratio is min(10log10(L), T), where L is the total number of PUSCH layers.**   + **Principle 2: When the *ptrs-Power* configures 00, the PTRS to PUSCH power ratio is determined as the following**      - **Principle 2.1: For fully coherent TPMIs, PTRS to PUSCH power ratio is min(10log10(L), T), where L is the total number of PUSCH layers.**     - **Principle 2.2: For non-coherent TPMIs, PTRS to PUSCH power ratio is min(10log10(Qp), T), where Qp is the number of PTRS ports configured to the UE.**     - **Principle 2.3: For non-codebook PUSCH, PTRS to PUSCH power ratio is min(10log10(Qp), T), where Qp is the number of PTRS ports configured to the UE.**     - **FFS: The PTRS to PUSCH power ratio for partial coherent TPMIs**   + **Send LS to RAN4 to ask for their advice on the value of T** |
| InterDigital | Support |
| OPPO | Fine with the proposal. We don’t think T as proposed by google is necessary. It depends on the output of RAN4. |
| Nokia/NSB | Support the original proposal. |
| CATT | Support FL proposal#3.4A. For partial-coherent TPMIs, when the *ptrs-Power* configures 00, the PTRS to PUSCH power ratio can be dB, where is the number of PUSCH layers sharing the same non-zero power antenna ports as the PUSCH layer the PTRS port is associated to, *Qp* is the number of PTRS ports configured to the UE and *L* is the total number of PUSCH layers. |
| Huawei, HiSilicon | Support in general.  The definition of Qp should be modified from “**the number of PTRS ports configured to the UE**” to “**the number of scheduled PTRS ports**”. |
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## Other proposals

Following proposals are also proposed.

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| **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.

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| **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.

**To be updated:**

# 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~~ | |