**3GPP TSG RAN WG1 #112b-e R1-2302307**

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

**Agenda Item: 9.1.4.2**

**Source: Moderator (InterDigital, Inc.)**

**Title:** **FL Summary on SRI/TPMI Enhancements; Preparatory**

**Document for: Discussion and Decision**

# Background

In RAN plenary #94, the WID for Rel-18 MIMO enhancements was finalized [1]. According to the WID, some enhancements for SRI/TPMI are necessary to enable 8 TX UE transmission.

|  |
| --- |
| *Objective 5: 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.* |

To accomplish the objective, the scope of this agenda item centers on codebook design for 8TX, enhancements for dual CW operation, enhancements on SRS configuration, impacts resulted from coherency characteristics of such UEs as well as UE operation with full power.

Based on the progress and agreements made in the last meeting [2-3], the following topics are the focal point of the discussion in this meeting.

**High Priority Topics**

* **Partially/Non-coherent precoding:**
	+ Codebook structure for Ng=2
	+ Decision for supported cases of layer to antenna group mapping for Ng=4
	+ Discuss precoding indication
* **Fully-coherent precoding:**
	+ Decision on applicability of oversampling values (2,1) and (2,2) per agreed (N1, N2)
	+ Discuss precoding indication
		- Based on UL legacy indication by using an index
		- Based on DL indication by using i1, i2, … etc.
* **Remaining details for specification support of dual CW transmission:**
	+ Down-selection between the two alternatives as the target CW for UCI multiplexing
	+ Enabling/Disabling the second CW
	+ Discuss other aspects; CBG, configured grant operation, etc.

**Other Topics**

* **Others:**
	+ Down-selection between the two options for NCB SRI indication

# Codebook Design for Coherent 8TX UE

In the last meeting, baseline values for (N1, N2) and (O1, O2) parameters were agreed. Remaining details on this topic is whether other values, i.e., (O1, O2) = (2,1), (2,2) should be optionally supported.

|  |
| --- |
| AgreementFor fully coherent uplink precoding by an 8TX UE, based on NR Rel-15 single panel DL Type I codebook, the following pairs of (N1, N2) values are supported,* (N1, N2) = (4, 1)
* (N1, N2) = (2, 2)`

A pair of (N1, N2) can be configured with subject to UE capability.**Agreement**For fully coherent uplink precoding by an 8TX UE, based on NR Rel-15 single panel DL Type I codebook (CodebookMode=1), * Study whether/how to support (O1, O2) = (2,1), (2,2)
	+ whether for all rank, or rank 1-2, or rank 3-8
	+ applicability of different (O1, O2) values per agreed (N1, N2)
	+ companies are encouraged to submit simulation results
 |

Table 1 captures the number of precoders for the supported range as well as the suggested UE-capability-based values of over-sampling ratios and (N1, N2) values of interest. For this meeting, 10 companies have reported their evaluations of optional O1, O2 values for full-coherent codebook design. The observations can be summarized as follows,

* **ZTE**: Higher oversampling ratios can be at least supported for low ranks, e.g., rank<=2, or 3.
* **Sharp**: Higher oversampling ratios can be at least supported for low ranks, e.g., rank<=2.
* **Lenovo**: For (N1, N2)=(4,1), (O1, O2)=(2,1) exhibits 0.45dB gain, and for (N1, N2)=(2, 2), (O1, O2) =(2,2) and (2,1) shows 1.1dB and 0.3dB respectively. (no info on rank setting)
* **Ericsson**: FC precoders with (O1,O2)=(2,2) has a visible gain in the performance, especially at the cell-edge (low rank).
* **vivo**: The gain from higher oversampling values is marginal for rank up to 2, and negligible for higher ranks.
* **OPPO**: The gain from higher oversampling values is marginal for rank 1, and negligible for higher ranks.
* **Xiaomi**: The gain from higher oversampling values is marginal for rank 1, and negligible for higher ranks.
* **Huawei**:Larger oversampling ratios in all considered cases have very marginal throughput gain.
* **Nokia**:Oversampling ratios of(2,1) and (2,2) exhibit negligible gains over the baseline value (1, 1).
* **Qualcomm:** For either antenna layout, the gain of O1, O2 values larger than 1 is not significant.
* **MediaTek:** There is a marginal improvement in terms of cell edge performance in some cases of restricted rank (rank≤4) transmission.

Based on the above observations, and earlier comments from the preparation phase, a cell-edge UE with antenna layout (N1, N2) = (2, 2) can benefit from using oversampling ratios of (O1, O2) = (2, 2). By restricting the usage of (O1, O2) = (2, 2) to transmissions with rank ≤ 2, the DCI payload size will not increase unnecessary. Therefore, the proposal is updated as follows,

*~~Proposal 2.1 - For fully coherent uplink precoding by an 8TX UE, based on NR Rel-15 single panel DL Type I codebook (CodebookMode=1), following optional over-sampling values are supported,~~*

* **~~(O1, O2) = (2, 2) for (N1, N2) = (2, 2)~~**
* **~~(O1, O2) = (2, 1) for (N1, N2) = (4, 1) and (N1, N2) = (2, 2)~~**

*Proposal 2.1 - For fully coherent uplink precoding by an 8TX UE, based on NR Rel-15 single panel DL Type I codebook (CodebookMode=1), the following optional over-sampling ratio is supported,*

* **(O1, O2) = (2, 2) for (N1, N2) = (2, 2) when transmitting with rank ≤ 2**

Table 1 – UL Precoding overhead

|  |  |
| --- | --- |
| Configuration parameters | Number of precoders using NR Rel-15 single panel DL Type I |
| (*N*1, *N*2, *O*1, *O*2) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
| (2, 2, 1, 1) | 16 | 32 | 24 | 24 | 8 | 8 | 8 | 8 | 128 |
| (2, 2, 2, 1) | 32 | 64 | 48 | 48 | 16 | 16 | 16 | 16 | 256 |
| (2, 2, 2, 2) | 64 | 128 | 96 | 96 | 32 | 32 | 32 | 32 | 512 |
| (4, 1, 1, 1) | 16 | 32 | 24 | 24 | 8 | 8 | 4 | 4 | 120 |
| (4, 1, 2, 1) | 32 | 64 | 48 | 48 | 16 | 16 | 8 | 8 | 240 |
| (4, 1, 2, 2) | 64 | 128 | 96 | 96 | 16 | 16 | 8 | 8 | 432 |

Table 2 - Companies’ views

|  |  |
| --- | --- |
| **Company** | **Perspective** |
| Google | It looks (O1,O2)=(2,2) cannot provide good performance gain, but it increases the overhead. We failed to see the necessity for the proposal. |
| NTT DOCOMO | Agree with Google. |
| OPPO | Agree with Google. |
| Lenovo | Proposal 2.1: Our simulation is done in rank 1. We support this proposal. We also think the case (N1,N2)=(4,1) needs further study. |
| CATT | Agree with Google, DOCOMO and OPPO. We prefer not to support additional combination of (O1, O2) other than (1, 1). |
| ZTE | We support proposal 2.1.* On one hand, for full coherent codebook, the number of the introduced candidate precoders is not large compared with partial coherent codebook. Especially, we observe clear benefit(s) for cell-edge UEs, based on the results of contributions at least from Ericsson, MTK, and ZTE.
* On the other hand, (O1, O2) = (1, 1) has been agreed for (N1, N2) = (2, 2) as a baseline, then we assume that (O1, O2) = (2, 2) for (N1, N2) = (2, 2) for rank < 2 as a optional feature can be supported based on gNB configuration (e.g., beneficial to cell-edge UE as an option for higher accuracy).
 |
| MediaTek | Not support. Agree with comment by Google, we don’t see the benefit of introducing (O1,O2)=(2,2).  |
| QC | We don’t support this proposal. There is no much gain to introduce (O1, O2) = (2, 2) in general. Introducing (O1, O2) = (2, 2) for particular rank is even worse, which unnecessarily complicate spec and UE implementation. With this rank dependant (O1,O2), do we need different # bits in DCI to signal precoder per rank? If so, how to solve the dynamic DCI size issue? |
| Intel | For full coherent precoder, the overhead for Type I codebook should be considered in the design.If larger oversampling factor is supported, we think some restriction could be introduced on the parameters i11, i12, i13 and i2 to reduce the overhead.We suggest the following change*Proposal 2.1 - For fully coherent uplink precoding by an 8TX UE, based on NR Rel-15 single panel DL Type I codebook (CodebookMode=1), the following optional over-sampling ratio is supported,** **(O1, O2) = (2, 2) for (N1, N2) = (2, 2) when transmitting with rank ≤ 2**
* **FFS: restriction on i11, i12, i13 and i2 to reduce overhead**
 |
| ZTE2 | A short comment: If our understanding is correct, the intention of current proposal 2.1 is much relevant to the improvement of cell-edge UE (which has rank of less than or equal to 2). If so, we may need to pay a little bit attention on cell-edge UPT.After reviewing companies’ input having cell-edge UPT results, there are clear performance improvement (~10% UPT gains). If our understanding or reviewing companies’ input is incorrect, please feel free to correct them.BTW, in our views, the functionality of TPMI remains, and the only enhancement if the above proposal is approved, is relevant to have some more TPMI candidates (e.g., basic feature for (N1,N2) = (2,2) #. candidate TPMI is 128; but if the optional feature is enabled, #. candidate TPMI is 272) |
| Xiaomi | We also prefer not to introduce rank-specific oversampling factors due to the marginal performance gain. |
| Nokia, NSB | To study OVS design, we shall have both fixed rank selection and adaptive rank selection to demonstrate different OVS in system level simulation.In our simulations (shown in R1-2303011), with fixed rank selection, at rank 1, 2, 3 or 4, there is little performance difference between the different choices of (O1, O2). For ranks fixed at values higher than 4, the performance difference between the highest overhead configuration and the other configurations can be moderate to severe. With adaptive rank selection, the losses from not using the highest overhead configuration can be moderate to severe, where the losses are higher in situations where higher ranks tend to get selected more often (e.g., FTP1).Not supporting the highest overhead configuration for 8Tx can severely impact UL system performance. Given that support for ranks higher than 4 will be specified, it is important to avoid sacrificing the performance when a rank higher than 4 is selected, otherwise the overall benefits of supporting ranks higher than 4 will be reduced, significantly so in some situations.With our simulations, the proposal “**(O1, O2) = (2, 2) for (N1, N2) = (2, 2) when transmitting with rank ≤ 2**” does not show much gain. However, we support (O1, O2) = (4,1) based on UE capability for (N1,N2)=(4,1), and (O1, O2) = (4,4) for (N1, N2)=(2, 2) based on UE capability, because of significant gain shown in these configurations, as demonstrated in R1-2303011. |
| QC2 | To ZTE: At least in our simulation, we only see 3.9% gain from (O1,O2) =(1,1) to (O1,O2) =(2,2) for (N1,N2)=(2,2). We don’t see the gain is significant enough to justify the 4 times overhead. **Chart, waterfall chart  Description automatically generated** |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

# Codebook Design for Partially/Non-Coherent UE

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Agreement**For partially coherent uplink precoding by an 8TX UE codebook,* When Ng=2
	+ Precoding design is based on Rel-15 UL 4TX codebook,
		- Full-coherent precoders are used
			* FFS whether partial-coherent precoders are needed
* When Ng=4, down-select from,
	+ Alt1:
		- Precoding design is based on Rel-15 UL 2TX codebook,
			* Full-coherent precoders are used
	+ Alt2:
		- Precoding design is based on Rel-15 UL 4TX codebook,
			* Partial-coherent precoders are used

**Agreement**For partially coherent uplink precoding by an 8TX UE codebook, Ng=2, * Following rank and layer splitting cases are supported

|  |  |  |
| --- | --- | --- |
| **Rank** | **All layers in one Antenna Group** | **Layers split across 2 Antenna Groups** |
| 1 | (1,0), (0,1) |  |
| 8 |  | (4,4) |

* Select from the following cases based on the performance and overall DCI overhead

|  |  |  |
| --- | --- | --- |
| **Rank** | **All layers in one Antenna Group** | **Layers split across 2 Antenna Groups** |
| 2 | (2,0), (0,2) |  |
| 2 |  | (1,1) |
| 3 | (3,0), (0,3) |  |
| 3 |  | (2,1), (1,2) |
| 4 | (4,0), (0,4) |  |
| 4 |  | (2,2), (3,1), (1,3) |
| 5 |  | (4,1), (1,4), (2,3), (3,2) |
| 6 |  | (4,2), (2,4), (3,3) |
| 7 |  | (4,3), (3,4) |

Note: Above is not relevant to how precoders are indicated.  |

Based on the discussion in the last meeting, it was agreed to use full-coherent precoders from Rel-15 UL 4TX codebook for when Ng=2. Therefore, the precoder indication can be simply based on indication of two full-coherent 4TX precoders. Furthermore, different options of layer splitting were identified for discussion and down-selection in this meeting.

According to the agreement, for Ng=2, full-coherent precoders from Rel-15 UL 4TX codebook are used to construct the 8TX codebook. Based on the Rel-15 UL 4TX codebook, as shown in Table 3, there are a total of 30 fully coherent precoders that can be indicated by 5 bits. Therefore, to indicate an 8TX precoder for a partially coherent UE with Ng=2, 10 bits can be used to maintain flexibility and support all possible cases of layer splitting.

**Table 3**

|  |  |
| --- | --- |
| **Rank** | **Number of fully coherent precoders** |
| 1 | 16 |
| 2 | 8 |
| 3 | 4 |
| 4 | 2 |

***~~Proposal 3.1: For partially coherent 8TX UE with Ng=2, the precoder indication is based on indication of two full-coherent 4TX precoders.~~***

***~~Proposal 3.2:~~* ~~For partially coherent uplink precoding by an 8TX UE codebook, Ng=2,~~**

* **~~TPMI indication is based on using 2 TPMI each with a length of 5 bits~~**
* **~~Down-select from one the followings~~**
	+ **~~Alt1 - Following combinations of layer splitting are supported~~**

|  |  |  |
| --- | --- | --- |
| **~~Rank~~** | **~~All layers in one Antenna Group~~** | **~~Layers split across 2 Antenna Groups~~** |
| ~~2~~ | ~~(2,0), (0,2)~~ |  |
| ~~2~~ |  | ~~(1,1)~~ |
| ~~3~~ | ~~(3,0), (0,3)~~ |  |
| ~~3~~ |  | ~~(2,1), (1,2)~~ |
| ~~4~~ | ~~(4,0), (0,4)~~ |  |
| ~~4~~ |  | ~~(2,2), (3,1), (1,3)~~ |
| ~~5~~ |  | ~~(4,1), (1,4), (2,3), (3,2)~~ |
| ~~6~~ |  | ~~(4,2), (2,4), (3,3)~~ |
| ~~7~~ |  | ~~(4,3), (3,4)~~ |

* + **~~Alt2 - Following combinations of layer splitting are supported, where for rank>4, e~~*~~ach CW is mapped to only one antenna group.~~***

|  |  |  |
| --- | --- | --- |
| **~~Rank~~** | **~~All layers in one Antenna Group~~** | **~~Layers split across 2 Antenna Groups~~** |
| ~~2~~ | ~~(2,0), (0,2)~~ |  |
| ~~2~~ |  | ~~(1,1)~~ |
| ~~3~~ | ~~(3,0), (0,3)~~ |  |
| ~~3~~ |  | ~~(2,1), (1,2)~~ |
| ~~4~~ | ~~(4,0), (0,4)~~ |  |
| ~~4~~ |  | ~~(2,2), (3,1), (1,3)~~ |
| ~~5~~ |  | ~~(2,3), (3,2)~~ |
| ~~6~~ |  | ~~(3,3)~~ |
| ~~7~~ |  | ~~(4,3), (3,4)~~ |
|  |  |  |

Based on the comments from the preparation phase, companies have indicated the following points for proposals 3.1 and 3.2,

* Further discuss other options for precoder indication,
* The TPMI indication can be done with less overhead than the FL proposed 10 bits,
* For layer splitting, only cases based on an almost balanced layer splitting should be supported.

Therefore, proposals 3.1 and 3.2 are updated as follows,

***Proposal 3.1: For partially coherent 8TX precoding with Ng=2, the precoder indication is based on indication of up to two full-coherent 4TX precoders.***

***Down-select at least one of the following options for precoder indication,***

* ***Option 1 – A single TPMI is indicated and applied on both antenna groups***
* ***Option 2 – A single TPMI is indicated, from which a second precoder is derived for the second antenna group***
* ***Option 3 - Two TPMIs are indicated, where the first is applied on the first antenna group, and the second is applied on the second antenna group***

***Proposal 3.2:* For partially coherent uplink precoding by an 8TX UE, Ng=2,**

* **Following combinations of layer splitting are supported, where for rank>4, each CW is mapped to only one antenna group.**

|  |  |  |
| --- | --- | --- |
| **Rank** | **All layers in one Antenna Group** | **Layers split across 2 Antenna Groups** |
| 2 | (2,0), (0,2) |  |
| 2 |  | (1,1) |
| 3 | (3,0), (0,3) |  |
| 3 |  | (2,1), (1,2) |
| 4 | (4,0), (0,4) |  |
| 4 |  | (2,2) |
| 5 |  | (2,3), (3,2) |
| 6 |  | (3,3) |
| 7 |  | (4,3), (3,4) |

Another aspect of partially coherent uplink precoding by an 8TX UE is related to the case with Ng=4. In the last RAN1 meeting, two alternatives were identified for down-selection. The main difference between the two alternatives can be captured as follows,

* Alt1 offers a cleaner design that could benefit from having a same framework for TPMI indication as the case with Ng=2
* Alt2 could offer a better performance due to having a larger selection of 2TX precoder, however that comes with a large overhead and more challenging path for down-selection and specifications.

Based on the review of companies’ contributions and comments received during the preparation phase, there is a strong majority for support of Version A.

***Proposal 3.3:***

***Version A -* For partially coherent uplink precoding by an 8TX UE codebook, Ng=4, Alt1 is supported where**

* **Precoding design is based on Rel-15 UL 2TX codebook,**
	+ **Full-coherent precoders are used**

***~~Version B -~~* ~~For partially coherent uplink precoding by an 8TX UE codebook, Ng=4, Alt2 is supported where~~**

* **~~Precoding design is based on Rel-15 UL 4TX codebook,~~**
	+ **~~Partial-coherent precoders are used~~**

Following the same principle as the case with Ng=2, proposal 3.4 is prepared for the partial coherent UEs with Ng=4 antenna groups.

***Proposal 3.4:***

**For partially coherent uplink precoding by an 8TX UE codebook, Ng=4,**

* **Following rank and layer splitting cases are supported**

|  |  |  |
| --- | --- | --- |
| **Rank** | **All layers in one Antenna Group** | **Layers split across ~~2~~ 4 Antenna Groups** |
| 1 | (1,0,0,0), (0,1,0,0),(0,0,1,0), (0,0,0,1) |  |
| 2 | (2,0,0,0), (0,2,0,0), (0,0,2,0), (0,0,0,2) |  |
| 8 |  | (2, 2, 2, 2) |

* **Select from the following cases based on the performance and overall DCI overhead**

|  |  |  |
| --- | --- | --- |
| **Rank** | **All layers in one Antenna Group** | **Layers split across ~~2~~ 4 Antenna Groups** |
| 2 |  | (1,1,0,0), (1,0,1,0), (1,0,0,1)(0,1,1,0), (0,1,0,1) (0,0,1,1) |
| 3 |  | (2,1,0,0), (2,0,1,0), (2,0,0,1)(1,2,0,0), (0,2,1,0), (0,2,0,1)(1,0,2,0), (0,1,2,0), (0,0,2,1)(1,0,0,2), (0,1,0,2), (0,0,1,2) |
| 4 |  | (2,2,0,0), (2,0,2,0), (2,0,0,2)(0,2,2,0), (0,2,0,2), (0,0,2,2) |
| 5 |  | (2,2,1,0), (2,2,0,1), (2,1,2,0), (2,1,0,2), (2,0,1,2), (2,0,2,1)(0,2,2,1), (0,2,1,2), (1,2,2,0), (1,2,0,2)(0,1,2,2), (1,0,2,2) |
| 6 |  | (2,2,2,0), (2,2,0,2), (2,0,2,2),(0,2,2,2) |
| 7 |  | (2,2,2,1), (2,2,1,2), (2,1,2,2), (1,2,2,2) |

***Note: Above is not relevant to how precoders are indicated.***

Table 4 - Companies’ views

|  |  |
| --- | --- |
| **Company** | **Perspective** |
| Google | 3.1: We think we should discuss TPMI indication after we finalize the codebook design. Option 1 and option 2 depend on the codebook design. We cannot see any benefit from option 3. Usually, 2 TPMI indication (separate indication) would require larger overhead than 1 TPMI indication (joint indication).3.2/3.3/3.4: Support |
| NTT DOCOMO | 3.1: Agree with Google to discuss TPMI discussion after we finalize the CB design. And we donot understand Option 2. Some clarification on Option 2 is appreciated.3.2: Support3.3: Support3.4: Not support. First, there should be ‘4 Antenna Groups’ instead of ‘2 Antenna Groups’ in the table. Second, not sure the reason to preclude some layer splitting cases, e.g., (1,1,1,0) and its permutations for rank=3, (1,1,1,1) and its permutations for rank=4, (2,2,1,1) and its permutations for rank=6, etc. |
| NEC | 3.1: In our understanding, TPMI is just an index corresponding to a precoder. No matter how the precoder is designed. If we really need an agreement, we support single TPMI.3.2/3.3: Support. |
| OPPO | 3.1: The difference between Option 1 and Option 2 is unclear to us. 3.2: We think there would be performance loss for (3,0), (0,3) and (4,0), (0,4) compared to mapping the layers to both antenna groups. We prefer FFS for (3,0), (0,3) and (4,0), (0,4).3.3: We prefer version B. As shown in proposal 3.4, there are too many layer splitting cases for version A. The overhead of version A would be significantly lager than that of version B. 3.4: agree on 3.3 first.  |
| Lenovo | Proposal 3.1: Agree with Google. Such details should be discussed after we make some progress in the codebook design. Proposal 3.2: We think it is important to balance the power between the two groups, so the layer split like (2,0),(0,2),(3,0),(0,3),(4,0),(0,4) should not be included. Splitting the layers across two groups can also provide higher performance, since there are more precoder to select from in the lower ranks. So we think only the right column (layer split between 2 antenna groups with (almost) the same number of layers) should be specified.Proposal 3.3: Do not support. More study is needed to compare the two alternatives, including the signalling overhead and performance. Basing the Ng=4 design on 2TX precoder offers better performance than 4TX. The TPMI overhead can be mitigated by limiting the 2TX precoder combinations, such as only allow different 2TX precoders to be used in different antenna groups. Proposal 3.4: Do not support. This decision should be made after an agreement is reached on the issue of Proposal 3 (2TX or 4TX codebook).  |
| CATT | **Proposal 3.1**:The proposal is not clear for us. Does a single TPMI in option 2 means a single 8Tx TPMI or a single 4Tx TPMI? As we explained in last round, we prefer to indicate a single 8Tx TPMI to the UE.Besides, we have concern on indicating two full-coherent 4TX precoders. As shown in our contribution (R1-2302686), for rank = 3, 8Tx precoders generated with full-coherent 4Tx precoder + partial-coherent 4Tx precoder slightly outperforms 8Tx precoders generated with two full-coherent 4Tx precoders, and can keep the constant modulus property. We prefer to consider 8Tx precoders generated with full-coherent 4Tx precoder + partial-coherent 4Tx precoder, partial-coherent 4Tx precoder + partial-coherent 4Tx precoder, and partial-coherent 4Tx precoder + non-coherent 4Tx precoder for rank 3, 5 and 7 respectively.**Proposal 3.2**: We believe that one layers split is sufficient regardless of ranks. Thus, following modifications are suggested: **Following combinations of layer splitting are supported, where for rank>4, each CW is mapped to only one antenna group.**

|  |  |  |
| --- | --- | --- |
| **Rank** | **All layers in one Antenna Group** | **Layers split across 2 Antenna Groups** |
| 1 | (1,0), (0,1) |  |
| 2 | (2,0), (0,2) |  |
| 2 |  | (1,1) |
| 3 | (3,0), (0,3) |  |
| 3 |  | ~~(2,1),~~ (1,2) |
| 4 | (4,0), (0,4) |  |
| 4 |  | (2,2) |
| 5 |  | (2,3)~~, (3,2)~~ |
| 6 |  | (3,3) |
| 7 |  | ~~(4,3),~~ (3,4) |
| 8 |  | (4,4) |

**Proposal 3.3**: Support in principle with following modifications:***Proposal 3.3:*** ***Version A -* For partially coherent uplink precoding by an 8TX UE codebook, Ng=4, Alt1 is supported where** * **Precoding design is based on Rel-15 UL 2TX codebook, at least:**
	+ **Full-coherent precoders are used**

**Proposal 3.4**:We believe that we should make decisions on proposal 3.3 firstly and then turn to designing the combinations of layer splits for the partial coherent UEs with Ng=4 antenna groups. |
| ZTE | 3.1: Support option 3. Option 1 and option 2 need more clarification. Single TPMI should be joint TPMI which can indicate two 4 Tx TPMIs. It seems only one 4Tx TPMI is used for 2 port groups in Option 1. 3.2: We can support the table for rank 2-4, but have concern on (3, 2) and (4, 3). If following legacy UL codebook scheme, permutation is not needed for higher rank. 3.3: Support. 3.4: The format of layer splitting cases for rank=1 seems not correct, which is for Ng=2. It should be modified as (1/0/0/0), (0/1/0/0), (0/0/1/0), (0/0/0/1) for rank 1.* We agree with the candidates for rank 2, 7, 8 in above table.
* For rank 3 and rank 4, group balanced candidates should be added. E.g, 1/1/1/0, 1/1/0/1, 1/0/1/1, 0/1/1/1 for rank 3, and 1/1/1/1 for rank 4.
* For rank 6, group balanced splitting such as 2/1/2/1, 1/2/1/2, 2/2/1/1, 1/1/2/2/ should be added for discussion.
* For rank 5, group balanced splitting such as combinations of one 2 and three 1 should also be added for discussion.

Some considerations:1. For higher rank, permutation can be either not supported or partially supported.
2. We need to determine the relation among four 2Tx port groups, whether first two 2Tx port groups correspond to one 4Tx port group or the 1st and the 3rd 2Tx port groups correspond to one 4Tx port group, because Ng=2 UE can support Ng=4 codebook. This issue is relevant to port indexing for 8Tx. The former means [0, 1, 4, 5] and [2, 3, 6, 7], the latter means [0, 2, 4, 6] and [1, 3, 5, 7] assuming 2Tx ports of [0, 4], [1, 5], [2, 6] and [3, 7]. After this is determined, we can choose [2/1/2/1] or [2/2/1/1/], instead of both. Note that such port indexing splitting is also discussing for 8Tx SRS in AI 9.1.3.2.
 |
| MediaTek | **Proposal 3.1:** We prefer to have this discussion after finalizing precoder design, but in general we prefer single TPMI.**Proposal 3.2:** We believe the entries in the table can be further reduced, i.e.,**Following combinations of layer splitting are supported, where for rank>4, each CW is mapped to only one antenna group.**

|  |  |  |
| --- | --- | --- |
| **Rank** | **All layers in one Antenna Group** | **Layers split across 2 Antenna Groups** |
| 1 | (1,0), (0,1) |  |
| 2 | (2,0), (0,2) |  |
| 2 |  | (1,1) |
| 3 | (3,0), (0,3) |  |
| 3 |  | (2,1), ~~(1,2)~~ |
| 4 | (4,0), (0,4) |  |
| 4 |  | (2,2) |
| 5 |  | ~~(2,3),~~ (3,2) |
| 6 |  | (3,3) |
| 7 |  | (4,3), ~~(3,4)~~ |
| 8 |  | (4,4) |

**Proposal 3.3:** Support**Proposal 3.4:** We would like to prioritize finishing the codebook design for Ng =2 and then move to Ng=4. |
| QC | Proposal 3.1: Support option 3, which is the most straightforward solution. Option 1 has a restriction that the two antenna groups have to use same precoder. We don’t support option 2, before it is clarified how to derive the precoder for the second antenna group. Proposal 3.2: Support the spirit of the proposal. But we think overhead can be further reduced by only keep “1,2” out of “(2,1), (1,2)”, “2,3” out of “(2,3), (3,2)”, “3,4” out of “(3,4), (4,3)”. There seems no strong motivation to keep both. Proposal 3.3: supportProposal 3.4: Need more discussion. For example, for layer 4, why not support (1,1,1,1)? |
| Intel | *Proposal 3.1*We also think the details of TPMI indication could be the next step. We are fine with the main bullet.Regarding the options, more discussions are required. For single TPMI/two TPMI, does it mean single TPMI field or two TPMI fields?We think we can firstly focus on the main bullet and suggest the following change.***Proposal 3.1: For partially coherent 8TX precoding with Ng=2, the precoder indication is based on indication of up to two full-coherent 4TX precoders.******~~Down-select at least one of the following options for precoder indication,~~**** ***~~Option 1 – A single TPMI is indicated and applied on both antenna groups~~***
* ***~~Option 2 – A single TPMI is indicated, from which a second precoder is derived for the second antenna group~~***
* ***~~Option 3 - Two TPMIs are indicated, where the first is applied on the first antenna group, and the second is applied on the second antenna group~~***

*Proposal 3.2*What’s the motivation to have the CW mapping to antenna group, i.e., “**where for rank>4, each CW is mapped to only one antenna group.**”?*Proposal 3.3*OK with Version A.*Proposal 3.4*Generally fine. |
| ZTE | Proposal 3.4: Thanks for considering our suggestion. We are fine now. |
| Xiaomi | Proposal 3.1: We also prefer to have this discussion after finalizing precoder designProposal 3.2: Support.Proposal 3.3: Support. More layer splitting flexibility can be obtained by using 2Tx precoder.Proposal 3.4: We can deprioritize it before we have an agreement on Proposal 3.3. |
| Nokia, NSB | Proposal 3.1: There is no much difference between Option 1 and Option 2. Option 3 provides most flexibility. However, it is still not quite clear about the payload size of various options. We can keep these options open to check the TPMI payload size to determine the performance of these options.Proposal 3.2: The key issue related to the layer splitting is to identify overall the payload size for the precoder indication. However, given various types of layer splitting, it is still not clear how much payload each selection would be and how much impact on the payload size. We probably need a complete design on precoder indication. Simply picking some layer splitting won’t help much. Do not support.Proposal 3.3: Okay with this design.Proposal 3.4: Similar to 3.2, the payload size of such layer splitting among groups is still missing. We can further discuss on the details of the design. |
| QC2 | We have an additional comment on proposal 3.2. Similar to Intel, we are not sure what’s the motivation to have the CW mapping to antenna group, i.e., “**where for rank>4, each CW is mapped to only one antenna group.**”? So we don’t support this part in the proposal as well. By the way, isn’t this discussion already happening in DMRS FL summary? We are not sure we need duplicate the discussion here.  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

# Support of Two Codewords

|  |
| --- |
| **Agreement**To support dual CW PUSCH transmission for rank>4 by an 8TX UE, for MCS indication, support* Alt.2: A second MCS field (5 bits) is indicated for the second codeword

**Agreement**To support dual CW PUSCH transmission for rank>4 by an 8TX UE, a second set of NDI (1 bit) and RV (2 bits) fields are indicated. * FFS: Details on how to signal

**Agreement**To support dual CW PUSCH transmission for rank>4 by an 8TX UE, reuse DL PDSCH scrambling mechanism to initialize the scrambling sequence generator for codeword q$\in ${0,1}, $$c\_{init}=n\_{RNTI}∙2^{15}+q∙2^{14}+n\_{ID}$$where $n\_{RNTI}$, and $n\_{ID}$ are defined similar to the legacy single CW PUSCH transmission.**Agreement**To support UCI multiplexing on PUSCH for transmission with rank>4 by an 8TX UE, UCI is always multiplexed only on one of the CWs, down-select from,* Alt1: First CW
* Alt2: The CW with the highest MCS (if MCSs are the same, UCI is multiplex on the first CW)
 |

On the support of two codeword transmissions, several key agreements were reached, however there are a few more issues to be discussed in this meeting. Following the discussion from the preparation phase, proposals 4.1, 4.2 and 4.3 are adjusted to better reflect companies’ views. Here is a summary of changes,

* Proposal 4.1: Clarified that configuration of max layers is by extension of the legacy maxRank parameter
* Proposal 4.2: To ensure flexibility for network, the target CW is configured by RRC
* Proposal 4.3: Add the alternative of disabling a CW through rank indication
* Proposal 4.4: Add bracket to confirm the range of the N later
* Proposal 4.5: No update.
	+ @Apple: The previous agreement was intended for dynamic scheduling.
	+ @Ericsson, Intel: There are several scenarios, such as warehouse monitoring, port automation, factory setting where 2CW-based Type1 CG-PUSCH could be used to enhance spectrum efficiency of the network.

***~~Proposal 4.1: To configure dual CW PUSCH operation by an 8TX UE, down-select from,~~***

* ***~~Alt1: Max number of codewords is RRC configured.~~***
* ***~~Alt2: Max number of MIMO layers is RRC configured.~~***
* ***~~Note: Either alternative will be subject to UE capability.~~***

***~~Proposal 4.2: To support UCI multiplexing on PUSCH for transmission with rank>4 by an 8TX UE, UCI is always multiplexed only on one of the CWs,~~***

* ***~~Alt2: The CW with the highest MCS (if MCSs are the same, UCI is multiplex on the first CW)~~***

***~~Proposal 4.3: To support dual CW PUSCH operation by an 8TX UE, the DL principle is reused for disabling transmission of a transport block, where~~***

* ***~~The combination of IMCS = 26 and rvid = 1 indicated for a CW is used as an indication to disable transmission of its corresponding TB,~~***
* ***~~The remaining transport block is mapped to the first CW.~~***
* ***~~Note: When the transmission of a transport block is disabled, the maximum number of layers is ≤ 4.~~***

***~~Proposal 4.4: To support dual CW PUSCH operation by an 8TX UE,~~******~~if CBG-based transmission is configured, the DL principle for CBGTI DCI field is reused where,~~***

* ***~~The first half of CBGTI field bits is used to indicate the transmission state of CBGs of the first transport block, while the second half of CBGTI field bits is used to indicate the transmission state of CBGs of the second transport block.~~***
* ***~~The bit field may be configured to have a length of N bits that can support operation of N/2 CBGs, where N=2, 4, 6 or 8.~~***

***Proposal 4.1: To configure PUSCH transmission by an 8TX UE,***

* ***Alt2: Max number of MIMO layers is RRC configured by extending the range of the legacy parameter maxRank to 8***

***Proposal 4.2: To support UCI multiplexing on PUSCH for transmission with rank>4 by an 8TX UE, UCI is always multiplexed only on one of the scheduled CWs, where the target CW is configured by RRC from,***

* ***Alt1: First CW***
* ***Alt2: The CW with the highest MCS (if MCSs are the same, UCI is multiplex on the first CW)***

***Proposal 4.3: To support dual CW PUSCH operation by an 8TX UE, down-select from,***

* ***Alt1 – DL principle is reused for disabling transmission of a transport block, where***
	+ ***The combination of IMCS = 26 and rvid = 1 indicated for a CW is used as an indication to disable transmission of its corresponding TB,***
	+ ***The remaining transport block is mapped to the first CW.***
	+ ***Note: When the transmission of a transport block is disabled, the maximum number of layers is ≤ 4.***
* ***Alt2 – Disabling of a transport block can be implicitly determined from the indicated rank for re-transmission of a transport block.***

***Proposal 4.4: To support dual CW PUSCH operation by an 8TX UE,*** ***if CBG-based transmission is configured, the DL principle for CBGTI DCI field is reused where,***

* ***The first half of CBGTI field bits is used to indicate the transmission state of CBGs of the first transport block, while the second half of CBGTI field bits is used to indicate the transmission state of CBGs of the second transport block.***
* ***The bit field may be configured to have a length of N bits that can support operation of N/2 CBGs, where N=[2, 4, 6 or 8].***

***Proposal 4.5: To support dual CW PUSCH operation by an 8TX UE,***

* ***For Type-1 CG:*** ***A second mcsAndTBS parameters is configured in rrc-ConfiguredUplinkGrant.***
* ***For Type-2 CG:*** ***A second MCS field is added in DCI format activating a Type-2 CG-PUSCH.***

Table 5 - Companies’ views

|  |  |
| --- | --- |
| **Company** | **Perspective** |
| Google | 4.1: Support4.2: As we mentioned, current formulation on Alt2 would cause the incorrect CW selection when the indicated MCS is reserved MCS (e.g., MCS = 29/30/31 as follows). In our view, it should be “MCS with highest SE” instead of “the highest MCS”. Current Alt2 can only work for initial transmission.4.3: Support Alt1. 4.4: OK.4.5: For Type-2 CG, we think we should exclude DCI format 0\_0.  |
| NTT DOCOMO | 4.1: support.4.2: not support. We donot need to support two alts by configuration. One alt is sufficient.4.3: OK.4.4: support.4.5: support. |
| NEC | 4.1: Support.4.2: We also think there is no need of two schemes. Support Alt 2 only.4.3/4/5: Fine. |
| OPPO | Fine with 4.1, 4.3, 4.4 and 4.5.For 4.2, we prefer to down-select one of the options.  |
| Lenovo | Proposal 4.1: Support.Proposal 4.2: Do not support. We think Alt 1 is sufficient. We prefer Alt 1 due to its simplicity.Proposal 4.3-4.5: Support. |
| CATT | **Proposal 4.1:**Support.**Proposal 4.2**: Not support. We support Alt 2 and only one alt for this proposal is sufficient.**Proposal 4.3:**Support the proposal in general with preference on Alt2. Same view as in the last round discussion. Specifically, the indication mentioned is the same as that for PDSCH. For PUSCH, reusing the same scheme is not necessary. Since only one CW is enabled when rank$\leq $4, and 2 CWs are enabled when rank>4, the number of transmission layers can be used to determine whether the second transport block is disabled.**Proposal 4.4&4.5**: support. |
| ZTE | **Proposal 4.1:** Support.**Proposal 4.2:** Do not support the compromised Proposal 4.2. Since MCS fields of two CWs are all configured/indicated to UE, gNB can know which CW is multiplexed with the UCI bits. Therefore, no additional complexity will be introduced to gNB side if Alt 2 is adopted. Meanwhile, UCI capacity in Alt 2 will be higher than that Alt 1 due to the mapping of layer to CW. In short, it is unnecessary to support both Alts, so we prefer Alt 2.**Proposal 4.3**: Support Alt 1.In our understanding, Proposal 4.3 is for dynamical disabling one of the two CWs for PUSCH transmission with rank > 4, and the application scenario is for retransmission of PUSCH. For instance, UE is scheduled an initial transmission of a PUSCH with 2 CWs, and then gNB only requires UE to re-transmit either first or second CW of the PUSCH retransmission, the other CW can be dynamically disabled.However, for Alt 2, if the rank of initial transmission of PUSCH is indicated to be >4, and the rank of retransmission of PUSCH is indicated to be <4, UE can not know which CW/TB/UL-SCH should be disabled. It is confusing how Alt 2 work for dynamical disabling one of the CWs.In Alt 1, if the first CW is indicated to be disabled, only the second CW will be transmitted, and layers of PUSCH transmission will be <=4. In such case, from the perspective of specification, single CW is mapped for the PUSCH and it can be regarded as the first CW accordingly (i.e., q =0). In our view, ‘***The remaining transport block is mapped to the first CW.’*** in the proposal might be ambiguous, hence we prefer to revise the proposal as follows: ***Proposal 4.3: To support dual CW PUSCH operation by an 8TX UE, ~~down-select from~~,**** ***Alt1 – DL principle is reused for disabling transmission of a transport block, where***
	+ ***The combination of IMCS = 26 and rvid = 1 indicated for a CW is used as an indication to disable transmission of its corresponding TB,***
	+ ***The remaining transport block is mapped to the ~~first~~ enabled CW transmission.***
	+ ***Note: When the transmission of a transport block is disabled, the maximum number of layers is ≤ 4.***
* ***~~Alt2 – Disabling of a transport block can be implicitly determined from the indicated rank for re-transmission of a transport block.~~***

**Proposal 4.4:** Support in principle.**Proposal 4.5:** Support.Besides MCS parameter for CG-PUSCH, we would like to clarify the RV sequence parameter (*repK-RV*) as well. |
| MediaTek  | **Proposal 4.1:** Support.**Proposal 4.2:** We support down selecting one option only. Our preference is Alt 1. **Proposal 4.3/4.4 and 4.5:** Fine |
| QC | Proposal 4.1: supportProposal 4.2: don’t support. There is no need to introduce RRC signaling to support both in spec. Down selecting to one was agreed in last meeting and we should do the down selection. Proposal 4.3: support Alt 1. Proposal 4.4 and 4.5: support.  |
| Intel | *Proposal 4.1*Besides *maxRank*, the maximum number of layers is also configured by *maxMIMO-Layers*.Suggest the following update to make the proposal more accurate.***Proposal 4.1: To configure PUSCH transmission by an 8TX UE,*** * ***Alt2: Max number of MIMO layers is RRC configured by extending the range of the legacy parameter maxRank and maxMIMO-Layers to 8***

*Proposal 4.2*Similar view as other companies, it’s not necessary to have RRC configuration.*Proposal 4.3*For Alt 1, when the configured max number of layers is larger than 4, single CW is possible if the transmission rank is <=4. The note text should be updated for accuracy.For Alt 2, we don’t understand why it is only for retransmission.The following update is suggested.***Proposal 4.3: To support dual CW PUSCH operation by an 8TX UE, down-select from,**** ***Alt1 – DL principle is reused for disabling transmission of a transport block, where***
	+ ***The combination of IMCS = 26 and rvid = 1 indicated for a CW is used as an indication to disable transmission of its corresponding TB,***
	+ ***The remaining transport block is mapped to the first CW.***
	+ ***Note: When the transmission of a transport block is disabled, the ~~maximum~~ number of layers is ≤ 4.***
* ***Alt2 – Disabling of a transport block can be implicitly determined from the indicated rank ~~for re-transmission of a transport block~~.***

*Proposal 4.4*Generally fine.*Proposal 4.5*We still don’t see strong need for dual CW operation for CG PUSCH. But we could be open for discussion. |
| KDDI | Proposal 4.1: Support. We are also fine with intel’s modification.Proposal 4.2: As indicated by other companies, we also think that it is not necessary to have two schemes. Also, the agreement made in the last meeting mentions that one scheme is down-selected from the listed two schemes. So, we should do so.Proposal 4.3: Fine.Proposal 4.4: Support.Proposal 4.5: Support |
| Xiaomi | Proposal 4.1: fine with the proposalProposal 4.2: same view with companies, down selection is needed and we prefer alt.1.Proposal 4.3 ,4.4,4.5 : fine to support |
| Nokia, NSB | Proposal 4.1: supportProposal 4.2: supportProposal 4.3: okay Proposal 4.4: okayProposal 4.5: we may need to have a discussion on the support of the configured grant for 8Tx.  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

# Full Power Operation

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Agreement**Study full TX power uplink codebook-based transmission by a partially/non-coherent 8TX precoder,* Reuse Rel-16 UE capability definitions for discussion purpose, i.e., UE Capability 1, 2 and 3
* For full TX power transmission by UE Capability 2/3, at least, following exemplary PA architectures can be considered

Other cases of interest are not **precluded**, down-select preferred potential architecture for the purpose of 8TX full power study in RAN#112.* + This can be used for other UE Power Classes as well.

|  |
| --- |
| 8TX UE, Power class 3 (23 dBm)Pi= Nominal power rating of each PA |
|  | Regular UE | P1=P2= …=P8=14 dBm (Full power supported by Mode1) |
| Full-power capable UE | **Full power capability with any PA comb. (CAP1)**Example: P1=P2= …=P8= 23 dBm |
| **Full power capability with 1 PA (CAP3)**Example: P1=P2= …=P7= 14 dBmP8= 23 dBm |
| **(lower priority) Full power capability with 2 PAs (CAP2)**Example 2a: P1=P2= …=P6= 14 dBm, P7=P8 ≥ 20 dBmExample 2b:P1=P2= …= P8= 20 dBm |
| **(lower priority) Full power capability with 4 PAs (CAP2)**Example 3a: P1=P2= …=P4= 14 dBm, P5=P6= …=P8 ≥ 17 dBmExample 3b: P1=P2= …= P8 = 17 dBm |
| **(lower priority) Full power capability with 6 PAs (CAP2)**Example 4a: P1=P2= 14 dBm, P3=P4= …=P8 ≥ 15.3 dBmExample 4b: P1=P2= …= P8≥ 15.3 dBm |
|  |
|  |
|  |

**Agreement**For an 8TX partial/non-coherent precoder, for study on full power codebook-based PUSCH transmissions, use Rel-16 full power modes as the starting point for the design. Note: This does not mandate support of all Rel-16 modes. |

For an 8TX partial/non-coherent precoder, it has been agreed to re-use Rel-16 full power modes as the starting point for the design in Rel-18. Based on the definition of Mode0 and Mode1, an 8TX partial/non-coherent UE can re-use Rel-16 procedures for Mode0 and Mode1, respectively, with no and limited changes in specifications.

Following the discussion from the preparation phase, proposals 5.1 and 5.2 are adjusted to better reflect companies’ views. Furthermore, proposal 5.3 is added based on several companies’ interest. Here is a summary of the changes,

* Proposal 5.1: Added the FFS for evaluating the specification impact.
* Proposal 5.2: Clarified the bullet that any subset of full-coherent precoder can be used, and we can decide on the subset later. Also, as stated by several other companies, support of Mode1 does not have any impact on codebook or TPMI design, and vice versa.

***~~Proposal 5.1: To support full power transmission with Mode0, Rel-16 Mode0 (fullPower) is re-used with no change in specifications.~~***

***~~Proposal 5.2: To support full power transmission with Mode1, Rel-16 Mode1 (fullPowerMode1) is re-used with following enhancements,~~***

* ***~~Introduction of 8TX full power precoders and their associated TPMIs.~~***

***Proposal 5.1: To support full power transmission with Mode0, Rel-16 Mode0 (fullPower) is re-used.***

* ***FFS if any change is required in the specifications.***

***Proposal 5.2: To support full power transmission with Mode1, Rel-16 Mode1 (fullPowerMode1) is re-used.***

* ***FFS if more than one of the 8TX full coherent precoders is used.***

***Proposal 5.3: [Working Assumption] To support full power transmission with Mode2, Rel-16 Mode2 (fullPowerMode2) is re-used.***

* ***FFS definition of precoder groups (G0, G1, …)***
* ***FFS enhancements for SRS configuration***

Table 6 - Companies’ views

|  |  |
| --- | --- |
| **Company** | **Perspective** |
| Google | We think both proposal 5.2 and 5.3 should be a working assumption. |
| NTT DOCOMO | Okay with 5.1/5.2/5.3 in principle.For 5.2, suggest following revision.* ***FFS if more than one of the 8TX full coherent precoders is used per rank.***
 |
| OPPO | Fine with proposal 5.1, 5.2 and 5.3. |
| Lenovo | Proposal 5.1: SupportProposal 5.2: This should be discussed after the codebook is finalized.Proposal 5.3: This should be discussed after the codebook is finalized. |
| CATT | **Proposal 5.1:** Support. **Proposal 5.2:** More discussion is needed.**Proposal 5.3:** Support.  |
| ZTE | Fine with 5.1. For 5.2, we still prefer to deprioritize mode 1, till the codebook design is stable. For 5.3, mode 2 is a more flexible way, and can be supported with similar to R16 scheme or a simpler scheme for full power capability reporting for precoders. We don’t support mode 2 to be a working assumption.  |
| MediaTek | **Proposal 5.1**: Support**Proposal 5.2 and 5.3:** Not support.We believe these modes will depend on the codebook design and we prefer to deprioritize them at least until codebook design is complete. |
| QC | Support proposal 5.1, 5.2. Although we still have concerns on the heavy workload of mode 2, we don’t object the WA in proposal 5.3.  |
| Intel | Generally fine with Proposal 5.1, Proposal 5.2, and Proposal 5.3.But we think the wording of “*is re-used*” in the proposals is not accurate. Suggest replacing “*is re-used*” with “*is extended*”. |
| Xiaomi | Support in principle |
| Nokia, NSB | Proposal 5.1: supportProposal 5.2: supportProposal 5.3: support in general. However, more details might be needed. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

# TRI/SRI/TPMI Indication for Codebook UL Transmission

|  |
| --- |
| AgreementFor fully coherent uplink precoding by an 8TX UE, based on NR Rel-15 single panel DL Type I codebook, the following pairs of (N1, N2) values are supported,* (N1, N2) = (4, 1)
* (N1, N2) = (2, 2)`

A pair of (N1, N2) can be configured with subject to UE capability.**Agreement**For fully coherent uplink precoding by an 8TX UE, based on NR Rel-15 single panel DL Type I codebook (CodebookMode=1), * Study whether/how to support (O1, O2) = (2,1), (2,2)
	+ whether for all rank, or rank 1-2, or rank 3-8
	+ applicability of different (O1, O2) values per agreed (N1, N2)
	+ companies are encouraged to submit simulation results
 |

For precoding by coherent UEs, RAN1 has agreed to use NR Rel-15 single panel DL Type I codebook (CodebookMode=1). The next step of the discussion for coherent precoding is related to TPMI indication. Legacy TPMI definition has been based on simple indexing of different precoding options that can be re-used for the partial and non-coherent 8TX precoders. However, for TPMI indication of full-coherent precoders, where Rel-15 DL codebook is utilized, it seems more efficient to re-use the DL indication mechanism based on *ix* values.

*~~Proposal 6.1 - For TPMI indication of full-coherent codebook, the TPMI signaling is based on indication of i~~~~1,1~~~~, i~~~~1,2~~~~, i~~~~1,3~~ ~~and i~~~~2~~ ~~values.~~*

* *~~FFS details related to applicability of each value.~~*

|  |
| --- |
| **Agreement**For NCB-based 8TX PUSCH transmission with $N\_{SRS}>4$, where $N\_{SRS}$ is the number of configured single-port SRS resources in a resource set,* All SRS port combinations are supported
* For SRI indication, down-select from,
	+ Option 1: Use an $N\_{SRS}$ bit length bitmap
	+ Option 2: Use a legacy-based solution
* Consideration of Lmax for SRI indication

For $N\_{SRS}\leq 4$, Rel-15 SRI indication is reused |

In the last meeting, for a UE configured for NCB-based PUSCH transmission with $N\_{SRS}>4$, RAN1 has agreed to down-select from two identified options for SRI indication with following design principles,

* Support of all SRS port combinations,
* Consideration of Lmax for SRI indication,
* For $N\_{SRS}\leq 4$, Rel-15 SRI indication is reused.

***~~Proposal 6.2~~***

***~~Version A - For NCB-based 8TX PUSCH transmission with~~*** $N\_{SRS}>4$***~~, where~~*** $N\_{SRS}$ ***~~is the number of configured single-port SRS resources in a resource set,~~***

* *~~Support Option 1 where an~~* $N\_{SRS}$ *~~bit length bitmap is used~~*

***~~Version B - For NCB-based 8TX PUSCH transmission with~~*** $N\_{SRS}>4$***~~, where~~*** $N\_{SRS}$ ***~~is the number of configured single-port SRS resources in a resource set,~~***

* *~~Support Option 2 where a legacy-based solution is used.~~*

Another topic related to codebook-based operation is related to codebooksubset configuration. According to the legacy operation, fully-coherent UEs can be configured with 'fullyAndPartialAndNonCoherent', 'partialAndNonCoherent' or ‘nonCoherent’ codebook subset. However, given different nature of codebook design for fully-, partial- and non-coheremt UEs in Rel-18, the legacy mechanism cannot be easily realized and supported.

*~~Proposal 6.3: For codebook-based 8TX PUSCH transmission, legacy codebooksubset mechanism is not supported. Down-select from the~~*

* *~~Alt1. - Further study whether,~~*
	+ *~~A fully-coherent UE can be configured to operate only with partially- or non-coherent codebook.~~*
	+ *~~A partially-coherent UE can be configured to operate only with non-coherent codebook~~*
	+ *~~Note: This is subject to UE capability.~~*
* *~~Alt2. - Fully- and partially-coherent UEs cannot be configured with any other codebook, except their corresponding full- and partially-coherent codebooks.~~*

Based on the provided comments during the preparation phase, Proposal 6.1, 6.2 and 6.3 are updated. Here is a summary of the updates,

* Proposal 6.1: The only objective of Proposal 6.1 is to avoid creation of several tables as they exist today in the specifications. Needless to say, that the tables for 8TX will be even larger than the ones for 4TX. Also, as stated in the FFS, which *ix* to be used is for further discussion and not the intention of the proposal to specify which and in what range. Further, to address a comment, an additional FFS related to TRI is added.
* Proposal 6.2: There seem to be a majority in support for Version B, however Version A is still kept for this round. Also, for version B, alternative way-forwards are suggested for down-selection.
* Proposal 6.3: There were a few alternative formulations of the original proposal provided by companies. Based on the suggested alternatives, the proposal is updated, and an additional alternative is included.

*Proposal 6.1 - For TPMI indication of full-coherent codebook, support indication of a single field containing at least one of i1,1, i1,2, i1,3 and i2 values.*

* *FFS details related to range and applicability of each value.*
* *FFS whether the TRI is jointly indicated or separately.*

***Proposal 6.2***

***Version A - For NCB-based 8TX PUSCH transmission with*** $N\_{SRS}>4$***, where*** $N\_{SRS}$ ***is the number of configured single-port SRS resources in a resource set,***

* *Support Option 1 where an* $N\_{SRS}$ *bit length bitmap is used*

***Version B - For NCB-based 8TX PUSCH transmission with*** $N\_{SRS}>4$***, where*** $N\_{SRS}$ ***is the number of configured single-port SRS resources in a resource set,***

* *Support Option 2 where a legacy-based solution is used.*
* *Down-select from*
	+ *Alt1. – Extend the existing SRI indication tables to include NSRS=8 and lmax=8*
	+ *Alt2. – Reuse the existing SRI indication tables by dividing the NSRS ports to two groups of 4 ports*

*Proposal 6.3: For codebook-based 8TX PUSCH transmission, down-select from,*

* *Alt1*
	+ *A fully-coherent UE can be configured with fully- and partially- and non-coherent precoders*
	+ *A partially-coherent UE can be configured with partially- and non-coherent precoders*
	+ *A non-coherent UE can only be configured with non-coherent precoders*
* *Alt2*
	+ *A fully-coherent UE can only be configured with fully- or partially- or non-coherent precoders*
	+ *A partially-coherent UE can only be configured with partially- or non-coherent precoders*
	+ *A non-coherent UE can only be configured with non-coherent precoders*
	+ *FFS whether the configuration can be done dynamically, e.g., MAC-CE or DCI*
* *Alt3*
	+ *A fully-coherent UE can only be configured to operate with fully-coherent precoders*
	+ *A partially-coherent UE can only be configured to operate with partially precoders*
	+ *A non-coherent UE can only be configured with non-coherent precoders*

Table 7 - Companies’ views

|  |  |
| --- | --- |
| **Company** | **Perspective** |
| Google | 6.1: Support in principle6.2: Support version B.6.3: For partial-coherent, we think we need to consider 4-port partial coherent and 2-port partial coherent. We suggest adding the following alternative:* *Alt4*
	+ *A fully-coherent UE can be configured with fully-coherent and partially-coherent (Ng=2 and Ng=4) and non-coherent precoders*
	+ *A partially-coherent UE (Ng=2) can be configured with partially-coherent (Ng=2 and Ng=4) and non-coherent precoders*
	+ *A partially-coherent UE (Ng=4) can be configured with partially-coherent precoders (Ng=4) and non-coherent precoders*
	+ *A non-coherent UE can only be configured with non-coherent precoders*
 |
| NTT DOCOMO | 6.1: OK.6.2: slightly prefer version A. Also okay with version B.6.3: If we consider the two partial coherent cases separately, as suggested by Google, we suggest adding sub-alt under partially-coherent UE for each Alt.*Proposal 6.3: For codebook-based 8TX PUSCH transmission, down-select from,* * *Alt1*
	+ *A fully-coherent UE can be configured with fully- and partially- (Ng=2 and Ng=4) and non-coherent precoders*
	+ *A partially-coherent UE can be configured with partially- and non-coherent precoders*
		- *Alt1-1: A partially-coherent UE (Ng=2) can be configured with partially-coherent (Ng=2 and Ng=4) and non-coherent precoders. A partially-coherent UE (Ng=4) can be configured with partially-coherent precoders (Ng=4) and non-coherent precoders*
		- *Alt1-2: xxx*
	+ *A non-coherent UE can only be configured with non-coherent precoders*
* *Alt2*
	+ *A fully-coherent UE can only be configured with fully- or partially- (Ng=2 or Ng=4) or non-coherent precoders*
	+ *A partially-coherent UE can only be configured with partially- or non-coherent precoders*
		- *A partially-coherent UE (Ng=2) can only be configured with partially-coherent (Ng=2) or non-coherent precoders. A partially-coherent UE (Ng=4) can only be configured with partially-coherent precoders (Ng=4) or non-coherent precoders.*
	+ *A non-coherent UE can only be configured with non-coherent precoders*
	+ *FFS whether the configuration can be done dynamically, e.g., MAC-CE or DCI*
* *Alt3*
	+ *A fully-coherent UE can only be configured to operate with fully-coherent precoders*
	+ *A partially-coherent UE can only be configured to operate with partially precoders*
		- *A partially-coherent UE (Ng=2) can only be configured with partially-coherent (Ng=2). A partially-coherent UE (Ng=4) can only be configured with partially-coherent precoders (Ng=4).*
	+ *A non-coherent UE can only be configured with non-coherent precoders*
 |
| OPPO | 6.1: Fine6.2: Support version B.6.3: Fine with the proposal.  |
| Lenovo | Proposal 6.1: OK.Proposal 6.2: Support Version A. A bitmap-based design reduces the standardization effort.Proposal 6.3: We prefer to postpone this decision after the precoders for full/partial(Ng=2,4)/non-coherent UEs are finalized. |
| CATT | **Proposal 6.1:**Not support. It is our view that codebook design should be discussed firstly. BTW, we are fine for adding more tables on the specs.**Proposal 6.2:** Support version B. Alt 1 is preferred.  **Proposal 6.3**:Support Alt 1. |
| ZTE | **Proposal 6.1**: Support in principle**Proposal 6.2:** Support version B and select Alt1. From perspective of spec drafting, it may not need 8 tables for Lmax=1, 2, ..., 8, as legacy. That would be very redundant. It can define only one complete table for Lmax=8, then describe that only part of entries are used for other values of Lmax for each column of NSRS. For Alt2, the overhead cannot be reduced in some cases, e.g., if Lmax=2, and 2 SRS resources are from 2 groups, two 4-bit SRIs are needed with Alt2, but only 5 bits is needed with Alt1. **Proposal 6.3:** For partial-coherent, we agree with DOCOMO’s suggestion for clarification. Among the 3 Alts, we prefer Alt2 in principle, and suggest the following changes based on DOCOMO’s version:* *Alt2*
	+ *A fully-coherent UE can only be configured with at least one of fully- or partially- (Ng=2 ) or partially-(Ng=4) or non-coherent precoders*
	+ *A partially-coherent UE can only be configured with at least one of partially- or non-coherent precoders*
		- *A partially-coherent UE (Ng=2) can only be configured with at least one of partially-coherent (Ng=2) or partially-(Ng=4) or non-coherent precoders.*
		- *A partially-coherent UE (Ng=4) can only be configured with at least one of partially-coherent precoders (Ng=4) or non-coherent precoders.*
	+ *A non-coherent UE can only be configured with non-coherent precoders*
	+ *FFS whether the configuration can be done dynamically, e.g., MAC-CE or DCI*
 |
| MediaTek | **Proposal 6.1**: Support in principle**Proposal 6.2:** Support Version A, as it is a simpler design. **Proposal 6.3:** Agree with the modified proposal by DOCOMO/ZTE. We prefer Alt 3. |
| QC  | Proposal 6.1: Don’t support. Whether reuse *i1,1, i1,2, i1,3 and i2* or define a table for 8 Tx coherent CB can be up to editor. Proposal 6.2: Support version B. Given we already agreed $N\_{SRS}\leq 4$ use legacy approach, we support $N\_{SRS}>4$ also using legacy approach to have a unified signaling design. It does not make sense to have two different signalling designs for $N\_{SRS}\leq 4$ and $N\_{SRS}>4. $If bitmap was agreed for $N\_{SRS}\leq 4$, we could support it for $N\_{SRS}>4$ as well. But that is not the case here.Proposal 6.3: needs more discussion. What is the different between Alt 1 and Alt 2? Is the only difference the FFS? We don’t support adding the FFS. We don’t see the motivation to change the configuration dynamically.  |
| Intel | *Proposal 6.1*Support the proposal in principle.*Proposal 6.2*Prefer with Version B. We also think rank restriction could be introduced to further reduce the overhead.In Alt 1 of Version B, why only N\_SRS=8 is included? What about N\_SRS=5,6,7?*Proposal 6.3*Some question for clarification. What is the difference among the alternatives regarding the codebook subset configuration? |
| Xiaomi | Proposal 6.1: Do not support. Indication of the parameters leads to higher DCI overhead generally.Proposal 6.2: prefer Version A. Proposal 6.3: Fine with Google’s or DOCOMO’s versions. |
| Nokia, NSB | Proposal 6.1: we are supportive to the general principle. Proposal 6.2: Support Version A:Proposal 6.3: Alt3 shall be the default choice. Alt 1 and Alt2 provide more flexibility. We need to justify the benefit (gains?) of using Alt 1/2 if more flexible Alt 1 or Alt 2 is supported. |
| QC2 | A question to DCM: Regarding this proposal “*Alt1-1: A partially-coherent UE (Ng=2) can be configured with partially-coherent (Ng=2 and Ng=4) and non-coherent precoders…*”, do we really such flexibility, i.e., to configure a Ng=2 partial coherent UE as a Ng=4 partial coherent UE? This seems like an over-design to me.  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

# Feature-lead Proposals for Approval

# Round 1

# Round 2

# Round 3

# List of Companies’ Proposals

|  |  |
| --- | --- |
| **InterDigital** | ***Proposal 1:*** *Confirm the working assumption to support dual codeword when more than 4 layers, where it is applicable associated with considered UE types, coherency types, etc., based on UE capability.* ***Proposal 2:*** *For UCI multiplexing on PUSCH for transmission with rank>4 by an 8TX UE, support multiplexing the UCI on the CW with the highest MCS (if MCSs are the same, UCI is multiplex on the first CW).* ***Proposal 3:*** *Consider UE to report its capabilities on the number of antenna groups, supported type of antenna/panel structure or virtualization capability across UE antenna ports, etc.* ***Proposal 4:*** *For partially coherent uplink precoding for 8TX UE, consider supporting a precoder generation capturing from Rel-15 UL 4TX codebook commonly for both Ng=2 and Ng=4.* ***Proposal 5:*** *For fully-coherent precoding case based on using NR Rel-15 single panel DL Type I codebook, supported pairs of (N1, N2) values should be a part of UE capability parameters, and a pair of them can be confirmed by RRC to be enabled and used for the UE.* ***Proposal 6:*** *Only the pair of (O1, O2) = (1, 1) is supported as a minimal set of oversampling factors supported for fully coherent uplink precoding by an 8TX UE, based on NR Rel-15 single panel DL Type I codebook, in consideration of the overhead associated for precoding indication.* ***Proposal 7:*** *RAN1 studies determination of preferred basis vectors based on UE’s precoded SRS transmissions, where the gNB can signal preferred basis vectors, through SRI indication.* ***Proposal 8:*** *To reduce signaling overhead associated to SRI/TPMI indication for a 8TX UE, RAN1 studies partial update of TPMI/SRI information for 8TX UE.* ***Proposal 9:*** *RAN1 defines some basic PA architecture for UEs with CAP2 capability.*  |
| **Huawei, HiSilicon** | ***Proposal 1:*** *Confirm the WA that supporting dual CW for uplink transmission with rank>4.* ***Proposal 2:*** *For dual CW PUSCH transmission with up to 8 layers by an 8TX UE** *support to reuse Rel-15 NR DL scheme to indicate CBGTI*
* *support to reuse Rel-15 NR DL enabling/disabling scheme*
* *support to always multiplex UCI on the CW with the highest MCS.*

***Proposal 3:*** *For SRS configuration required for non-codebook-based UL transmission by an 8TX UE, configuration of up to two, or four SRS resource sets is not supported.* ***Proposal 4:*** *For NCB-based 8TX PUSCH transmission with* 𝑵𝑺𝑹𝑺>𝟒*, a legacy-based SRI indication solution is supported.* ***Proposal 5:*** *Consider to use the reserved NDI field of the disabled transport block for rank<=4 to reduce DCI overhead.* ***Proposal 6*：***For fully coherent precoder by an 8TX UE, don’t support larger O1, O2 values.* ***Proposal 7*：***For fully coherent precoder by an 8TX UE, support to enhance DL Type I SP codebook to mitigate the impact of phase alignment error.* ***Proposal 8*：***For partially coherent precoder with Ng=2 by an 8TX UE, support all possible layer splitting schemes for each rank.* ***Proposal 9*：***For partially coherent precoder with Ng=4 by an 8TX UE, support to design precoder based on Rel-15 UL 4TX codebook.* ***Proposal 10*：***For partially/non-coherent precoder by an 8TX UE, support the following precoding structures* * *For rank = 1*
	+ $\left[\begin{matrix}A\\0\_{4×1}\end{matrix}\right]\_{8×1}$ ***or*** $\left[\begin{matrix}0\_{4×1}\\A\end{matrix}\right]\_{8×1}$
* *For rank = 2, 3, 4*
	+ $\left[\begin{matrix}A\\0\_{4×rank}\end{matrix}\right]\_{8×rank}$ ***or*** $\left[\begin{matrix}0\_{4×rank}\\A\end{matrix}\right]\_{8×rank}$***or*** $\left[\begin{matrix}A\_{1}&0\_{4×rank(A2)}\\0\_{4×rank(A1)}&A\_{2}\end{matrix}\right]\_{8×rank}$
* *For rank >4,*
	+ $\left[\begin{matrix}A\_{1}&0\_{4×rank(A2)}\\0\_{4×rank(A1)}&A\_{2}\end{matrix}\right]\_{8×rank}$

*where* 𝑨*,* 𝑨𝟏 *and* 𝑨𝟐 *are fully coherent or partially coherent or non-coherent precoding matrices taken from Rel-15 UL 4TX codebook for partial coherent precoders with Ng=2 or partial coherent precoders Ng=4 or non-coherent precoders.* ***Proposal 11:*** *The beamformed CSI-RS should be considered to indicate UL precoders to UE.* |
| **ZTE** | ***Proposal 1:*** *Regarding full-coherent codebook design for UL 8-Tx based on Rel-15 DL type I codebook, value range of parameters of DL Type-I 8-Tx codebook should be determined as:* * *(O1, O2) = (2, 2) can be supported for (N1, N2) = (2, 2), at least for lower ranks, e.g., 4 for rank<=2 or 3*
* *(O1, O2) = (2, 1) can be supported for (N1, N2) = (4, 1) and (N1, N2) = (2, 2), at least for lower ranks, e.g., 4 for rank<=2 or 3*
* *Definition and range of (i1,1, i1,2, i1,3, i2) in DL Type-I 8-Tx codebook should be reused.*

***Proposal 2:*** *Regarding partial-coherent codebook design for UL 8-Tx with Ng=2 and Ng=4 based on NR Rel-15 UL 4-Tx/2-Tx UL codebooks,* - *For TPMI of each port group, only full-coherent UL 4-Tx/2-Tx UL codebook is preferred instead of full+partial+non coherent UL 4-Tx/2-Tx UL codebooks,* - *For layer splitting, group balanced codebooks can be supported without rank permutation; group selected codebooks can be considered for some UEs with special antenna layout; other codebooks should NOT be supported.* ***Proposal 3:*** *Regarding non-coherent codebook design, the following aspects can be considered to reduce number of candidate non-coherent codebooks:* * *Number of port groups*
* *Limited starting port index, e.g., depending on number of port groups*
* *A predefined port index order, e.g., (0,4,1,5,2,6,3,7)*

***Proposal 4:*** *Regarding port index order,* * *For Ng=2, select Alt 2: two coherent groups of {0,1,4,5} and {2,3,6,7}*
* *For Ng=4, select* *Alt 1: four coherent groups of {0,4}, {1,5}, {2,6}, and {3,7}*

***Proposal 5:*** *Regarding codebook indication for 8-Tx, individual TPMI indication for each group based on indication of number of port groups should be supported:* * *For 1-group: one TPMI indicates one 8Tx precoder which needs new defined UL 8Tx codebook for rank 1-8*
* *For 2-group: 2 TPMI (rank and UL precoding info), and each for a respective port group*
* *For 4-group: 4 TPMI (rank and UL precoding info), and each for a respective port group*
* *For 8-group or non-coh: 8 or less bits indicate presence of respective ports*

***Proposal 6:*** *Regarding overhead reduction for codebook indication for 8-Tx:* * *A set of available Ng(s) can be configured by RRC, and then one from the set can be dynamically indicated for a scheduled PUSCH transmission.* ▪ *For instance, for a UE supporting full-coherent 8-Tx ports, a list of candidate values of Ng=1, and Ng=2 can be configured by RRC, and DCI only needs to indicate one of them as UL codebook selection.*

***Proposal 7:*** *Regarding codebook-based SRS configuration,* * *One SRS resource set is enough, i.e., no need to extend to more than one SRS resource set.*
* *One SRI in one SRS resource set indicating one SRS resource is enough, i.e., no need to support more than one SRI in one SRS resource set, or one SRI to indicate more than one SRS resource to combine 8 ports.*

***Proposal 8:*** *Regarding non codebook based transmission design for 8-Tx, option 2 is supported for SRI indication* * *Option 2: Use a legacy-based solution*

***Proposal 9:*** *Regarding non-codebook-based SRS configuration,* * *One SRS resource set is enough, i.e., no further extension for having more than one SRS resource set.*

***Proposal 10:*** *To support 2 CWs for PUSCH transmission with rank > 4, CBGTI field is used as for legacy PDSCH, i.e., the first half of CBGTI field bits is used to indicate the transmission state of CBGs of the first transport block, while the second half of CBGTI field bits is used to indicate the transmission state of CBGs of the second transport block.* ***Proposal 11:*** *To support 2 CWs for CG-PUSCH transmission with rank > 4, support to introduce MCS, RV, NDI and CBGTI field for the second transport block of DG-PUSCH in DCI format 0\_1 and format 0\_2.* * *For Type-1 CG-PUSCH, a second MCS field is indicated in DCI format activating the CG-PUSCH.*
* *For Type-2 CG-PUSCH, a second mcsAndTBS parameter is configured for the second CW.*
* *A RV sequence parameter (repK-RV) is commonly used by two codewords.*

***Proposal 12:*** *To support 2 CWs for UL 8-Tx transmission, disabling one of the codewords can be applied in case of retransmission of one of the CWs, where the CW which does not require retransmission can be disabled.* * *Note: Legacy mechanism defined for PDSCH to disable one of the CWs is reused.*

***Proposal 13:*** *To support UCI multiplexing on PUSCH with rank>4, UCI is multiplexed on the CW with the highest MCS (Alt 2).* ***Proposal 14****: Regarding full power mode for Rel-18 UL Tx, full power mode 2 is supported as a starting point.* |
| **vivo** | ***Proposal 1****: Configuration of up to two SRS resource sets, each configured with up to 4, or 2 single-port SRS resources is supported.****Proposal 2:*** *At least for 1 max L = when 𝑵𝑺𝑹𝑺 > 𝟒 legacy combinatorial SRI indication is supported, and for larger 𝑳max value when 𝑵𝑺𝑹𝑺 > 𝟒 bitmap is used to indicate SRI.****Proposal 3****: Support indicating 2 SRI fields in DCI, which jointly indicates transmission rank. Further study whether/how to split number of layers between two SRI fields.****Proposal 4****: For 8Tx UE, support SRS configuration of an SRS resource set, configured with at least two 4-port SRS resources.****Proposal 5:*** *At least for configured max rank=1, TPMI indices as in legacy is used, for larger configured max rank value a bitmap of 8 bits is used to indicate precoders.****Proposal 6:*** *Support indicating 8Tx non-coherent precoder by 2 TPMI fields in DCI, further study how to select one of the 2 TPMI fields, e.g. for rank=1 transmission****Proposal 7:*** *for rank>4, if dual CW is supported, support one CW is transmitted from one antenna group****Proposal 8****: Support antenna port grouping as {0, 2, 1, 3} and {4, 6, 5, 7}, legacy 4Tx precoders can be applied directly where antenna group {4, 5, 6, 7} corresponds to precoder elements {0, 1, 2, 3}.****Proposal 9:*** *For UEs supporting 2CWs transmission, different codebook subsets are used when 2nd CW is disabled and 2nd CW is enabled by DCI.****Proposal 10****: Codebook constructed by two 4Tx precoders indicated by two TPMI fields is supported for partial-coherent 8Tx UE, one codebook can support antenna structure with Ng=2 and Ng=4.****Proposal 11:*** *Support additional field in DCI to indicate whether one or both of the 2 TPMI fields are applicable for current transmission.****Proposal 12:*** *Do not support additional precoders generated via Alt2a****Proposal 13:*** *Do not support other O1, O2 values than 1, 1 for all rank values****Proposal 14:*** *TPMI for full coherent codebook is generated by sequential indexing of codebook parameters such as rank, i\_1,1, i\_1,2, i\_1,3.****Proposal 15:*** *Confirm the working assumption “for uplink transmission with rank>4, support dual CW transmission”.****Proposal 16:*** *Maximum number of codewords is RRC configured, and second codeword is enabled/disabled dynamically indicated by DCI.****Proposal 17:*** *Support alt 2, that is, UCI is multiplexed on the CW with highest MCS.****Proposal 18:*** *Consider the following full power enhancement for CPE/FWA 8 Tx operation.** *Depending on UE capability, UL full-power mode0 is supported.*
* *Depending on UE capability, UL full-power mode1 can be supported by introducing non-antenna selection matrices, especially for lower rank*
* *Depending on UE capability, further discuss UL full-power mode2 for partial and non-coherent UEs*
	+ *For partial-coherent codebook, take Ng values {2, 4} into account for full-power precoders grouping*

***Proposal 19:*** *Discuss potential UE capabilities/features after the overall design becomes clear.****Proposal 20:*** *Further discuss PTRS-DMRS association indication when rank>4, if supported* |
| **OPPO** | ***Proposal 1:*** *For full-coherent uplink codebook, (O1 O2) = (1,1) is sufficient.****Proposal 2:*** *For partial-coherent uplink codebook with Ng=4, Alt2 is preferred for unified signaling design with different values of Ng.****Proposal 3:*** *For partial-coherent uplink codebook with Ng=2, the following layer splitting is supported for each rank:** *(1,1) or (0,2) or (2,0) for rank2*
* *(1,2) or (0,3) or (3,0) for rank3*
* *(2,2) for rank4*
* *(2,3) for rank5*
* *(3,3) for rank6*
* *(3,4) for rank7*
* *(4,4) for rank8*

***Proposal 4:*** *For non-coherent 8Tx codebook, consider whether all the antenna port combinations are supported or not.* ***Proposal 5:*** *Strive for unified TPMI signaling at least for partial coherent codebook with different Ng and non-coherent codebook.****Proposal 6:*** *For Ng=2, support two coherent groups of {0,1,4,5} and {2,3,6,7}; For Ng=4, support four coherent groups of {0,4}, {1,5}, {2,6} and {3,7}.****Proposal 7:*** *Support separate indication of TRI and TPMI.****Proposal 8:*** *Multiple SRS resource sets for CB or NCB based 8-port transmission is not needed.* ***Proposal 9:*** *one SRI/TRI/TPMI indication is sufficient for uplink codebook based 8-port transmission.* ***Proposal 10:*** *For uplink transmission with rank>4, support UCI to be always multiplexed on the first CW.****Proposal 11:*** *For NCB-based 8TX PUSCH transmission with NSRS>4, prefer option 2 (legacy mechanism) for SRI indication.* ***Proposal 12:*** *For study of full power transmission, antenna ports in one antenna port group can be assumed with the same maximal transmit power.* |
| **Spreadtrum Communications** | ***Proposal1:*** *For a fully-coherent uplink precoding by an 8TX UE,* * *Only support NR Rel-15 single panel DL Type I codebook.*
* *Only support Ng=1.*

***Proposal 2:*** *For a partially-coherent 8TX UE with Ng=2, support the following precoding structure based on Rel-15 UL 4TX fully-coherent codebook** $\left[\begin{matrix}A\\0\_{4×1}\end{matrix}\right]\_{8×1}$ *or* $\left[\begin{matrix}0\_{4×1}\\A\end{matrix}\right]\_{8×1}$*for rank=1*
* $\left[\begin{matrix}A\\0\_{4×rank}\end{matrix}\right]\_{8×rank}$ *or* $\left[\begin{matrix}0\_{4×rank}\\A\end{matrix}\right]\_{8×rank}or\left[\begin{matrix}A\_{1}&0\_{4×rank(A2)}\\0\_{4×rank(A1)}&A\_{2}\end{matrix}\right]\_{8×rank}$ *for rank=2~4*
* $\left[\begin{matrix}A\_{1}&0\_{4×rank(A2)}\\0\_{4×rank(A1)}&A\_{2}\end{matrix}\right]\_{8×rank}$ *for rank=5~8*

*where* 𝑨, 𝑨𝟏 *and* 𝑨𝟐 *are precoding matrices taken from Rel-15 4TX UL fully-coherent codebook.* ***Proposal 3:*** *For a partially-coherent 8TX UE with Ng=4, support the similar principle as Ng=2, i.e. the precoding matrices for 4 antenna groups are taken from Rel-15 2TX UL fully-coherent codebook.* ***Proposal 4:*** *For a non-coherent 8TX UE, support the same codebook structure as partially-coherent codebook, and the precoding matrices can be taken from Rel-15 4TX UL non-coherent codebook for Ng=2 and from Rel-15 2TX UL non-coherent codebook for Ng=4.* ***Proposal 5:*** *For enabling/disabling CW,* * *An RRC parameter is configured in PUSCH-config to indicate the maximal number of CWs scheduled by DCI.*
* *The special values of MCS field and RV field can be used to enable/disable the corresponding transport block.*

***Proposal 6:*** *For CBG based dual CW transmission for PUSCH, the design principle in DL DCI can be reused for CBGTI field in UL DCI.* ***Proposal 7:*** *For UCI multiplexing on PUSCH, support Alt1, i.e. UCI is always multiplexed on the first CW.* ***Proposal 8:*** *Don’t support more than one SRS resource sets configuration for non-codebook-based UL transmission by an 8TX UE.****Proposal 9:*** *For SRI indication for non-codebook-based UL transmission by an 8TX UE, support Option 2, i.e. legacy-based solution.****Proposal 10:*** *Consider the potential method to reduce SRI overhead.* ***Proposal 11:*** *Only support one SRS resource set containing 8-port SRS resource(s) for codebook-based UL transmission by an 8TX UE.* ***Proposal 12:*** *For codebook-based 8TX PUSCH transmission, TPMI design should be decided after codebook design.* ***Proposal 13:*** *Support full power mode1 for an 8TX UE and introduce 8TX full power precoder(s).* |
| **CATT** | ***Proposal 1:*** *For UL 8TX operation, whether a subset or all of precoding matrices in non-coherent codebook are included in partial-coherent codebook and full-coherent codebook shall be studied.****Proposal 2:*** *For UL 8TX operation, if a subset of port selection precoding matrices is supported for non-coherent codebook, where all port selection precoding matrices for low ranks (e.g. for rank=1,2) are kept and precoding matrices for high ranks (e.g. for rank>2) are down selected.* ***Proposal 3:*** *For partially coherent uplink precoding by an 8TX UE codebook, Ng=2, the following rank and layer splitting cases are supported:* * *For rank 1, support (1,0) and (0,1);*
* *For rank 2, support (1,1);*
* *For rank 3, support (1,2);*
* *For rank 4, support (2,2);*
* *For rank 5, support (2,3);*
* *For rank 6, support (3,3);*
* *For rank 7, support (3,4);*
* *For rank 8, support (4,4).*

***Proposal 4:*** *For partially coherent uplink precoding by an 8TX UE codebook, Ng=2,** *For rank 3, precoding design is based on Rel-15 UL 4TX codebook with a full-coherent precoder and a partial-coherent precoder used;*
* *For rank 5, precoding design is based on Rel-15 UL 4TX codebook with two partial-coherent precoders used;*
* *For rank 7, precoding design is based on Rel-15 UL 4TX codebook with a partial-coherent precoder and a non-coherent precoder used.*

***Proposal 5****: For partially coherent uplink precoding (maxRank = 4) by an 8TX UE codebook, Ng=4,* * *Precoding design is based on Rel-15 UL 2TX codebook,*
	+ *If Alt 1 (i.e., precoding design is based on Rel-15 UL 2TX codebook) is adopted, down selection on precoders for several ranks is considered to restrict the codebook size be the same level as that for Ng=4.*
	+ *If Alt 2 (i.e., precoding design is based on Rel-15 UL 2TX codebook) is adopted, the number of precoding matrixes for rank 3 and rank 4 shall be larger than that for rank 1 and rank 2.*

***Proposal 6:*** *For fully coherent uplink precoding by an 8TX UE, based on NR Rel-15 single panel DL Type I codebook (CodebookMode=1), combinations of (O1, O2) other than (1, 1) are not supported.* ***Proposal 7:*** *For TPMI indication for codebook based 8TX PUSCH, the legacy framework in Rel-15 is reused, i.e., TPMI and TRI are jointly indicated by a single field.****Proposal 8:*** *For SRS configuration for non-codebook based 8TX PUSCH, except for M-TRP transmission schemes, configuring multiple SRS resource sets is not supported.* ***Proposal 9:*** *For NCB-based 8TX PUSCH transmission with 𝑵𝑺𝑹𝑺>𝟒, a legacy-based SRI indication solution is supported.* ***Proposal 10:*** *For NCB-based 8TX PUSCH transmission, candidate values of 𝑳𝒎𝒂𝒙 is extended to include values of up to 8.****Proposal 11:*** *Confirm the following working assumption:** *For uplink transmission with rank>4, support dual CW transmission.*

***Proposal 12:*** *For PUSCH transmission with rank>4, UE always applies 2 CWs transmission.****Proposal 13:*** *For codebook based 8TX PUSCH transmission, maxRank and maxRankDCI-0-2 are used to indicate whether two CWs transmission is enabled for DCI format 0\_1 and 0\_2 respectively.* ***Proposal 14:*** *For non-codebook based 8TX PUSCH transmission, maxMIMO-Layers, if is configured, is used to indicate whether 2 CWs transmission is enabled; if maxMIMO-Layers is not configured, if the maximum number of layers for PUSCH supported by the UE is larger than 4, 2 CWs transmission is enabled, and if the maximum number of layers for PUSCH supported by the UE is no more than 4, 2 CWs transmission is disabled.* ***Proposal 15:*** *For 8TX PUSCH transmission, if 2 CWs for rank>4 is supported, the number of transmission layers for the PUSCH is used to determine whether the second transport block is disabled.* ***Proposal 16:*** *To support UCI multiplexing on PUSCH for transmission with rank>4 by an 8TX UE, UCI is always multiplexed only on the CW with the highest MCS (if MCSs are the same, UCI is multiplex on the first CW).* ***Proposal 17:*** *To support dual CW PUSCH transmission for rank>4 by an 8TX UE, two new fields are used to indicate the second set of NDI (1 bit) and RV (2 bits) fields respectively.****Proposal 18:*** *For 8TX PUSCH transmission with rank > 4 and configured with maximum 2 PTRS ports, the reserved field in antenna ports field is used to indicate the associated DMRS for UL PTRS port 1.****Proposal 19:*** *For an 8TX UE with UE Capability 1, scaling factor s=1 for all precoders is supported.****Proposal 20:*** *Support Rel-16 UL FTxP mode 2 for an 8TX UE with UE Capability 2/3.* |
| **Lenovo** | ***Proposal 1:*** *Use antenna grouping to represent different UL Tx coherence assumptions, with the following conditions* * *Antennas within an antenna group are coherent.*
* *Antennas within an antenna group are uniformly spaced.*
* *Antenna configurations of different antenna groups are identical.*
* *Coherence assumptions of two antennas across two antenna groups are the same.*

***Proposal 2:*** *A number of antenna coherence groups Nc is used to characterize the coherence assumption across Ng antenna groups, where Nc is the number of antenna groups in which all antennas of the antenna groups are coherent, and* 𝑵𝒄≤𝑵𝒈*.* ***Proposal 3:*** *For coherence-based antenna grouping under partial-coherent UEs:* * *Nc=2: Support Alt-2, i.e.,: two coherent groups of {0,1,4,5} and {2,3,6,7}*
* *Nc=4: Support Alt-1, i.e.,: four coherent groups of {0,4}, {1,5}, {2,6}, and {3,7}*

***Proposal 4:*** *Support layer splitting across two antenna groups in Table 1 for Ng=2.* ***Proposal 5:*** *Support to have separate fields for TRI and TPMI in the DCI.* ***Proposal 6:*** *At least for rank 1 and 2, consider using non-coherent and partial coherent and full coherent codewords from R15 rank 1 codebook.* ***Proposal 7:*** *When codewords for each antenna group can be non-coherent or partial coherent or full coherent codeword, the two 4TX codewords shall have the same type.* ***Propoal 8:*** *The TPMI field indicates a combination of two precoding matrices of the corresponding rank for the two antenna groups.* ***Proposal 9:*** *Support to base the precoders for Ng=4 on R15 2TX full coherent codewords (Alt 1).* ***Proposal 10:*** *Construct the rank 1 and rank 2 codebook for individual antenna group for Ng=4 using the four rank 1 full coherent precoders* (𝟏√[$\begin{matrix}1\\1\end{matrix}$],𝟏√𝟐[$\begin{matrix}1\\-1\end{matrix}$],𝟏√𝟐[$\begin{matrix}1\\j\end{matrix}$],𝟏√𝟐[$\begin{matrix}1\\-j\end{matrix}$]) *alone, and apply multiple such codewords to multiple antenna groups for high rank transmission.****Proposal 11:*** *For Ng=4, r=1,2,3, the TPMI signals r rank-1 2TX full coherent precoders for r antenna groups, each codeword applied to an antenna group.* ***Proposal 12:*** *For Ng=4, r=4, the four rank-1 2TX full coherent precoders are applied to the four antenna groups in a fixed order, giving a single rank-4 precoder.* ***Proposal 13:*** *For Ng=4, r>4, r-4 additional rank-1 2TX full coherent precoders are applied to r-4 antenna groups on top of the respective rank-1 precoders used for rank-4 transmission, making these r-4 antenna groups each transmit two layers. The additional rank-1 2TX full coherent precoders shall be different from the rank-1 precoders used for rank-4 transmission in the same group, and shall be different from each other.* ***Proposal 14:*** *The TPMI field in the DCI scheduling PUSCH signals (antenna groups, codewords) combination jointly.* ***Proposal 15:*** *Study mechanism to indicate paramters for a UE to obtain a full coherent precoding matrix and use only mode 1 of Rel-15 DL Type 1 codebook for full coherent 8TX UE.****Proposal 16:*** *TPMI signaling overhead is considered as a performance metric together with the performance.* ***Proposal 17:*** *For full coherent UE, support (O1, O2)=(2,1) for (N1,N2)=(4,1), and (O1, O2)=(2,2) for (N1,N2)=(2,2) in addtion to* (O1, O2) = (1, 1)*.* ***Proposal 18:*** *Define the supported values for* (O1, O2) as UE capability. ***Proposal 19:*** *Introduce bitmap based TPMI indication for non-coherent 8Tx.* ***Proposal 20:*** *Introduce bitmap based SRI indication for non-codebook based 8Tx PUSCH transmission for NSRS>4.* ***Proposal 21:*** *Introduce two SRI fields for transmission rank higher than 4.* ***Proposal 22:*** *The maximal number of layer is RRC configured subject to UE capability. When a UE is configured to support more than 4 layers of PUSCH transmission, dual CW is automatically enabled.****Proposal 23:*** *When dual CWs PUSCH transmission is enabled by the NW, the UL grant should indicate the MCS, NDI, RV indication for the second CW.****Proposal 24:*** *For two codewords, UCI is always multiplexed in the first codeword.****Proposal 25:*** *Support permutation of the layers in the precoding matrix.* ***Proposal 26:*** *De-prioritize the full power operation for partial and non-coherent 8Tx UE based on full power mode 1.* ***Proposal 27:*** *Study the performance benefits, signaling overhead and specification impact of supporting frequency-selective precoding for 8Tx UE.* |
| **Intel Corporation** | ***Proposal 1:*** *For the design of 8-port full coherent precoders based on DL Type I codebook, the overhead should be considered – in order to enable TPMI signaling efficiency, introducing restrictions on parameters* 𝑖1,1*,* 𝑖1,2*,* 𝑖1,3*, and* 𝑖2 *could be considered.* ***Proposal 2:*** *For partial coherent precoders with two antenna groups (Ng=2), support the layer splitting across both antenna groups for Rank-{2,3,4}.* ***Proposal 3:*** *For partial coherent precoders with four antenna groups (Ng=4), support Alt 1, i.e., the precoding design could be based on Rel-15 UL 2Tx full coherent codebook.* ***Proposal 4:*** *For partial coherent precoders with four antenna groups (Ng=4), RAN1 to further discuss the layer splitting among antenna groups to reduce TPMI overhead.* ***Proposal 5:*** *For non-coherent precoder design with 8-port, consider similar design scheme as partial coherent precoder construction, i.e., based on up to two Rel-15 4Tx non-coherent precoders.* ***Proposal 6:*** *For full coherent precoder indication, support DCI indication of the parameters for Type I codebook, i.e.,* 𝑖1,1*,* 𝑖1,2*,* 𝑖1,3*, and* 𝑖2*.* ***Proposal 7:*** *For 8-port partial coherent precoders with Ng=2, up to two Rel-15 4Tx full coherent precoders could be indicated in DCI.* ***Proposal 8:*** *For 8-port partial coherent precoders with Ng=4, up to four Rel-15 2Tx full coherent precoders could be indicated in DCI.* ***Proposal 9:*** *For 8-port non-coherent precoders, up to two Rel-15 4Tx non-coherent precoders could be indicated in DCI.* ***Proposal 10:*** *For the indication of 8-port precoder with different coherence, discuss whether the TPMI components are signaled separately (via single or multiple TPMI fields) or jointly (via single TPMI field).* ***Proposal 11:*** *Regarding the separate encoding or joint encoding between rank indication and precoder indication, discuss whether the same scheme or different scheme could be applied for precoders with different coherence type.* ***Proposal 12:*** *Consider flexible rank restriction (bitmap) to reduce the DCI overhead for TPMI indication.* ***Proposal 13:*** *RAN1 to discuss the following options on codebook subset configuration in Rel-18:* * *Option 1: the codebook subset contains precoders of only one coherence type*
* *Option 2: the codebook subset contains precoder of multiple coherence types (similar as Rel-15). MAC-CE or DCI could further indicate the coherence type which is used for precoder indication.*

***Proposal 14:*** *Regarding UCI multiplexing, support Alt 1, i.e., UCI is multiplexed with the first codeword.* ***Proposal 15:*** * *When the configured maximum number of layers is <=4, only one MCS/NDI/RV field is present in DCI.*
* *When the configured maximum number of layers is >4, both MCS/NDI/RV fields are present in DCI. The DL principle is reused for disabling transmission of one codeword.*

***Proposal 16:*** *RAN1 to consider supporting full power Mode 0 for 8Tx UE.* ***Proposal 17:*** *For full power Mode 1 operation, RAN1 to consider similar design principle as Rel-16, i.e., adding full coherent precoder to the non-coherent codebook subset and the partial coherent codebook subset.* ***Proposal 18:*** *For full power Mode 2 operation, RAN1 to consider extending the Rel-16 framework to 8Tx UE.* ***Proposal 19:*** *For non-codebook based PUSCH transmission with 8Tx, support joint encoding of SRI and rank indicator. Rank restriction (e.g., a bitmap) could be considered to further reduce overhead.*  |
| **Sony** | ***Proposal 1:*** *RAN1 should confirm the working assumption* * *For uplink transmission with rank>4, support dual CW transmission.*

***Proposal 2:*** *For UCI multiplexing on PUSCH for transmission with rank>4, support Alt 1: First CW****Proposal 3:*** *A second set of NDI and RV fields for the second CW should be indicated by UL grant.****Proposal 4:*** *For codebook design of an 8TX partial-coherent UE, the following alternative for coherent groups should be supported** *For when Ng=2, the following convention for assumption of port coherency scheme is used*
	+ *Alt 2: two coherent groups of {0,1,4,5} and {2,3,6,7}*
* *For when Ng=4, the following convention for assumption of port coherency scheme is used*
	+ *Alt 1: four coherent groups of {0,4}, {1,5}, {2,6}, and {3,7}*
 |
| **Xiaomi** | ***Proposal 1:*** *Confirm the Working Assumption to support dual CW for RANK>4 8Tx transmission.* ***Proposal 2:*** *Support separate MCS, NDI and RV indication fields for the second CW, the definition for each indication field can be the same as the first codeword.* ***Proposal 3:*** *Specify the RRC signaling to enable/disable the second CW.****Proposal 4:*** *For better scheduling flexibility, support configuration of up to 2 or 4 SRS resource sets, each configured with up to 4 or 2 single-port SRS resources accordingly.* ***Proposal 5:*** *For non-codebook based PUSCH transmission with 8Tx, support Option 1 to use a bitmap corresponding to all SRS resources configured which is preferred for the simplicity without any effort on the design of new SRI tables.****Proposal 6:*** *Introduce a UE capability to report the supported antenna configuration to gNB.****Proposal 7:*** *To make a trade-off among performance, signalling overhead, and implementation complexity, only support (O1,O2) = (1,1) for (N1,N2) = (4,1) and (N1,N2) = (2,2).* *Observation 4: For both (N1,N2) = (4,1) and (N1,N2) = (2,2), when rank=4, there is almost no performance loss for the codebook with fixed i1,3={0} compared to the codebook with flexible i1,3={0,1,2,3}.* ***Proposal 8:*** *For Rel-18 UL 8Tx fully-coherent codebook, support the following configuration parameters.* * *(N1,N2,O1,O2) = (4,1,1,1)* ▪ *Rank=1: i1,1={0,1,2,3}, i1,2={0}, i2={0,1,2,3}*
	+ *Rank=2,3,4: i1,1={0,1,2,3}, i1,2={0}, i1,3={0}, i2={0,1}*
	+ *Rank=5,6: i1,1={0,2}, i1,2={0}, i2={0,1}*
	+ *Rank=7,8: i1,1={0}, i1,2={0}, i2={0,1}*
* *(N1,N2,O1,O2) = (2,2,2,2)* ▪ *Rank=1: i1,1={0,1}, i1,2={0,1}, i2={0,1,2,3}*
	+ *Rank=2,3,4: i1,1={0,1}, i1,2={0,1}, i1,3={0}, i2={0,1}*
	+ *Rank=5,6: i1,1={0,1}, i1,2={0}, i2={0,1}*
	+ *Rank=7,8: i1,1={0}, i1,2={0}, i2={0,1}*

***Proposal 9:*** *For Rel-18 UL 8Tx fully-coherent codebook, support the union set of codebook with (N1,N2) = (4,1) and codebook with (N1,N2) = (2,2).* ***Proposal 10:*** *For Rel-18 UL 8Tx fully-coherent codebook, further study how to introduce the non DFT codewords or select the indices {i1,1, i1,2, i1,3, i2} candidate.* ***Proposal 11:*** *Support Alt2 for two coherent groups of {0,1,4,5} and {2,3,6,7} for Ng=2. Support Alt1 for four coherent groups of {0,4}, {1,5}, {2,6}, and {3,7} for Ng=4.****Proposal 12:*** *Support the following rank splitting rule for Ng=2.*

|  |  |  |
| --- | --- | --- |
| *Rank*  | *All layers in one Antenna Group*  | *Layers split across 2 Antenna Groups*  |
| *2*  | *(2,0), (0,2)*  | -  |
| *2*  | -  | *(1,1)*  |
| *3*  | *(3,0), (0,3)*  | -  |
| *3*  | -  | *(1,2), (2,1)*  |
| *4*  | *(4,0), (0,4)*  | -  |
| *4*  | -  | *(2,2)*  |
| *5*  | -  | *(2,3), (3,2)*  |
| *6*  | -  | *(3,3)*  |
| *7*  | -  | *(3,4), (4,3)*  |

***Proposal 13:*** *For PUSCH transmission by a partially-coherent 8TX UE with Ng=2, support the precoding structure*$\left[\begin{matrix}A\_{1}&0\_{4×rank(A2)}\\0\_{4×rank(A1)}&A\_{2}\end{matrix}\right]\_{8×rank}$*where* $A\_{1}$ *and* $A\_{2}$ *are precoding matrices taken from Rel-15 UL 4Tx fully-coherent codebook or empty matrix, the rank=rank****(***$A\_{1}$***)*** *+ rank****(***$A\_{2}$***)*** *is one of 1, 2, 3, 4, 5, 6, 7 or 8, and rank****(***$A\_{1}$*) and rank****(***$A\_{2}$***)*** *are determined based on the rank splitting rule.****Proposal 14:*** *For partially-coherent codebook, the candidate of Rel-15 UL 4Tx fully-coherent codebook should be further down-selected to reduce the signalling overhead, e.g., based on the principle that minimizing the cosine similarity between each codewords.****Proposal 15:*** *For PUSCH transmission by a partially-coherent 8TX UE with Ng=4, support the precoding structure*$\left[\begin{matrix}\begin{matrix}A\_{1}&0\_{2×rank(A2)}\\0\_{2×rank(A1)}&A\_{2}\end{matrix}&\begin{matrix}0\_{2×rank(A3)}&0\_{2×rank(A4)}\\0\_{2×rank(A3)}&0\_{2×rank(A4)}\end{matrix}\\\begin{matrix}0\_{2×rank(A1)}&0\_{2×rank(A2)}\\0\_{2×rank(A1)}&0\_{2×rank(A2)}\end{matrix}&\begin{matrix}A\_{3}&0\_{2×rank(A4)}\\0\_{2×rank(A3)}&A\_{4}\end{matrix}\end{matrix}\right]\_{8×rank}$*where*$A\_{1}$***,*** $A\_{2}$***,*** $A\_{3}$*and*$A\_{4}$*are precoding matrices taken from Rel-15 2TX UL fully-coherent codebook or empty matrix, the rank= rank****(***$A\_{1}$***)*** *+ rank****(***$A\_{2}$***)*** *+ rank****(***$A\_{3}$***)*** *+ rank****(***$A\_{4}$***)*** *is one of 1, 2, 3, 4, 5, 6, 7 or 8, and rank****(***$A\_{1}$***),*** *rank****(***$A\_{2}$*), rank****(***$A\_{3}$***)****, and rank****(***$A\_{4}$***)*** *are determined based on the rank splitting rule for Ng=4 when Rel-15 UL 2Tx fully-coherent codebook is used.****Proposal 16:*** *For PUSCH transmission by a partially-coherent 8TX UE with Ng=4, support the precoding structure*$\left[\begin{matrix}A\_{1}&0\_{4×rank(A2)}\\0\_{4×rank(A1)}&A\_{2}\end{matrix}\right]\_{8×rank}$*where* $A\_{1}$ *and* $A\_{2}$ *are precoding matrices taken from Rel-15 UL 4Tx partially-coherent codebook or empty matrix, the rank=rank****(***$A\_{1}$***)*** *+ rank****(***$A\_{2}$***)*** *is one of 1, 2, 3, 4, 5, 6, 7 or 8, and the rank splitting rule can follow the same rule as that of Ng=2.****Proposal 17:*** *Row/Column-interleaving operation should be used for Rel-18 UL 8Tx partially-coherent codewords to satisfy different port coherency schemes.****Proposal 18:*** *Antenna selection vectors/matrixes can be used for the Rel-18 UL 8Tx non-coherent codebook. Considering the signalling overhead, all antenna selection vectors/matrixes can be used for 1≤rank≤X, a part of antenna selection vectors/matrixes can be used for X<Rank≤Y, and only one antenna selection vector/matrix can be used for Y<Rank≤8. The value of X and Y can be left for further study, e.g., X=2 and Y=4.* ***Proposal 19:*** *For Rel-18 8Tx UE, the legacy codebook subset configuration rule can be reused, i.e., the fully-coherent UE can be configured with 'fullyAndPartialAndNonCoherent' codebook, partially-coherent UEs can be configured with 'partialAndNonCoherent' codebook, and non-coherent UE can be configured with 'NonCoherent' codebook.* ***Proposal 20:*** *For TPMI design, reusing the joint indication of TRI and TPMI (legacy rule). Considering the signalling overhead, the bit width of precoding information and number of layers for Rel-18 UL 8Tx codebook can be set as 7 or 8 bits.* ***Proposal 21:*** *For TPMI design, using 2 bits to indicate the coherence type (fully-coherent, or partially-coherent, or non-coherent), and in each coherence type, legacy joint indication of TRI and TPMI is supported.* ***Proposal 22:*** *For TPMI design, using 1 bit to indicate the coherence type (fully-coherent, or partially-coherent + non-coherent), and in each coherence type, legacy joint indication of TRI and TPMI is supported.* ***Proposal 23:*** *For TPMI design, considering non-unified indication rule for different coherence types if non-nested codebook is supported. For example, using i1,1, i1,2, i1,3, and i2 to indicate fully-coherent codebook and using two/four fields to indicate two/four Rel-15 UL 4Tx/2Tx precoding matrices.* ***Proposal 24:*** *If separate/joint indication of antenna group and TPMI as well as the nested codebook are supported, the actual antenna group number of the precoding matrix indicated by the gNB should be defined, e.g., using notation Ng’.* |
| **Nokia, Nokia Shanghai Bell** | ***Proposal 1:*** *For (N1, N2) = (4,1), consider supporting at least (O1, O2) = (4,1) based on UE capability. For (N1, N2) = (2,2), consider supporting at least (O1, O2) = (4,4) based on UE capability.****Proposal 2:*** *For Ng=2, study the listed TPMI designs of either single TPMI or two TPMIs with system-level simulations, together with consideration of TPMI signaling size.****Proposal 3:*** *For Ng=4, study the listed TPMI designs of 4 TPMIs, 2TPMIs and 1 TPMI with system-level simulations, together with considerations of precoder indication size.* ***Proposal 4:*** *Study other possible implementations other than Ng=2 and Ng=4****Proposal 5:*** *The precoder indication field in DCI can be shared for both coherent codebook and partial/non-coherent codebook, subject to UE capability indication and gNB RRC signaling.****Proposal 6:*** *Support all SRS port combination and 8-bit bit-map SRI for 8Tx.****Proposal 7:*** *Study channel models that capture the effect of differing average per layer BLER performance for link level evaluation of 8TX.****Proposal 8:*** *Study and support Rel-16 full power mode 1 and mode 2 for 8Tx support.****Proposal 9:*** *Use these two antenna layouts with Ng=2 and Ng=4 to support model-1 and model-2 for full Tx power feature.****Proposal 10:*** *For UCI multiplexing on PUSCH, support Alt 1: UCI is always multiplexed on the first CW.*  |
| **Google** | ***Proposal 1:*** *Support a modified Alt2 for UCI multiplexing as follows:* * *Alt2: The CW with the MCS with highest SE (if MCSs are the same, UCI is multiplex on the first CW)*

***Proposal 2:*** *Support the 8Tx UE to report the UE capability with regard to spatial domain fallback operation, including:** *Supported UL full power mode when it is configured as 2Tx, 4Tx and 8Tx based UL transmission*
* *Supported codebook coherency subset when it is configured as 2Tx, 4Tx and 8Tx based UL transmission*

***Proposal 3:*** *Support joint indication of TRI and TPMI for 8Tx PUSCH.* |
| **Sharp** | ***Proposal 1:*** *Rel-18 8TX does not support the pairs of values other than (N1, N2) = {(4,1), (2,2)}.****Proposal 2:*** *Support the pairs of oversampling value (O1, O2) = {(1,1), (2,1), (2,2)}.****Proposal 3:*** *UE should report the capability of supported (O1, O2).****Proposal 4:*** *Support the following precoding structure of codebook design for partial-coherent with Ng = 2 according to the agreement in the previous meeting.*$W= \left[\begin{matrix}A\_{1}&0\_{4×rank(A2)}\\0\_{4×rank(A1)}&A\_{2}\end{matrix}\right]\_{8×rank}$***,*** *where 𝐀𝟏 and 𝐀𝟐 are precoding matrices taken from Rel-15 4TX UL codebook, the rank = rank(𝐀𝟏) + rank(𝐀𝟐) is one of 1, 2, 3, 4, 5, 6, 7 or 8.* ***Proposal 5:*** *The performance difference between Alt1 and Alt2 of codebook design for partial coherent with Ng = 4 should be clarified.****Proposal 6:*** *The codebookSubset should be separated by one coherent capability.****Proposal 7:*** *Support the following precoding structure of codebook design for partial-coherent with Ng = 2 and 4.* $W= \left[\begin{matrix}A\_{1}&0\_{4×rank(A2)}\\0\_{4×rank(A1)}&A\_{2}\end{matrix}\right]\_{8×rank}$***,****where 𝐀𝟏 and 𝐀𝟐 are precoding matrices taken from Rel-15 4TX UL codebook, the rank = rank(𝐀𝟏) + rank(𝐀𝟐) is one of 1, 2, 3, 4, 5, 6, 7 or 8.* * *Ng = 2: A1 and A2 correspond to only FC precoder.*
* *Ng = 4: A1 and A2 correspond to only PC precoder.*

***Proposal 8:*** *It should be a UE capability for rank>4 to support dual codeword transmission.* ***Proposal 9:*** *Support the disabling the second CW following method, used for DL specification.** *The combination of IMCS = 26 and rvid = 1 indicated for a CW is used as an indication to disable transmission of its corresponding TB.*

***Proposal 10:*** *Support the Alt2 for UCI multiplexing on PUSCH for transmission with rank>4 by an 8TX UE.** *Alt2: The CW with the highest MCS (if MCSs are the same, UCI is multiplex on the first CW)*

***Proposal 11:*** *UE capability should indicate only the number of antennas needed to achieve full power transmission.****Proposal 12:*** *Both of Mode 0 and Mode 1 for uplink full power transmission should be supported.* |
| **LG Electronics** | ***Proposal 1:*** *For full coherent 8Tx UL codebook, oversampling factor other than (O1, O2) = (1, 1) is not supported.* ***Proposal 2:*** *Support Ng=2 and Ng=4 for fully coherent codebook.****Proposal 3:*** *Support two-level partial coherency for codebook based 8Tx UL transmission.** *Level-1: 2-group 4Tx coherency (Ng=2)*
	+ *Coherency PUSCH port groups consist of {1000, 1001, 1004, 1005} and {1002, 1003, 1006, 1007}.*
* *Level-2: 4-group 2Tx coherency (Ng=4)*
	+ *Coherency PUSCH port groups consist of {1000, 1004}, {1001, 1005}, {1002, 1006}, and {1003, 1007}.*

***Proposal 4:*** *For Ng=2 partially coherent codebook, layer split across 2 antenna groups can be prioritized. FFS on further reduction.* ***Proposal 5:*** *For Ng=4 partially coherent codebook, Alt 1 (using Rel-15 2 Tx fully coherent codebook) can be prioritized.* ***Proposal 6:*** *For non-coherent codebook, discuss how to efficiently reduce the number of codebooks especially for rank 3 to 7.* ***Proposal 7:*** *Reuse principle of Rel-15 codebook subset for CB based UL transmission.****Proposal 8:*** *Rank-1 uplink codebook for DFT-s-OFDM is supported in 8 Tx UL transmission.****Proposal 9:*** *For UCI multiplexing for 2CW, support Alt 2 (The CW with the highest MCS).* ***Proposal 10:*** *For indication of disabled TB of 8Tx transmission with rank>4, use MCS=26 and RV=1 combination.****Proposal 11:*** *Postpone the discussion of full power operation until finalizing the non and partial coherent codebook.****Proposal 12:*** *For SRS configuration of non-codebook based UL, support Option 1 (use an* $N\_{SRS}$ *bit length bitmap bit-map).****Proposal 13:*** *Further consider following alternatives for overhead reduction for 8Tx codebook based UL transmission.** *Alt1. Codebook sub sampling*
* *Alt2. Hierarchical indication (e.g., MAC-CE + DCI)*
 |
| **Samsung** | ***Proposal 1****: antennae within a group are coherent, and antennae across multiple groups are non-coherent* * *Do not support full coherent precoders with 𝑁𝑔=2,4*

***Proposal 2:*** *reuse DL Type I codebook parameters (*𝑁𝑔,𝑁1,𝑁2*) to describe/configure 8Tx UL codebook for different coherence types* * *FC: (𝑁𝑔,𝑁1,𝑁2,𝑃)=(1,4,1,2),(1,2,2,2)*
* *PC: (𝑁𝑔,𝑁1,𝑁2,𝑃)=(2,2,1,2),(4,1,1,2)*
* *NC: (𝑁𝑔,𝑁1,𝑁2,𝑃)=(8,−,−,−)*
* *FC/PC precoders: comprises two components*
	+ *selection of antenna group(s)*
	+ *precoder associated with the selected antenna group(s)*
	1. • *NC precoders: selection of antenna group(s), where a group comprises single antenna*

***Proposal 3****: similar to Rel.16-18 Type II codebook design, the metric for evaluating different 8Tx codebook alternatives should be UPT gain vs codebook size (TPMI overhead).* ***Proposal 4:*** *support the following regarding full-coherent precoder design* * *Codebook parameters*
	+ *𝐿=1*
	+ *Oversampling factor 𝑂𝑖=2 can be supported at least for rank 1-2*
* *Codebook subsampling: Rel. 16 DL Type I single codebook is subsampled by a factor 𝑁, i.e., a subset of Rel. 15 Type I codebook is used as FC precoders in 8Tx UL codebook*
	+ *Rank 1-2: 𝑁=1 (no subsampling)*
	+ *Rank 3-4: 𝑁=2 (subsampling by 2)*
	+ *Rank 5-8: 𝑁=4 (subsampling by 4)*
	+ *(𝑖1,1,𝑖1,2,𝑖2): number of supported values decreases with rank (e.g. rank 1-2 supports all values, and rank > 2 supports a subset of values)*
	+ *𝑖1,3: support only 𝑖1,3=0*

***Proposal 5:*** *support the following regarding partial coherent precoder design* * *𝑁𝑔*=2*: based on one Rel. 15 UL 4Tx full-coherent precoder* 𝑃𝑅 o *Group 1: Layers (columns)* 1,…𝐿1 *of the 4Tx precoding matrix* 𝑃𝑅
	+ *Group 2: Layers (columns)* 4−𝐿2+1,…4 *of the 4Tx precoding matrix* 𝑃𝑅
* *𝑁𝑔*=4*: Alt2 (based on Rel. 15 UL 4Tx partial-coherent precoders)*

***Proposal 6:*** *support the following mechanisms to reduce TPMI payload* * *Mechanism 1: based on codebook parameter*
	+ *𝐿=1*
	+ *Lower oversampling factors: 𝑂𝑖=2 for rank 1-2 and 𝑂𝑖=1 for rank > 2*
* *Mechanism 2: based on efficient signalling for the indication of (A) antenna group(s), and (B) UL precoding matrix, e.g.* two separate indicators, e.g. SRI for (A) and TPMI for (B)

***Proposal 7****: Discussion on full power modes can start after the 8Tx codebook design is sufficiently mature* ***Proposal 8****: regarding 8Tx NCB based UL transmission,* * *Number of SRS resource sets: support two SRS resource sets in addition to one SRS resource set*
* *When 𝑁𝑆𝑅𝑆>4, support Option1 (the SRI indication is based on a length-𝑁𝑆𝑅𝑆 bitmap*

***Proposal 9****: regarding 2 CWs for > 4 layers* * *confirm the working assumption*
* *UCI multiplexing: support Alt1 (UCI is multiplexed on the 1st CW)*
* *Enable/disable 2nd CW: do not support any new signalling, and higher layer indication of maxRank can be used to enable/disable the 2nd CW.*
 |
| **CMCC** | ***Proposal 1:*** *For fully coherent uplink precoding by an 8TX UE, (O1, O2) = (1,1) is supported for (N1, N2) = (4, 1), and (O1, O2) = (2,1), (2,2) is supported for (N1, N2) = (2, 2).* ***Proposal 2:*** *For codebook design of an 8TX partial-coherent UE, when Ng=2, support Alt 2: two coherent groups of {0,1,4,5} and {2,3,6,7}, when Ng=4, support Alt 1: four coherent groups of {0,4}, {1,5}, {2,6}, and {3,7}.* ***Proposal 3:*** *For codebook design of an 8TX partial-coherent UE, one precoding matrix* 𝑾𝟎 *and phase offset* 𝜶 *are indicated to UE for generating 8 TX codebook* $W\_{8×8}=\left[\begin{matrix}W\_{0}&0\\0&α\*W\_{0}\end{matrix}\right]$***.******Proposal 4:*** *For codebook design of an 8TX partial-coherent UE, the phase offset equals to 0 could support to indicate the codebook of antenna groups selection.* ***Proposal 5:*** *Support joint indication of rank and precoding information, where RI is the total number of transmission layers from different antenna groups.****Proposal 6:*** *Support the following combinations of layer splitting:*

|  |  |  |
| --- | --- | --- |
| Rank | All layers in one Antenna Group | Layers split across 2 Antenna Groups |
| 2 | (2,0), (0,2) |  |
| 2 |  | (1,1) |
| 3 | (3,0), (0,3) |  |
| 3 |  | (2,1), (1,2) |
| 4 | (4,0), (0,4) |  |
| 4 |  | (2,2)~~, (3,1), (1,3)~~ |
| 5 |  | ~~(4,1), (1,4),~~ (2,3), (3,2) |
| 6 |  | ~~(4,2), (2,4),~~ (3,3) |
| 7 |  | (4,3), (3,4) |

***Proposal 7:*** *For 8 TX CAP1 UE, fullpower mode specified in Rel-16 can be reused for 8TX full power transmission, where the power scaling factor is fixed to 1 for PUSCH power control.****Proposal 8:*** *For fullpowerMode1, at least one full coherent precoder per rank is selected for full power transmission.****Proposal 9:*** *For fullpowerMode2 with antenna virtualization, a maximum of 4 SRS resources with 8 ports, 4 ports, 2 ports, or 1 port can be supported for usage set to ‘codebook’ in a set to not increase the overhead of SRI field in DCI.****Proposal 10:*** *The enhancement of fullpowerMode2 with TPMI groups indication can be discussed later when codebook design has been finished.****Proposal 11:*** *Support Option 2 that use a legacy-based solution for SRI indication for NCB transmission.****Proposal 12:*** *The UE capable of “fullyAndPartialAndNonCoherent” transmission could be configured with fullCoherent codebook subset, or partialCoherent codebook subset or nonCoherent codebook subset, the UE capable of “partialAndNonCoherent” transmission could be configured with partialCoherent codebook subset or nonCoherent codebook subset, the UE capable of “nonCoherent” transmission only could be configured with nonCoherent codebook subset.* |
| **MediaTek Inc.** | ***Proposal 1:*** *Consider only (O1, O2) = (1,1) with DL Type I CBs for full coherent UE as there is not significant benefits observed with oversampling factor greater than 1.* ***Proposal 2:*** *Prioritize CB design for Ng = 2, specifically for partial coherent transmission.* ***Proposal 3:*** *Support to split the layers across the coherency groups as it allows for efficient power utilization in case of different PAs associated with different coherency groups.* ***Proposal 4:*** *Restrict layer splitting combinations as explained in the Table III to limit the TPMI field size.* ***Proposal 5:*** *Precoder structure as presented in Table II can be adopted for partial coherent CBs.* ***Proposal 6:*** *Consider 2Tx basis and co-phasing factors to generate co-phased beams which will serve as the precoders of partially coherent UE (Ng = 2 or 4). The following predefined basis set is considered to generate all the possible precoders.* * {[11];[1−1];[1j];[1−j]}; {[111−1];[11j−j]}; ∅∈{1,j,−1,−j}

***Proposal 7:*** *Rank dependent co-phasing factors restriction to be considered for DCI overhead saving.* ***Proposal 8:*** *Support to reuse Rel-16 Mode 0 full power operation for UL 8Tx.* |
| **FGI** | ***Proposal 1:*** *Support configuration of at least one SRS resource set, configured with 𝟖/𝑴 of M-port SRS resources for SRS configuration supporting codebook-based UL transmission by an 8TX UE (𝑴=𝟐,𝟒)****Proposal 2:*** *For codebook design of an 8TX partial-coherent UE* * *Support antenna numbering with two coherent groups with {0,1,2,3} and {4,5,6,7} when 𝑵𝒈=𝟐*
* *Support antenna numbering with four coherent groups with {0,1} and {2,3} and {4,5} and {6,7} when 𝑵𝒈=𝟒*

***Proposal 3:*** *Support joint indication of TRI and TPMI for CB-based 8TX PUSCH transmission* ***Proposal 4:*** *For partial coherent uplink precoding by an 8TX UE codebook,* * *When Ng=4, support Alt1: Precoding design is based on Rel-15 UL 2TX codebook,*
* *Full-coherent precoders are used*
 |
| **KDDI Corporation** | **Proposal 1:** MCS, NDI and RV indication for 2nd CW is specified in DCI format 0\_1.**Proposal 2:** if the gain when multiplexing UCI to the CW with a higher MCS among the two CWs can besufficiently confirmed, Alt 2 should be adopted.**Proposal 3:** The bit field for MCS, NDI and RV for the second codeword is included in the DCI format only when the maximum number of layers that UE can transmit is configured by maxrank to be greater than 4.**Proposal 4:** Even if the bit field for MCS, NDI and RV for the second codeword is included in the DCI format, UE ignores the field for the second CW and only transmit the first CW when the number of layers indicated by the field “Precoding information and number of layers” or "SRS resource indicator" is less than or equal to 4. |
| **Apple** | ***Proposal 1:*** *For the support of 8 Tx UL with codebook based transmission scheme, UE reports:** *Whether it supports full coherent, partial coherent, and/or non-coherent codebook.*
* *For a UE supporting a full-coherent codebook, it further reports whether it supports (N1, N2) = (2, 2) or (N1, N2) = (4, 1).*
* *For a UE supporting a partial coherent codebook, it further reports the number of non-coherent antenna group, i.e., Ng = 2 or 4.*

***Proposal 2:*** *For a UE with 8 Tx UL configured with full coherent codebook, by default partial/non-coherent precoders are not included. For a UE with 8 Tx UL configured with partial coherent codebook, by default non-coherent precoders are not included.* * *FFS whether gNB can configure whether partial or non-coherent precoders are included*

***Proposal 3:*** *For 8Tx full coherent codebook design based on R15 single DL Type I codebook, do not support precoding matrices generated according to (O1, O2) where O1>1 and/or O2>1.****Proposal 4:*** *For partial coherent codebook design with Ng = 2, each antenna group is indicated with a NR Rel-15 UL full coherent 4TX precoder, with separate TPMI field provided in the DCI. Each TPMI field is 5 bit.* ***Proposal 5:*** *For partial coherent codebook design with Ng = 2, there is no restriction that one codeword is mapped to one antenna group only.* ***Proposal 6:*** *For partial coherent codebook design with Ng = 4, adopt Alt 1 (precoding design is based on Rel-15 UL 2TX codebook).****Proposal 7:*** *For non-coherent codebook design, TPMI indication reuses the mechanism for SRI for non-codebook based transmission, which requires up to 8 bits.* ***Proposal 8:*** *For non-codebook based transmission scheme with 8Tx UL, the existing SRI indication mechanism is extended to support up to 8 single-port SRS resources in a resource set.****Proposal 9:*** *For 8 Tx PUSCH, new fields are added in the DCI to indicate NDI and RV for the second codeword.* ***Proposal 10:*** *For 8 Tx PUSCH with two codewords, UCI is always multiplexed only on the CW with the highest MCS (if MCSs are the same, UCI is multiplex on the first CW).* ***Proposal 11:*** *For 8 Tx PUSCH, two codewords are used whenever rank > 4, and no additional signaling is necessary.* |
| **Qualcomm Incorporated** | ***Proposal 1:*** *For 8 Tx PUSCH in Rel-18, Ng=2, 4 are not applicable to fully coherent 8 Tx.* ***Proposal 2:*** *For a fully coherent uplink precoding by an 8TX UE, 26/28* * *Support NR Rel-15 single panel DL Type I codebook mode 1 as the starting point for design of the codebook*
* *Do not support sub-band based precoding.*

***Proposal 3:*** *Do not support O1>1 and O2>1 for fully coherent uplink 8 Tx codebook.* ***Proposal 4:*** *Do not support different (O1, O2) values per rank.****Proposal 5:*** *Update the agreement made in RAN1 #111 as the following.* *For a fully coherent uplink precoding by an 8TX UE,* * *Support NR Rel-15 single panel DL Type I codebook as the starting point for design of the codebook o FFS: For a constructed codebook with size M based on above method, unless 𝑴=𝟐𝑵; otherwise, round up the codebook size to the smallest integer 𝟐𝑵>𝑴 by adding 𝟐𝑵−𝑴 precoders generated via Alt 2a.*
* *No LS to RAN4 will be needed*

***Proposal 6:*** *For fully coherent 8 Tx codebook, further study the following hybrid codebook design.** *Reduce the number of DFT precoders for rank 1,2,3,4 generated based on NR Rel-15 single panel DL Type I codebook*
* *Add nonDFT precoders generated via Alt 2a to rank 2, 3, 4.*

***Proposal 7:*** *Following Table 5 and Table 6, NR Rel-18 concatenate existing Rel-15 4 Tx or 2 Tx PUSCH precoders to support 8 Tx PUSCH precoders with partial coherent or noncoherent 8 Tx.** *FFS how to reduce the size of the codebook.*

***Proposal 8:*** *For partially coherent uplink precoding by an 8TX UE codebook,** *When Ng=2, do not support using Rel-15 UL 4 TX partial-coherent precoders to construct 8 Tx partial coherent codebook.*
* *When Ng=4, support the following Alt 1.*
	+ *Alt1:*
		- *Precoding design is based on Rel-15 UL 2TX codebook,*
		- *Full-coherent precoders are used.*

***Proposal 9:*** *update the agreement made in RAN1 112 as the following.**For partially coherent uplink precoding by an 8TX UE codebook, Ng=2,* * *Following rank and layer splitting cases are supported*

|  |  |  |
| --- | --- | --- |
| **Rank**  | **All layers in one Antenna Group**  | **Layers split across 2 Antenna Groups**  |
| 1  | (1,0), (0,1)  | -  |
| 8  | -  | (4,4)  |

* *Support the following cases. Select from the following cases based on the performance and overall DCI overhead*

|  |  |  |
| --- | --- | --- |
| **Rank**  | **All layers in one Antenna Group**  | **Layers split across 2 Antenna Groups**  |
| 2  | (2,0), (0,2)  | -  |
| 2  | -  | (1,1)  |
| 3  | (3,0), (0,3)  | -  |
| 3  | -  | (2,1), (1,2)  |
| 4  | (4,0), (0,4)  | -  |
| 4  | -  | (2,2), (3,1), (1,3)  |
| 5  | -  | (4,1), (1,4), (2,3), (3,2)  |
| 6  | -  | (4,2), (2,4), (3,3)  |
| 7  | -  | (4,3), (3,4)  |

* *Note: Above is not relevant to how precoders are indicated.*

***Proposal 10:*** *Following Table 5 and Table 6, a single TPMI is used to signal the precoder index for partial coherent and noncoherent 8 Tx PUSCH.****Proposal 11:*** *For codebook design of an 8TX partial-coherent UE, configured with an 8-port SRS resource** *For when Ng=2, the following convention for assumption of port coherency scheme is used*
	+ *Alt 3: two coherent groups of {0,1,2,3} and {4,5,6,7}*
* *For when Ng=4, the following convention for assumption of port coherency scheme is used*
	+ *Alt 2: four coherent groups of {0,1}, {2,3}, {4,5}, and {6,7}*

***Proposal 12:*** *For SRS configuration for non-codebook UL transmission for an 8TX UE, further support configuration of up to two, or four SRS resource sets, each configured with up to 4, or 2 single-port SRS resources, respectively.****Proposal 13:*** *For SRI indication for NCB-based 8TX PUSCH transmission with 𝑵𝑺𝑹𝑺>𝟒, support Option 2: Use a legacy-based solution, as in Rel-15.****Proposal 14:*** *In DCI format 0\_1 and 0\_2, use a combination of MCS=26 and RV ID =1 corresponding to a CW/TB to disable the TB for a 2 TB PUSCH transmission, and gNB make sure the indicated rank is not exceeding 4 for this PUSCH.****Proposal 15:*** *Support CBG based PUSCH with 2 CWs by reusing the design principle as Rel-15 CBG based PDSCH with 2 CWs.** *Configure up to 2X (where X≤𝟒) CBGs for a UE supports 2 CW PUSCH.*
* *Up to 2X bits of CBGTI is allowed in an UL grant to schedule the CBG based PUSCH with 2 CWs. The first X CBGTI bits are for 1st CW and the second X CBGTI bits are for the 2nd CW.*
* *If only 1 CW is scheduled in the UL grant, only the X bits of CBGTI corresponding to the scheduled CW are valid, the rest X bits of CBGTI are obsolete.*

***Proposal 16:*** *in Rel-18, for a PUSCH transmission with 2 TBs/CWs, the two TBs/CW are with a same PHY layer priority.****Proposal 17:*** *For PUSCH transmission with rank>4 by an 8TX UE, UCI is always multiplexed on one of the CWs with higher MCS. If both CWs have the same MCS, UCI is multiplexed on the first CW.****Proposal 18:*** *Confirm the scope of Rel-18 8Tx PUSCH includes CG-PUSCH with 2 TBs/CWs and up to 8 layers.****Proposal 19:*** *For CG-PUSCH with 2 TBs/CWs, support new CG-UCI fields of “Redundancy version” and “new data indicator” for the second TB/CW.****Proposal 20:*** *For CG-PUSCH with 2 TBs/CWs, study the following** *How to enable/disable the second CW of the CG-PUSCH*
* *How to multiplex the CG-UCIs for the two TBs/CWs onto the CG-PUSCH.*

***Proposal 21:*** *Full power operation for a partial/non-coherent 8TX UE should support at least PA architecture which does not have full rated PA on each of the 8 Tx chains.****Proposal 22:*** *In addition to reusing Rel-16 full power mode 0/1/2, support a new mode 0A for full power transmission for PUSCH with 8 Tx.** *Mode 0A set the power scaling factor 𝜶 = 𝐦(𝟏,Σ𝜶𝒊𝜹𝒊𝟖𝒊=𝟏) for a PUSCH transmission, where 𝜶𝒊 is the power scaling factor the i-th Tx port. 𝜹𝒊=𝟏 if i-th Tx port is used in the PUSCH transmission, 𝜹𝒊=𝟎 otherwise.*
 |
| **Ericsson** | ***Proposal 1:*** *For UL 8 Tx partial-coherent codebooks with two antenna groups, i.e., 𝐍𝐠=𝟐, ‘Group-Selection + Balanced’ partial-coherent precoders are used, including (a) precoders where a single antenna group is selected and a single UL Rel-15 4 Tx precoder is used for rank ≤𝟒 and additionally (b) precoders where combinations of two UL Rel-15 4 Tx precoders with a nearly equal number of layers are used. The following additional restrictions are applied to limit the codebook size:* * *Restrict the UL Rel-15 4 Tx precoders to the precoders with the oversampling factor of 𝐎𝟏=𝟏, and*
* *Restrict the layer distribution over the antenna groups to match the DL codeword-to-layer mapping for 𝐫>𝟒, i.e., the larger number of layers is mapped to the second group.*

***Proposal 2:*** *For UL 8 Tx partial-coherent codebooks with four antenna groups, i.e., 𝐍𝐠=𝟒, ‘Group-Selection + Balanced’ partial-coherent precoders are used, including (a) precoders that strive to minimize the number of active antenna groups and one or more Rel-15 2 Tx UL precoders are used and additionally (b) precoders where combinations of Rel-15 2 Tx UL precoders with a nearly equal number of layers are used. The following further restrictions are used to limit the codebook size:* * *Restrict the 2 Tx FC precoders to the precoders with co-phasing factors between the two antenna ports restricted to {𝟏,−𝟏}, and*
* *Form two antenna group pairs, each with two antenna groups and restrict the layer distribution over the antenna group pairs to match the DL codeword-to-layer mapping for 𝐫>𝟒, i.e., the larger number of layers is mapped to the second antenna group pair.*

***Proposal 3:*** *Restrict codebooks for 8 TX UEs such that elements of the precoding matrices are limited to the set {+1, +j, -1, -j}. This implies that (𝐎𝟏, 𝐎𝟐) = (1,1) for 𝐍𝐠 = 1 and (𝐍𝟏, 𝐍𝟐) = (4, 1), and that (𝐎𝟏, 𝐎𝟐) = (2, 2) for 𝐍𝐠 = 1 and (𝐍𝟏, 𝐍𝟐) = (2, 2).* ***Proposal 4:*** *8 Tx codebook subset design uses at least fully- and non-coherent precoders, targeting power saving, coherence fallback, and directional antennas with the non-coherent precoders.****Proposal 5:*** *8 Tx fully coherent precoders are not constructed by cophasing across Rel-15 precoders* ***Proposal 6:*** *In addition to the PA powers per Tx chain of [0 0 0 0 0 0 0 0], [0 -9 -9 -9 -9 -9 -9 -9], and [-9 -9 -9 -9 -9 -9 -9 -9] dB relative to their power class agreed for study in RAN1#111, consider at least a [-3 -3 -3 -3 -3 -3 -3 -3] configuration when designing Rel-18 8 Tx full power UL MIMO operation* ***Proposal 7:*** *Focus study of UL FPTx on minimal implementations of each of Modes 0, 1, and 2* ***Proposal 8:*** *A working assumption is made that CSI is multiplexed with UL-SCH only on the first codeword.* ***Proposal 9:*** *Unless multi-SRS resource set operation is defined for 8 Tx CB-based operation, it is not defined for 8 Tx NCB-based operation.****Proposal 10:*** *Support indication of up to 8 single port SRS resources using the Rel-15 non-codebook based mechanisms by expanding the number of single port SRS resources.* ***Proposal 11:*** *A PDCCH carries a single TPMI/TRI field for 8 Tx operation, where the indicated precoder corresponds to one SRS resource.* |
| **NEC** | ***Proposal 1:*** *Support (O1,O2) where O1>1 or O2>1, for example, (O1, O2) = (2,2) for (N1,N2) = (2,2) and (O1, O2) = (2,1) for (N1,N2) = (4,1).* ***Proposal 2:*** *For 8Tx partial coherent codebook with Ng=2, at least support percoders with layer split for rank = 2/3/4, specifically, support layer split (2,2) for rank =4, layer split of (2,3), (3,2) for rank =5, and layer split of (3,3) for rank =6.* ***Proposal 3:*** *For 8Tx partial coherent codebook with Ng=2 and rank = 2/3/4, support at least 4Tx precoders with rank = 2/3/4 with subset of column(s) mapped on one of the two antenna groups, respectively.****Proposal 4:*** *For 8Tx partial coherent codebook with Ng=4, support precoding design based on 2Tx full-coherent precoders.* |
| **NTT DOCOMO, INC.** | **Proposal 1:** *Confirm the working assumption to support dual CW for uplink transmission with rank>4.* ***Proposal 2:*** *For UCI multiplexing, Alt2 is preferred.** *Alt2: The CW with the highest MCS (if MCSs are the same, UCI is multiplex on the first CW)*

***Proposal 3:*** *Support 2-CW PUSCH transmission only, in case of rank>4.* * *If DL principle is reused for disabling UL transmission of a transport block, its impact to RI indication design should be considered.*

***Proposal 4:*** *Separate the discussions on port indexing and codebook structure.* * *The precoders from the determined codebook structure can be re-permuted based on the port indexing.*

***Proposal 5:*** *For non-coherent precoders for a rank i other than 1, support one of following options based on supported codebooksubset configuration method. Option 1 is preferred.* * *Option 1: all the port selection precoders are supported (if nested codebook is not supported and new codebooksubset configuration is introduced).*
* *Option 2: a subset of precoders can be selected and supported from all the port selection precoders (if nested codebook is supported and legacy codebooksubset configuration is reused).*

***Proposal 6:*** *For partially-coherent precoders with Ng=2,* * *For rank=2, 3, 4, both cases of ‘all layers in one antenna group’ and ‘layers split across 2 antenna groups’ are supported.*
* *For rank=4, 5, 6, for the case of ‘layers split across 2 antenna groups’, the almost equal layer split cases are supported.*
	+ *For rank=4, the layer split cases of (4,0), (0,4) and (2,2) are supported.*
	+ *For rank=5, the layer split cases of (3,2) and (2,3) are supported.*
	+ *For rank=6, the layer split case of (3,3) is supported.*
* *To reduce the number of precoders for a certain layer split case for a certain rank,*
	+ *support precoder selection for layer split cases of (1,1), (1,2), (2,1).*
	+ *study precoder selection for layer split cases of (2,2), (3,2), and (2,3).*
* *(Above proposals are also shown in Table 3 and Table 4.)*

***Proposal 7:*** * *For partially-coherent precoders with Ng=2, partial-coherent precoders from Rel-15 UL 4TX codebook are not used.*
* *For partially-coherent precoders with Ng=2, following codebook structure is supported,*
	+ *For rank<=4,* $P=\left[\begin{matrix}A\\0\_{4×rank}\end{matrix}\right]\_{8×rank} or$$P=\left[\begin{matrix}0\_{4×rank}\\A\end{matrix}\right]\_{8×rank}$
	+ *For rank>1,* $P=\left[\begin{matrix}A\_{1}&0\_{4×rank(A2)}\\0\_{4×rank(A1)}&A\_{2}\end{matrix}\right]\_{8×rank}$*, where rank=rank(*$A\_{1}$*) + rank(*$A\_{2}$*)*

***Proposal 8:*** *For partially-coherent precoders with Ng=4, support Alt1.* * *Alt1: Precoding design is based on Rel-15 UL 2TX codebook.*
	+ *Full-coherent precoders are used.*

**Proposal 9:** For partially-coherent precoders with Ng=4, following codebook structure is the starting point. * *For rank=1,* $P=\left[\begin{matrix}A\\0\_{6×1}\end{matrix}\right]\_{8×1}$*or* $P=\left[\begin{array}{c}\begin{matrix}0\_{2×1}\\A\end{matrix}\\0\_{4×1}\end{array}\right]\_{8×1}$ *or* $P=\left[\begin{array}{c}\begin{matrix}0\_{4×1}\\A\end{matrix}\\0\_{2×1}\end{array}\right]\_{8×1}$ *or* $P=\left[\begin{matrix}0\_{6×1}\\A\end{matrix}\right]\_{8×1}$
* *For rank=2, one or two 2TX precoders can be selected to use one or two antenna groups for transmission.*
* *For 2<rank<=6, two or three or four 2TX precoders can be selected to use corresponding antenna groups for transmission.*
* *For 6<rank<=8,* $P=\left[\begin{array}{c}\begin{matrix}A\_{1}&0\_{2×rank\left(A2\right)}\\0\_{2×rank\left(A1\right)}&A\_{2}\end{matrix}\\\begin{matrix}0\_{2×rank\left(A1\right)}&0\_{2×rank\left(A2\right)}\\0\_{2×rank\left(A1\right)}&0\_{2×rank\left(A2\right)}\end{matrix}\end{array}\begin{array}{c}\begin{matrix}0\_{2×rank\left(A3\right)}&0\_{2×rank\left(A4\right)}\\0\_{2×rank\left(A3\right)}&0\_{2×rank\left(A4\right)}\end{matrix}\\\begin{matrix}A\_{3}&0\_{2×rank\left(A4\right)}\\0\_{2×rank\left(A3\right)}&A\_{4}\end{matrix}\end{array}\right]\_{8×rank}$
* $A$*,* $A\_{1}$*,* $A\_{2}$*,* $A\_{3} $*and* $A\_{4}$ *are full-coherent precoders from Rel-15 2TX UL precoders.*

***Proposal 10****: For partially-coherent precoders with Ng=4,* * *Support all the layer splitting cases across 4 antenna groups for each rank.*
* *Support to study precoder selection for each layer split case for each rank.*

**Proposal 11:** * *For fully-coherent precoders, not support additional oversampling values other than (O1, O2) = (1, 1).*
* *For fully-coherent precoders, support one codebook mode only, e.g., codebook mode 1.*

**Proposal 12:** *Support to discuss codebooksubset configuration mechanism before TPMI/RI indication method. Option 2 is preferred.* * *Option 1: codebooksubset configuration follows legacy mechanism, e.g., fully-coherent UEs can be configured with 'fullyAndPartialAndNonCoherent', 'partialAndNonCoherent' or ‘nonCoherent’ codebook subset; partial-coherent UE can be configured with 'partialAndNonCoherent' or ‘nonCoherent’ codebook subset.*
* *Option 2: new codebooksubset configuration, e.g., fully-coherent UEs can be configured with 'fullyCoherent', or 'partialCoherent' or ‘nonCoherent’ codebook subset; partial-coherent UE can be configured with 'partialCoherent' or ‘nonCoherent’ codebook subset.*

**Proposal 13:** * *For codebooksubset configurations of 'fullyCoherent', or ‘nonCoherent’, support joint indication of TRI and 8TX TPMI for from 1-layer transmission to 8-layer transmission, similar as legacy indication for ‘precoding information and number of layers’.*
* *For codebooksubset configurations of 'partialCoherent' with Ng=2 or Ng=4, study following two options,*
	+ *Option 1: the same indication method as 'fullyCoherent' and ‘nonCoherent’, i.e., joint indication of TRI and 8TX TPMI for from 1-layer transmission to 8-layer transmission, similar as legacy indication for ‘precoding information and number of layers’*
	+ *Option 2: different indication method from 'fullyCoherent' or ‘nonCoherent’, e.g., multiple fields are used to indicate multiple antenna groups, with additional indication on layer-split case or whether a field for an antenna group exists or not.*

**Proposal 14:** *For NCB-based 8TX PUSCH transmission, for SRI indication, Option 1 is slightly preferred.** + *Option 1: Use an 𝐍𝐒𝐑𝐒 bit length bitmap*
 |

# RAN1 AGREEMENTS FOR SUB-AGENDA 9.1.4.2

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **RAN1 Meeting #112**AgreementFor fully coherent uplink precoding by an 8TX UE, based on NR Rel-15 single panel DL Type I codebook, the following pairs of (N1, N2) values are supported,* (N1, N2) = (4, 1)
* (N1, N2) = (2, 2)`

A pair of (N1, N2) can be configured with subject to UE capability.**Agreement**Fully coherent uplink precoding by an 8TX UE, based on NR Rel-15 single panel DL Type I codebook* Precoding matrices generated according to (O1, O2) = (1, 1) is supported
* Further study additional support of precoding matrices generated according to (O1, O2) where O1>1 or O2>1
	+ Subject to UE capability
* FFS: Different O1, O2 values for different ranks

**Agreement**To support dual CW PUSCH transmission for rank>4 by an 8TX UE, for MCS indication, support* Alt.2: A second MCS field (5 bits) is indicated for the second codeword

**Agreement**To support dual CW PUSCH transmission for rank>4 by an 8TX UE, a second set of NDI (1 bit) and RV (2 bits) fields are indicated. * FFS: Details on how to signal

**Agreement**To support dual CW PUSCH transmission for rank>4 by an 8TX UE, reuse DL PDSCH scrambling mechanism to initialize the scrambling sequence generator for codeword q$\in ${0,1}, $$c\_{init}=n\_{RNTI}∙2^{15}+q∙2^{14}+n\_{ID}$$where $n\_{RNTI}$, and $n\_{ID}$ are defined similar to the legacy single CW PUSCH transmission.**Agreement**For fully coherent uplink precoding by an 8TX UE, based on NR Rel-15 single panel DL Type I codebook (CodebookMode=1), * Study whether/how to support (O1, O2) = (2,1), (2,2)
	+ whether for all rank, or rank 1-2, or rank 3-8
	+ applicability of different (O1, O2) values per agreed (N1, N2)
	+ companies are encouraged to submit simulation results

**Agreement**To support UCI multiplexing on PUSCH for transmission with rank>4 by an 8TX UE, UCI is always multiplexed only on one of the CWs, down-select from,* Alt1: First CW
* Alt2: The CW with the highest MCS (if MCSs are the same, UCI is multiplex on the first CW)

**Agreement**For non-coherent uplink precoding by an 8TX UE, following precoders are supported for 1 layer transmission. $$\left[\begin{array}{c}\begin{matrix}\begin{matrix}1\\0\end{matrix}\\\begin{matrix}0\\0\end{matrix}\end{matrix}\\0\\0\\0\\0\end{array}\right],\left[\begin{array}{c}\begin{matrix}\begin{matrix}0\\1\end{matrix}\\\begin{matrix}0\\0\end{matrix}\end{matrix}\\0\\0\\0\\0\end{array}\right],\left[\begin{array}{c}\begin{matrix}\begin{matrix}0\\0\end{matrix}\\\begin{matrix}1\\0\end{matrix}\end{matrix}\\0\\0\\0\\0\end{array}\right],\left[\begin{array}{c}\begin{matrix}\begin{matrix}0\\0\end{matrix}\\\begin{matrix}0\\1\end{matrix}\end{matrix}\\0\\0\\0\\0\end{array}\right],\left[\begin{array}{c}\begin{matrix}\begin{matrix}0\\0\end{matrix}\\\begin{matrix}0\\0\end{matrix}\end{matrix}\\1\\0\\0\\0\end{array}\right],\left[\begin{array}{c}\begin{matrix}\begin{matrix}0\\0\end{matrix}\\\begin{matrix}0\\0\end{matrix}\end{matrix}\\0\\1\\0\\0\end{array}\right],\left[\begin{array}{c}\begin{matrix}\begin{matrix}0\\0\end{matrix}\\\begin{matrix}0\\0\end{matrix}\end{matrix}\\0\\0\\1\\0\end{array}\right],\left[\begin{array}{c}\begin{matrix}\begin{matrix}0\\0\end{matrix}\\\begin{matrix}0\\0\end{matrix}\end{matrix}\\0\\0\\0\\1\end{array}\right]$$with the scaling factor of $\frac{1}{2\sqrt{2}}$.**Agreement**For NCB-based 8TX PUSCH transmission with $N\_{SRS}>4$, where $N\_{SRS}$ is the number of configured single-port SRS resources in a resource set,* All SRS port combinations are supported
* For SRI indication, down-select from,
	+ Option 1: Use an $N\_{SRS}$ bit length bitmap
	+ Option 2: Use a legacy-based solution
* Consideration of Lmax for SRI indication

For $N\_{SRS}\leq 4$, Rel-15 SRI indication is reused**Agreement**For CB-based 8TX PUSCH transmission, where Mode 2 uplink full power transmission (if supported) is not used, re-use legacy Rel-15 mechanism, that is* when only one SRS resource in a resource set is configured, the SRI field in DCI is absent,
* when two SRS resources are configured in a resource set, 1 bit of SRI field in DCI is used to indicate the selected SRS resource in the set.

**Agreement**For partially coherent uplink precoding by an 8TX UE codebook,* When Ng=2
	+ Precoding design is based on Rel-15 UL 4TX codebook,
		- Full-coherent precoders are used
			* FFS whether partial-coherent precoders are needed
* When Ng=4, down-select from,
	+ Alt1:
		- Precoding design is based on Rel-15 UL 2TX codebook,
			* Full-coherent precoders are used
	+ Alt2:
		- Precoding design is based on Rel-15 UL 4TX codebook,
			* Partial-coherent precoders are used

**Agreement**For partially coherent uplink precoding by an 8TX UE codebook, Ng=2, * Following rank and layer splitting cases are supported

|  |  |  |
| --- | --- | --- |
| **Rank** | **All layers in one Antenna Group** | **Layers split across 2 Antenna Groups** |
| 1 | (1,0), (0,1) |  |
| 8 |  | (4,4) |

* Select from the following cases based on the performance and overall DCI overhead

|  |  |  |
| --- | --- | --- |
| **Rank** | **All layers in one Antenna Group** | **Layers split across 2 Antenna Groups** |
| 2 | (2,0), (0,2) |  |
| 2 |  | (1,1) |
| 3 | (3,0), (0,3) |  |
| 3 |  | (2,1), (1,2) |
| 4 | (4,0), (0,4) |  |
| 4 |  | (2,2), (3,1), (1,3) |
| 5 |  | (4,1), (1,4), (2,3), (3,2) |
| 6 |  | (4,2), (2,4), (3,3) |
| 7 |  | (4,3), (3,4) |

Note: Above is not relevant to how precoders are indicated.**RAN1 Meeting #111****Agreement**For a fully coherent uplink precoding by an 8TX UE, 1. Support NR Rel-15 single panel DL Type I codebook as the starting point for design of the codebook
	1. FFS: For a constructed codebook with size M based on above method, unless $M=2^{N}$; otherwise, round up the codebook size to the smallest integer $2^{N}>M$ by adding $2^{N}-M$ precoders generated via Alt 2a.
2. No LS to RAN4 will be needed

**Agreement**For PUSCH transmission with rank>4 by an 8TX UE, to support dual CW transmission, * specify MCS, NDI, RV indication for the second CW
* specify PUSCH Scrambling for the second CW
* specify UCI multiplexing on PUSCH for dual CW transmission
* study whether/how Enabling/Disabling the second CW

FFS: Optimization of DCI to indicate the aboveNote: Strive to reuse Rel-15 NR DL schemes where possible.**Agreement**For PUSCH transmission with rank>4 by an 8TX UE, to support UCI multiplexing on PUSCH, down-select at least one of the following options in RAN1#112,* Option1: UCI is always multiplexed on one of the CWs
* Option2: UCI is multiplexed on both CWs
* Option3: Based on UCI (e.g., type, payload size, etc.) UCI is multiplexed on one or both CWs
* Option4: UCI is multiplexed only when single CW is enabled
* Option5: UCI is repeated across the two CWs
* Other options are not precluded

**Agreement**For CB-based 8TX PUSCH transmission, for rank indication, down-select among the following* Separate indication of TRI and TPMI
* Joint indication of TRI and TPMI

**Agreement**Study full TX power uplink codebook-based transmission by a partially/non-coherent 8TX precoder,* Reuse Rel-16 UE capability definitions for discussion purpose, i.e., UE Capability 1, 2 and 3
* For full TX power transmission by UE Capability 2/3, at least, following exemplary PA architectures can be considered
	+ Other cases of interest are not precluded, down-select preferred potential architecture for the purpose of 8TX full power study in RAN#112.
	+ This can be used for other UE Power Classes as well.

|  |
| --- |
| 8TX UE, Power class 3 (23 dBm)Pi= Nominal power rating of each PA |
|  | Regular UE | P1=P2= …=P8=14 dBm (Full power supported by Mode1) |
| Full-power capable UE | **Full power capability with any PA comb. (CAP1)**Example: P1=P2= …=P8= 23 dBm |
| **Full power capability with 1 PA (CAP3)**Example: P1=P2= …=P7= 14 dBmP8= 23 dBm |
| **(lower priority) Full power capability with 2 PAs (CAP2)**Example 2a: P1=P2= …=P6= 14 dBm, P7=P8 ≥ 20 dBmExample 2b:P1=P2= …= P8= 20 dBm |
| **(lower priority) Full power capability with 4 PAs (CAP2)**Example 3a: P1=P2= …=P4= 14 dBm, P5=P6= …=P8 ≥ 17 dBmExample 3b: P1=P2= …= P8 = 17 dBm |
| **(lower priority) Full power capability with 6 PAs (CAP2)**Example 4a: P1=P2= 14 dBm, P3=P4= …=P8 ≥ 15.3 dBmExample 4b: P1=P2= …= P8≥ 15.3 dBm |
|  |
|  |
|  |

**Agreement**For an 8TX partial/non-coherent precoder, for study on full power codebook-based PUSCH transmissions, use Rel-16 full power modes as the starting point for the design. Note: This does not mandate support of all Rel-16 modes.**RAN1 Meeting #110bis-e****Agreement**Support the following cases for codebook design for 8TX precoders* Full coherent precoders with Ng=1
	+ FFS: Full coherent precoders with Ng=2, Ng=4
* Partial coherent precoders with Ng=2 and Ng=4
	+ This does not imply any relation with the number of TPMI indications for 8TX precoder
* Non-coherent precoders

**Agreement**For codebook design of an 8TX partial-coherent UE, configured with an 8-port SRS resource* For when Ng=2, down-select of the following convention for assumption of port coherency scheme is used
	+ Alt 1: two coherent groups of {0,2,4,6} and {1,3,5,7}
	+ Alt 2: two coherent groups of {0,1,4,5} and {2,3,6,7}
	+ Alt 3: two coherent groups of {0,1,2,3} and {4,5,6,7}
* For when Ng=4, down-select of the following convention for assumption of port coherency scheme is used
	+ Alt 1: four coherent groups of {0,4}, {1,5}, {2,6}, and {3,7}
	+ Alt 2: four coherent groups of {0,1}, {2,3}, {4,5}, and {6,7}
	+ Alt3: four coherent groups of {0, 2}, {4, 6}, {1, 3} and {5, 7}
* Note: Other alternatives which are not foreseen are not precluded

**Agreement**For SRI and/or transmitter precoder matrix indication for codebook-based uplink transmission by an 8TX UE, study* Whether/how to indicate one or multiple TPMI/SRI, according to the number of antenna groups, coherence capability, codebooksubset configuration, etc.
* Whether/how to extend Rel-17 framework, e.g., TPMI/SRI indication in MTRP PUSCH
* Whether/how to separate/joint indication of rank and precoding information.
* Whether/how to indicate n (<=Ng) selected antenna group(s) separately from TPMI/TRI indication

**Agreement**In Rel-18, on support of full power operation by a partial/non-coherent 8TX UE configured with codebook-based transmission, * Identify and agree on at least one potential PA architecture by RAN1 meeting #111

**Agreement**For 8TX UE codebook-based uplink transmission,* For partially/non-coherent precoding,support NR Rel-15 UL 2TX/4TX codebooks and/or 8x1 antenna selection vector(s) as the starting point for design of codebook

**Agreement**For SRS configuration required for non-codebook-based UL transmission by an 8TX UE, Alt1 is supported, that is* Alt1: A single SRS resource set configured with up to 8 single-port SRS resources
* FFS: Configuration of up to two, or four SRS resource sets, each configured with up to 4, or 2 single-port SRS resources, respectively.

**Agreement**For SRS configuration supporting codebook -based UL transmission for an 8TX UE ,  * Support configuration of 1 SRS resource set containing up to X 8-port SRS resource(s), where X = 2
	+ FFS : Other values for X, if needed
* FFS : Configuration of at least one SRS resource set, configured with more than one SRS resources where each SRS resource may have the same or different number of SRS ports, e.g., for support full power operation, if supported
* FFS : Configuration of at least one SRS resource set, configured with 8/M of M-port SRS resources, for example,
	+ Configuration of an SRS resource set, configured with at least 4 of 2-port SRS resources
	+ Configuration of an SRS resource set, configured with at least 2 of 4-port SRS resources

**Working Assumption**For uplink transmission with rank>4, support dual CW transmission.**Agreement**If dual CW is supported for uplink transmission with Rank>4 by an 8TX UE, reuse DL Rel-15 codeword to layer mapping for both codebook-based and non-codebook-based transmission.**Agreement**For SRS configuration supporting codebook -based UL transmission for an 8TX UE ,  * Support configuration of 1 SRS resource set containing up to X  8-port SRS resource(s), where X = 2
	+ FFS : Other values for X, if needed
* FFS : Configuration of at least one SRS resource set, configured with more than one SRS resources where each SRS resource may have the same or different number of SRS ports, e.g., for support full power operation, if supported
* FFS : Configuration of at least one SRS resource set, configured with 8/M of M-port SRS resources, for example,
	+ Configuration of an SRS resource set, configured with at least 4 of 2-port SRS resources
	+ Configuration of an SRS resource set, configured with at least 2 of 4-port SRS resources

**RAN1 Meeting #110****Agreement**8TX PUSCH is supported in Rel-18**Agreement**For 8TX PUSCH, at least support * Ng=1, 2, 4

Note: The above does not restrict the Ng for the non-coherent case**Agreement**For evaluation purpose of codebook alternatives when a precoder based on Rel-15 DL Type I is used, following oversampling ratios are assumed* (O1, O2) = (1,1), (2,1), (2,2)
* Note: Other values may be used and reported by companies
* Note: When deciding the supported O1, O2 combination, the signalling overhead, performance, UE complexity, etc should be considered

**Agreement**RAN1 further studies Alt1b and Alt2a for down-selection of one of the two in RAN1 meeting #110b-e.* Transmission using one or multiple precoders corresponding to one or multiple SRS resources can be studied as part of the above alternatives.

**Agreement**Support up to X layers for codebook and non-codebook UL transmission for 8TX UE where X=4, 8 is determined based on separate UE capability* For uplink transmission with rank<=4, single CW is supported
* For uplink transmission with rank>4, whether single or dual CW is used will be decided in RAN1 meeting #110b-e

The above applies only with regards to the work scope of this agenda item.**Agreement**For SRS configuration for non-codebook UL transmission for an 8TX UE, down-select from* Alt1: A single SRS resource set configured with up to 8 single-port SRS resources
* Alt2: Up to two SRS resource sets, each configured with up to 4 single-port SRS resources
* Alt3: Support both alternatives.

**Agreement**Study low overhead solutions for SRI and/or transmitter precoder matrix indication for codebook-based, and SRI indication for non-codebook-based UL transmission by an 8TX UE, * FFS using single or separate (exiting or new) fields for the indication, other solutions are not precluded.
* Note: Low overhead schemes for study include those using Rel-15 SRI/TPMI indication mechanisms

**RAN1 Meeting #109-e****Agreement** **Study fully-coherent, partially-coherent and non-coherent UEs for uplink transmission with 8TX UEs.** **Agreement****Study full power transmission for 8TX UEs.*** **Details are FFS upon completion of codebook design**

Agreement**Adopt the following Table as the reference EVM for LLS evaluation*** **Companies may provide additional evaluation results per their case of interest**
* **LLS is optionally used for 8Tx UL evaluation, if needed**

|  |  |
| --- | --- |
| **Parameter** | **Value** |
| Carrier Frequency | 3.5 GHz |
| Waveform | CP-OFDM |
| SCS | 30 KHz |
| System bandwidth | 20 MHz, 100 MHz |
| Scheduled PRBs | 5, 25, 50, 260 PRBs |
| gNB RX antenna setup and port layouts(𝑀,𝑁,𝑃,𝑀𝑔,𝑁𝑔,𝑀𝑝,𝑁𝑝)  | (8,8,2,1,1,4,8) with (𝑑H, 𝑑V) = (0.5, 0.8)𝜆(4,4,2,1,1,4,4) with (𝑑H, 𝑑V) = (0.5, 0.8)𝜆(2,2,2,1,1,2,2) with (dH , dV ) = (0.5, 0.5)λ  |
| UE TX antenna configuration | To be defined according to outcome of Proposal 2.1 |
| UE speed | 3 Km/h |
| Number of Layers | Adaptive, Fixed (reported by company)  |
| AMC | Adaptive, Fixed (reported by company)  |
| DMRS configuration | Type 1; 1 front loaded + 1 additional symbol |
| Channel estimation | Real |
| Channel Model | CDL-A (30ns), CDL-B (100ns), CDL-C (300ns) |

 **Agreement**For 8TX UE uplink transmission, study codebook- and non-codebook-based transmission with maximal layer number of both 4 and 8 layers.**Agreement**Adopt the following Table as the reference EVM for SLS evaluation.* Companies may provide additional evaluation results per their case of interest.

|  |  |
| --- | --- |
| **Parameter** | **Value** |
| Frequency range | 3.5 GHz |
| Multiple access | OFDMA  |
| Numerology | 14 OFDM symbol slotSCS , 30 KHz   |
| Scenario | Outdoor FWA (38.901): UMa (ISD = 500 m), 100% Outdoor, 3Km/h |
| Indoor FWA (38.901): UMi (ISD = 200 m), 100% Indoor, 3Km/h |
| Industrial (38.901): Indoor Office (Inh ), 3Km/h |
| Channel model | 38.901 |
| System bandwidth | 20 MHz, 100 MHz  |
| gNB RX antenna setup and port layouts(𝑀,𝑁,𝑃,𝑀𝑔,𝑁𝑔,𝑀𝑝,𝑁𝑝)  | Outdoor FWA : (8,8,2,1,1,4,8) with (𝑑H, 𝑑V) = (0.5, 0.8)𝜆(4,4,2,1,1,4,4) with (𝑑H, 𝑑V) = (0.5, 0.8)𝜆 Indoor FWA : (8,8,2,1,1,4,8) with (𝑑H, 𝑑V) = (0.5, 0.8)𝜆(4,4,2,1,1,4,4) with (𝑑H, 𝑑V) = (0.5, 0.8)𝜆 Industrial:(2,2,2,1,1,2,2) with (dH , dV ) = (0.5, 0.5)λ  |
| gNB antenna radiation pattern parameters | Outdoor/Indoor FWA : 38.901 Table 7.3-1, 8 dBi , 65° HPBW Industrial:IMT.2412 Table 10,5 dBi , 90° HPBW  |
| gNB receiver noise figure | 5dB  |
| gNB receiver | MMSE-IRC |
| gNB scheduler | Single user with proportional fair |
| Modulation | -    Up to 64 QAM  -    Up to 256QAM   |
| MIMO scheme | SU-MIMO with rank adaptation |
| UE speed | 3 Km/h |
| UE TX antenna configuration | To be defined according to outcome of Proposal 2.1 |
| Traffic model | -    FTP model 1: Packet size 500KB, RU= 50% and suggested low/high RU of values of 20% and 70%-   Full buffer (optional)  |
| Suggested benchmarking | R15 UL 4-Tx codebook , Eigen-based, companies report PRG assumption  |
| Precoder granularity | Wideband  |
| Power control | Open loop, -    alpha = 0.8-    P0= -50, -80 dBm  to be selected according to the deployment scenario  |
| UE power rating | 23 dBm (UE, 38.101)32 dBm (FWA, 38.101) |
| Metric | UL mean-user throughput, 5%-ile and 95%-ile UPT |

**Agreement**For 8TX UE, consider the following UE antenna layouts for codebook design,·        For non-coherent UEs, consider linear array (1D/2D) of cross-polarized or single-polarized antenna configuration·        For fully/partial-coherent UEs, consider linear array (1D/2D)o   Where the array is either cross-polarized antenna configuration or single polarized antenna configurationo   Ng>=1 antenna groups can be considered where each group comprises coherent antennas, and across groups, antennas can be non-coherent/coherent depending on device types§  An example of an antenna group is a panelo   Within an antenna group, antenna elements are uniformly spaced. Across different antenna groups, companies to provide details.* Additional information for definition of antenna layout
	+ Based on the number of coherent groups, following exemplary cases can be considered where, within each group, antenna elements are spaced by 0.5λ, and then dG-H, dG-V represent the horizontal and vertical spacings between the centers of adjacent antenna groups, respectively
		- Further down-selection can be done in the next meeting, if needed
		- The shown exemplary placing of antenna groups can be used for evaluation purpose, but the codebook design is not restricted to shown cases.
		- Other antenna layouts for other use cases are not precluded.
		- **To start companies may report their results according to their preferred layout.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Case** | **Ng** | **(M, N, P) per group** | **Antenna Layout** | **Antenna Pattern/Antenna Element Gain** |
| 1 | 1 | (2, 2, 2), (1, 4, 2) | **A picture containing icon    Description automatically generated** | Isotropic (Indoor/Outdoor FWA & Industrial) 8 dBi, 65° HPBW(Outdoor FWA) |
| 2 | 2 | (1, 2, 2) | Graphical user interface    Description automatically generated | Isotropic (Indoor/Outdoor FWA & Industrial) 8 dBi, 65° HPBW(Outdoor FWA)  |
| 3 | 4 | (1, 1, 2) |  | Isotropic (Indoor/Outdoor FWA & Industrial) 4 dBi, 110° HPBW(Indoor FWA & Industrial |

o   **Other UE antenna assumption for the purpose of evaluation**

|  |  |  |  |
| --- | --- | --- | --- |
|   | Outdoor FWA | Indoor FWA | Industrial |
| UE antenna height | 6, 3 m (To start) | According to 36.873 | According to 38.901 |

**Agreement**For 8TX UE codebook-based uplink transmission, down-select one of* Alt1-a:
	+ Study NR Rel-15 UL 2TX/4TX codebooks and/or 8x1 antenna selection vector(s) as the starting point for design of the codebook for non-coherent UEs
	+ Study NR Rel-15 DL Type I codebook as the starting point for design of the codebook for fully/partially-coherent UEs
* Alt1-b:
	+ Study NR Rel-15 UL 2TX/4TX codebooks and/or 8x1 antenna selection vector(s) as the starting point for design of the codebook for partially/non-coherent UEs
	+ Study NR Rel-15 DL Type I codebook as the starting point for design of the codebook for fully-coherent UEs
* Alt2-a:
	+ Study NR Rel-15 UL 2TX/4TX codebooks and/or 8x1 antenna selection vector(s) as the starting point for design of codebook for fully/partially/non-coherent UEs
* Alt2-b:
	+ Study NR Rel-15 UL 2TX/4TX codebooks and/or 8x1 antenna selection vector(s) in combination with those based on NR Rel-15 DL Type I codebooks as the starting point for design of codebook for fully/partially/non-coherent UEs
* Alt3:
	+ Study NR Rel-15 DL Type I codebook as the starting point for design of codebook for fully/partially/non-coherent UEs
* Transmission using one or multiple precoders corresponding to one or multiple SRS resources can be studied as part of the above alternatives.
 |

# References

1. RP-213598, New WI: MIMO evolution for Downlink and Uplink, Samsung, 3GPP RAN Meeting #94e, Dec.6-17, 2021
2. Chairman’s Notes, 3GPP TSG RAN WG1 Meeting #112, February 2023
3. R1-2300166, Recommended Direction on SRI/TPMI Enhancements for RAN1#112b, Moderator (InterDigital), 3GPP TSG RAN WG1 Meeting #112, February 2023
4. R1-2302305, Further Discussion on 8TX UE Operations InterDigital, Inc.
5. R1-2302310, Recommended Direction on SRITPMI Enhancements for RAN1#113 Moderator (InterDigital, Inc.)
6. R1-2302376, Discussion on SRI/TPMI enhancement for enabling 8 TX UL transmission Huawei, HiSilicon
7. R1-2302422, SRI/TPMI enhancement for enabling 8 TX UL transmission ZTE
8. R1-2302475, Further discussion on enabling 8 TX UL transmission vivo
9. R1-2302538, SRI TPMI enhancement for 8 TX UL transmission OPPO
10. R1-2302591, Discussion on SRI/TPMI enhancement for enabling 8 TX UL transmission Spreadtrum Communications
11. R1-2302686, Discussion on SRI/TPMI enhancement for 8TX UL transmission CATT
12. R1-2302729, SRI/TPMI enhancement for enabling 8TX UL transmission Lenovo
13. R1-2302786, Discussion on enhancement for 8Tx UL transmission Intel Corporation
14. R1-2302840, Considerations on SRI/TPMI enhancement for enabling 8 TX UL transmission Sony
15. R1-2302965, Enhancements on 8Tx uplink transmission Xiaomi
16. R1-2303011, UL enhancements for enabling 8Tx UL transmission Nokia, Nokia Shanghai Bell
17. R1-2303048, On SRI/TPMI Indication for 8Tx Transmission Google
18. R1-2303067, Views on 8 TX UL transmission Sharp
19. R1-2303074, SRI/TPMI enhancement for enabling 8 TX UL transmission LG Electronics
20. R1-2303118, Views on TPMI/SRI enhancements for 8Tx UL transmission Samsung
21. R1-2303222, Discussion on SRI/TPMI enhancement for enabling 8 TX UL transmission CMCC
22. R1-2303330, SRI/TPMI enhancement for enabling 8 Tx UL transmission MediaTek Inc.
23. R1-2303407, Discussion on SRI/TPMI Enhancements for 8 TX UL Transmission FGI
24. R1-2303420, Discussion on SRI/TPMI enhancement for enabling 8 TX UL transmission KDDI Corporation
25. R1-2303473, Views on SRI/TPMI enhancement for enabling 8 TX UL transmission Apple
26. R1-2303579, Enhancements for 8 Tx UL transmissions Qualcomm Incorporated
27. R1-2303660, SRI/TPMI Enhancement for Enabling 8 TX UL Transmission Ericsson
28. R1-2303680, Discussion on SRI/TPMI enhancement NEC
29. R1-2303703, Discussion on 8 TX UL transmission NTT DOCOMO, INC.