**3GPP TSG RAN WG1 #112b-e R1-23xxxx**

**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.

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| *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.

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| 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. While companies are encouraged to bring more simulation results for this meeting; based on the available evaluation results and discussion from the last RAN1 meeting, the following proposal is formulated,

*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)**

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** |
| NTT DOCOMO | We donot think we need to support so many over-sampling values.In our simulations, the performance gap between different over-sampling values is not so big.Thus, we think this issue can be low priority, and we can finish the whole design on CB first. |
| OPPO | Based on our evaluation results, (O1, O2) = (2, 2) (2,1) cannot provide significant performance gain over (O1, O2)=(1,1). Considering the feedback overhead and configuration signaling, it is proposed not to introduce additional values for (O1, O2). |
| ZTE | We can support proposal 2.1 in principle. Even the largest number of 512 is acceptable. If we have to down-select from non-highlighted entries in above table 1, (N1/N2) = (2, 2) should have higher priority than (N1/N2) = (4, 1), since higher complexity caused by higher oversampling factor O1 for N1=4 than N1=2 for UE implementation. For (N1, N2) = (2, 2), higher oversampling factor can be supported for scenario which needs a more accurate codebook, e.g., (O1, O2) = (2, 2) and (O1, O2) = (2, 1). At least higher O1/O2 should be supported for low rank, e.g., rank<=2, or 3, considering low rank are more likely to be selected in practice. Some more evaluation results can be found in our previous contribution R1-2300187. |
| FL | @NTT DOCOMO: Thank you for your comment. I agree that not all oversampling ratios need to be supported, however we have to make a decision, since it impacts the DCI size. |
| MediaTek | We agree with the comment made by Oppo. Based on simulation results we do not see significant benefit from over sampling factors greater than 1. Hence, we proposed to deprioritize $O\_{1}, O\_{2}>1.$ |
| Huawei, HiSilicon | Based our simulation, (O1, O2) = (2, 2) and (O1, O2) = (2, 1) have marginal throughput gains than (O1, O2) = (1, 1) . Hence, we prefer to only support (O1, O2) = (1, 1). |
| vivo | Based on our simulation results larger O1, O2 values provide marginal performance gain over O1, O2=1, hence we prefer not support other O1, O2 values |
| Google | We think we need to check simulation results in the contirbutions in the next meeting before making the decision.  |
| Intel | In our simulation, higher oversampling value doesn’t provide obvious performance gain. Therefore, our preference is not to introduce additional oversampling factors other than (1,1).If higher oversampling factor is supported, then some restriction should be considered on the parameters i11, i12, i13 and i2 to reduce the overhead. |
| QC | Based on our simulations results on both indoor and outdoor FWA scenarios, no significant gain is observed with O1>1 O2>1. So we think only supporting baseline (O1, O2) = (1, 1) is enough.  |
| LG | We also think oversampling values other than (O1, O2) = (1, 1) are not needed.  |
| CATT | We prefer to save the overheads and such the configuration is also aligned with DL that only one combination is used. We agree that supporting baseline (O1, O2) = (1, 1) is sufficient. |
| Lenovo | As UE capability, we support to have one additional (O1,O2) value for each of (N1,N2)=(4,1) and (2,2):For (N1,N2)=(2,2), (O1,O2)=(2,2). For (N1,N2)=(4,1), (O1,O2)=(4,1).Compared with the baseline (O1,O2)=(1,1), these oversampling provides gain of 1.1dB and 0.45dB respectively. Detailed simulation results can be found in our contribution R1-2302729. |
| CMCC | Support (O1, O2) = (1,1) for (N1, N2) = (4, 1), and (O1, O2) = (2,1), (2,2) for (N1, N2) = (2, 2). When the channel condition of a UE is deteriorating, higher values of (O1, O2) can be used to improve the performance. |
| Nokia, NSB | To address this OVS design, we conducted detailed system-level simulations with fixed rank selection and adaptive rank selection. Please see our contribution R1-2303011 in Section 2.1.3.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.For 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).As shown in the system level simulation results, 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.Therefore, we support at least (O1, O2) = (4,1) based on UE capability for (N1,N2)=(4,1). For (N1, N2) = (2,2), support (O1, O2) = (4,4) based on UE capability. |
| Apple | The oversampling ratio of 2 provides limited or very little gain compared to oversampling ratio of 1 based on the evaluation results provided by companies. Therefore, supporting oversampling ratio of 1 seems sufficient already. |
| Xiaomi | Based on our simulation results, higher oversampling factor can only provide marginal performance gain over lower oversampling factor for (N1,N2)=(4,1) codebook, while the performance gap between different oversampling factors is negligible for (N1,N2)=(2,2) codebook. To make a trade-off among performance, signalling overhead, and implementation complexity, we also prefer to only support (O1,O2)=(1,1). |
| Ericsson | We agree that O1,O2=1,1 is sufficient for N1,N2=4,1. However, O1,O2=2,2 is beneficial for at least low rank transmissions: we see a few percent mean throughput and 5% cell edge throughput from using O1,O2 for rank 1 and 2, with O1,O2=1,1 for ranks > 2 compared to only using O1,O2=1,1 for all ranks. This reduces the number of precoders to 272, and with some further pruning we expect could go below 256 without affecting performance. Since the price for this improved throughput is pretty minimal: a bit in DCI, we think that O1,O2=2,2 should be supported for N1,N2=2,2, and are open to using reduced O1,O2 for ranks > 2. |
| InterDigital | We prefer to minimize supported oversampling values, considering signaling overhead. However, we would be OK if additional oversampling values are supported per UE capability. |
| Samsung | In our view, O1,O2=2 should be supported at least for (N1,N2)=(2,2) and low rank (e.g. rank 1-2). There is non-negligible performance gain with O1,O2=2.  |

# 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) |
|  |  |  |

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.

***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**

Table 4 - Companies’ views

|  |  |
| --- | --- |
| **Company** | **Perspective** |
| NTT DOCOMO | Proposal 3.1 and 3.2: Not support.First, as we commented many times before, for DCI indication design, it is important to decide the codebooksubset configuration method first. Only if non-nested codebook is supported and a PC UE can be configured with PC precoders, separate DCI indication method can be considered for indication of FC, PC, NC precoders, separately. Otherwise, a unified DCI indication should be considered for indication of FC, PC, NC precoders.Second, we have not decided whether to support all the possible cases of layer splitting or whether to utilize all the 4TX FC precoders. It is too early to determine the indication is based on 2 TPMI each with a length of 5 bits.Third, for each proposal, we suggest separating the proposal and discussion for codebook design and DCI indication signalling. And we think the DCI indication related proposal can be discussed in section 6.For Proposal 3.2, for the case of ‘layers split across 2 antenna groups’ for a certain rank, since it is more likely to be used when the channel condition of two antenna groups is similar, the almost equal layer split is better and could be sufficient for such channel condition. Thus, we suggest following revisions for Proposal 3.2 with a new Alt3.***Proposal 3.2a:* 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) |
|  |  |  |

* + **Alt3 - 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) |
| 5 |  | (2,3), (3,2) |
| 6 |  | (3,3) |
| 7 |  | (4,3), (3,4) |

For the proposal related to TPMI indication method, we suggest listing all the options from different companies first. Based on understanding of each option from different companies, down-selection is performed in the second step. Thus, Proposal 3.1 can be re-formulated as follows. And we suggest moving it to section 6 for discussion.***Proposal 6.x (re-formulation of 3.1): For partially coherent 8TX UE, the precoder indication is selected from one of following options.**** ***Option 1:***
* ***Option 2:***

For Proposal 3.3, we support Version A. |
| OPPO | For Proposal 3.1, we agree with DOCOMO that it is too early to discuss PMI signaling. The signaling design should be based on the supported layer split. For example, if only a small number of layer split is supported, the PMI overhead may be reduced. We should strive for agreeing on the layer splitting first. For proposal 3.2, we don’t think we need to support so many different combinations of layer splitting. Considering there won't be significant difference between the SINR of two antenna groups, layer split such as (1,3) (3,1) (4,1) (1,4) seems unnecessary. Based on a trade-off among signaling overhead, performance and compatibility with CW-to-layer mapping, the following combinations of layer splitting are proposed:

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

For proposal 3.3, our preference is Alt.2, which can practically have a unified framework for TPMI indication as the case with Ng=2. Furthermore, we also prefer a unified PMI indication for FC, PC, NC precoders, as mentioned by DOCOMO. |
| ZTE | **Proposal 3.1**: Support it for Ng=2. Because only 2 full-coherent 4Tx precoder is mentioned, we suggest to add the condition of Ng=2 for this proposal. It has not been agreed to use 2 4Tx TPMI to indicate partial-coh 8Tx precoder with Ng=4, so it should not be applicable to Ng=4. **Proposal 3.2**: We support the first bullet which is a good way-forward suggestion. As mentioned in the FL, the number of TPMI for RANK1 (i.e., 16) is beyond a half of RANK 1~4, and therefore two individual TPMI is a straightforward solution.Regarding the second bullet, layer splitting scheme, our views are as follows:

|  |  |  |
| --- | --- | --- |
| 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) |

The yellow highlighted ones follow group balanced splitting rule, without rank permutation, which is aligned with legacy UL 4Tx codebook design. This part should have highest priority.The green highlighted ones follow one group selection rule, can be considered to support for a UE with special antenna layout. This part should have medium priority. The blue highlighted ones are similar to yellow highlighted ones, nearly even splitting. This part has low priority to be supported.The non highlighted ones should NOT be supported. **Proposal 3.3**: version A is preferred. Note that the rule for down-selection layer splitting for Ng=2 can be reused for Ng=4.  |
| FL | @ZTE: Thank you for your comment. You are right, Proposal 3.1 is intended for Ng=2. Proposal is corrected now. |
| MediaTek | **Proposal 3.1**:Fine to support.**Proposal 3.2**: We believe its too early to determine the bit width of each TPMI field at this point, hence we suggest removing it from the proposal now. We also agree with DOCOMOs comments, that the tables listed in Proposal 3.2 have too many entries and combinations for layer-splitting case and suggest down selecting fewer entries. We are ok with supporting the updated table/proposal by DOCOMO.**Proposal 3.3**: We prefer version A, i.e., 2Tx Full-coherent precoders based solution. |
| Huawei, HiSilicon | For proposal 3.1, our understanding is that the intention is to decide the indication of precoding, instead of UE, therefore, we propose to update it as below ***Proposal 3.1: For partially coherent 8TX precoding ~~UE~~ with Ng=2, the precoder indication is based on indication of two full-coherent 4TX precoders.***For Proposal 3.2, we support first bullet to have a simple indication scheme. For second bullet, we support Alt1 with all possible layer splitting to accommodate various UE layouts and dynamically varied channel environments.For Proposal 3.3, we support version B. In my simulation, Alt 1 has marginal throughput gain than Alt 2, but requires three bit more indication overhead, reaching 12 bits. Intuitively, it is not necessary to use so much overhead for partially-coherent precoders with Ng=4, where only two antenna ports can be used with coherent transmission. |
| vivo | For proposal 3.1, our preference is to support same or similar mechanism for both Ng=2 and 4. For proposal 3.2, similar comment to 3.1, add Ng=4 case as well, and I assume 5 bits is maximum length each TPMI field. With codebook subset restriction, each TPMI payload can be smaller than 5. And, regarding layer splitting table, we support alt3 from DOCOMO.***Proposal 3.2:* For partially coherent uplink precoding by an 8TX UE codebook, Ng=2 and 4,** * **TPMI indication is based on using 2 TPMI each with a maximum length of 5 bits**

For proposal 3.3, we support version B. Using 4Tx partial-coherent precoders and 2 TPMI field in DCI is simple solution and further codebook subset restriction can limit the size of each TPMI fields. |
| Google | We think we need to define the codebook first before determining the precoder indication |
| Intel | *For Proposal 3.1:*We think the indication should be up to two 4Tx precoders. For example, for Rank-1, only one 4Tx precoder will be indicated. Therefore, we suggest the following to make it more accurate.***Proposal 3.1: For partially coherent 8TX UE with Ng=2, the precoder indication is based on indication of up to two full-coherent 4TX precoders.****For Proposal 3.2:*Firstly, we agree with NTT DoCoMo that the DCI indication signalling should be discussed separately. We think the number of TPMI fields, the field length is next level details. We suggest removing the sub-bullet of “TPMI indication is based on using 2 TPMI each with a length of 5 bits”.Secondly, regarding the layer splitting options, in our simulation, for Rank-{2,3,4}, transmission over both antenna groups provides obvious gain than transmission over only one group. Therefore, if down selection is to made, we support the layer splitting over both antenna groups for Rank-{2,3,4}.In addition, for Alt 2, what is the intention to have mapping between codeword and antenna group?*For Proposal 3.3:*We are fine with Version A. With version B, it would be more complicated. The mapping between antenna groups and the 4Tx precoder should be defined, and the layer splitting would be more complicated. |
| Spreadtrum | For proposal 3.1, support.For proposal 3.2, support first bullet because 2 TPMI indicating two full-coherent 4TX precoders is a straightforward solution. For layer splitting, we are fine with DOCOMO’s comment where nearly equal numbers of layers are divided into two antenna groups under the similar channel condition.For proposal 3.3, support version A with the similar principle as Ng=2. |
| LG | Proposal 3.1 can be decided when issue on the layer split combination is finished.For proposal 3.2, agree with MediaTek that it is too early to decides bit-width for Partial coherent codebook with Ng=2. And we are open to discuss on both Alts.For proposal 3.3, support version A as Alt 1 is a super set of Alt 2.  |
| NEC | Proposals 3.1/3.2: we share similar view with DoCoMo and OPPO that PMI indication can be further discussed, and if each precoding matrix is associated with an index (similar as current spec), one TPMI field is sufficient, and the overhead of one TPMI field is always no larger than two TPMI fields. Also considering unified design for full-coherent/non-coherent codebook (if nested precoding structure agreed), 2 TPMI fields seem not a good way to go. And regarding layer splitting, we also think there is no need to support all possibilities, the number of layers for two antenna groups should be similar.We support the updated proposal 3.2a from DoCoMo and we prefer Alt 3.Proposal 3.3, prefer version A |
| CATT | **Proposal 3.1**:Not support. Same view as DOCOMO, OPPO and Google. We prefer to use one TPMI for indication.**Proposal 3.2**: We do not support the first bullet as we prefer that one TMPI indication is sufficient. Same view as the last comment. For the second bullet, we prefer that where for rank>4, each CW is mapped to only one antenna group. While based on our simulation results, following highlighted combinations are preferred:* + **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) |
|  |  |  |

**Proposal 3.3**: We prefer to version A, i.e., 2Tx Full-coherent precoders based solution. Still, we are open for discussion or down selections on other options. |
| Lenovo | Proposal 3.1: Do not support. This does not enable all the potentials for 8TX UE. For example, using only full-coherent 4TX precoders does not allow port selection, which is supported by 4TX even for full-coherent UE. At least for rank 1 and 2, we should consider including non-coherent and partial coherent 4TX precoders.Proposal 3.2: Do not support. There is no need to support the layer splitting where all layers are transmitted from a single antenna group, because this leads to significant power imbalance between the two groups and limit the UL coverage for each rank. We support the entries in the right column where a codeword is transmitted from only one antenna group.Proposal 3.3: We support Version A because it gives more codewords and more flexibility.  |
| CMCC | Proposal 3.1: It has been agreed in last meeting that rank 1 is supported with one antenna group transmission, in this case, indication of one full-coherent 4TX precoder is enough. For rank>1, if the precoders of two antenna groups are same or can be derived from each other, then indication of one full-coherent 4TX precoder is also enough. So, proposal 3.1 could be revised to “indication of up to two full-coherent 4TX precoders”.Proposal 3.2: Support Alt 3 proposed by DoCoMo. It is possible that one of the antenna groups is blocked or with worse channel condition, then the first column to support all layers in one antenna group could be supported with highest priority. Otherwise, if the channel condition of two antenna groups is similar, group balanced layer splitting of antenna group is preferred.Proposal 3.3: Support version A to have a same framework for TPMI indication as the case with Ng=2. |
| Nokia, NSB | 3.1: support in general. 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.3.3: Either approach is fine. The decision point depends on the overall payload size and their related performance. |
| Apple | P3.1: supportP3.2: we are generally fine with the proposal and prefer Alt 1.P3.3: We slightly prefer version A as it provides more flexbility. |
| Xiaomi | Proposal 3.1: we think the legacy indication rule (joint indication by TRI and TPMI) should not be precluded at this stage. If nested codebook is supported, a unified solution is preferred.Proposal 3.2: we prefer DOCOMO’s version Alt.3;Proposal 3.3: we are open to discuss. |
| Ericsson | P3.1: Do not support. As multiple other companies have commented, the DCI design should be based on the needed precoders, not the other way around. We think a good Ng=2 design needs only 196 precoders (where some pruning is used on top of layer splitting), and so 10 bits is far too much.P3.2 Do not support the first bullet. Alt 2 seems a good direction, and the principle of mapping only one codeword to a group seems required by the agreement to use the DL CW to layer mapping. Only one layer split is needed for ranks > 2 in our view. Therefore, we propose the following:**For partially coherent uplink precoding by an 8TX UE codebook, Ng=2,** * + **Following combinations of layer splitting are supported, where for rank>4, e*ach CW is mapped to only one antenna group.***

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

P3.3: Support version A. Version A has better performance that version B, as we show in our contribution R1-2303660. We find that a 2 Tx Ng=4 based design with 288 precoders significantly outperforms a 4 Tx design with 440 precoders by roughly 10% mean throughput when directional antennas are used. Note that since 288 precoders are used, the Ng=4 design does not require excessive overhead when based on 2 Tx precoders. |
| InterDigital | Proposal 3.1: Support for the case of Ng=2 at least, which should be regarded as a super set for the precoder indication where further details can be discussed, e.g., one out of the two precoders is only indicated as valid, depending on the DCI being signalled. The case with Ng=4 needs to be also discussed. Proposal 3.2: Support in general. OK to consider Alt3 as well, suggested by DOCOMO. We are fine to update the proposal with ‘up to’ 5 bits per precoder mentioned by vivo.Proposal 3.3: We are open for discussions, as each version has its own pros and cons. |
| Samsung | P 3.1: * we prefer to discuss indication part separately, hence suggest to remove the wodk “**indication**”.
* Then, for (L1,0) or (0,L2) layer split, we don’t need two FC 4Tx precoders. Even for L1,L2>0 layer split, we can have a design for only one 4Tx FC precoders, e.g. layers of a 4Tx FC precoder can be distributed across two groups.
* Finally, we also have the view that the payload of 8Tx precoder indication shouldn’t be large (10 bit is large), 1-2 bits over legacy (4Tx) should be sufficient.

P3.2: we are fine with either alt, as long as, the 8Tx precoder indication overhead is 1-2 bits overhead (legacy 4Tx).P3.3: we prefer version B. This can simplify codebook design for Ng=4.  |

# 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. Based on the discussion and contributions from the last RAN1 meetings, the following proposals are prepared for consideration,

***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 4.5: 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** |
| NTT DOCOMO | Proposal 4.1:For PUSCH with layer > 4 , we think 2 CWs should be used. We donot need to define both 1 CW and 2 CWs for PUSCH with layer > 4. Thus, no UE capability is needed for the number of CWs.We suggest deleting the note, and we support Alt2.Proposal 4.2: support.Proposal 4.3: Not support.For DL, such implicit indication is needed because DMRS antenna port indication tables for rank>4 and rank<=4 share the same DCI indication codepoint. For UL, the case is different from DL. For non-codebook based UL transmission, the rank is indicated by SRI, so that when rank<=4 is indicated by SRI, the 2nd CW can be regarded as disabled and no other indication method is needed. For codebook-based UL transmission, the rank is indicated by TRI/TPMI indication, similarly, no other indication method is needed. Thus, we don’t think the indication for disabling a CW is needed.Proposal 4.4: support in principle.Proposal 4.5: support in principle. |
| OPPO | For proposal 4.1, we think two CWs should be always applied for rank >4 without any RRC signaling. For Alt.2, current spec. can already support gNB to configure the max number of MIMO layers by RRC. The only issue is to extend the signaling to support more than 4 layers. For proposal 4.2, our preference is Alt.1. The SINR of different layers would not differ much for codebook-based transmission. For non-codebook based transmission, it is likely that UE would apply the best precoder to the first layers which are mapped to the first CW. Hence, Alt.1 can be a simpler solution. For proposal 4.3, We think the issue is associated with the TRI/SRI signaling design. If different tables for TRI/TPMI signaling are used for single CW and two CWs case, and different SRI mapping tables are used for Rank <5 and Rank >4, the proposal is needed and reusing DL design is fine. Otherwise, the proposal is not needed since the rank (1-8) can be used to derive the CW number. Also, we can agree on this proposal first, and then design the TRI/SRI signaling based on the conclusion. For proposal 4.5: support.  |
| ZTE | Proposal 4.1: Support Alt 2.We prefer to reuse the layer to codeword mapping for legacy PDSCH, i.e., there is one-to-one correspondence between the number of codewords and the number of layers. In such case, Alt 2 should be supported.Regarding Alt 1 and the UE capability, they intend to support 1 CW for PUSCH with layer > 4. However, supporting both 1 CW and 2 CWs for PUSCH with layer > 4 seems unnecessary in our observations. We prefer not to introduce the UE capability.Proposal 4.2: Support.According to the recent agreement of mapping of layer to CW, the number of layers mapped onto the first CW is not greater than that onto the second CW, hence Alt 1 should not be supported from the perspective of UCI capacity. Proposal 4.3: Support in principle.In our understanding, the DL principle of disabling transmission of a transport block is used for re-transmission of one of the two CWs. When only one of the two CWs requires re-transmission, another CW can be disabled. The transmission power of the re-transmitted CW gets larger due to the decrease of transmission layers, and the transmission reliability can be improved. Proposal 4.4: Support.Proposal 4.5: Support. In addition, the RV sequence parameter (*repK-RV*) configured for CG-PUSCH should be clarified as well, and we prefer that two CWs share the same RV sequence parameter. |
| MediaTek  | **Proposal 4.1:**We prefer Alt 2.**Proposal 4.2, 4.3, 4.4, 4.5:**Support |
| Huawei, HiSilicon | For proposal 4.1, we prefer Alt 1 to reuse DL scheme. With the RRC configuration, it can be configured by gNB whether the second set of MCS/RV exists in the DCI to save DCI size.For Proposal 4.2, 4.3, 4.4, 4.5, support. |
| vivo | For proposal 4.1, we support alt 1.For proposal 4.2, 4.3, 4.4, 4.5 we support the FL proposal |
| Google | 4.1: Support Alt2. 4.2: The proposal is imcomplete. We suggest revising it as follows since there are some reserved MCSs with higher MCS index but with lower SE, and one CW may be disabled.***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,*** * ***Alt2: The CW with the MCS with highest SE (if MCSs are the same, UCI is multiplex on the first CW)***

4.3: Support4.4: OK with a working assumption, since this is the first time to discuss this issue.4.5: Support |
| Intel | *For Proposal 4.1:*Support Alt2. Agree with OPPO that parameter on max number of layers is already in uplink.*For Proposal 4.2:*Our preference is Alt1. But if majority is ok with Alt2, then it’s fine.*For Proposal 4.3:*We should firstly decide on the condition that both MCS/NDI/RV version are present in DCI. As commented in previous meeting, we suggest the following:***Proposal 4.3:*** *For codebook and non-codebook based PUSCH transmission by an 8Tx UE,** *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.* ***~~To support dual CW PUSCH operation by an 8TX UE, t~~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.~~***

*For Proposal 4.4:*Fine with it.*For Proposal 4.5:*What is the use case to support dual codewords operation for PUSCH with configured grant? In downlink, only single codeword is applied for SPS PDSCH. |
| Spreadtrum | Proposal 4.1: Support Alt1. Similar as DL PDSCH, an RRC parameter is configured in PUSCH-config to indicate the maximal number of CWs scheduled by DCI.Proposal 4.2, 4.3, 4.4, 4.5: Support. |
| LG | For Proposal 4.1, support in principle. But, Alt 2 is little bit misleading as maxRank parameter is already supported in RRC spec. For Proposal 4.2, 4.3, 4.4, 4.5: Support. |
| NEC | Proposal 4.1: Alt 2 preferred Proposal 4.2: SupportProposal 4.3: generally fine. While we think reusing specific MCS/RV value to is for flexibility to disable one of the two CWs, then the remaining TB should be mapped on remaining enabled CW, not always the first CW, otherwise, it seems the disabling is only for 2nd CW, which is not needed as number of layers can already indicate number of CWs.***Updated 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 remaining not disabled ~~first~~ CW.***
* ***Note: When the transmission of a transport block is disabled, the maximum number of layers is ≤ 4.***

Proposal 4.4/4.5: Fine.  |
| CATT | **Proposal 4.1:**For PUSCH with layer > 4 , we believe 2 CWs should be used. We support Alt2.**Proposal 4.2**: support. In LTE, when the CQI/PMI information is multiplexed on a PUSCH transmission with 2 CWs, the CQI/PMI information is always multiplexed only the CW with the highest MCS, or the first CW for the case where MCSs are the same. That is, Alt 2 is supported for CQI/PMI information multiplexing on PUSCH transmission with 2 CWs in LTE. It is natural to reuse the mechanism for UCI multiplexing on PUSCH for transmission with rank>4 by an 8TX UE. **Proposal 4.3**: Not Support.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 in principle. |
| Lenovo | Proposal 4.1: Support Alt 2. When the number of layer is more than 4, 2 CWs is automatically transmitted. Proposal 4.2: Our preference is Alt 1 for its simplicity, but can go with Alt 2 if this is the majority view.Proposal 4.3, 4.4, 4.5: We are fine with it. |
| CMCC | Proposal 4.1: Support Alt 1, if it is intended to use RRC parameter to indicate whether the second set of MCS/RV exists in the DCI to save DCI size. Support Alt 2, if it is intended to use the RRC parameter of *maxRank*, which is already exists in current spec.Proposal 4.2, 4.3, 4.4, 4.5: Support. |
| Nokia, NSB | 4.1: Alt 2 is more flexible than Alt 1. Therefore we are supporting Alt 2.4.2: This issue has been discussed multiple times. We are supporting Alt 1: UCI is always multiplexed on the first CW, because of its simplicity. Besides, if it is still deadlock, we can be flexible to support of using RRC configuration to select whether UCI is multiplexed on the first CW.We probably need more time to discussion issues of 4.3, 4.4 and 4.5. |
| Apple | P4.1: We support Alt 2, and dual CW should be used whenever the indicated rank > 4.P4.2: supportP4.3: it is not clear to us why we need such signaling to disable a TB. We think one or two CWs can be decided based on rank already, and no additional signaling is needed.P4.4: okP4.5: ok in principle, but we think the 2nd bullet is not needed, as the field is already added in the DCI for dynamic scheduling and Type-2 CG just follows that. |
| Xiaomi | Proposal 4.1: we support alt.1.Proposal 4.2 4.3 4.4 4.5:support in general |
| Ericsson | P4.1: Not support. We don’t think 2 codewords should be a MIMO capability: if the UE supports more than 4 layers, it needs to be able to transmit two codewords. Since max number of PUSCH layers can be configured today, we think the existing capability can be extended to up to 8 layers, and no new mechanism is needed.P4.2: As we discuss in detail in R1-2303660, we think Alt 1 is better. * Selecting the highest MCS codeword for UCI does not seem to have clear performance advantages, since a) it does not necessarily minimize the number of UCI symbols (the TBS of a higher MCS codeword 0 can be smaller than codeword 1), b) multiplexing on the second codeword only happens for rank 5 and up, and c) the network may set a higher MCS codeword to be more or less robust than a lower MCS codeword.
* Although Alt 1 leads to fewer UCI symbols on codeword 0 than codeword 1 due to the codeword to layer mapping, this can be handled in a fixed way (independent of MCS) through proper selection of $β\_{offset}^{PUSCH}$ values.
* If Alt 1 is used, the network has full control over the MCS that carries the UCI, whereas Alt 2 constrains the network.
* Alt 2 is further complicated by requiring that the initial MCS be used to select the codeword that carries UCI.

All that being said, how UCI should be multiplexed on a codeword is a complicated issue, and deserves careful study. We do not bring simulation results to this meeting, and there could be other qualitative factors than those we list. However, it is fair to say that multiplexing on one codeword works (having been done since Rel-15 in NR), and so for progress we think a working assumption can be made and confirmed with further analysis and/or simulation results. So we propose:**Proposal:** A working assumption is made that CSI is multiplexed with UL-SCH only on the first codeword.P4.4: Would like to consider this further.P4.5: Do not support at this time, but can consider further. Like Intel, we would like to better understand the use case with high rank UL MIMO for CG-PUSCH. We particularly wonder about Type 1.  |
| InterDigital | Proposal 4.1: Alt2 is preferred. Proposal 4.2, 4.3, 4.4, 4.5: Support |
| Samsung | P4.1: in legacy maxRank is used to configure max rank value. So, it is straightforward to extend legacy to up to 8 layers. Hence, Alt2 is sufficient. There is no need for new signaling (as in Alt1).P4.2: we also think UCI mux based on MCS has unclear need/benefits, considering that the probability of rank > 4 < probability of rank <=4, and rank >4 can be beneficial only for some UEs (e.g. in cell-center), not all UEs, so overall there may not be any gain with Alt2. So, we prefer Alt1 (UCI mux on 1st CW), which is simpler and can be as competitive as Alt2.P4.3,4.4,4.5: open to discuss |

# 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.

***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.***

Table 6 - Companies’ views

|  |  |
| --- | --- |
| **Company** | **Perspective** |
| NTT DOCOMO | Proposal 5.1:Support it in principle. But whether it is ‘no change is specification’, we need further check.Proposal 5.2:More discussion is needed. If one fully-coherent precoder is added into the non-coherent or partial-coherent codebook subset, considering possible separate/different DCI indication methods for codebooksubset with different coherent type, how to indicate the added precoders should be discussed. |
| OPPO | Proposal 5.1: Fine.Proposal 5.2: Fine in principle. We think full power mode 2 can also be discussed.  |
| ZTE | **Proposal 5.1**: Agree with DOCOMO, support in principle, may need further check. We may don’t need to agree on this issue, which maybe only relevant to spec drafting. **Proposal 5.2**: Adding more codebooks for full power mode 1 would cause different codebook sets for UEs supporting and not supporting mode 1, and different overhead for indication. As we know, 8Tx codebook design has so many non-solved issues, e.g., whether nested structure is assumed, whether to use 2 4Tx TPMI to indicate codebooks for Ng=4 and non-coherent cases, and layer splitting issues, etc.. We tend NOT to support extending legacy R16 full power mode 1 mechanism for 8Tx. Mode 2 is more flexible, and could support all kinds of UE antenna layout.  |
| MediaTek | **Proposal 5.1**:Support**Proposal 5.2**:Agree with ZTEs comment. Given the limited time and number of open issues remaining for 8TX precoder design we would like to deprioritize extending Rel-16 mode 1 full power mode for 8TX operation.  |
| Huawei, HiSilicon | For Proposal 5.1, fine.For Proposal 5.2, similar view with ZTE that introduction of mode 1 will introduce more open issues. If companies prefer the case with non-full-rated PA, we prefer to discuss mode 2 firstly, where at least one PA is full rated PA. Note that full power mode 2 can have better performance than mode 1 and more flexible. |
| vivo | For proposal 5.1, it is fine which depends on UE capabilityFor proposal 5.2, it can be discussed after codebook is finalized. |
| Google | 5.1: Support5.2: Agree with ZTEBesides, we think we need to consider the full power mode for fallback operation for 8Tx UE, i.e., a 8Tx UE configured with 2 or 4 ports SRS. |
| Intel | For full power operation, we think all the three modes should be supported in Rel-18. It would be weird if only one or two modes are supported.*For Proposal 5.1:*Generally fine.*For Proposal 5.2:*Generally fine. But we are also fine to discuss it after we have clear picture on codebook design. |
| QC | Support proposal 5.1 and 5.2 in general. Regarding ZTE/Huawei’s comments on full power mode 1, we don’t agree. We have opposite view. Extending mode 1 from 4 Tx to 8 Tx is extremely easy, RAN1 just need to pick any one of 8Tx full coherent precoder per rank and use it as “full power” precoder for non-coherent and partial coherent UE. We don’t see any open issue that ZTE listed relates to full power mode 1 design. By the way, they do impact/delay mode 2 design as explained below. On the other hand, full power mode 2 design for 8Tx is very challenging. Full power mode 2 heavily depends on PA assumption and we cannot decide PA structure for future 8 Tx UEs at all. Another huge issue with mode 2 is deciding how to group the 8 Tx TPMIs into several groups and report the full power capability for the groups. If we recall how complicated the grouping (G0, G1, G2…G7) is in Rel-16 with only 4 Tx, we will realize this is a much more complicated grouping problem with 8Tx. To make things even worse, we don’t even have the codebook design ready for 8Tx, how can we work on the grouping problem with the codebook still unavailable?   |
| Spreadtrum | Proposal 5.1, 5.2: fine in principle. The mode 1 is more practical and feasible for a partially/non-coherent 8TX UE with full power transmission. Similar as in Rel-16, a new codebook subset can be introduced, where only a small number of precoders need to be introduced. |
| LG | Proposal 5.1: fine in principle. Proposal 5.2: Since mode 1 is related to the codebook subset, it can be discussed after we agree on codebook and codebook subset.  |
| CATT | **Proposal 5.1:** Support. **Proposal 5.2:** We agree with ZTE, MTK, HUAWEI and Google to deprioritize Rel-16 mode 1 full power mode for 8TX operation. We are fine to support mode 2. |
| Lenovo | Proposal 5.1: Fine in principleProposal 5.2: We share the same view with ZTE, MediaTek, HW and Google. Mode 1 should be deprioritized considering the many issues of codebook are still open. |
| CMCC | Proposal 5.1: Support.Proposal 5.2: Support. It is easy to support full power transmission with Mode1, we could add one note in the proposal to have a restriction that only one full coherent precoder per rank will be selected for full power transmission.Besides, fullpowerMode2 with antenna virtualization can be also supported, which is not related to the PA architecture, for example, 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. |
| Nokia, NSB | 5.1: okay5.2: The wording “Introduction of 8Tx full power precoders” might cause some confusions. We are supportive if this means that the restriction of newly defined 8Tx precoders for full power support, like Rel-16 FPTx feature. If this means “adding more codebooks”, we need to be very careful about that. |
| Apple | P5.1: generally fine. But may need to be careful on “no change in specifications” statement. Maybe this part can be decided later.P5.2: generally fine with the principle, but this starts to interact with the signaling detail on how TPMI is indicated, and we probably should not agree to something in isolation. We would also be fine to deprioritize the full power operation given that we still have many unsolved issues. |
| Xiaomi | Proposal 5.1,5.2 ,support in general |
| Ericsson | P5.1,5.2: Do not support. We see no reason to prioritize among the UL FPTx modes now. Our understanding is that with the currently agreed PA configurations for study, all 3 UL FPTx modes are in scope, including for Mode 2 where SRI is used and where full power TPMI is used. If we stick with the agreed PA configurations, or better still add one more with [-3 -3 -3 -3 -3 -3 -3 -3], we can agree a few simply precoders and SRS configurations, avoiding the excessive complexity of the Rel-16 designs. Propose the following:**Proposal:** Working assumption: UL MIMO full power modes 0, 1, and 2 are supported for 8 Tx operation. |
| InterDigital | Proposal 5.1: Support, agree with FL assessment. Proposal 5.2: Fine in principle, and our understanding is that the subbullet does not intend to add more (new) precoders for this purpose.  |
| Samsung | P 5.1,5.2; do not support. We need to prioritize/finalize CB design, without which there is no point discussing full power modes. |

# 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 i1,1, i1,2, i1,3 and i2 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 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.*

Table 7 - Companies’ views

|  |  |
| --- | --- |
| **Company** | **Perspective** |
| NTT DOCOMO  | Proposal 6.1:Not sure the exact meaning of Proposal 6.1. Does it mean DCI needs to indicate 4 fields?If so, we donot support it. We think DCI just needs to indicate one field for joint layer and TPMI indication, similar as legacy.Proposal 6.2:Slightly prefer version A.Proposal 6.3:Suggest following revisions for Alt1.*Proposal 6.3a: 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 fully- or partially- or non-coherent codebook.*
	+ *A partially-coherent UE can be configured to operate only with partially- or 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.*
 |
| OPPO | For proposal 6.1, we think at least the indication of i1,3 needs further study. For example, a fixed k1, k2 may be sufficient. A unified TPMI signaling is preferred for different coherent codebooks. For proposal 6.2, we prefer version B. An *NSRS* bit length bitmap can simplify the signing design, but would lead to high overhead regardless of *Lmax*. Considering there could be waste of 5bits at the worst case, option 2 is preferred.For proposal 6.3, we prefer the revision from DOCOMO for Alt1. For Alt2, we suggest the following wording to make it clearer:* *Alt2.*
	+ *A fully-coherent UE can only be configured to operate with fully -coherent codebook.*
	+ *A partially-coherent UE can only be configured to operate with partially codebook.*

And a note is needed to clarify that the above is only applied when UE is not configured with full power mode 1.  |
| ZTE | **Proposal 6.1:** Agree with FL in principle. But we believe this is more relevant to spec drafting, so it may not need an agreement, at least for now. **Proposal 6.2**: Slightly prefer version B. Version A may have less spec impact, and it does not need a large table as in version B. But version B may be a better choice from perspective of unified design for both $N\_{SRS}>4$ and NSRS<=4, and less overhead in case that Lmax is not larger than 4. **Proposal 6.3**: Tend to prefer Alt 1, which is a flexible way to determine which codebook subset can be dynamically selected from. The codebook subset should be determined according to RRC signaling.  |
| *FL* | @ NTT DOCOMOThank you for your question. The intention is to avoid designing a new table for FC precoders, and indication of *ix*values are sufficient. As for the field, it would be a single field where each subset of field would be interpreted for a different *ix*.  |
| MediaTek  | **Proposal 6.1:**We believe this discussion needs to revisit after the final codebook design. Indicating individual i1,1, i1,2, i1,3 and i2 values explicitly can lead to wasted overhead depending on the final codebook entries agreed and perhaps some joint indication may be beneficial. **Proposal 6.2:**We prefer version A.**Proposal 6.3:**We are ok with the modification made with DOCOMO and OPPO, however, we would like to keep the UE capability clause. *Proposal 6.3a: 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 fully- or partially- or non-coherent codebook.*
	+ *A partially-coherent UE can be configured to operate only with partially- or non-coherent codebook*
	+ *Note: This is subject to UE capability.*
* *Alt2.*
	+ *A fully-coherent UE can only be configured to operate with fully -coherent codebook.*
	+ *A partially-coherent UE can only be configured to operate with partially codebook.*

We prefer Alt 2. |
| Huawei, HiSilicon | For proposal 6.1, fine with it.For proposal 6.2, support version B. For option 2, the overhead of SRI is  bits, which is up to $N\_{SRS}$ bits and related to RRC parameter $L\_{max}$. For example, if $N\_{SRS}=8$, the overhead of SRI is 6 bits when $L\_{max}=2$ and 3 bits when $L\_{max}=1$. On the contrary, for option 1, the overhead of SRI is always 8 bits no matter what $L\_{max}$. To save SRI overhead, we support version B.For proposal 6.3, we don’t support it. We believe the legacy codebooksubset is needed considering dynamically varied channel environments. Take fully coherent 8TX UE as an example. It is possible that some antenna ports of 8TX UE are blocked by nearby obstacle. At that time, there will be performance loss if fully coherent precoder is used for PUSCH.  |
| vivo | For proposal 6.1, fine in principle. Details need to be further discussedFor proposal 6.2, considering balance between complexity and overhead, we support version B when configured Lmax is small, e.g. 1 or 2, and support version A when configured Lmax is larger, e.g. larger than 2For proposal 6.3, needs further discussion. A UE capable of full-coherent transmission can be configured with partial or non-coherent codebook subset. Now the question is for a UE capable of full-coherent transmission, whether the codebook includes all full-coherent, partial-coherent, and non-coherent precoders. Since the full-coherent precoders are based on DFT precoders, and partial-coherent precoders are based on legacy 4Tx or 2Tx codebook, nested design as in rel-15 may not be possible. And, if all full, partial, non-coherent precoders are kept in single codebook, the codebook size will be huge leading unacceptable DCI overhead. One way could be similar to number of RRC configured TCI states and MAC CE activates few of them. This provides some dynamic flexibility in codebook subset switching between fully-coherent or partially-coherent or non-coherent subsets, the TPMI overhead is based on MAC CE activated codebook subset.  |
| ***Google*** | 6.1: We also think we can decide it after we finish the codebook. We should have a common scheme for precoder indication for all types of codebook subsets.6.2: Support option B6.3: We think we need to consider the fallback operation, e.g., 8Tx UE configured with 2 or 4 ports SRS. For 8Tx, we think there should be the following 4 types of codebook subsets:* **Subset 1: fully coherent + 4-port partial coherent + 2-port partial coherent + non-coherent**
* **Subset 2: 4-port partial coherent + 2-port partial coherent + non-coherent**
* **Subset 3: 2-port partial coherent + non-coherent**
* **Subset 4: non-coherent**
 |
| Intel | *For Proposal 6.1:*Agree with FL that it could be single field, and different subsets could indicate the parameters i\_11, i12, i13 and i2.But we think it may require more discussion. For example, if some parameter is just one value, then it’s not necessary to indicate.In addition, we think separate encoding of rank indicator and precoder indicator is needed for full coherent precoder.*For Proposal 6.2:*We prefer with Version B.*For Proposal 6.3:*The codebook subset design is important and requires more discussion.Firstly, we share similar view with other companies that new scheme is needed for Rel-18, since the codebook design and indication are different for different coherence type. So, the codebook subset containing precoders of only one coherence type could simplify the signalling design.Secondly, we think the UE capable of full coherence should also be able to be configured with partial coherent or non-coherent precoders, similar with legacy operation.Therefore, we have the following proposal.*Proposal 6.3: For codebook-based 8TX PUSCH transmission in Rel-18, down-select from the following** *Alt1: the codebook subset contains precoders of only one coherence type*
	+ *The fullCoherent codebook subset only contains full coherent precoders*
	+ *The partialCoherent codebook subset only contains partial coherent precoders*
	+ *The nonCoherent codebook subset only contains non-coherent precoders*
	+ *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.*
* *Alt2: the codebook subset contains precoders of multiple coherence types*
	+ *MAC-CE or DCI could be used to further indicate the coherence type of the precoders to be indicated to the UE*
	+ *The “fullyAndPartialAndNonCoherent” codebook subset contains full coherent precoders, partial coherent precoders and non-coherent precoders*
	+ *The “partialAndNonCoherent” codebook subset contains partial coherent precoders and non-coherent precoders*
	+ *The “nonCoherent” codebook subset only contains non-coherent precoders*
	+ *The UE capable of “partialAndNonCoherent” transmission can’t be configured with “fullyAndPartialAndNonCoherent” codebook subset.*
	+ *The UE capable of “nonCoherent” transmission can’t be configured with “fullyAndPartialAndNonCoherent” codebook subset or “partialAndNonCoherent” codebook subset.*
 |
| QC | Proposal 6.1: Similar to other companies, we think it is too early to discuss this proposal. Actually, with only 8 Tx, it is fine to use a table in spec to list the precoders (up to editor). If so, then we don’t need to even discuss this proposal.  |
| Spreadtrum | Proposal 6.1: Fine in principle. The details of TPMI signalling can be decided after codebook design.Proposal 6.2: Support version B which is a unified solution regardless of NSRS.Proposal 6.3: Prefer DOCOMO’s modification, where the codebook subset can be configured by RRC. |
| LG | Proposal 6.1: Similar to other companies, we think it is too early to discuss this proposal. Proposal 6.2: Support version A.Proposal 6.3: Not support.  |
| NEC | Proposal 6.2: Version B preferred. |
| CATT | **Proposal 6.1:**Not support. Similar to other companies, we believe that codebook design should be discussed firstly (e.g., whether PC codeword and non-coherent codeword are included in the FC codeword), then turning to the discussion on TPMI indication. We prefer to include both PC codeword and NC codeword. **Proposal 6.2:** Support version B. Version B is preferred since compared to version A It can save large SRI indication overheads in several cases. For example, when Lmax = 1 is configured, only 3 bits is needed for option 2, but $N\_{SRS}$ bits are always needed for version A. Then, compared to version A, 2, 3, 4, and 5 bits can be saved by option 2 for $N\_{SRS}$ = 5, 6, 7, 8, respectively.  **Proposal 6.3**:Prefer to Alt 1, which is more flexible. |
| Lenovo | Proposal 6.1: It is premature to discuss these details.Proposal 6.2: Support version A.  |
| CMCC | Proposal 6.1: Similar to other companies, we think it is too early to discuss this proposal. Proposal 6.2: Support version B as legacy scheme, which is less overhead when Lmax is small.Proposal 6.3: Not support. The legacy flexibility of codebook subset indication could be also kept for 8TX UE. For example, for a full-coherent UE, the channel condition of different antenna ports may be various, and partial-coherent codebook may have better performance. |
| Nokia, NSB | Proposal 6.1: the proposal itself is not clear about the meaning of various i-values, although we are oaky with the general principle. However, these details shall be finalized after the codebook design.Proposal 6.2: Support Version A.Proposal 6.3: Alt 1 likely will need higher overhead than Alt 2, although Alt 1 might provide more flexibility. Alt 2 shall be the default choice. We need to justify the benefit (gains?) of using Alt 1 if more flexible Alt 1 is supported. |
| Apple | P6.1: fine with the principle, but the exact signaling detail would need to be discussed and clarified.P6.2: we prefer version B.P6.3: Intel’s proposal seems to be a better formulation of the two alternatives. The question is what we are discussing here, e.g., (1) whether a fully-coherent UE can be configured with a partial-coherent codebook (moderator’s proposal), or (2) whether a fully-coherent UE can be configured with full-coherent codebook + partial-coherent codebook + non-coherent codebook (Intel’s proposal) |
| Xiaomi | Proposal 6.2 : we prefer version A.  |
| Ericsson | P6.1: Do not support. As we and others have commented above, DCI design should be after the we decide the precoders / codebook. Independent *i1,1, i1,2, i1,3 and i2* values is constraining on the codebook design, and may lead to higher overhead. This proposal also seems to require that TRI is independently indicated of TPMI, again leading to higher overhead.P6.2 Support version B; similar views as Huawei.P6.3. Do not support, but can understand FL’s motivation. Adding PC precoders to the FC precoders can more than double the size of an FC+PC codebook, and may not increase performance (at least for single panel designs), as we show in R1-2303660. However, similar to others’ comments, we think there are a number of reasons to nest precoders with different coherence together:* Power saving
	+ PAs operate more efficiently at higher power, and so transmitting on one PA with a given amount of power is more efficient than N PAs. Other components than the PA may also be turned off. Therefore, precoders that allow Tx chains to be turned off can enable power saving.
* Coherence fall back
	+ RAN4 specs say that fully coherent UEs may not transmit coherently if SRS is not transmitted within 20ms of PUSCH. Therefore, it can be beneficial to have non-coherent precoders available to fully coherent UEs in scenarios where coherence is intermittently needed, or when SRS capacity is limited.
* Support for directional antennas
	+ Fully coherent precoders may not work well with directional antennas, as shown in R1-2303660.

Nesting naturally increases codebook size. This is more problematic for 8 Tx than for 4 Tx, since there are so many PC precoders for 8 Tx, vs. a small number few for 4 Tx. Then since there is limited performance gains in some important scenarios, whether PC precoders should be included should be carefully considered. On the other hand, only a small number of NC precoders are needed to reap the benefits of power saving, coherence fall back, and direction antenna support. Therefore we propose the following:**Proposal**: 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. |
| InterDigital | Proposal 6.1: Support the intension of the proposal to avoid designing a new table for FC precoders, where mapping between TPMI index and indication of *ix*values are sufficient.Proposal 6.2: We prefer the approach based on Version B to be further considered, where details on how to achieve overhead saving can be further discussed.Proposal 6.3: Support Alt1 in principle. |
| Samsung | P 6.1: support in principle, but the range of values of these indicators can be less than DL T1 CB. For example, i1,3 can be fixed (hence not reported), and the range of (i1,1,i1,2) can be reduced for high rank, just like we did for 4Tx case in Rel.15.P 6.2: support Version A as it can simplify the spec (no need to add new very long tables), and overhead saving with Version B is quite small.P 6.3: do no support. We don’t need to discuss this “*legacy codebooksubset mechanism is not supported*”. We are open to discuss Alt1/2. Our preference is Alt1 but the configured CB size shouldn’t be too large (i.e., TPMI payload should not be large). For discussion, we can use Ng value since we have two PC Ng values. For ex:* Ng=1 (FC), 2, 4, 8 (NC)
* UE capability:
	+ Alt1.1: only one Ng value
	+ Alt1.2: >1 Ng values, if so, how many values (2, 3, …)
* CodebookSubset
	+ Alt2.1: when UE supports Alt1.1 (e.g. Ng=X)
		- Alt2.1.1: Only (Ng=X) can be configured
		- Alt2.1.2: (Ng=X) or (Ng<X) can be configured
		- Alt2.1.2: (Ng=X) and (Ng<X) can be configured
	+ Alt2.1: when UE supports Alt1.2 (e.g. Ng=X1,X2 with X1>X2)
		- Alt2.2.1: Only (Ng=X1 or X2) can be configured
		- Alt2.2.2: (Ng=X1 and X2) can be configured
		- Alt2.2.3: (Ng=X1 or X2) or (Ng<X2) can be configured
		- Alt2.2.4: (Ng=at least two of (X1, X2 and (Ng<X) can be configured
 |

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