**3GPP TSG RAN WG1 #110bis-e R1-2210407**

**e-Meeting, October 10th – 19th, 2022**

**Source: Moderator (NTT DOCOMO)**

**Title: FL summary on DMRS#3**

**Agenda item: 9.1.3.1**

**Document for: Discussion and Decision**

# Introduction

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

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| 1. Study, and if justified, specify larger number of orthogonal DMRS ports for downlink and uplink MU-MIMO (without increasing the DM-RS overhead), only for CP-OFDM,
* Striving for a common design between DL and UL DMRS
* Up to 24 orthogonal DM-RS ports, where for each applicable DMRS type, the maximum number of orthogonal ports is doubled for both single- and double-symbol DMRS

[…]1. Study, and if justified, specify UL DMRS, SRS, SRI, and TPMI (including codebook) enhancements to enable 8 Tx UL operation to support 4 and more layers per UE in UL targeting CPE/FWA/vehicle/Industrial devices
* Note: Potential restrictions on the scope of this objective (including coherence assumption, full/non-full power modes) will be identified as part of the study.
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This document contains summary of the company’s proposal and FL proposals.

# Objective #3 (increasing DMRS ports)

## Details on Opt.1 (FD-OCC)

### 2.2.3 Orphan REs in length 4 FD-OCC in DMRS type 1

If FD-OCC length 4 is supported in sect. 2.2.1, FD-OCC length 4 can be applied across consecutive PRBs. If the number of PRBs is odd, there is orphan REs. How to deal with the orphan REs should be discussed.



**Figure 12. Example of orphan RB/REs of Type1 DMRS [26]**

Following options can be considered.

* **If FD-OCC length 4 is supported in DMRS type 1, down select from the following to handle orphan REs:**
	+ **Alt.1: Introduce scheduling restriction (e.g. gNB always schedules PDSCH/PUSCH with even number of PRBs).**
		- **FFS: details.**
	+ **Alt.2: Not introducing scheduling restriction (i.e. gNB can schedules PDSCH/PUSCH with any number of PRBs).**
		- **Alt.2-1: FD-OCC length 4 can be decoded per a PRB at a receiver.**
		- **Alt 2-2: DMRS is not transmitted in the last 2 REs corresponding to the DMRS port in the orphan RB.**

Alt.2-1 is illustrated in figure below, RE#4 and RE#6 are used twice for FD-OCC decoding on CE window 1 and 2.

 

Alt.1: Channel estimation across two RBs[7]  Alt.2-1: Two channel estimations based on FD-OCC=4 in one RB [7]

ZTE shows evaluations result to compare performance between Alt.2-1 (purple), and Alt.2-2 (red). Based on the result, Alt.2-2 has slightly better performance than Alt.2-1.

Mod: due to the large size of FL summary, the figures are deleted.

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| ZTE [4]**Figure 1** Performance comparison of different schemes of frequency domain multiplexing***Observation 1:*** *For DMRS type 1, DMRS with PRB bundling without mapping the last two REs in the last PRBs performs a little better than two CE windows when the number of scheduled DMRS port in one PRG is odd.* |

Vivo shows evaluations result to compare performance between Alt.1 (red with square), and Alt.2-1 (red with circle). Based on the result, both performances are almost the same.

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| In vivo [6]d) 64QAM, DS=3001. For DMRS type 1, FD-OCC=4 with two channel estimations in one RB has a similar performance to FD-OCC=4 with 2RB as scheduling granularity.
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Multiple companies mention the scheduling restriction of Alt.1 is not preferred. For Alt.2, Alt.2-1 requires additional receiver complexity. Some companies mention Alt.2-2 would degrade performance significantly, however, based on ZTE’s evaluation result, the performance degradation is not observed. Hence, FL proposal is to select Alt.2-2, which neither introduce additional scheduling restriction nor increase large receiver complexity.

**FL proposal#2.2.3: (Round1)**

* **If FD-OCC length 4 is supported in DMRS type 1, select the following to handle orphan REs:**
	+ **Alt.2: Not introducing scheduling restriction (i.e. gNB can schedules PDSCH/PUSCH with any number of PRBs).**
		- **Alt 2-2: DMRS is not transmitted in the last 2 REs corresponding to the DMRS port in the orphan RB.**

Apple [21] makes a good point that it is important to align CDM group index from common freq. resource (e.g. Point A). MU-MIMO is also not possible in case of figure 2.2.3. Also, Apple shows assessment that only limited scenario, the orphan RE issue happens.

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| Next, we need to handle the orphan CDM group issue for DRMS Type I for both the FDRA type 0 and FDRA type 1. The following facts of the current NR specification need to be taken into considering when designing the restriction* PRG (Precoding Resource Block Group) is configured with reference to Point A (common resource block 0)
	+ PRG can be configured to contain 2 PRB, or 4 PRB, or wideband
* For FDRA type 0,
	+ The frequency resource allocation is bitmap with unit of RBG (Resource Block Group)
	+ RBG is counted with reference to Point A (common resource block 0)
	+ RBG is always even number
* For FDRA type 1,
	+ The frequency resource allocation is a set of contiguously allocated PRB indicated by the starting PRB, and a number of contiguously allocated PRBs

To avoid orphan CDM group across PRG boundary, one principle is to start CDM group from Point A (common resource 0) which aligns with the PRG. Since PRG is always even number of PRBs, i.e., 2 or 4, this ensure that there is no orphan CDM group issue for almost all the PDSCH PRBs, except under certain condition, the first and the last PRB of the scheduled PDSCH***Proposal 1.2, When FD-OCC length 4 is used to double the number of DMRS port for CP-OFDM, for DMRS Type 1, to avoid orphan CDM group issue, start CDM group operation from Point A (common resource block 0)**** ***Consider the restriction, e.g., no DMRS, only for the following cases***
	+ ***For FDRA type 0***
		- ***The first PRB of the scheduled PDSCH, when the first indicated RBG contains odd number of PRBs***
		- ***The last PRB of the scheduled PDSCH, when the last indicated RBG contains odd number of PRBs***
	+ ***For FDRA type 1***
		- ***The first PRB of the scheduled PDSCH, when it is located at odd number of PRBs from Point A***
		- ***The last PRB of the scheduled PDSCH, when it is located at odd number of PRBs from Point A***
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**Figure 2.2.3. MU-MIMO is impossible if different starting PRB of FD-OCC for Type1 DMRS with length 4 FD-OCC for different UEs.**

Please provide your views for FL proposal 2.2.3 and Apple’s proposal.

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| **Company** | **Comment** |
| NTT DOCOMO | Support FL proposal 2.2.3. We think it is good to start PRB index of FD-OCC for Type1 DMRS with length 4 FD-OCC from Point A. |
| Apple | Proposal 2.2.3 may still have some issue.The true issue is CDM group cross PRG boundary. In the current specification, PRG starts from point A and PRG is either wideband or always even (2 or 4). So if we start the CDM group also from point A, we remove almost all the issue since CDM will advance synchronously with PRG. The only issue is that for the first and last PRB of the FDRA, it might have problem, which is only for the first few RE for the first PRB and last few RE for the last PRB. We can discuss this further.  |
| InterDigital  | Support Alt 2, but for the sub-bullet we prefer DMRS to be still transmitted in the scheduled RB, but it would be left to UE as how to use it.  |
| Futurewei | Support FL proposal 2.2.3. We are ok that for supporting MU-MIMO with Type 1 DMRS, the starting PRB of length-4 FD-OCC of different UEs should be aligned.  |
| Google | Support proposal 2.2.3, but we think it is better to have a clear definition on orphan RE, as this could have spec impact.We are also open to study Apple’s proposal.  |
| OPPO | Support Alt 2. For the sub-bullet, we prefer no restriction on the transmission of DMRS in the last two REs at least for PUSCH. For example, if MU-MIMO is not scheduled for uplink, the two REs can still be used for channel estimation at gNB. |
| Ericsson | We support length 6 FD-OCC. We can consider support length 4 only if there’s no scheduling restriction and it’s assumed that the UE utilize the DMRS at scheduling edge for an extra raw channel estimate. |
| ZTE | Support FL proposal#2.2.3Regarding case of figure 2.2.3, it seems as long as the CDM group index of UE#2 starting from PRB#1 or PRB#3, inter-UE orthogonality can be guaranteed for MU-MIMO scenario. Apparently, it can be up to gNB implementation. |
| Lenovo | Support FL proposal 2.2.3. We are open for more discussion on orphan CDM group issue. |
| Huawei, HiSilicon | Support Alt.2. How to perform channel estimation can be left for implementation. |
| NEC | We support Apple’s proposal in general. While only starting from point A seems not enough, common RB index should be applied for FD-OCC mapping. Or in other words, if common RB index (point A already applied) is applied for FD-OCC mapping, we don’t need to say point A again. |
| Xiaomi | We are not sure whether the simulation results of vivo where the performance of length 4 OCC is better than length 6 OCC is still valid when Alt 2-2 is supported. If this is how we solve the Orphan REs problem, we would rather support length 6 OCC than length 4 OCC. |
| Spreadtrum | Our first preference is Alt.1. We are fine with FL proposal 2.2.3 if there’s majority view.  |
| vivo | Support Alt 2-1, which doesn’t require any spec effort. We would like to mention that 1. It is up to receiver implementation whether to perform two channel estimations for FD-OCC=4 decoding in each RB or just in the orphan RB. When only performing two channel estimations in the orphan RB, its performance would be almost the same as FD-OCC=4 with 2RB granularity as shown below.
2. After two FD-OCC=4 decoding, only one MMSE filtering operation would be performed to complete the channel estimation in each PRG (2/4/wideband). Therefore, the receiver complexity is acceptable, just with more additive operations when performing the FD-OCC=4 decoding.

Regarding Alt 2-2, if DMRS is not transmitted in the last 2 REs, there are three key points should be noticed.1. It changes the pattern of DMRS, which would lead to many additional issues, such as power boosting, channel estimation accuracy
2. The last 2 REs can be still transmitted, UE can determine whether to use them for eatimation.
3. Additional MMSE filtering matrix should be calculated for the last PRG containing the orphan RB due to the different number of REs occupied by DMRS from other PRGs, which would increase the UE complexity

Moreover, regarding Alt 1, we would like to clarify that it is not enough to just introduce the restriction on the number of scheduled RB as even. For FD-OCC=4 decoding, it is also necessary to align the offset of the start RB of each UE in MU-MIMO as even. As shown in the figure below, if two UEs in MU-MIMO don’t align the offset of the start RB as even (offset=1 RB in the figure below), FD-OCC=4 decoding in the red box can’t be performed correctly for UE 1. Therefore, Alt 2 is a better way without any restriction.Regarding Apple’s proposal, in the current TS 38.211, it has been specified that the reference point for DMRS mapping is subcarrier 0 in common resource block 0 (Point A). That implies that FD-OCC=4 would be mapped from point A. Based on this principle, we find there is a mistake of FD-OCC mapping for UE#2 from PRB#2 in Figure 2.2.3, where the OCC value of one port should be the same on the same subcarrier for all UEs. Therefore, we think it’s unnecessary to discuss starting CDM group operation from Point A again.According the above analysis, we prefer to modify the proposal as follow.**FL proposal#2.2.3:*** **If FD-OCC length 4 is supported in DMRS type 1, select the following to handle orphan REs:**
	+ **Alt.2: Not introducing scheduling restriction (i.e. gNB can schedules PDSCH/PUSCH with any number of PRBs).**
		- **Up to the receiver how to implement DMRS channel estimation.**
 |
| Samsung | Support original Alt.1 which can be the simplest solution. Actually scheduling restriction on even number of RBs is not a big restriction, since the smallest unit of FDRA type 0 and PRG is 2 PRBs. If Alt2-2 (DMRS is not transmitted in the last 2 REs) is adopted, then channel estimation on the last RB may be degraded, and power boosting for the DMRS symbol would be complicated. |
| Nokia/NSB | We support Alt.1 at least on the perspective to OCC code mapping. We prefer to distinguish the discussions about OCC-code mapping and orphan RE handling.  |
| QC | We object this proposal. Among the three alternatives, Alt 2-2 is the worst solution. From performance point of view, it should yield worst performance, because of losing 2 DMRS tones per comb on the edge RB. We appreciate ZTE provide simulation result. But the result is counter intuitive. It is very unlikely that why a DMRS pattern with less DMRS tones can yield better performance than a DMRS pattern with more DMRS tones. From spec/implementation impact point of view, Alt 2-2 introduced a new DMRS pattern in freq domain, which would impact DMRS sequence generation, channel estimation interpolation, PDSCH/PUSCH rate matching, and DMRS/PDSCH power ratio. With the above reasoning, we cannot accept Alt 2-2. The most reasonable scheme to solve the orphan RB issue is Alt 1. Based on multiple companies’ input, RA type 0 does not have orphan RB issue (unless at BWP boundary). RA type 1 may have orphan RB issue. But how difficult it is for gNB to schedule even RB for Rel-18 UE by add or subtract 1 RB? We fail to see it is a critical issue for gNB scheduling. Maybe we missed some point on gNB scheduling. But can opponents of Alt 1 please provide a few examples/cases to help us understand why a gNB can (actually has to) schedule even RBs with RA type 0 but then suddenly think schedule even RB is a “mission impossible” in RA type 1? |
| CATT | Support FL proposal#2.2.3. |
| Intel | Do not support this proposal.  |
| Sharp | Support Alt 2 and we have similar view with OPPO. |
| Fraunhofer IIS/HHI | Support Alt 1. Agree with QC’s views. |

### **ROUND-2**

In the 1st round discussion, following if FL observation.

* Alt.1 does not have big issue at least for PDSCH.
	+ For PUSCH, it may impact on coverage.
* It is better to clarify “orphan REs”. (Text suggestion will be appreciated)
* Alt.2-2 is objected by Qualcomm/Intel/ Fraunhofer IIS/HHI.
* For starting the CDM group from point A, Apple/NEC/vivo shows views. More views are needed.

Let’s generally discuss whether we need gNB scheduling restriction or not. Starting CDM group from point A can be discuss separately.

**FL proposal#2.2.3a (scheduling restriction):**

* **For FD-OCC length 4 in Rel.18 eType 1 DMRS for PDSCH, down-select one from the following to handle orphan REs (i.e. if the total number of REs of DMRS in a CDM group is not multiples of 4, how to handle the remainder of REs) in RAN1#111:**
	+ **Alt.1: Introduce scheduling restriction.**
		- * **FFS: details.**
	+ **Alt.2: Not introducing scheduling restriction (i.e. gNB can schedules PDSCH with any number of PRBs).**
		- **FD-OCC length 4 can be decoded per a RB at a receiver.**
			* **Up to the receiver how to implement DMRS channel estimation.**
* **Note: For FD-OCC length 4 in Rel.18 eType 1 DMRS for PUSCH, there is no orphan RE issue, because gNB (receiver) can decide whether to schedule with the restriction (e.g. even number of PRBs) or not.**

**FL note: Based on the discussion, orphan RE issue only exist for PDSCH. In the above proposal, we clarified there is no issue for PUSCH. For PDSCH, we will down select in RAN1#111.**

**Support/fine: CATT,…**

* **Support Alt.1 (14): NTT DOCOMO (2nd pref.), Apple, Spreadtrum, OPPO, Samsung, ZTE, Xiaomi, MediaTek, Fraunhofer IIS/HHI, QC, Nokia/NSB, LGE**
* **Support Alt.2 (9): NTT DOCOMO, Ericsson, Futurewei, New H3C, OPPO, Sharp, Lenovo, ZTE, vivo**

**No (0):**

**FL proposal#2.2.3b for conclusion:**

* **For FD-OCC length 4 in Rel.18 eType 1 DMRS, FD-OCC de-spreading would not be performed across RRG.**

**FL note: Apple raised an issue of CDM group cross PRG boundary. However, based on the vivo’s explanation, there is no issue because the reference point for DMRS mapping is subcarrier 0 in common resource block 0 (Point A) in the current TS 38.211, and it implies the mapping of FD-OCC length 4 starts from Point A.**

**Support/fine (): vivo, Apple, OPPO**

**No ():**

Please provide your views to the above two proposals.

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| **Company** | **Comment** |
| Apple (ROUND1) | The true issue is CDM group cross PRG boundary. In the current specification, PRG starts from point A and PRG is either wideband or always even (2 or 4). So if we start the CDM group also from point A, we remove almost all the issue since CDM will advance synchronously with PRG. The only issue is that for the first and last PRB of the FDRA, it might have problem, which is only for the first few RE for the first PRB and last few RE for the last PRB. We can discuss this further. |
| NEC (ROUND1) | We support Apple’s proposal in general. While only starting from point A seems not enough, common RB index should be applied for FD-OCC mapping. Or in other words, if common RB index (point A already applied) is applied for FD-OCC mapping, we don’t need to say point A again. |
| Vivo (ROUND1) | Regarding Apple’s proposal, in the current TS 38.211, it has been specified that the reference point for DMRS mapping is subcarrier 0 in common resource block 0 (Point A). That implies that FD-OCC=4 would be mapped from point A. Based on this principle, we find there is a mistake of FD-OCC mapping for UE#2 from PRB#2 in Figure 2.2.3, where the OCC value of one port should be the same on the same subcarrier for all UEs. Therefore, we think it’s unnecessary to discuss starting CDM group operation from Point A again. |
| NTT DOCOMO | Our preference is Alt.2, But we don’t see any big issue on Alt.1. Alt.1 will disable gNB to schedule PUSCH with 1 PRB, which may limit coverage. However, Rel.18 DMRS would be configured for MU-MIMO or SU-MIMO scenario, which is not coverage limited scenario. |
| Ericsson | Alt.2 is our preference. We can leave the performance discussion to RAN4. |
| Apple | We support Proposal 2.2.3bOur second preference is Alt1. in proposal 2.2.3aAlt2 is problematic. For example, for DL, if PRG is 2PRB and a contiguous PDSCH in frequency domain starts from the middle of a PRG (second PRB). Then we may have issue of orphan RE every other PRB depending on how we start the CDM group, if we do not have any further restriction. Orphan RE can be avoided with minimum impact to gNB scheduling flexibility. But gNB needs to schedule to accommodate UE channel estimation concern, instead of ignoring the orphan RE problem. |
| Futurewei | We prefer Alt. 2 in FL proposal#2.2.3a. |
| New H3C | We support Alt.2 in proposal 2.2.3a |
| Spreadtrum | The orphan RE issue may happen in both DL and UL. Without scheduling restriction, both gNB and UE will have to handle it with additional implementation complexity. Therefore, we think having scheduling restriction is simpler not only for UE implementation, but also for gNB implementation. Also, with scheduling restriction, the performance issue cause by orphan RE can be avoided and further discussion on potential enhancements are not needed.  |
| OPPO | For proposal 2.2.3a, we are fine with either Alt.1 or Alt.2. With Alt.2, we think some restriction on channel estimation is needed at least for PDSCH DMRS. For example, UE cannot assume that there is no co-scheduled UEs in the same CDM group for channel estimation in orphan REs.For in proposal 2.2.3b, we are fine with it.  |
| Sharp | We support Proposal 2.2.3b.We are fine with the Alt 2 in FL proposal#2.2.3a, but don’t support Alt 2-1. In our view, spec effort is needed at least for wf(k’). Furthermore, we prefer a common design for eType1 and eType2. |
| Lenovo | For the discussion of FL proposal#2.2.3a, we support original FL proposal#2.2.3 in round 1 or Alt.1 on account that the complexity is larger for Alt.2-1. For FL proposal#2.2.3, it is simple and has no restriction for scheduling. For the BLER performance, we think the performance between Alt.1 and Alt.2-2 (FL proposal#2.2.3) is similar in case of large PRB number.  |
| Samsung | We support Alt.1 in proposal 2.2.3a, which seems not a big restriction on scheduling, and can easily solve orphan RE problem. We are fine with proposal 2.2.3b. |
| ZTE | Ok to take proposal#2.2.3b as a conclusion. We tend to agree with vivo’s assessment that reference starting point of DMRS mapping has already captured by specification. Besides, this depends on gNB scheduling only when MU-MIMO, which can be handled by gNB implementation when any issue exists.Either Alt 2-2 in original proposal#2.2.3 or Alt 2 in proposal#2.2.3a is fine to us. Alt 1 in proposal#2.2.3a will strict gNB schedule flexible especially when MU-MIMO.@QC, tanks to your question about our simulation result of FD-OOC 4 w/o 2 orphan REs vs FD-OCC 4 w/ 2 CE windows, basically, BLER gap is quite closed (~0.1dB) which far below common imagination. For FD-OCC 4 w/ 2 CE windows, it is proceed per PRB and where the estimation of the overlapped part is comes from the second CE window. Besides, the number of allocated PRBs in total is set to 25 in our simulation, the impact caused by the last 2 REs without DMRS is super marginal, which is actually closed to DMRS transmitted in all REs, i.e., the case of FD-OCC 4 with 2RB bundling. For your reference, simulation results provided by vivo can also prove this point. |
| Xiaomi | For FL proposal#2.2.3a, we support Alt.1.Fine with FL proposal#2.2.3b. |
| Ericsson | We want to clarify that the restriction is only needed for PDSCH, for PUSCH there should be no restriction because gNB can decide if to schedule and handle the orphan RB. I hope removing the “PUSCH” shall be acceptable for the group.**FL proposal#2.2.3a (scheduling restriction):*** **For FD-OCC length 4 in Rel.18 eType 1 DMRS, select the following to handle orphan REs (i.e. if the total number of REs of DMRS in a CDM group is not multiples of 4, how to handle the remainder of REs):**
	+ **Alt.1: Introduce scheduling restriction (e.g. gNB always schedules PDSCH~~/PUSCH~~ with even number of PRBs).**
		- **FFS: details.**
	+ **Alt.2: Not introducing scheduling restriction (i.e. gNB can schedules PDSCH~~/PUSCH~~ with any number of PRBs).**
		- **Alt.2-1: FD-OCC length 4 can be decoded per a PRB at a receiver.**
			* **Up to the receiver how to implement DMRS channel estimation.**

**Mod: this is reasonable suggestion.** |
| MediaTek | We propose Alt. 1 for Proposal 2.2.3a. |
| vivo | **Regarding FL proposal#2.2.3a,** we support Alt 2.As for Alt 1, we have mentioned that it is not enough to restrict the number of scheduled RB as even. There are three restrictions should be introduced as follows.1. The number of scheduled RB as even.
2. The RB offset of scheduled PDSCH from point A as even
3. The RB offset between scheduled PDSCH of different UEs in MU-MIMO as even

Therefore, Alt 2 is a simpler solution to handle the orphan RE issue with limited increase of UE complexity, without any additional spec effort.**Regarding FL proposal#2.2.3b**, we think it is unnecessary.As we have mentioned in Round-1, it has been specified that the reference point for DMRS mapping is subcarrier 0 in common resource block 0 (Point A) in the current TS 38.211. That implies that FD-OCC=4 would be mapped from point A. Besides, the current spec TS 38.214 has specified that precoding is applied per PRG, and UE should perform channel estimation in each PRG separately. In other words, UE would not perform FD-OCC de-spreading in the CDM group across PRG. Therefore, according to two points mentioned above, there is no need to discuss FL proposal#2.2.3b. |
| Apple | Regarding Proposal 2.2.3.b, we need to discuss how to start CDM group with respect to PRB considering the orphan RE issue. Based on vivo’s explanation, Proposal 2.2.3.b is already supported by the current specification. If all the other companies agree, we can just draw a conclusion, and clarify that this may not mean any specification change. |
| Fraunhofer IIS/HHI | We prefer Alt. 1 in proposal 2.2.3a. We believe the scheduling of even number of RBs for a gNB is not a critical issue and this simplifies UE implementation as well. |
| QC | For proposal 2.2.3a, we only support Alt. 1, based on the following reason.1. So far, we did not hear any technical concern why gNB cannot schedule even number of RBs for a PDSCH and has to allocation odd number of RB for it. VIVO raised three points. But isn’t that automatically satisfied for type 0 RA? Then for type 1 RA, why gNB cannot move/change RB allocation by just a single RB to make everything even? We still fail to see what is the critical technical issue which stop gNB to do so.
2. On the other hand, if orphan RB on PDSCH is allowed by spec, which would require UE to implement special channel estimation algorithm to handle the orphan RB. UE can implement a change to enhancement something. But benefit/motivation of this “something” has to be justified. In this case, we don’t see the justification, based on the reasoning in 1).
3. This is a secondary point: The suggested special channel estimation algorithm from VIVO is a smart algorithm. But it only works with an assumption that UE does de-spreading first to separate 4 ports. But not all UE receivers do de-spreading first.
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| CATT | Support Proposal 2.2.3a.With regard to Proposal 2.2.3b, we wonder whether RA type 1 have orphan RB/RE issue. If RA type 1 does have orphan RB/RE issue, Proposal 2.2.3b is not enough. |
| Nokia/NSB | For Proposal 2.2.3a, we support Alt.1. We don’t expect very small PRB allocation with Rel-18 DMRS, and the added 1 PRB if any, should not be high overhead . 1 RB increase/decrease can be handled by scheduling, MCS selection. We don’t support Proposal 2.2.3b. Preserving orthogonality among UEs scheduling is upto NW. So, we don’t need any further proposal.  |
| LGE | We prefer Alt.1 in proposal 2.2.3a, which we believe can easily solve orphan RE problem.  |
| vivo2 | Add some additional views on this issue.Even if we align that FD-OCC4 de-spreading would not be performed across RRG, there would still be orphan RE issue, such as the first two REs in the first RB, the last two REs in the last RB in some case. In other words, starting CDM group operation from Point A can’t avoid orphan CDM group issue. It still depends on Alt 1 or Alt 2 in FL proposal#2.2.3a to handle it. If we need a conclusion, we think the following one is ok for us, to clarify that FD-OCC4 de-spreading would not be performed across RRG.**FL proposal#2.2.3b (for conclusion):****For FD-OCC length 4 in Rel.18 eType 1 DMRS, FD-OCC de-spreading would not be performed across RRG.** |
| OPPO | We are fine with current proposal 2.2.3a. Further study is needed to select between Alt.1 and Alt.2. With current DMRS/FD-OCC4 starting from CRB0, Alt.1 cannot solve the orphan RE issue for some cases as mentioned by vivo. For proposal 2.2.3b, we are fine to have a conclusion.  |
| New H3C | We are fine with updated proposal 2.2.3a |
| **Mod** | **FL proposal#2.2.3a and #2.2.3b are moved to EMAIL ENDORSMENT 1.** |

### **ROUND-3**

In Round 2, following proposal are under discussion for EMAIL ENDORSMENT 1. For progress, I’d like to try to down select in this meeting, in case the proposal is agreed on 10/14.

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| **FL proposal#2.2.3a:*** **For FD-OCC length 4 in Rel.18 eType 1 DMRS for PDSCH, down-select one from the following to handle orphan REs (e.g. if the total number of REs of DMRS in a CDM group is not multiples of 4, how to handle the remainder of REs) by RAN1#111:**
	+ **Alt.1: Introduce scheduling restriction (e.g. gNB always schedules PDSCH with even number of PRBs).**
		- **FFS: details.**
	+ **Alt.2: Not introducing scheduling restriction (i.e. gNB can schedules PDSCH with any number of PRBs).**
		- **Up to UE how to implement DMRS channel estimation.**
	+ **Alt.3: Support both Alt 1 and Alt 2, where Alt 2 is an optional UE feature**
		- **If UE reports it can support PDSCH scheduled with any number of PRBs, no scheduling restriction is applied for PDSCH.**
		- **Otherwise, scheduling restriction is applied for PDSCH.**
* **Note: For FD-OCC length 4 in Rel.18 eType 1 DMRS for PUSCH, no spec. enhancement is needed to handle ~~there is no~~ orphan RE issue, because gNB (receiver) can decide whether to schedule with the restriction (e.g. even number of PRBs) or not.**
 |

There are three remaining discussion points for orphan issue.

**1. what is potential scheduling restriction in Alt.1?**

Based on vivo’s input in round 2, following scheduling restriction can be considered.

**FL proposal#2.2.3c:**

* **“Alt.1: Introduce scheduling restriction” in the agreement in RAN1#110bis-e for FD-OCC length 4 in Rel.18 eType 1 DMRS for PDSCH, means satisfying all of the following conditions:**
	1. **The number of scheduled RBs for PDSCH is even.**
	2. **The number of RBs offset of scheduled PDSCH from point A (common resource block 0) is even**
	3. **The number of RBs offset between scheduled PDSCH of different UEs in MU-MIMO is even**

**2. Down selection between Alt.1 and Alt.2**

|  |
| --- |
| Companies’ views until round 2:* **Support Alt.1 (14): NTT DOCOMO (2nd pref.), Apple, Spreadtrum, OPPO, Samsung, ZTE, Xiaomi, MediaTek, Fraunhofer IIS/HHI, QC, Nokia/NSB, LGE**
* **Support Alt.2 (10): NTT DOCOMO, Ericsson, Futurewei, New H3C, OPPO, Sharp, Lenovo, ZTE, vivo, Nokia/NSB**
 |

In the last moment of email discussion, Alt.3 is added, and it seems compromised solution.

**3. Whether/how to handle orphan RE issue for PUSCH**

In the email discussion, we had the following discussion for whether/how to handle the orphan issue for PUSCH DMRS.

* Google: for PUSCH, we think there could still be orphan RE issues. The gNB's uplink scheduling can create orphan REs, and UE can select not to transmit DMRS in the orphan REs as Alt2.
* FL: For PUSCH, indeed muting some DMRS REs can also solve the issue. But, that option (Alt.2-2) was already discussed in round 1, and objected by multiple companies (QC, Intel, Fraunhofer IIS/HHI, etc.). For PUSCH, considering that gNB implementation can solve the issue, by selecting Alt.1 or Alt.2 by gNB implementation, I think the necessity of taking Alt.2-2 (miting DMRS) is little for PUSCH. Even if we remove the note and keep open for PUSCH, I don't the situation will be changed.
* Ericsson: For PUSCH transmission with odd number of RBs, if a UE does not transmit the DMRS on the orphan REs, would UE transmit data on those DMRS REs? If that is the intension of the group we are fine to discuss the issue on PUSCH. Otherwise probably better to keep the note as it is?
* FL: We haven't discuss it. My assumption is No, those muting DMRS REs are not used for data, because otherwise it would be hard to enable MU-MIMO with Rel.15 DMRS ports, and it impacts PUSCH rate matching. In the 1st round, Qualcomm objected Alt.2-2, and one reason was the rate matching.
	+ Qualcomm (round 1): From spec/implementation impact point of view, Alt 2-2 introduced a new DMRS pattern in freq domain, which would impact DMRS sequence generation, channel estimation interpolation, PDSCH/PUSCH rate matching, and DMRS/PDSCH power ratio. With the above reasoning, we cannot accept Alt 2-2.
* Google: it is possible to ask UE to transmit PUSCH in the orphan REs to improve the PUSCH performance. Another option is not to transmit anything, which can be helpful to reduce interference.

**FL Question#2.2.3:**

* **Do you think spec. enhancement is needed for DMRS orphan RE issue for PUSCH? If so, how to enhance the spec?**

So far, we have the following options to handle orphan RE issue for PUSCH DMRS.

**FL proposal#2.2.3d (for PUSCH):**

* **For FD-OCC length 4 in Rel.18 eType 1 DMRS for PUSCH,**
	+ **Opt.1: No spec. enhancement is needed to handle orphan RE issue, because gNB (receiver) can decide whether to schedule with the restriction (e.g. even number of PRBs) or not.**
	+ **Opt.2: For orphan REs (e.g. if the total number of REs of DMRS in a CDM group is not multiples of 4, the remainder of REs), DMRS is not transmitted in the orphan REs.**
		- **Opt.2-1: PUSCH is transmitted on the orphan REs.**
		- **Opt.2-2: PUSCH is not transmitted on the orphan REs.**

Please provide your views on the above discussion points 1), 2), 3).

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Samsung | For FL Question#2.2.3, as Ericsson and FL clarified, we agree that gNB can manage there is no orphan RE issue. For this, we share Qualcomm’s view and especially agree on DMRS/PUSCH power ratio/boosting issue when orphan DMRS REs are not transmitted. Hence, we are fine with no spec impact on PUSCH, i.e., support Opt.1 in FL proposal#2.2.3d. |
| DOCOMO | 1) FL proposal#2.2.3c: OK.2) Any of Alt.1-3 is ok. We think Alt.3 is a compromised solution.3) FL Question#2.2.3: No, gNB implementation can solve the issue. We agree with Qualcomm/Samsung that spec. impact of supporting muting DMRS is not small.FL proposal#2.2.3d (for PUSCH):Support Opt.1. |
| Sharp | We are fine with the FL proposal#2.2.3d and support Option 2-1 which has no spec impact. |
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### 2.2.5 TD-OCC across consecutive DMRS symbols

### **ROUND-3**

In RAN1#110bis-e, following agreements were made. During the discussion, Huawei/HiSilicon raised issue of current TD-OCC for consecutive DMRS symbols, and proposed new TD-OCC.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| **Agreement**For enhanced FD-OCC length for DMRS of PDSCH/PUSCH for Rel.18 eType 1 DMRS, support* Opt.1-2: Length 4 FD-OCC is applied to 4 REs of DMRS within a PRB or across consecutive PRBs within an CDM group

**FL proposal#2.2.4:*** **For Rel.18 eType 1/eType 2 DMRS ports of PDSCH/PUSCH with FD-OCC length 4, association between DMRS port indexes, CDM group index, FD-OCC index, and TD-OCC index (across consecutive DMRS symbols, if any) are determined by the following Table 1 and Table 2.**
	+ **The *p* in Table 1 and Table 2 corresponds to DMRS port index for PUSCH.**
	+ **DMRS port index for PDSCH is determined by *p* +1000 in Table 1 and Table 2.**

**Table 1. Rel.18 eType 1 DMRS ports for PUSCH**

|  |  |  |  |
| --- | --- | --- | --- |
| *p* | CDM group index  | FD-OCC index  | TD-OCC index  |
| 0  | 0  | 0  | 0  |
| 1  | 0  | 1  | 0  |
| 2  | 1  | 0  | 0  |
| 3  | 1  | 1  | 0  |
| 4  | 0  | 0  | 1  |
| 5  | 0  | 1  | 1  |
| 6  | 1  | 0  | 1  |
| 7  | 1  | 1  | 1  |
| 8  | 0  | 2  | 0  |
| 9  | 0  | 3  | 0  |
| 10  | 1  | 2  | 0  |
| 11  | 1  | 3  | 0  |
| 12  | 0  | 2  | 1  |
| 13  | 0  | 3  | 1  |
| 14  | 1  | 2  | 1  |
| 15  | 1  | 3  | 1  |

 **Table 2. Rel.18 eType 2 DMRS ports for PUSCH**

|  |  |  |  |
| --- | --- | --- | --- |
| *p* | CDM group index  | FD-OCC index  | TD-OCC index  |
| 0  | 0  | 0  | 0  |
| 1  | 0  | 1  | 0  |
| 2  | 1  | 0  | 0  |
| 3  | 1  | 1  | 0  |
| 4  | 2  | 0  | 0  |
| 5  | 2  | 1  | 0  |
| 6  | 0  | 0  | 1  |
| 7  | 0  | 1  | 1  |
| 8  | 1  | 0  | 1  |
| 9  | 1  | 1  | 1  |
| 10  | 2  | 0  | 1  |
| 11  | 2  | 1  | 1  |
| 12  | 0  | 2  | 0  |
| 13  | 0  | 3  | 0  |
| 14  | 1  | 2  | 0  |
| 15  | 1  | 3  | 0  |
| 16  | 2  | 2  | 0  |
| 17  | 2  | 3  | 0  |
| 18  | 0  | 2  | 1  |
| 19  | 0  | 3  | 1  |
| 20  | 1  | 2  | 1  |
| 21  | 1  | 3  | 1  |
| 22  | 2  | 2  | 1  |
| 23  | 2  | 3  | 1  |

 |

Since we haven’t discussed whether we should enhance TD-OCC across consecutive symbols or not, I’d like to collect companies’ views on this issue.

**Proposal#2.2.5 from Huawei/HiSilicon:**

**For length 2 TD-OCC (across consecutive DMRS symbols, if any) for DMRS of PDSCH/PUSCH for Rel.18 eType 1/2 DMRS, support one from the following TD-OCCs:**

* **Opt.1:**

|  |  |  |
| --- | --- | --- |
| **TD-OCC index** | **Wt(0)** | **Wt(1)** |
| 0 | +1 | +1 |
| 1 | +1 | -1 |

* **Opt.2:**

|  |  |  |
| --- | --- | --- |
| **TD-OCC index** | **Port 0~7 for eType 1****Port 0~11 for eType 2** | **Port 8~15 for eType 1****Port 12~23 for eType 2** |
| **Wt(0)** | **Wt(1)** | **Wt(0)** | **Wt(1)** |
| 0 | +1 | +1 | +1 | +j |
| 1 | +1 | -1 | +1 | -j |

Please see Huawei/HiSilicon’s comment and provide your views.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Huawei, HiSilicon (Round2) | As we’ve described in our Tdoc and FL summary, both the FD-OCC and TD-OCC design is for balancing the performance of different DMRS ports given that the perfect orthogonality in realistic scenario can hardly be ensured.As shown in the figure below, if the orthogonality between the length-4 FD-OCC of legacy and expanded DMRS ports is destroyed due to large delay spread or compatibility issue and Walsh-based FD-OCC and TD-OCC are used, DMRS ports P1 and P12 can still approximately keep mutual orthogonality thanks to their orthogonal inner cover codes (formed by the Kronecker product of the length-2 subsequence of the length-4 FD-OCC and the length-2 TD-OCC) and nearly flat channel on two adjacent subcarriers. However, for DMRS ports P0 and P12 using the same inner cover code, the interference between them can be significant and great performance gap between DMRS ports will appear, which will bring greater challenge to channel estimation and/or DMRS ports allocation algorithm and may encumber the overall system performance. |
| DOCOMO | We prefer simpler approach and support Opt.1. |
| Sharp | Support Opt 1. |
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## DCI-based dynamic switching between FD-OCC length 2 and 4

15 companies (FUTUREWEI, Huawei/HiSilicon, InterDigital, Spreadtrum, vivo, Lenovo, CATT, NEC, Sharp, Samsung?, Ericsson, NTT DOCOMO, Nokia/NSB) mentioned it is beneficial to support dynamic switching between FD-OCC length 2 and M (M = 4 or 6) due to the following reasons:

* It enables to MU-MIMO with Rel.15-17 UEs within a CDM group.
* If the large MU-MIMO capacity is not required, gNB can dynamically indicate DMRS with FD-OCC length 2 because it has better performance than FD OCC length4/6 in case of large delay spread.

On the other hand, 8 companies (OPPO, Google, Xiaomi, MediaTek, Fraunhofer IIS/HHI, Apple, Qualcomm) think the dynamic switching is not needed due to the following reasons:

* It increases UE complexity
* Performance difference between FD-OCC length 2 and 4/6 is not significant.

Regarding to the UE complexity,

* Ericsson [25] says: Dynamic fallback is already supported by using different DL DCI format (DCI format 1\_0 is Rel.15 DMRS, and DCI format 1\_1 can be configured with Rel.18 DMRS).
* Samsung [22] says: In current specification, dynamic switching between DMRS type 1 and type 2 can be done by TDRA field in DCI. To be specific, different DMRS type can be configured with different PDSCH/PUSCH mapping type, and each TDRA entry can indicate different PDSCH/PUSCH mapping type. Similarly, switching between current DMRS type 1 (or 2) and new DMRS type 1 (or 2) can be studied and supported if justified.

Regarding to the performance difference between FD-OCC length 2 and 4/6, multiple companies show the results.

Mod: due to the large size of FL summary, the figures are deleted.

d) 64QAM, DS=300

The BLER performance of R18 DMRS type 2 in MU-MIMO with 2 UEs [7]

Fig.3 Comparison of MSE performance of enhanced DMRS pattern and R15 legacy DMRS pattern for type 1 DMRS [8].

**Fig 13: Performance comparison between assuming FD-OCC 2 vs FD-OCC 4 with joint MMSE channel estimation [24]**

Considering that majority companies think it is beneficial to support the dynamic switching, FL suggestion is to agree the dynamic switching, but this feature can be optional UE capability. Also, the intention of the proposal is to support the dynamic switching within/using a DCI format. Nokia/NSB and vivo mention detail on how to enable the dynamic switching (e.g. new DCI field, use existing TDRA field, etc.), which can be discussed later.

**FL proposal#2.3 (round1):**

* **For increased DMRS ports for enhanced FD-OCC, support DCI based dynamic switching between DMRS port(s) associated with length 2 FD-OCC and DMRS port(s) associated with length M FD-OCC (where M > 2), within a DCI format 1\_1/1\_2/0\_1/0\_2.**
	+ **This feature is optional UE feature of Rel.18 DMRS port(s).**

**Support/fine (14): DOCOMO, InterDigital, Futurewei, Ericsson, ZTE, Lenovo, NEC, vivo, Samsung, CMCC, Nokia/NSB, CATT, Sharp**

**No (11): Apple, Google, OPPO, Xiaomi, MediaTek, Spreadtrum, LGE, Qualcomm, Intel, Fraunhofer IIS/HHI**

**Discuss later (2): Huawei/HiSilicon**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| DOCOMO | Support. |
| Apple | We still have concern on this proposal  |
| InterDigital | Support FL proposal. |
| Futurewei | Support in principle. We suggest removing the term “within a DCI format 1\_1/1\_2/0\_1/0\_2” from the proposal as this term may imply that the existing DCI is to be used without introducing a new DCI field, which is still to be discussed.  |
| Google | We would like to clarify the DMRS ports associated with FD-OCC-2 and FD-OCC-M, does it mean to use different FD-OCC sequence or just to provide some reference for the UE to identify the FD-OCC despreading length? In our view, it is sufficient to keep the same FD-OCC-M sequence, but the gNB only needs to tell UE some co-scheduled UE info to identify the FD-OCC despreading length. |
| OPPO | We think the dynamic switching is not needed. No matter the switching is implemented via a new DCI field or a current field, it would lead to larger DCI overhead and/or loss of flexibility. The benefit doesn’t deserve the cost. |
| Ericsson | This can be one of the solutions to mitigate the performance issue with FD-OCC 4/6. We are open for discussion.  |
| ZTE | Support |
| Lenovo | Support |
| Huawei, HiSilicon | Can be postponed after 2.2 is decided. |
| NEC | Support  |
| Xiaomi | From our understanding, this is actually a DMRS type switching problem about how to support the switching of R18 DMRS type and legacy DMRS type. FD-OCC length 2 is legacy DMRS type and length 4/6 is R18 DMRS type. We are OK to discuss how to support the switching between R18 DMRS and legacy DMRS. While, we don’t see any convincing reason that the switching has to be dynamic yet. More discussion is needed and we think RRC based switching can be the base line because the DMRS type is indicated/updated by RRC signalling in current specification. |
| MediaTek | Not support. As mentioned by OPPO and Xiaomi we don’t believe such dynamic switching is needed.  |
| Spreadtrum | Support the proposal. Besides, as mentioned by FL in section 2.5, this feature can avoid the need of MU-MIMO between Rel.15 DMRS ports and Rel.18 DMRS ports. |
| vivo | Support in principle.Regarding the sub-bullet, i.e., as an optional feature, we wonder why UE can’t support the dynamic switching. In our understanding, R18 UE would prepare for FD-OCC=2 decoding for fallback DCI format, while preparing for FD-OCC=4 or 6 decoding for DCI format 1\_1/1\_2/0\_1/0\_2. In other words, anyway R18 UE would prepare two FD-OCC decoding process for different FD-OCC length, so why can not support dynamic switching in the same DCI format? |
| Samsung | Support in principle and similar view with vivo. |
| CMCC | Support the proposal. |
| Nokia/NSB | Support in principle.  |
| LGE | We also believe that the dynamic switching is not needed, as mentioned by OPPO and Xiaomi. |
| QC | We thank FL’s effort to settle down the issue. But we still cannot accept this proposal in its formulation. We might be able to accept the proposal if it can be reformulated in the direction of use DCI to indicate some information of co-schedule MU. The reasons we don’t accept this proposal are the following. * It does not help allowing MU scheduling between Rel-15 and Rel-18 UE at all. A rank 1 Rel-15 UE and a rank 1 Rel-18 UE can always be co-scheduled with code [1,1,1,1] and [1,-1,1,-1], even without this bit. Rel-15 UE just treat the Rel-18 UE as a Rel-15 UE. While the Rel-18 UE can treat the Rel-15 UE as a Rel-18 UE.
* If this bit has any benefit, the benefit is for the following scenario. A Rel-18 UE is scheduled with rank 2 on port 0/1, with this bit to tell OCC-2, the Rel-18 UE can run channel estimation assuming OCC-2, which “might” improve channel estimation. We have run simulation for this scenario in R1-2209970. However, the gain is only very small. With almost zero performance gain, consider the complexity it brings to UE implementation, we do not support this proposal.

* If the group want to introduce a field to dynamic to dynamically indicate OCC size in DCI, we think a more appropriate usage of such a field is to indicate co-scheduled MU existence/port information, rather than telling the target UE how to interpret the OCC size. As a matter of fact, if we use 1 bit to indicate MU exist or not, it is equivalent to indicate the OCC size. Take the above figure as an example, if the rank 2 target UE is scheduled on port 0/1, and 1 bit in DCI tells the target UE there is MU on port 8/9, then target UE knows that it must assume OCC-4 for channel estimation. If the bit tells target UE there is NO MU on port 8/9, then target UE knows that it can assume OCC-2 (or OCC-4) for channel estimation. Assuming OCC-2 or OCC-4 for the latter case is up to UE implementation, why gNB has to force UE to assume OCC-2 with 1 bit (as in the FL proposal). Again, a more reasonable proposal is that gNB use 1 bit tell UE whether MU exist or not on port 8/9, whether UE assume OCC-2 or OCC-4 is up to UE.
* Following the above, if we formulate the proposal to use one field in DCI to indicate co-scheduled MU information, we can further discuss whether use >1 bits to indicate a little more information, such as 2 whether only port 8 has MU, or only port 9 has MU, or both port 8/9 has MU, which can benefit UE’s channel and noise estimation.

In summary, we cannot accept current FL proposal. We suggest reformulating the proposal in the direction of indicating co-scheduled MU information, such as the following: **Proposal: In Rel-18, study whether/how to introduce a new field in DCI scheduling PDSCH to indicate the information of co-scheduled MU.*** **FFS: number of bits and detail of indicated information, e.g., existence and/or ports of MU.**

**If supported, this feature is an optional UE feature of Rel.18 DMRS enhancements** |
| CATT | Support. |
| Intel | Before agreeing on dynamic switching, we need to clarify how we differentiate between Rel-18 and Rel-15 ports. Are they assigned the same port numbers and different OCC lengths? We also fail to see how this facilitates better MU-MIMO pairing. For length 2 OCCs which are sub-length orthogonal to length 4/6 OCCs, pairing is already possible within the same DM-RS CDM group with no impact to UEs using length-2 OCC.  |
| Sharp | Support |
| Fraunhofer IIS/HHI | Prefer to have the FD-OCC length (i.e., DMRS configuration) configured via RRC. Considering that dynamic switching is proposed mostly to enable MU-MIMO scheduling in the same CDM group by falling back to Rel. 15-17 configuration, the resulting increase in UE complexity and possibly, DCI overhead, may outweigh the aforementioned narrow advantage. Moreover, in our simulations, we observed negligible or no difference in performance between different FD-OCC lengths for any given delay spread if the number of ports per CDM group is kept constant. Therefore, dynamic switching between different FD-OCC lengths may be unnecessary. |
|  |  |

### **ROUND-2**

In the 1st round, whether to support the dynamic switching of FD-OCC length between 2 and 4 were discussed. Since the FL proposal#2.3 seems not acceptable, let’s try Qualcomm’s proposal. From FL perspective, for UE with Rel.18 DMRS ports, if the information of co-scheduled MU in the same CDM group is indicated, UE can decide whether to de-spread with length 2 or 4. Hence, the performance benefit of the dynamic switching can be also obtained with FL proposal#2.3a. For the details, please check Qualcomm’s comment in the 1st round.

**FL proposal#2.3a:**

* **For Rel-18 UE, introduce a new field in DCI scheduling PDSCH to indicate the information of co-scheduled MU in the same CDM group.**
	+ **FFS: number of bits and detail of indicated information, e.g., existence and/or ports of MU.**
	+ **This feature is an optional UE feature of Rel.18 DMRS enhancements.**

**Support/fine ():**

**No ():**

Please provide your views.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| NTT DOCOMO | Our 1st preference is to support the dynamic switching, But, we are open to support FL proposal#2.3a. If the new bit is 1-bit, we think it is almost equivalent to support FD-OCC length switching. |
| ZTE | Support the original FL proposal#2.3 in round-1.Regarding QC’s comment above, we have the similar feeling to DOCOMO that proposal#2.3a is the same to FD-OCC length switching. In our view, the original FL proposal#2.3 in round-1 is more friendly to further study how to indicate dynamic switching between FD-OCC 2 and FD-OCC M. |
| Xiaomi | We do not really get the difference between FL proposal#2.3a and FL proposal#2.3 (round1). Does FL proposal#2.3a mean that it is UE that decide whether to switch, while, for FL proposal#2.3 (round1), it is the network that decide whether to switch?**Mod: For both proposals, it may be up to UE to decide which size of FD-OCC length UE actually use for de-spreading, because it would be not testable. FL proposal#2.3 (round 1) explicitly indicate FD-OCC length, which implies UE is expected to use the indicated FD-OCC for de-spreading. In FL proposal#2.3a, how to use the indicated FD-OCC length of MU is up to UE. Most probably, UE would use the information to decide FD-OCC length for de-spreading to improve the performance.** |
| Huawei, HiSilicon | Support FL proposal#2.3. Regarding QC’s comment in round-1 that “gNB has to force UE to assume OCC-2”, we think the detailed behavior UE conducts is not explicitly limited in the current Spec., i.e., length-4 despreading can also be adopted for Rel-15 DMRS ports although not preferred. |
| Ericsson | We are fine with this proposal. |
| vivo | Don’t support FL proposal#2.3a, prefer the FL proposal#2.3(Round-1). It’s unreasonable that when the network has sent the additional DCI signalling, it still depends on UE to decide the FD-OCC length for de-spreading. In other words, costing the same even more overhead (if DCI size is based on ports of MU), FL proposal#2.3a can’t achieve the same effect as FL proposal#2.3. If UE don’t support dynamic switching, RRC-based switching is a better choice than FL proposal#2.3a. If UE supports dynamic switching, it should be ready for dynamic switching.  |
| Apple | Proposal 2.3a probably needs more discussion. In the current form, the new filed is to indicate the co-scheduled MU in the same CDM group. It is still unclear what kind of information about the co-scheduled MU is provided by this field, the number of layer? The DMRS type? The DMRS ports? FDRA? TDRA? Etc? |
| Fraunhofer IIS/HHI | Prefer determining FD-OCC length via RRC configuration instead of UE implementation or dynamic indication. |
| Futurewei | We support the original FL proposal#2.3 (round1), but not FL proposal#2.3a. Regarding FL proposal#2.3a, to our understanding, depending on the exact DMRS ports allocated to the UE, in some cases, even if it is indicated that there is no co-scheduled MU in the same CDM group, the UE still needs to use FD-OCC length M>2. So in these cases the indication of information of co-scheduled MU in the same CDM group is redundant and FL proposal#2.3a can’t achieve the same effect as FL proposal#2.3 (round1).  |
| QC | Reading comments from companies, I think almost all companies (except VIVO) agree that even FL proposal#2.3(Round-1) is adopted, it is up to UE to assume OCC-2 or OCC-4 for channel estimation, because NW cannot mandate UE to use OCC-2 or OCC-4. If so, what is the point to add this field in DCI? To VIVO: channel estimation is UE implementation. Why gNB would force UE to use OCC-2 or OCC-4 to do channel estimation. As long as UE can meet PDSCH decoding requirements defined in RAN4 spec, why should NW care UE used OCC-2 or OCC-4 in channel estimation?To Apple, and all: if RAN1 want to introduce a field in DCI to help UE improve channel estimation, we think use this field to indicate co-scheduled MU information rather than the OCC length is the right way to go. As for what information should be indicated, we think the starting point could be use 2 bits to indicate the MU ports information, which can help UE to do channel and noise estimation, to avoid UE to do MU detection on port 8/9.   |
| Samsung | We support original FL proposal#2.3 (dynamic switching between FD-OCC 2 and 4). we think the purpose of the FL proposal#2.3 is not only for indicating different length of OCC and performance compensation by using shorter OCC (although it seems marginal gain based on companies’ inputs), but also for having more number of SU-MIMO layers. Our understanding is that Rel-18 DMRS is for enhancing MU-MIMO scheduling, so it does not make sense to support larger number of SU-MIMO layers, e.g., 2CW with more than 4 layers. Hence, in order to have larger number of layers by SU-MIMO scheduling, we think dynamic switching between Rel-15 DMRS and Rel-18 DMRS should be supported. Regarding FL proposal#2.3a, now it requires 2 bits based on QC’s example, so it requires more DCI overhead than FL proposal#2.3, and this cannot realize larger number of layers for SU-MIMO scheduling by switching into from Rel-18 DMRS to Rel-15 DMRS. |
| Nokia/NSB | We support original proposal #2.3. We have a fundamental question to the proponent objecting dynamic switching. The new proposal 2.3a by QC is the same functionality with dynamic switching by implicit signaling. The proponent is mentioning UE complexity from dynamic switching, but I think even the companies are also considering for applying the different channel estimation parameter according to the scheduling condition in DCI such as existence of co-scheduled UE or not. We think this is also dynamic switching. Companies to propose unified table for both FD-OCC2 and FD-OCC4, is also supporting dynamic switching. If we don’t support dynamic switching for UE complexity, UE shall use the same channel estimation algorithm for any case. Regarding to the overhead, we proposed an option to use TDRA table. This may be useful not to increase the DCI overhead, and this is already supported in Rel-15 for mapping Type change. (DMRS type is configured per mapping type.) So, we propose the same framework as used in REl-15.  |
| LGE | Do not support this proposal. We prefer determining FD-OCC length via RRC configuration |
| vivo2 | To QC:You may misunderstand our view. It doesn’t mean that gNB forces UE to use OCC-2 or OCC-4 to do channel estimation. The logic is that UE reports its capability of dynamic switching firstly. If UE reports yes, it implies UE has been ready for it, then gNB can indicate the dynamic switching based on DCI. Besides, the demod requirement in RAN4 might be different for dynamic switching and RRC-based switching, since dynamic switching would bring the benefit for channel estimation. |
| Lenovo | We support original FL proposal#2.3 for dynamic switching between FD-OCC length 2 and 4. We think whether/how to indicate the information of the co-scheduled MU is another issue and we are open to discuss it. |
| QC2 | To VIVO: we did not misunderstand VIVO’s point. Of course, if this feature is supported, it will be a optional feature with UE capability. However, even for UE report I can do dynamic switch, why gNB should use 1 bit to tell UE how to do channel estimation, given channel estimation is UE internal implementation? From performance perspective, based on our simulation results, we did not observe performance difference between assuming OCC-2 and OCC-4 in 1000ns delay channel. So we don’t think this feature of dynamic switch is useful. As for our 2-bits proposal, our intention is working together with proponents of dynamic switch to find a WF. Our simulation already showed 1-bit dynamic switch don’t not bring any gain. Then maybe with two bits, it can bring some performance gain. But we need study this. And our proposal is just a starting point. If companies just want to stay with 1-bit, then we don’t see the point to support 1-bit dynamic indication in DCI, as we already studied it and did not see any gain.  |
| vivo3 | We can’t agree that after UE has reported its capability of dynamic switching, it still doesn’t perform de-spreading based on better FD-OCC length when gNB tells UE it can achieve better performance. This is the key difference between the motivations of FL proposal#2.3a and FL proposal#2.3 (round1). Moreover, many companies have given the simulation results showing that FD-OCC=2 outperforms FD-OCC4 in the case of large delay spread, especially with DMRS eType2. Therefore, at least dynamic switching should be supported as a UE optional feature. Regarding the proposal to capture this motivation, we have the same preference as majority companies, i.e., FL proposal#2.3 (round1). |
| OPPO | Firstly, we prefer to determine the FD-OCC length via RRC configuration instead of DCI. Secondly, we think original proposal 2.3 seems better than proposal 2.3a. |
| QC3 | To VIVO: Even for a UE report capability of dynamic switch, we are not sure how gNB can make sure UE have to switch OCC size to do de-spreading. This is basically untestable. RAN4 might be able to define test case to test **static** switch. We are not sure how RAN4 can define test case to test **dynamic** switch. By the way, VIVO seems assuming that UE has to do de-spreading in receiver, which is not a correct assumption. There are more advanced UEs which do not do de-spreading but perform joint channel estimation across ports. With joint channel estimation, performance difference between OCC2 and OCC 4 vanishes.Another issue with dynamic switch is the impact to timeline. We need to re-evaluate and define new N1 numbers, which is a huge effort/spec impact.  |
| New H3C | Support FL proposal#2.3.  |
| vivo4 | Thank QC for providing an advanced algorithm, we wonder the UE complexity of advanced joint channel estimation across ports. At least, DMRS estimation based on FD-OCC de-spreading is one of the basic implementations, why not correct? We believe majority companies uses FD-OCC de-spreading in simulation. For UE using de-spreading mechanism, the performance difference between FD-OCC2 and FD-OCC4 is observed. By the way, the motivation of proposal 2.3a you proposed is also to improve the channel estimation performance, right? |
| QC4 | To VIVO: Sorry if I did not make myself clear in previous comment. I said “assuming that UE **has to** do de-spreading in receiver” is not a correct assumption. I did not mean de-spreading is an incorrect assumption. As for Proposal 2.3a, as we explained a few times, our original intention is to work with proponents of proposal 2.3 to find a solution that can benefit all type of UEs, with or without advanced channel estimation algorithm. Proposal 2.3a is simply a super set of proposal 2.3. An advanced UE which does joint channel estimation can potentially benefit from proposal 2.3. A UE which does de-spreading based channel estimation can also benefit from proposal 2.3. Lastly, dynamic indication has impact to PDSCH decoding timeline. We don’t think RAN1 would have enough TU to discuss new values for N2 with dynamic indication. To avoid huge effort to study timeline impact, I would suggest FL conclude not supporting dynamic indication of OCC size nor MU information, which is optimization anyway. We can live without this optimization.  |
| QC5 | By the way, for proposal 2.3, if we introduce this 1 bit in DCI to indicate OCC size, why not use it to indicate FD-OCC-1 vs other FD-OCC size? When gNB indicate FD-OCC [1,1,1,1] to a UE, telling the UE it is OCC 1 can even disable de-spreading, which can save UE complexity. Or why not using this bit to indicate TD-OCC size, i.e., TD-OCC 1 vs TD OCC 2? In high Doppler channel, when gNB indicate TD-OCC [1,1] to UE, why not use this bit to tell UE read the TD-OCC as OCC size 1, which can avoid dispreading in time domain and improve channel estimation as well.So, even for proposal 2.3 itself, the formulation is incomplete. Many aspects are missing. Current study is too immature.  |
| Intel | We prefer FL Proposal 2.3a over the original one. Co-scheduled MU-UE information should be enough to help UE figure out which OCC length to assume for channel estimation with the principle that UE is assigned legacy OCC first (which should be sub-length orthogonal) when no other co-scheduled UEs are present.Tend to agree with QC that if we are indicating OCC size then, options to enable UE to not do any dispreading would benefit complexity at the UE. This was discussed in Rel-15 and ultimately not supported since some companies opposed such “advanced” UEs. |
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### **ROUND-3**

In Round 1/2, following proposals were discussed.

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| **FL proposal#2.3 (round1):*** **For increased DMRS ports for enhanced FD-OCC, support DCI based dynamic switching between DMRS port(s) associated with length 2 FD-OCC and DMRS port(s) associated with length M FD-OCC (where M > 2), within a DCI format 1\_1/1\_2/0\_1/0\_2.**
	+ **This feature is optional UE feature of Rel.18 DMRS port(s).**

**Support/fine (17): DOCOMO, InterDigital, Futurewei, Ericsson, ZTE, Lenovo, NEC, vivo, Samsung, CMCC, Nokia/NSB, CATT, Sharp, Huawei/HiSilicon, New H3C****No (12): Apple, Google, OPPO, Xiaomi, MediaTek, Spreadtrum, LGE, Qualcomm (support#2.3a), Intel, Fraunhofer IIS/HHI, Intel (support#2.3a)****FL proposal#2.3a (round2):*** **For Rel-18 UE, introduce a new field in DCI scheduling PDSCH to indicate the information of co-scheduled MU in the same CDM group.**
	+ **FFS: number of bits and detail of indicated information, e.g., existence and/or ports of MU.**
	+ **This feature is an optional UE feature of Rel.18 DMRS enhancements.**

**Support/fine (4): Qualcomm, DOCOMO (2nd pref.), Ericsson, Intel** **No (5): ZTE (support #2.3), Futurewei (support#2.3), Samsung (DCI overhead), OPPO (#2.3 is better), Lenovo (open, but separate issue)****Support RRC only (5): Fraunhofer IIS/HHI, LGE, OPPO, Qualcomm (can live).** |

**Issue of 2.3:**

* QC: This is basically untestable. RAN4 might be able to define test case to test **static** switch. We are not sure how RAN4 can define test case to test **dynamic** switch.
* QC: UE has to do de-spreading in receiver, which is not a correct assumption. There are more advanced UEs which do not do de-spreading but perform joint channel estimation across ports. With joint channel estimation, performance difference between OCC2 and OCC 4 vanishes.
* QC: dynamic indication has impact to PDSCH decoding timeline. We don’t think RAN1 would have enough TU to discuss new values for N2 with dynamic indication.
* QC/Intel: if we are indicating OCC size then, options to enable UE to not do any dispreading would benefit complexity at the UE.

**Issue of 2.3a:**

* Samsung: it requires 2 bits based on QC’s example, so it requires more DCI overhead than FL proposal#2.3
* Lenovo: whether/how to indicate the information of the co-scheduled MU is another issue
* Vivo: It’s unreasonable that when the network has sent the additional DCI signalling, it still depends on UE to decide the FD-OCC length for de-spreading.

There are some discussion points.

**1. Does UE can decide FD-OCC length for de-spreading?**

Except for vivo, most of companies says yes. FL also thinks it is not testable because channel estimation is up to UE implementation.

**2. DCI overhead of Proposal#2.3a**

Samsung, Nokia/NSB claims Proposal#2.3a has more DCI overhead (e.g. 2-bit). Most of companies supporting Proposal#2.3 is to add new 1-bit DCI. Nokia/NSB’s proposal in #2.3 is to use TD-OCC table, which does not require additional DCI overhead.

**3. Proposal#2.3 impacts to PDSCH decoding timeline**

Qualcomm claims Proposal#2.3 impacts to PDSCH decoding timeline, which requires large RAN1 efforts. FL think this comment is based on “UE requires to switch “FD-OCC length for de-spreading”, but if which FD-OCC length is assumed for channel estimation is up to UE (not testable), FL is not sure why additional timeline is required.

**4. This discussion is for PDSCH, PUSCH or both?**

FL thinks companies discuss assuming PDSCH. FL would like to ask whether any issue/benefit to support dynamic switching for PUSCH.

More number of companies support FL proposal#2.3(round1) than FL proposal#2.3a(round2). Let’s continue discussion with FL proposal#2.3(round1).

**FL proposal#2.3b:**

* **For PDSCH/PUSCH, support DCI-based dynamic switching between Rel.15 Type1/Type2 DMRS ports and Rel.18 eType1/eType2 DMRS ports, within a DCI format 1\_1/1\_2/0\_1/0\_2.**
	+ **This feature is optional UE feature of Rel.18 DMRS port(s).**
	+ **Note: It is up to receiver implementation which FD-OCC length is assumed for de-spreading (if used) for channel estimation.**
	+ **FFS: whether additional DCI field is required, or existing DCI field can be reused for the switching.**

Please provide your views.

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| **Company** | **Comment** |
| Samsung | Support FL proposal#2.3b. As Nokia mentioned, even in Rel-15, dynamic switching between DMRS type 1 and 2 is possible by using different TDRA entry with different PDSCH/PUSCH mapping type. Hence, proposal#2.3b does not need additional DCI overhead if we reuse TDRA field. Also, as we mentioned in the previous round, we think that the dynamic switching between Rel.15 Type1/Type2 DMRS ports and Rel.18 eType1/eType2 DMRS ports can enable flexible scheduling between high-rank SU-MIMO and large number of MU-MIMO. |
| DOCOMO | FL proposal#2.3b: Support.  |
| Sharp | Support FL proposal#2.3b and we have the similar view with Samsung. |
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## 2.5 MU-MIMO between Rel.15 DMRS ports and Rel.18 DMRS ports

4 companies (e.g. ZTE, Samsung, NTT DOCOMO, Sharp) support MU-MIMO between Rel.15 DMRS ports and Rel.18 DMRS ports. Note that FL proposal#2.4 is assumed as definition of Rel.18 DMRS ports, that is

* + **Rel.15 DMRS ports: All DMRS ports with FD-OCC length =2.**
	+ **Rel.18 DMRS ports: All DMRS ports with FD-OCC length >2.**

Spreadtrum [6] mentioned spec. enhancement is not needed to multiplex Rel.15 DMRS ports and Rel.18 DMRS ports if gNB indicates only FD-OCC sequence of either [+1 +1 +1 +1] or [+1 -1 +1 -1] for Rel.18 DMRS ports, gNB can also indicate FD-OCC of [+1 +1] or [+1 -1] for Rel.15 DMRS ports for another UE.

FUTUREWEI mention that if DCI-level dynamic switching of FD-OCC length is supported, MU-MIMO between Rel.15 DMRS ports and Rel.18 DMRS ports is not needed. Huawei/HiSilicon mentions that this can be discussed later.

**From FL perspective, if dynamic switching is supported in sect. 2.3, MU-MIMO between Rel.15 DMRS ports and Rel.18 DMRS ports are not needed. Hence, I suggest to discuss this later.**

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| FL proposal#3.5 (may be discussed later):* Support MU-MIMO between Rel.15 DMRS ports and Rel.18 DMRS ports within a CDM group for PDSCH.
	+ - Note: the study includes MU-MIMO between Rel.15 UE and Rel.18 UE, and between Rel.18 UEs.

Companies views based on tdocs:Support/fine ():ZTE, Samsung, NTT DOCOMO, Sharp (only between Rel.18 or later UEs)No (): FUTUREWEI, vivo (up to gNB implementation), Xiaomi (there is no solution), MediaTek, Nokia/NSB,Discuss later: HW |

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| **Company** | **Comment** |
| DOCOMO | Agree with FUTUREWEI. Whether MU-MIMO between Rel.15 DMRS ports and Rel.18 DMRS ports is needed or not depends on whether DCI-level dynamic switching of FD-OCC length is supported. |
| Apple | Do not fully understand this. The issue is more from the UE interference cancellation perspective in case UE may need to assume what DMRS is used for the co-scheduled UE. In this case, irrespective of whether dynamic switch is supported, the problem is that a UE might be co-scheduled with legacy or Rel-18 UE. |
| InterDigital | We have a similar view as Spreadtrum that this could be potentially done without any enhancement. But we need to wait for the outcome of the FL Proposal #2.2.2. |
| Futurewei | As pointed out by FL, our view is that MU-MIMO between Rel.15 DMRS ports and Rel.18 DMRS ports is not needed if dynamic switching between FD-OCC length 2 and M is supported. So we are fine to discuss and make decision on dynamic switching in Section 2.3 first and then come back to this topic.  |
| Google | OK to postpone the discussion. |
| OPPO | We think the multiplexing is beneficial without specification impact. |
| Ericsson | We are OK to postpone the discussion.  |
| ZTE | Our understanding is different from FL’s assessment. Support of dynamic switching between FD-OCC-2 and FD-OCC-M does not mean MU-MIMO between Rel.15 DMRS ports and Rel.18 DMRS ports is not needed. Even though Rel-18 UE could dynamically switch to Rel-15 FD-OCC sequence to keep the orthogonality, however, it results in fewer DMRS ports available. For example, Rel-18 UE with FD-OCC [+1 -1 +1 -1] switch to [+1 -1] when co-scheduled with Rel-15 UE with FD-OCC [+1 +1], the available DMRS ports of Rel-18 UE will be halved in this case. It deviates from the WID that strive to larger number of orthogonal DMRS ports for DL and UL MU-MIMO. In terms of supporting MU-MIMO between Rel.15 DMRS ports and Rel.18 DMRS ports, it should specify the principle that the OCC sequence of Rel-18 DMRS ports should be orthogonal with Rel-15 DMRS ports. |
| Lenovo | We also think the discussion is related with conclusion of whether DCI-based dynamic switching between FD-OCC length 2 and 4/6 is supported and FD-OCC design (e.g. OCC sequence). So we prefer to discuss this issue later.  |
| Huawei, HiSilicon | OK to postpone. |
| NEC | OK to postpone. |
| Xiaomi | For clarification, all we said in our contribution is that there is no such a length 4/6 OCC can be orthogonal to length 2 OCC used in legacy DMRS as shown below.

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| Let’s assume that one of the length 4 OCC is $[A,B,C,D]^{T}$, like $[+1,-1,+1,-1]^{T}$or $[+1,-1,-1,+1]^{T}$ when the length 4 OCC is Walsh sequence. In order to support the multiplexing of R18 DMRS and legacy DMRS, $[A,B]^{T}$ is supposed to be orthogonal to $[+1,+1]^{T}$ and $[+1,-1]^{T}$. Then we have the following equation:Apparently, there is no non-zero solution for this equation. Hence, there is no such a length 4/6 OCC which is used in frequency to support larger number of DMRS ports can be orthogonal to length 2 OCC used in legacy DMRS.***Observation 1:*** ***There is no such a length 4/6 OCC which is used in frequency to support larger number of DMRS ports can be orthogonal to length 2 OCC used in legacy DMRS*** |

We do not know whether there is solution to support the multiplexing between legacy DMRS and R18 DMRS in MU-MIMO. And if there is way to support the multiplexing, we will support it. |
| MediaTek | We believe MU-MIMO scheduling of R15 and R18 is independent to whether DCI based switching of R15 and R18 is supported. As pointed out by Apple scheduling R15 and R18 in the same CDM group impact the interference cancellation performed at the UE. Nevertheless, we do not support scheduling of R15 and R18 ports within the same CDM group. |
| Spreadtrum | We are OK to postpone the discussion. |
| vivo | Support MU-MIMO between Rel.15 DMRS ports and Rel.18 DMRS ports within a CDM group for PDSCH. However, we think it is unnecessary to introduce any specification for it, since there is no any restriction on indicated DMRS port in one CDM group for MU-MIMO in the current TS 38.214.It is up to the network to ensure the DMRS ports indicated to UEs are orthogonal as much as possible in MU-MIMO. Due to the limited number of orthogonal DMRS port, the network can even configure different *scramblingID* of DMRS to UEs in MU-MIMO, which would lead to non-orthogonal MU-MIMIO scheduling in the current network. |
| Samsung | Support the proposal, and it can be discussed later after finalizing which option, length, and OCC are utilized. |
| CMCC | We share similar view with ZTE/MediaTek that MU-MIMO scheduling of R15 ports and R18 ports is independent to the dynamic switching of R15 and R18 ports. From our side, we should strive to double the number of orthogonal DMRS ports even when co-scheduling the R15 and R18 ports. |
| Nokia/NSB | We don’t need to agree this. Up to moderator to coordination.But, we don’t believe two issues are dependent. Though we use the same sequence, whether to apply FD-OCC2 or FD-OCC4 should be signalled, and they are different ports. For example, total number of DMRS ports to indicate for type 1 single symbol is 12 (4 Rel-15 + 8 Rel-18).  |
| LGE | Ok to postpone. |
| QC | We disagree with Futurewei. We think the 1 bit indication of OCC size does not help allowing MU scheduling between Rel-15 and Rel-18 UE at all. A rank 1 Rel-15 UE and a rank 1 Rel-18 UE can always be co-scheduled with code [1,1,1,1] and [1,-1,1,-1], even without this bit. Rel-15 UE can just treat the Rel-18 UE as a Rel-15 UE. While the Rel-18 UE can treat the Rel-15 UE as a Rel-18 UE.  |
| CATT | OK to postpone the discussion. However, we think that MU-MIMO between Rel.15 DMRS ports and Rel.18 DMRS ports (within one CDM group) needs to be discussed even if dynamic switching is supported in sect. 2.3. Dynamic switching is related to one UE, but MU-MIMO is related to more than one UEs. Therefore, both issues should be discussed. |
| Intel | OK to postpone. But like other companies, we think two issues are being mixed here. Dynamic switching between FD-OCC lengths should not impact MU-MIMO pairing and vice-versa.  |
| Sharp | Agree with the FL’s suggestion.Additionally, we don’t support MU-MIMO between Rel.15 DMRS ports and Rel.18 DMRS ports. Our interpretation was that Rel-18 DMRS ports have length 2 or M FD OCC. |
| Fraunhofer IIS/HHI | Postpone discussion after 2.3 is finalized |

### **ROUND-3**

In Round 1, different companies think different understanding whether this issue is dependent on the outcome of the dynamic switching between Rel.15 DMRS ports and Rel.18 DMRS ports. Also, there are different understanding of the consequence if there is no agreement of “MU-MIMO between Rel.15 DMRS ports and Rel.18 DMRS ports”. Since the current spec. only specified prohibited combinations of DMRS ports between different UEs, as in sect. 2.7. So, if we don’t have agreement, it seems any DMRS combination is allowed (including Rel.15 DMRS ports and Rel.18 DMRS ports).

**FL question2.5a:**

**Do you think the discussion of** **“MU-MIMO between** **Rel.15 DMRS ports and Rel.18 DMRS ports” should wait the outcome of the discussion of “DCI-based dynamic switching between FD-OCC length 2 and 4”?**

**FL question2.5b:**

**What is the consequence if no agreement is made for “MU-MIMO between Rel.15 DMRS ports and Rel.18 DMRS ports in Rel.18”?**

* **Alt.1: MU-MIMO between Rel.15 DMRS ports and Rel.18 DMRS ports is allowed, because the current spec. only captures prohibited combination of DMRS ports between different UEs.**
* **Alt.2: MU-MIMO between Rel.15 DMRS ports and Rel.18 DMRS ports is not allowed.**

Please provide your views.

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| **Company** | **Comment** |
| Samsung | For FL question 2.5a, **MU-MIMO between Rel.15 DMRS ports and Rel.18 DMRS ports”** and **“DCI-based dynamic switching between FD-OCC length 2 and 4”** are not related each other, since MU-MIMO between R15 and R18 DMRS is happened among different users, and DCI based switching is happened within a certain UE. For MU-MIMO between R15 and R18 DMRS, we think that Rel-15 DMRS in this issue covers not only R15 DMRS from R18 UE, but also R15 DMRS from R15 UE (i.e., legacy). For FL question 2.5b, our view is Alt.2 (it seems second Alt.1. is Alt.2.), since current specification prohibits MU-MIMO among different DMRS types as follows: (Clause 5.1.6.2 in TS38.214)*The UE is not expected to assume co-scheduled UE(s) with different DM-RS configuration with respect to the actual number of front-loaded DM-RS symbol(s), the actual number of additional DM-RS, the DM-RS symbol location, and DM-RS configuration type as described in Clause 7.4.1.1 of [4, TS 38.211].* |
| DOCOMO | FL question2.5a: We thought no, but open to discuss.FL question2.5b: Our understanding is Alt.1. Re Samsung’s text of specification, we need to discuss whether Rel.15 DMRS Type1 and Rel.18 DMRS eType1 are the same or different *DM-RS configuration type*. |
| Sharp | FL question2.5a: NoFL question2.5b: Support Alt 2 (second Alt 1) |
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## Rel.18 DMRS Ports Indication and Signaling

In TS38.212, antenna port(s) field in DCI format 0\_1/0\_2/1\_1/1\_2 indicates DMRS port index(es) of PDSCH/PUSCH. The current antenna port(s) table only captures DMRS port indexes of Rel.15 DMRS port(s) (p=#1000~1007 for type1 and p=#1000~1011 for type2), multiple companies mention it is necessary to add at least 1-bit in DCI format 0\_1/0\_2/1\_1/1\_2 to indicate Rel.18 DMRS ports in Rel.18, because total number of DMRS ports is doubled in Rel.18.

FUTUREWEI [1] proposes two possible options:

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| * Scheme A: Generate new tables similar to Tables 7.3.1.2.2-1/2/3/4 and Tables 7.3.1.2.2-1A/2A/3A/4A in [4]. To accommodate larger number of orthogonal DMRS ports, these new tables will in general have more entries/rows than its legacy counterparts. Therefore, it requires larger size of Antenna port(s) field in DCI to indicate one of the entries in the table. For example, the size of the Antenna port(s) field is increased from 4, 5, or 6 bits to 5, 6, or 7 bits, respectively.
* Scheme B: Reuse the existing Tables 7.3.1.2.2-1/2/3/4 and Tables 7.3.1.2.2-1A/2A/3A/4A in [4] and keep the size of the Antenna port(s) field in DCI unchanged. To accommodate larger number of orthogonal DMRS ports, introduce a new bit to the existing DCI message to indicate the DMRS port indexing offset. For example, if this bit is set to “0”, the Antenna port(s) field in DCI refer to one row in the existing tables to indicate the number of CDM groups without data, DMRS port(s), and number of front-load symbols. In this case, the operation is similar to that in legacy mode. On the other hand, if this bit is set to “1”, the Antenna port(s) field in DCI refers to one row in the legacy tables to indicate the number of CDM groups without data and the number of front-load symbols, while the real DMRS port(s) indexes is the ones read from the existing table plus an offset value, which is 8 for DMRS Type 1 and 12 for DMRS Type 2, respectively.
 |

Following illustrates examples of extension of Table 7.3.1.2.2-1 in TS38.212.



a) Scheme A b) Scheme B

Figure 2.6. Examples of extension of Table 7.3.1.2.2-1 in TS38.212.

From FL perspective, both Scheme A/B have not much difference. One thing we should carefully consider is that it seems Scheme B cannot indicate 3 or 4 DMRS ports within a CDM group (e.g. DMRS port index = 0,1,8,9 in DMRS type 1). This may be problem especially for >4 ranks, because in the current spec., in case of two CWs, all remaining DMRS ports are not used to other UEs. If UE#1 cannot use all of 4 DMRS ports within a CDM group, some of DMRS ports are wasted, which cannot not increase the max number of DMRS ports in MU-MIMO.

**FL proposal#2.6 (Round1):**

* **If Rel.18 DMRS is configured, increase/add at least 1-bit in DCI format 0\_1/0\_2/1\_1/1\_2 to indicate Rel.18 DMRS port(s).**
* **Down select one of the following on how to enhance TS38.212.**
	+ **Scheme A: Specify new antenna port(s) tables similar to Tables 7.3.1.2.2-1/2/3/4 and Tables 7.3.1.2.2-1A/2A/3A/4A in TS38.212. The size of the Antenna port(s) field is increased from 4, 5, or 6 bits to 5, 6, or 7 bits, respectively.**
		- **Existing rows in Tables 7.3.1.2.2-1/2/3/4 and Tables 7.3.1.2.2-1A/2A/3A/4A in TS38.212 are copied to the new tables except for “Reserved” row.**
			* **FFS for other rows in the new tables.**
	+ **Scheme B: Reuse the existing Tables 7.3.1.2.2-1/2/3/4 and Tables 7.3.1.2.2-1A/2A/3A/4A in TS38.212 and keep the size of the Antenna port(s) field in DCI unchanged. Introduce new 1-bit DCI field of “DMRS port(s) offset indicator” to indicate Rel.18 DMRS ports.**
		- **If “DMRS port(s) offset indicator” field is set “0”, DMRS port(s) are the same as indicated by antenna port(s) field in DCI format 0\_1/0\_2/1\_1/1\_2.**
		- **If “DMRS port(s) offset indicator” field is set “1”, DMRS port(s) are incremented with X from the indicated DMRS port(s) by antenna port(s) field in DCI format 0\_1/0\_2/1\_1/1\_2.**
			* **Value of X is 8 for DMRS type 1 and 12 for DMRS type 2.**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| NTT DOCOMO | Support in principle. We believe it is important to enable to indicate 3 or 4 DMRS ports within a CDM group to a UE to minimize DMRS overhead (e.g. DMRS port index = 0,1,8,9 in DMRS type 1). However, Scheme B seems not possible such operation. If we add new DMRS port combination in reserved bit, it may be possible. |
| Apple | The issue of Scheme B is that it will limit the DMRS port selection, i.e., either all selected from the first half of DMRS ports or the second half of DMRS ports.Maybe we first agree on OCC length, finalized the DMRS port pattern table similar as Table 7.4.1.1.2-1/2 in 38.211, and then discuss the antenna port indication table since we may also need to discuss for UL which is even harder since we need to discuss more than 4 layers  |
| InterDigital | Don’t agree with the first bullet that requires addition of a new bit. We could simply use one of the reserved codepoint to indicate whether the indicated DMRS ports are for Rel-18 DMRS.We are OK with scheme B, if the first bullet is corrected. |
| Futurewei | Support FL’s proposal. We are open to both schemes with a slight preference on Scheme B as it requires less specification effort. Our understanding is that the main goal for increased DMRS ports in this WI is to support pairing more users in MU-MIMO. In this case, supporting rank up to 2 per user within a CDM group is sufficient. In the case that it is really needed to support higher rank (e.g., 3 or 4) for a UE within a CDM group, the tables with maxLength = 2 can be used.  |
| Google | We think new table should be needed (Scheme A), but the first main bullet seems unnecessary. |
| OPPO | For the first bullet, we don’t think it is needed. RRC based table switching is sufficient. With Scheme A, Rel-15 and Rel-18 DMRS can use different tables with different size. Furthermore, more antenna port combinations should be supported for Rel-18 DMRS, e.g. 4 ports within one CDM group with only one CDM group without data, which is not supported in Rel-15. |
| Ericsson | Fine with the proposal. |
| ZTE | First things first, RAN shall clarify whether the first half of Rel-18 DMRS ports and the second half of Rel-18 DMRS ports can be allocated in one CDM group, e,g,. port 0, port 1, port 8 and port 9 are allocated in CDM group 0 when DMRS type 1 with single-symbol. The above can be supported by Scheme A in principle, but Scheme B seems to completely preclude this point. Besides, the first main bullet is not needed in the current phase and should be removed.**FL proposal#2.6:*** **Down select one of the following on how to enhance TS38.212.**
	+ **Scheme A: Specify new antenna port(s) tables similar to Tables 7.3.1.2.2-1/2/3/4 and Tables 7.3.1.2.2-1A/2A/3A/4A in TS38.212.**
		- **Existing rows in Tables 7.3.1.2.2-1/2/3/4 and Tables 7.3.1.2.2-1A/2A/3A/4A in TS38.212 can be copied to the new tables except for “Reserved” row at least.**
			* **FFS for other rows in the new tables.**
	+ **Scheme B: Reuse the existing Tables 7.3.1.2.2-1/2/3/4 and Tables 7.3.1.2.2-1A/2A/3A/4A in TS38.212 and keep the size of the Antenna port(s) field in DCI unchanged. Introduce new 1-bit DCI field of “DMRS port(s) offset indicator” to indicate Rel.18 DMRS ports.**
		- **If “DMRS port(s) offset indicator” field is set “0”, DMRS port(s) are the same as indicated by antenna port(s) field in DCI format 0\_1/0\_2/1\_1/1\_2.**
		- **If “DMRS port(s) offset indicator” field is set “1”, DMRS port(s) are incremented with X from the indicated DMRS port(s) by antenna port(s) field in DCI format 0\_1/0\_2/1\_1/1\_2.**
			* **Value of X is 8 for DMRS type 1 and 12 for DMRS type 2.**
 |
| Lenovo | Support FL’s proposal. We are open for more discussion on scheme A and scheme B. In general, scheme B reuses existed DMRS port indication table as much as possible and the standard effort is lower although some flexibility may be lost such as supporting DMRS port index = 0,1,8,9 in DMRS type 1. For scheme A, it need clarify on details and have more discussion on necessity for new entries/rows different from legacy antenna port table.  |
| Huawei, HiSilicon | Current version precludes some candidate options and further study is needed. Suggest to postpone after 2.2 is decided.  |
| NEC | We also think the first bullet is not needed. And we prefer scheme A in principle. While we think it’s not needed to copy each exiting row for Rel-18 DMRS ports. For example, the row “number of CDM group without data = 1, DMRS port = 8”, what’s the use case? Taking “DMRS type 1” “maxlength =1” for example, with number of CDM group without data =1, the maximum number of DMRS ports available is 4 (with doubled DMRS ports), while legacy Rel-15 configuration can support this already.So in our understanding, the additional DMRS ports (8,9,10,11,12,13,14,15) is only needed when legacy DMRS ports (0,1,2,3,4,5,6,7) are all allocated. In this case, the number of CDM group without data =2 for DMRS port 8 is sufficient.**FL proposal#2.6:*** **Down select one of the following on how to enhance TS38.212.**
	+ **Scheme A: Specify new antenna port(s) tables similar to Tables 7.3.1.2.2-1/2/3/4 and Tables 7.3.1.2.2-1A/2A/3A/4A in TS38.212.**
		- **At least some existing rows in Tables 7.3.1.2.2-1/2/3/4 and Tables 7.3.1.2.2-1A/2A/3A/4A in TS38.212 are copied to the new tables except for “Reserved” row.**
			* **FFS for the copied rows. For example, whether all existing rows are needed to be copied.**
			* **FFS for other rows in the new tables.**
	+ **Scheme B: Reuse the existing Tables 7.3.1.2.2-1/2/3/4 and Tables 7.3.1.2.2-1A/2A/3A/4A in TS38.212 and keep the size of the Antenna port(s) field in DCI unchanged. Introduce new 1-bit DCI field of “DMRS port(s) offset indicator” to indicate Rel.18 DMRS ports.**
		- **If “DMRS port(s) offset indicator” field is set “0”, DMRS port(s) are the same as indicated by antenna port(s) field in DCI format 0\_1/0\_2/1\_1/1\_2.**
		- **If “DMRS port(s) offset indicator” field is set “1”, DMRS port(s) are incremented with X from the indicated DMRS port(s) by antenna port(s) field in DCI format 0\_1/0\_2/1\_1/1\_2.**
			* **Value of X is 8 for DMRS type 1 and 12 for DMRS type 2.**
 |
| Xiaomi | Support FL proposal#2.6 with less details. **FL proposal#2.6:*** **Down select one of the following on how to enhance TS38.212.**
	+ **Scheme A: Specify new antenna port(s) tables similar to Tables 7.3.1.2.2-1/2/3/4 and Tables 7.3.1.2.2-1A/2A/3A/4A in TS38.212.**
	+ **Scheme B: Reuse the existing Tables 7.3.1.2.2-1/2/3/4 and Tables 7.3.1.2.2-1A/2A/3A/4A in TS38.212 and keep the size of the Antenna port(s) field in DCI unchanged.**

The details of DMRS ports indication can be discussed later. |
| MediaTek | Fine. We are open to discussing both Scheme A and B further.  |
| Spreadtrum | Support the proposal. Specifying new antenna port(s) tables is a more clear solution, and the additional port combinations can be further discussed. |
| vivo | In additional to scheme A and B, another potential solution could also be considered, i.e., specifying a new antenna port table only containing the rows for new DMRS port index, e.g., 8/9/10/11… for type 1.**FL proposal#2.6:*** **Down select one of the following on how to enhance TS38.212.**
	+ **Scheme A: Specify new antenna port(s) tables similar to Tables 7.3.1.2.2-1/2/3/4 and Tables 7.3.1.2.2-1A/2A/3A/4A in TS38.212.**
		- **Alt 1: Existing rows in Tables 7.3.1.2.2-1/2/3/4 and Tables 7.3.1.2.2-1A/2A/3A/4A in TS38.212 are copied to the new tables except for “Reserved” row.**
			* **Existing other rows for new DMRS port index in the new tables.**
		- **Alt 2: Not existing rows in Tables 7.3.1.2.2-1/2/3/4 and Tables 7.3.1.2.2-1A/2A/3A/4A in TS38.212 are copied to the new tables except for “Reserved” row.**
			* + **Existing other rows for new DMRS port index in the new tables.**
	+ **Scheme B: Reuse the existing Tables 7.3.1.2.2-1/2/3/4 and Tables 7.3.1.2.2-1A/2A/3A/4A in TS38.212 and keep the size of the Antenna port(s) field in DCI unchanged. Introduce new 1-bit DCI field of “DMRS port(s) offset indicator” to indicate Rel.18 DMRS ports.**
		- **If “DMRS port(s) offset indicator” field is set “0”, DMRS port(s) are the same as indicated by antenna port(s) field in DCI format 0\_1/0\_2/1\_1/1\_2.**
		- **If “DMRS port(s) offset indicator” field is set “1”, DMRS port(s) are incremented with X from the indicated DMRS port(s) by antenna port(s) field in DCI format 0\_1/0\_2/1\_1/1\_2.**
			* **Value of X is 8 for DMRS type 1 and 12 for DMRS type 2.**
 |
| Samsung | Support in principle. |
| CMCC | Support the proposal. The details can be discussed later. |
| Nokia/NSB | We don’t support the proposal. Using 1-bt DCI indication is similar to Scheme A, which is doubling the table size. We proposed a scheme without DCI bit increase. The tables provided cannot fully distinguish FD-OCC2 and FD-OCC4 for port#0-3 if they are FD-OCC2 or FD-OCC4. Frankly, we have 12 ports (4 FD-OCC2, and 8 FD-OCC4 ports). The above is only supporting 8 FD-OCC4 ports only. It is clear to explicitly indicate what port is used. We proposed DMRS indication into TDRA table similar to mapping type A/B clarification. At least, we prefer to study the proposed schemes and discuss the further down-scoping. Added Scheme C.**FL proposal#2.6:*** **~~If Rel.18 DMRS is configured, increase/add at least 1-bit in DCI format 0\_1/0\_2/1\_1/1\_2 to indicate Rel.18 DMRS port(s).~~**
* **Down select one of the following on how to enhance TS38.212.**
	+ **Scheme A: Specify new antenna port(s) tables similar to Tables 7.3.1.2.2-1/2/3/4 and Tables 7.3.1.2.2-1A/2A/3A/4A in TS38.212. The size of the Antenna port(s) field is increased from 4, 5, or 6 bits to 5, 6, or 7 bits, respectively.**
		- **Existing rows in Tables 7.3.1.2.2-1/2/3/4 and Tables 7.3.1.2.2-1A/2A/3A/4A in TS38.212 are copied to the new tables except for “Reserved” row.**
			* **FFS for other rows in the new tables.**
	+ **Scheme B: Reuse the existing Tables 7.3.1.2.2-1/2/3/4 and Tables 7.3.1.2.2-1A/2A/3A/4A in TS38.212 and keep the size of the Antenna port(s) field in DCI unchanged. Introduce new 1-bit DCI field of “DMRS port(s) offset indicator” to indicate Rel.18 DMRS ports.**
		- **If “DMRS port(s) offset indicator” field is set “0”, DMRS port(s) are the same as indicated by antenna port(s) field in DCI format 0\_1/0\_2/1\_1/1\_2.**
		- **If “DMRS port(s) offset indicator” field is set “1”, DMRS port(s) are incremented with X from the indicated DMRS port(s) by antenna port(s) field in DCI format 0\_1/0\_2/1\_1/1\_2.**
			* **Value of X is 8 for DMRS type 1 and 12 for DMRS type 2.**
	+ **Scheme C: Reuse the existing Tables 7.3.1.2.2-1/2/3/4 and Tables 7.3.1.2.2-1A/2A/3A/4A in TS38.212 and keep the size of the Antenna port(s) field in DCI unchanged. Introduce new table to indicate Rel.18 DMRS ports including full 8/16 or 12/24 ports.**
		- * **TDRA entry configured includes a entry indicate what DRMS ports is used for scheduling.**
 |
| LGE | Support FL's proposal. We prefer scheme B because it requires less specification effort. |
| QC | Similar view as Apple, Option B seems unnecessarily restrictive. We prefer option A in general. But we suggest to defer the discussion on the details of filling the entries of the expanded table, as this should be discussed together with MU scheduling restriction in section 2.7. We suggest to combing the discussion of section 2.6 and 2.7 together. They can be discussed after we more important topics in previous sessions are settled.  |
| CATT | Support the proposal and Scheme A is preferred. |
| Intel | Ok with proposal. Scheme B seems strange in that it may limit MU-MIMO pairing options. We are also OK with suggestion from QC on combining discussions 2.6/7.  |
| Sharp | Support NEC’s proposal. |
| Fraunhofer IIS/HHI | Open to discuss both schemes further. |
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### **ROUND-3**

I removed the 1st row. I added Scheme C by Nokia/NSB. I couldn’t catch a point of vivo’s suggestion for Scheme A. FL agree with Qualcomm’s comment that this issue is related to the discussion of MU-MIMO scheduling restriction. For example, to indicate DMRS ports for 4 ranks for eType1 DMRS with single symbol, whether DMRS ports {0,1,8,9} in a CDM group is allowed for a UE? If it is allowed, there is no issue. But, if it is not allowed and only DMRS ports {0,1,2,3} in two CDM groups are allowed, we need to discuss whether other/remaining DMRS ports {8,9,10,11} in two CDM groups can be indicated to another UE at the same time. If this is not allowed, we cannot increase the total number of DMRS ports in Rel.18 for some ranks.

**FL question2.6:**

* **Do you think it is beneficial to indicate 3 or 4 DMRS ports within a CDM group to a UE?**
	+ **For example, for eType1 DMRS with single symbol, do you think it is beneficial to indicate DMRS ports {0,1,8,9} in CDM group#0 for 4 ranks can be indicated to a UE.**
		- **If not (only DMRS ports {0,1,2,3} in two CDM groups are allowed), do you think other/remaining DMRS ports {8,9,10,11} in two CDM groups can be indicated to another UE at the same time?**

**FL proposal#2.6a:**

* **Down select one of the following on how to enhance TS38.212 to indicate Rel.18 DMRS ports.**
	+ **Scheme A: Specify new antenna port(s) tables similar to Tables 7.3.1.2.2-1/2/3/4 and Tables 7.3.1.2.2-1A/2A/3A/4A in TS38.212. The size of the Antenna port(s) field is increased from 4, 5, or 6 bits to 5, 6, or 7 bits, respectively.**
		- **Existing rows in Tables 7.3.1.2.2-1/2/3/4 and Tables 7.3.1.2.2-1A/2A/3A/4A in TS38.212 are copied to the new tables except for “Reserved” row.**
			* **FFS for other rows in the new tables.**
	+ **Scheme B: Reuse the existing Tables 7.3.1.2.2-1/2/3/4 and Tables 7.3.1.2.2-1A/2A/3A/4A in TS38.212 and keep the size of the Antenna port(s) field in DCI unchanged. Introduce new 1-bit DCI field of “DMRS port(s) offset indicator” to indicate Rel.18 DMRS ports.**
		- **If “DMRS port(s) offset indicator” field is set “0”, DMRS port(s) are the same as indicated by antenna port(s) field in DCI format 0\_1/0\_2/1\_1/1\_2.**
		- **If “DMRS port(s) offset indicator” field is set “1”, DMRS port(s) are incremented with X from the indicated DMRS port(s) by antenna port(s) field in DCI format 0\_1/0\_2/1\_1/1\_2.**
			* **Value of X is 8 for DMRS type 1 and 12 for DMRS type 2.**
	+ **Scheme C: Reuse the existing Tables 7.3.1.2.2-1/2/3/4 and Tables 7.3.1.2.2-1A/2A/3A/4A in TS38.212 and keep the size of the Antenna port(s) field in DCI unchanged. Introduce new table to indicate Rel.18 DMRS ports including full 8/16 or 12/24 ports.**
		- **TDRA entry configured includes a entry indicate what DRMS ports is used for scheduling.**

Please provide your views.

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| **Company** | **Comment** |
| Samsung | For FL question2.6, we are open to discuss whether to limit the maximum number of layers which a UE can be scheduled by using Rel-18 DMRS. We think that 2 or 4 layers for a UE is enough. Although it would be decided as 2, it is beneficial for other UEs to use the remaining DMRS ports within the same CDM group. We don’t need to make a limitation.For FL proposal#2.6a, we are fine with further discussion, but this proposal seems related to dynamic switching issue. Hence, we prefer that we can conclude dynamic switching issue first, and also clarify the maximum number of layers if needed, and come back to this issue.**Mod: Just for clarify, this proposal is how to indicate DMRS ports for Rel.18 DMRS ports.** |
| DOCOMO | FL question2.6: Yes. In current Rel.15 Type1 DMRS, to support more than 4 ranks, we need to use double symbol DMRS. However, double symbol DMRS requires additional DMRS overhead. To reduce the DMRS overhead, we believe it is beneficial to enable to indicate 3 or 4 DMRS ports within a CDM group to a UE.FL proposal#2.6a: Support. **Question to Nokia for Scheme C**, do you intend to specify two antenna ports table (one is existing table, and the other is new table), and TDRA indicate which table to use? |
| Sharp | FL question2.6: Yes, for eType1 DMRS with single symbol, when DMRS ports {0,1,8,9} in CDM group#0 are indicated to Rel-18 UE, other CDM group can be used for Rel-15 UE.FL proposal#2.6a: Support |
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## MU-MIMO scheduling restriction within a CDM group

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

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

In Qualcomm [24], following was proposed.

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| **Observation 4: To avoid co-scheduled SU+MU DMRS ports exceeding the total number of DMRS ports that a UE can support, certain restrictions are needed on co-scheduled MU ports.** **Proposal 6: Adopt Option 1 (for both type-1 and type-2 DMRS) to increase number of orthogonal DMRS ports for PDSCH and PUSCH, with restrictions as listed below** * **For single symbol DMRS, if the DMRS ports of a UE are in two or more CDM groups, the UE does not expect DMRS ports from a co-scheduled UE in a same CDM group as the UE.**
* **For double symbol DMRS, a UE does not expect DMRS ports from a co-scheduled UE in a same CDM group as the UE, unless the UE and the co-scheduled UE each associated with a distinct TD-OCC for their DMRS ports respectively.**
 |

Considering that MU-MIMO scheduling restriction is specified in Rel.15, Rel.18 DMRS ports also needs the scheduling restriction of MU-MIMO.

**FL proposal#2.7:**

* **For Rel.18 DMRS ports associated with FD-OCC length 4/6 for PDSCH/PUSCH, following MU-MIMO scheduling restriction is specified.**
	+ **For single symbol DMRS, if the DMRS ports of a UE are in two or more CDM groups, the UE does not expect DMRS ports from a co-scheduled UE in a same CDM group as the UE.**
	+ **For double symbol DMRS, a UE does not expect DMRS ports from a co-scheduled UE in a same CDM group as the UE, unless the UE and the co-scheduled UE each associated with a distinct TD-OCC for their DMRS ports respectively.**

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| **Company** | **Comment** |
| NTT DOCOMO | We’d like to postpone the discussion until antenna port(s) indication in sect. 2.6. Firstly, we’d like to see whether 4 DMRS ports within a CDM group can be allocated to a UE in R18. If not, we would have concern on the proposal, because some DMRS ports cannot be allocated for anybody, especially for > 4 ranks (i.e. two CWs). |
| Apple | We are open to discuss the restriction. But we also prefer to delay it since the DMRS port design is clearer.  |
| InterDigital | Same view as Apple; this can be discussed later. |
| Futurewei | This proposal can be discussed later. |
| Google | We think it can be decided after a DMRS ports indication table is agreed.  |
| OPPO | Support to discuss later. |
| Ericsson | In principle fine with the proposal.  |
| ZTE | Share the view with companies to discuss this later. |
| Lenovo | Same view and this proposal can be discussed later. |
| Huawei, HiSilicon | Can be postponed after 2.2 is decided. |
| NEC | Open to discuss later. |
| Xiaomi | Agree with NTT DOCOMO. |
| MediaTek | We also like to postpone this discussion to later. |
| Spreadtrum | Share the view with companies to discuss this later. |
| vivo | Discuss it later. |
| Samsung | We are fine with discussion what is needed for MU-MIMO within CDM group, which can be discussed later. |
| CMCC | Support to discuss later. |
| Nokia/NSB | We need further check on the proposal, but it is beneficial to discuss about the restrictions which determines the total number of DMRS ports to signal (Table size).  |
| LGE | We also agree with NTT DOCOMO. |
| QC | We thank other companies for agreeing to discuss the restrictions. We think these restrictions should be discussed together with the antenna ports indication table in section 2.6, because certain new entries might be labelled as “not allowed with co-scheduled MU if this entry is used”. To DCM: regarding “4 DMRS ports within a CDM group”, we think it should be allowed. We don’t see any problem to allow it, given we are doubling # DMRS ports. As a matter of fact, putting a SU with rank 4 in a CDM group (so that NW can FDM another user to another group) seems better than putting 4 ports into two CDM group (so that NW have to CDM another user which might create larger interference in large delay spread channels).  |
| CATT | Support to discuss later. |
| Intel | We should discuss this once antenna port definitions are settled.  |
| Sharp | Support to discuss later. |
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## Other proposals

Following proposals are also proposed.

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| **Proposals** | **Companies**  |
| 1. **PTRS-DMRS association for Rel.18 DMRS ports**
 | Lenovo |
| 1. **Study how to support dynamic switching between different number of additional DMRS symbols in Rel-18**
 | Ericsson |
| 1. **Sequence mapping equation needs to be modified to ensure that Rel.18 DMRS and Rel.15 DMRS have the same DMRS pattern**
 | Lenovo |
| 1. **Study on OCC disabling scheme for new DMRS type (Rel.17 feature in above 52.6GHz).**
 | Samsung |

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

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| **Company** | **Comment** |
| Google | We think new PT-RS RE offset table is needed, since there are more DMRS ports.  |
| Ericsson | We hope companies can consider to discuss Proposal 2). |
| Lenovo | For proposal 1, we have similar view as Google.For proposal 3, we agree to discuss sequence mapping equation for R18 DMRS pattern. But we prefer to discuss it later after the details on R18 DMRS pattern are agreed. |
| Nokia/NSB | Proposal 1: We can discuss it later.Proposal 2: We see the benefit, and fine to discuss.Proposal 3: We think the same DMRS sequence can be applied. Proposal 4: We don’t think DL single port DMRS usage should be prioritized in other than FR2-2.  |

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

## PTRS-DMRS association

Multiple companies (e.g. Huawei/HiSilicon, Lenovo?, LGE, CATT, Sharp?, Apple, Samsung, NTT DOCOMO, Qualcomm, etc.) propose to increase the size of PTRS-DMRS association filed in DCI format 0\_1/0\_2 to 4-bit for PUSCH > 4 ranks.

In ZTE [4]

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| One issue is when up to 8 DMRS ports are supported for UL transmission, the association between DMRS ports and PTRS ports should also be enhanced, where the PTRS-DMRS association indication field should be increased. More precisely, for the case of 8 DMRS ports share one PTRS port, 3 bits in total are needed. For case of 4 DMRS ports share one PTRS port, 4 bits (2bits + 2bits) in total are needed. For case of 2 DMRS ports share one PTRS port, 4 bits (1bit + 1bit + 1bit + 1bit) in total are needed. ***Proposal 7:*** *More than 2 bits should be used for the DMRS port and PTRS port association indication for UL transmission with more than 4 layers.* * *Support 3 or 4 bits of the PTRS-DMRS association field in DCI.*
* *Support 2 PTRS ports for up to 8 layers transmission.*
 |

**FL proposal#3.2:**

* **For more than 4 layers SU-MIMO PUSCH with up to 2 ports UL PTRS, support up to 4 bits of PTRS-DMRS association field in DCI format 0\_1/0\_2.**
	+ **For 1 port UL PTRS, 3bits are used for the indication of PT-RS and DMRS ports association for UL PTRS port 0.**
	+ **For 2 ports UL PTRS, 4bits are used for the indication of PTRS and DMRS association when 2 PTRS ports are used, 2bits MSB are for the indication of PTRS port 0, and 2 bits LSB are for the indication of PTRS port 1.**

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| **Company** | **Comment** |
| NTT DOCOMO | Support. |
| Apple | We need to separate discussion of (1) full-coherent (2) partial-coherent (3) non-coherent, instead of the current formulation. For partial-coherent, we now have more than 1 antenna architecture agreed in 8 Tx agenda  |
| InterDigital | First we need to discuss the multiplicity of the PTRS port which as Apple mentioned, for an 8TX UE, should be related to the number of antenna groups. |
| Google | We are not sure whether 2 PT-RS ports are needed or not. PT-RS port indication also depends on whether two codewords are supported. |
| OPPO | We can first agree on the number of UL PTRS ports.  |
| ZTE | Support.Basically, no matter antenna port coherency or antenna groups number of 8 Tx UE, the case of PTRS-DMRS association indication can be classified as *x* PTRS ports shared by *y* DMRS ports (where *x*=1 or 2, *y*=2 or 4 or 8, *x*<*y*). Consequently, 3 or 4 bits of the indication field are needed as elaborated in our contribution [4]. |
| Lenovo | Support |
| Huawei, HiSilicon | Not support. The overhead should strive to be minimized. |
| Xiaomi | Support the proposal targeting for 2-port PT-RS, in our view whether it is needed to support 4-port or not can be discussed further. |
| MediaTek | Agree with Oppo. We still haven’t agreed on supporting 2 ports UL PTRS ports yet.  |
| Spreadtrum | We suggest to decide the maximum number of PTRS ports first. |
| vivo | Support |
| Samsung | Support the proposal, and also fine with discussion after determining the maximum number of PTRS ports. |
| CMCC | We need to discuss the max number of PTRS ports firstly. For the discussion of PT-RS and DMRS ports association, it may be clearly to separate the discussion based on the antenna architecture agreed in 8 Tx agenda as Apple mentioned. In Rel-15, the max number of PTRS ports and PT-RS and DMRS ports association are also separately specified base on UE antenna architecture. |
| Nokia/NSB | We share view with OPPO, MTK and others. We don’t support increase of DCI indication.  |
| LGE | Support |
| QC | Similar as Apple’s and InterDigitial, we suggest to discuss the relationship between antenna groups and # PTRS ports first. We think one PTRS port for each antenna group is needed.  |
| CATT | Support. |
| Sharp | Support |
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## Max number of PTRS ports

In RAN1#110 meeting, in AI 9.1.4.2 (SRI/TPMI for 8Tx UL), antenna assumption of for full/partial coherent UE was agreed that the number of Ng (antenna coherent groups) is 1, 2, 4 where each group comprises coherent antennas, and antennas can be non-coherent/coherent across groups, depending on device types. From technically speaking, if different antenna groups do not share the same PA (Power Amplifier), different phase noise would be observed for different antenna groups.

Multiple companies (Lenovo, LGE, CATT, Xiaomi, Apple, NTT DOCOMO, Qualcomm) mention the max number of PTRS should be enhanced to up to 4 ports. On the other hand, some other companies ( Samsung, Nokia/NSB) think the enhancement is not needed.



**Fig 15:** **Examples 8 Tx PUSCH transmission requires 4 PTRS ports [24]**

**FL proposal#3.3:**

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

**Support/fine (12): NTT DOCOMO, Apple, InterDigital, ZTE, Lenovo, Huawei/HiSilicon, Xiaomi, CMCC, LGE, Qualcomm, CATT**

**No, i.e. up to 2 PTRS ports (8): Google, OPPO, NEC, vivo, Samsung, MediaTek, Nokia/NSB**

**Postpone (1): Sharp**

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| **Company** | **Comment** |
| NTT DOCOMO | Support. |
| Apple | We think it is for 8 Tx UL operation * **For 8 TX UL operation ~~more than 4 layers SU-MIMO PUSCH~~, support up to 4 ports PTRS for CP-OFDM.**
 |
| InterDigital  | We are fine with Apple’s revision. |
| Google | We think 1 PT-RS port is sufficient. There seems to be no multi-panel transmission for 8Tx based on current agreement.  |
| OPPO | We think two PTRS ports are sufficient. If the number of PTRS ports should be the same as the number of antenna groups, does it mean that we need 8 ports for non-coherent antenna layout? |
| ZTE | Support. In our view, Apple’s update is the same to FL proposal#3.2. |
| Lenovo | Suggest the following update:* **For ~~more than 4 layers SU-MIMO PUSCH~~ 8Tx PUSCH, support up to 4 ports PTRS for CP-OFDM.**
 |
| Huawei, HiSilicon | Support. |
| NEC | We also think up to 2 PTRS ports are sufficient. |
| Xiaomi | Support the proposal |
| MediaTek | We don’t believe number of PTRS ports need to scale with number of panels. |
| vivo | Don’t support 4 PTRS ports. Up to 2 PTRS ports are sufficient, since each pair of antenna groups can be linked to the same oscillator among 4 antenna groups.  |
| Samsung | Not support, we think up to 2 PTRS is enough. |
| CMCC | Support.Up to 4 antenna coherent groups have been agreed in 8 Tx agenda, which may require up to 4 PTRS ports.In Rel-15, the max number of PTRS ports for non-coherent is same as partial-coherent antenna architecture, this principle can be reused that up to 4 ports PTRS is enough. |
| Nokia/NSB | As long as 3GPP support upto two UL panels (or two TRPs), up to 2 PTRS ports is enough.  |
| LGE | Support |
| QC | Support FL proposal. We are also fine with Apple revision.  |
| CATT | Support. |
| Sharp | We suggest waiting progress of AI 9.1.4.2 because Ng is not defined yet. It is unclear that different antenna groups do not share the same PA. |
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### **ROUND-3**

Let’s continue the following proposal.

**FL proposal#3.3:**

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

For supporting companies, please check and reply to comments from opponent companies.

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| **Company** | **Comment** |
| Samsung | Not support. Enabling up to 8-layer PUSCH is for throughput enhancement, hence up to 4 PTRS ports may affect UL throughput and make some degradation. Also, the relevant scenario for up to 8-layer PUSCH is FR1, where PTRS is optional. Hence, we think that 2 PTRS ports are enough to support and it is not necessary to have more number of PTRS ports rather than current specification. |
| DOCOMO | Support.  |
| Sharp | Not support. In our view, Ng is not the number of panels. |
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## Antenna port(s) table for >4 layers PUSCH

Multiple companies mentioned enhancement of antenna port(s) table for rank 5/6/7/8 is needed to support >4 layers PUSCH. Some companies (e.g. Huawei/HiSilicon, vivo, OPPO, CMCC, etc) think the baseline is to reuse the same or a subset of DMRS port combination for rank 5/6/7/8 for PDSCH. On the other hand, Note/CATT pointed out that DMRS port indication mechanism is different between PUSCH and PDSCH:

* For PUSCH, DMRS is indicated from ports combinations with total ports number equals to the number of layers indicated by TPMI/SRI.
* For PDSCH, DMRS is indicated from all ports combinations.

In RAN1#110, following was proposed. However, some companies commented that it is not possible to reuse DMRS port combinations of PDSCH.

|  |
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| **FL proposal#4.3:*** **For > 4 layers PUSCH, support new antenna port indication table for rank = 5,6,7,8 for both DMRS type 1/2, and for both single-symbol/double-symbol DMRS.**
	+ **For Rel.15 DMRS ports (if supported), following options can be considered**
		- **Alt.1: same DMRS port combinations as that for rank = 5,6,7,8 for PDSCH are reused.**
		- **Alt.2: new DMRS port combinations are used for rank = 5,6,7,8 (FFS: details).**
	+ **For Rel.18 DMRS ports (if supported), following options can be considered**
		- **Alt.1: same DMRS port combinations as that for rank = 5,6,7,8 for PDSCH are reused.**
		- **Alt.2: new DMRS port combinations are used for rank = 5,6,7,8 (FFS: details).**
			* **Note: whether the DMRS port combination allows to use single symbol DMRS for rank = 5,6,7,8 should be checked.**
 |

From FL perspective, it is clear that we need to define new antenna port(s) table for rank = 5,6,7,8 for PUSCH. Question is either/both of Rel.15 DMRS ports or Rel.18 DMRS ports should be assumed. This will be solved after FL proposal#3.1 is agreed.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Apple | We are fine with the proposal  |
| InterDigital | Support FL proposal. For Alt2., we even believe that support of every combination may not be necessary, but we can discuss it later. |
| Google | Support in principle |
| OPPO | We are fine with the proposal.  |
| ZTE | Support |
| Lenovo | We are fine with the proposal. The details on new DMRS port combination can be clarified and discussed later. |
| Huawei, HiSilicon | Support. |
| NEC | Fine with the proposal. |
| Xiaomi | We support the proposal in principle.First, in our view the “Note” mentioned the issue for the single symbol DMRS should be under the bullet for Rel-15 DMRS.Second, we think whether the DMRS table defined for RANK 5/6/7/8 separately or jointly for all RANKs similar as DL also needs to be clarified, or we agree that the details can be discussed later. |
| MediaTek | Fine |
| Spreadtrum | Support. |
| vivo | Support |
| Samsung | Fine with the proposal in principle. |
| CMCC | Support. |
| Nokia/NSB | We think Rel-15 DL port combinations can be used for full-coherent case only, and also for rank>4, we don’t need DCI filed of “Antenna port(s)”. For partial coherent with 2 or 4 groups of ports, we have to consider the option to distribute the port group into the different DMRS CDM group.  |
| LGE | In our view is to support only one port combination for each of UL rank 5/6/7/8 and it can be one of supported DL DMRS port combinations. Specifically, in the DL DMRS table, rank 5 can be indicated by one of two port combinations and if the same UL DMRS port combinations as DL DMRS port combination are introduced for rank 5, 1 bit in the UL DMRS port indication field needs to be used. In the same way, 1bit is needed for UL rank 6 DMRS port indication if the same port combinations are supported as DL. Thus we’d like the following version:**FL proposal#4.3:*** **For > 4 layers PUSCH, support new antenna port indication table for rank = 5,6,7,8 for both DMRS type 1/2, and for both single-symbol/double-symbol DMRS.**
	+ **For Rel.15 DMRS ports (if supported), following options can be considered**
		- **Alt.1: same DMRS port combinations as that for rank = 5,6,7,8 for PDSCH are reused.**
		- **Alt.2: new DMRS port combinations are used for rank = 5,6,7,8 (FFS: details).**
		- **Alt.3: only one port combination for each of rank=5,6,7,8 for PDSCH are reused.**
	+ **For Rel.18 DMRS ports (if supported), following options can be considered**
		- **Alt.1: same DMRS port combinations as that for rank = 5,6,7,8 for PDSCH are reused.**
		- **Alt.2: new DMRS port combinations are used for rank = 5,6,7,8 (FFS: details).**
		- **Alt.3: only one port combination for each of rank=5,6,7,8 for PDSCH are reused.**

**Note: whether the DMRS port combination allows to use single symbol DMRS for rank = 5,6,7,8 should be checked.** |
| QC | Can FL please clarify what is the relationship between this proposal and the proposal in section 2.6? They seem targeting the same issue? Are we duplicate the discussion? Mod: Thank you for the question. Yes, both sect. 2.6 and sect. 3.4 tries to specify new antenna port(s) table for Rel.18 DMRS ports. But, in sect. 3.4, we will define two new tables for PUSCH with rank = 5,6,7,8 for Rel.15 DMRS ports and Rel.18 DMRS ports. In sect. 2.6, we will define new tables for PUSCH with rank = 1,2,3,4 with Rel.18 DMRS ports only, and new tables for PDSCH with Rel.18 DMRS ports only. |
| CATT | Support. |
| Intel | OK with FL’s proposal |
| Sharp | Support |
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### **ROUND-3**

Based on the following comment, I added Proposal#3.4a.

* Xiaomi: whether the DMRS table defined for RANK 5/6/7/8 separately or jointly for all RANKs similar as DL also needs to be clarified

My understanding was to use antenna ports field in DCI format 0\_1/0\_2 to indicate all DMRS ports for all ranks.

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| - Antenna ports – number of bits determined by the following |

**@Nokia, can you clarify why you think (*for rank>4, we don’t need DCI filed of “Antenna port(s)”*)?**

For FL proposal#3.4b, I added Alt.1-3/2-3 by LGE.

Re Xiaomi, I think the note should be applied to Alt.2-2, because Rel.15 Type 1 DMRS port combination for >4 ranks for PDSCH does not include DMRS ports combination of {0,1,8,9}. But, I put the note under 2nd sub-bullet, so that companies can double-check Rel.15 DMRS ports for PDSCH.

**FL proposal#3.4a:**

* **For > 4 layers PUSCH, antenna ports field in DCI format 0\_1/0\_2 indicates DMRS ports for all DMRS ports for rank = 5,6,7,8.**

**FL proposal#3.4b:**

* **For > 4 layers PUSCH, support new antenna ports tables for rank = 5,6,7,8 for both single-symbol/double-symbol DMRS.**
	+ **For Type 1/Type 2 Rel.15 DMRS ports, new antenna ports tables are down selected from the following:**
		- **Alt.1-1: same DMRS port combinations as that for rank = 5,6,7,8 for PDSCH are reused.**
		- **Alt.1-2: new DMRS port combinations are used for rank = 5,6,7,8 (FFS: details).**
		- **Alt.1-3: only one port combination for each of rank=5,6,7,8 for PDSCH are reused.**
	+ **For Rel.18 eType1/eType2 DMRS ports, new antenna ports tables are down selected from the following:**
		- **Alt.2-1: same DMRS port combinations as that for rank = 5,6,7,8 for PDSCH are reused.**
		- **Alt.2-2: new DMRS port combinations are used for rank = 5,6,7,8 (FFS: details).**
		- **Alt.2-3: only one port combination for each of rank=5,6,7,8 for PDSCH are reused.**
		- **Note: whether the DMRS port combination allows to use single symbol DMRS for rank = 5,6,7,8 should be checked.**

For supporting companies, please check and reply to comments from opponent companies.

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| **Company** | **Comment** |
| DOCOMO | FL proposal#3.4a: Support.FL proposal#3.4b: Support. We think Alt.1-2 and Alt.2-2 are straightforward. |
| Sharp | Support FL proposal 3.4b. |
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## Other proposals

Following proposals are also proposed. Note that discussion of two CW or one CW, and CW to layer mapping is not listed because it is not related to DMRS enhancement. These proposals can be discussed in AI 9.1.4.2.

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| **Proposals** | **Companies**  |
| 1. **Study power boosting of PTRS for up to 8-layer PDSCH and PUSCH transmission**
 | Lenovo, OPPO |
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Please provide your views on the above proposals, or other aspects which are not included in the summary, if any.

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| **Company** | **Comment** |
| OPPO | We think PTRS power boosting needs to be discussed anyway, now or later.  |
| Lenovo | We have similar view as OPPO. |
| Nokia/NSB | We can discuss it according to the decision of the other issue.  |
| QC | PTRS power boosting is a valid issue. Agree with Lenovo/OPPO to discuss it.  |
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# Conclusion

Based on the email discussion, following FL proposals are proposed.

 **To be updated.**

# References

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| --- | --- | --- | --- |
| [1] | **R1-2208375** | On increasing the number of orthogonal DM-RS ports for MU-MIMO | FUTUREWEI |
| [2] | **R1-2208442** | Enhancements on DMRS in Rel-18 | Huawei, HiSilicon |
| [3] | **R1-2208496** | Discussion on DMRS Enhancements | InterDigital, Inc. |
| [4] | **R1-2208505** | DMRS enhancement for UL/DL MU-MIMO and 8 Tx UL SU-MIMO | ZTE |
| [5] | **R1-2208529** | Discussions on increased number of orthogonal DMRS ports | New H3C Technologies Co., Ltd. |
| [6] | **R1-2208542** | Discussion on increased number of orthogonal DMRS ports | Spreadtrum Communications |
| [7] | **R1-2208629** | Discussion on DMRS enhancements | vivo |
| [8] | **R1-2208743** | Discussion of increased number of orthogonal DMRS ports | Lenovo |
| [9] | **R1-2208795** | DMRS enhancement for Rel-18 MIMO | OPPO |
| [10] | **R1-2208873** | On DMRS Enhancement | Google |
| [11] | **R1-2208894** | Increased number of orthogonal DMRS ports | LG Electronics |
| [12] | **R1-2208948** | Discussion on DMRS enhancements | CATT |
| [13] | **R1-2209042** | DMRS Enhancements for Rel-18 NR | Intel Corporation |
| [14] | **R1-2209141** | Discussion on increased number of orthogonal DMRS ports | NEC |
| [15] | **R1-2209259** | Discussion on DMRS enhancement | xiaomi |
| [16] | **R1-2209323** | Discussion on increased number of orthogonal DMRS ports | CMCC |
| [17] | **R1-2209382** | Increased number of orthogonal DMRS ports | Sharp |
| [18] | **R1-2209495** | Increased number of orthogonal DMRS ports | MediaTek Inc. |
| [19] | **R1-2209544** | Increased number of orthogonal DMRS ports | Fraunhofer IIS, Fraunhofer HHI |
| [21] | **R1-2209571** | Views on supporting increased number of orthogonal DMRS ports | Apple |
| [22] | **R1-2209717** | Views on DMRS enhancements | Samsung |
| [23] | **R1-2209891** | Discussion on DMRS enhancements | NTT DOCOMO, INC. |
| [24] | **R1-2209970** | Design for increased number of orthogonal DMRS ports | Qualcomm Incorporated |
| [24] | **R1-2210064** | Rel-18 UL and DL DMRS Enhancements | Nokia, Nokia Shanghai Bell |
| [25] | **R1-2210078** | On DMRS enhancement in Rel-18 | Ericsson |
| [26] | **R1-2205882** | Enhancements on DMRS in Rel-18 (in RAN1#110) | Huawei, HiSilicon |

# **Appendix**

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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| **EVM**Agreement* LLS is used for objective #3 (increasing DMRS ports for MU-MIMO) in Rel.18 MIMO, while SLS can be used optionally.

Agreement* No EVM discussion is needed for objective #5 (>4 layers PUSCH DMRS) in AI 9.1.3.1 (DMRS) in Rel.18.

Agreement* LLS for increasing DMRS ports in AI 9.1.3.1 in Rel.18:
	+ Evaluated channel: PDSCH as baseline (Companies can additionally submit evaluation results of PUSCH).
	+ Evaluation metric:
		- BLER for fixed MCS and rank as baseline
		- User throughput for adaptive MCS and rank as optional
		- MSE or NMSE of DMRS as optional
	+ Evaluation baseline (i.e. compared with):
		- For evaluation of enhanced single-symbol DMRS, baseline refers to Rel.15 single-symbol DMRS or Rel.15 double-symbol DMRS.
		- For evaluation of enhanced double-symbol DMRS, baseline refers to Rel.15 double-symbol DMRS.

Agreement* Following evaluation assumptions are used for LLS for increasing DMRS ports in AI 9.1.3.1 in Rel.18.

|  |  |
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| **Parameter** | **Value** |
| Duplex, Waveform  | TDD, OFDM Note: FDD, OFDM is not precluded  |
| Carrier Frequency  | 4 GHz  |
| Subcarrier spacing   | 30kHz  |
| Channel Model  | CDL-B or CDL-C in TR 38.901 with 30ns or 300ns delay spread as baseline for MU-MIMO and SU-MIMO Note: Other delay spread is not precluded.  Note: Simulation using TDL-A with 30ns or 300ns for MU-MIMO is not precluded.   |
| Delay spread  | Baseline: 30ns, 300ns Optional: 1000ns  |
| UE velocity  | Baseline: 3km/h, 30km/h Optional: 60km/h, 120km/h  |
| Allocation bandwidth  | 20MHz Note: Other bandwidth smaller than 20MHz is not precluded  |
| MIMO scheme  | Baseline: MU-MIMO Optional: SU-MIMO  |
| BS antenna configuration  | Companies can select and need to report which option(s) are used between - 32 ports: (M, N, P, Mg, Ng, Mp, Np) = (8,8,2,1,1,2,8), (dH,dV) = (0.5, 0.8)λ - 16 ports: (M, N, P, Mg, Ng, Mp, Np) = (8,4,2,1,1,2,4), (dH,dV) = (0.5, 0.8)λ Other configurations are not precluded.  |
| UE antenna configuration  | Companies can select and need to report which option(s) are used between 4RX: (M, N, P, Mg, Ng, Mp, Np) = (1,2,2,1,1,1,2), (dH,dV) = (0.5, 0.5)λ for rank > 2 2RX: (M, N, P, Mg, Ng, Mp, Np) = (1,1,2,1,1,1,1), (dH,dV) = (0.5, 0.5)λ for (rank 1,2) Other configuration is not precluded.  |
| MIMO Rank  | 1, 2, or 4 per UE (rank fixed or rank adaptation)  |
| UE number for MU-MIMO  | 1, 2, 4, 8, or 12  |
| Precoding and precoding granularity  | For PDSCH: Companies can select and need to report which option(s) are used between * [ZF or SVD] based sub-band precoding (with 4PRB precoding granularity) on ideal channel knowledge
* CSI codebook based sub-band precoding (with 4PRB precoding granularity) on ideal CSI feedback.

For PUSCH: Companies can select and need to report which option(s) are used between * [ZF or SVD] based wide-band precoding on ideal channel knowledge
* Codebook based wide-band precoding on ideal CSI feedback.
 |
| Feedback delay for precoding  | 5ms  |
| DMRS type  | Type 1E and/or Type 2E, which are enhanced DMRS that are based on the legacy RE mappings of DMRS Type 1/2, where the enhanced DMRS support larger DMRS ports. Note: The terminology of Type 1E and/or Type 2E is for discussion purpose.  |
| DMRS configurations  | Baseline:  * Single symbol DMRS without additional DMRS symbols and 1 additional DMRS symbol
* Double symbol DMRS without additional DMRS symbols.

Note: evaluation of other additional DMRS symbol(s) are not precluded.  |
| DMRS mapping type  | Mapping type A (slot based) for PDSCH. Mapping type A (slot based) for PUSCH.  |
| Link adaptation  | * Fixed modulation, coding and rank for BLER evaluation as baseline.
* Adaptation of both MCS and rank for throughput evaluation as optional.
 |
| HARQ  | Baseline: Off Optional: On (HARQ with max. 4 re-transmissions) for throughput evaluation  |
| Channel estimation  | Realistic channel estimation with ideal info of frequency sync, SNR, doppler and delay spread  |
| Receiver type  | MMSE as baseline  |
| EVM  | No radio impairments   |

Agreement* For LLS assumptions for increasing DMRS ports in AI 9.1.3.1 in Rel.18:
	+ Precoding assumption of PUSCH, “[ZF or SVD]” in RAN1#109e agreement is updated by
		- Alt.2-2: SVD

AgreementFor LLS assumptions for increasing DMRS ports in AI 9.1.3.1 in Rel.18: * Precoding assumption of PDSCH, “[ZF or SVD]” in RAN1#109e agreement is updated by SVD.

Agreement* For MU-MIMO LLS of PDSCH, for evaluation of SVD/CSI-codebook based sub-band precoding, companies shall report the pre-coding assumption of interference of co-scheduled UEs from the following:
	+ Alt.1: calculated by pre-coder of channel of each co-scheduled UE.
		- For precoding assumption of PDSCH, precoder of target UE and precoder of co-scheduled UE are generated independently.
		- Companies can report a set of azimuth and zenith angle offset used for evaluation (For example, azimuth angle offsets from [30o, 60o, 90o] and zenith angle offset from [3o, 6o] can be considered).
	+ Alt.2: calculated by random pre-coder (i.e. precoder selected randomly from a predefined set of precoders) which is different from the pre-coder of target UE.
		- For precoding assumption of PDSCH, only the channel of one target UE, i.e. *Hd*, needs to be modelled. Precoder is generated based on *Hd* to obtain the precoder for this UE only. The interference from co-scheduled UEs can be modelled as, cid:image002.png@01D86C43.8E5DA4E0, wherein *Wi* can be randomly selected from a predefined set of precoders
			* Companies shall report how to generate the predefined set of precoders for simulation.
	+ Alt.3: the same pre-coder as scheduled UE.
		- PDSCH interference and interfering DMRS ports are emulated using the same pre-coder as for the scheduled UE.
		- Power offset of the co-scheduled UE is one value from {0dB, -3dB, -6dB} as fixed evaluation parameter. Other values are not precluded.
		- For precoding assumption of PDSCH, only the channel of one target UE, i.e. *Hd*, needs to be modelled. Precoder for the target UE (denoted as *Wd*) is generated based on *Hd* only. Denote the precoding matrix/vector of the ith co-scheduled UEs as *Wi*, and *Wi*=*Wd* (*Wi* for all th co-scheduled UEs are same). Then the interference from co-scheduled UEs can be modelled as cid:image003.png@01D86C43.8E5DA4E0.​

For the above Alt.1-3, only PDSCH performance of the target UE is evaluated, while interference of both PDSCH and DMRS of co-scheduled UE(s) is simulated.Agreement* For SLS assumption for increasing DMRS ports in AI 9.1.3.1 in Rel.18,
	+ Scenario: Dense Urban (Macro only) at 4GHz is a baseline. Other scenarios (e.g. Umi, Uma) are not precluded.
	+ Following evaluation assumptions are used for SLS.

|  |  |
| --- | --- |
| **Parameter**  | **Value**  |
| Scenario  | Dense Urban (macro only)  |
| Carrier frequency  | 4GHz  |
| Duplex, Waveform   | TDD, OFDM Note: FDD, OFDM is not precluded  |
| Multiple access   | OFDMA   |
| Frequency Range  | FR1 only.  |
| Inter-BS distance  | 200 m   |
| Channel model  | According to the TR 38.901   |
| Antenna setup and port layouts at gNB  | Companies need to report which option(s) are used between * 32 ports: (M, N, P, Mg, Ng, Mp, Np) = (8,8,2,1,1,2,8), (dH,dV) = (0.5, 0.8)λ
* 16 ports: (M, N, P, Mg, Ng, Mp, Np) = (8,4,2,1,1,2,4), (dH,dV) = (0.5, 0.8)λ Other configurations are not precluded.
 |
| Antenna setup and port layouts at UE  | 4RX: (M, N, P, Mg, Ng, Mp, Np) = (1,2,2,1,1,1,2), (dH,dV) = (0.5, 0.5)λ for rank > 2 2RX: (M, N, P, Mg, Ng, Mp, Np) = (1,1,2,1,1,1,1), (dH,dV) = (0.5, 0.5)λ for (rank 1,2)  Other configurations are not precluded.  |
| BS Tx power   | 41 dBm for 10MHz, 44dBm for 20MHz, 47dBm for 40MHz  |
| BS antenna height   | 25 m   |
| BS noise figure  | 5 dB  |
| UE noise figure  | 9 dB  |
| UE antenna height & gain  | Follow TR36.873   |
| Modulation   | Up to 256 QAM  |
| Coding on PDSCH  | LDPC Max code-block size=8448bit  |
| Numerology  | Slot/non-slot   | 14 OFDM symbols per slot  |
| SCS   | 30 kHz   |
| Simulation bandwidth   | 20 MHz  |
| Number of RBs  | 52 for 30 kHz SCS  |
| Frame structure   | Slot Format 0 (all downlink) for all slots  |
| MIMO scheme  | SU/MU-MIMO with rank adaptation is a baseline  For low RU, SU-MIMO or SU/MU-MIMO with rank adaptation are assumed  For medium/high RU, SU/MU-MIMO with rank adaptation is assumed  |
| MIMO layers  | For all evaluation, companies to provide the assumption on the maximum MU layers (e.g. 8 or 12)  |
| CSI feedback  | Feedback assumption at least for baseline scheme CSI feedback periodicity (full CSI feedback): 5 ms,  Scheduling delay (from CSI feedback to time to apply in scheduling): 4 ms  |
| Overhead  | Companies shall provide the downlink overhead assumption  |
| Traffic model  | Baseline: FTP1 with 50% Resource Utilization Optional: Full buffer  |
| UE distribution  | [80%] indoor (3km/h),  [20%] outdoor (30km/h)  |
| UE receiver  | MMSE-IRC as the baseline receiver  |
| Feedback assumption    | Realistic  |
| Channel estimation       | Realistic  |

**For increasing orthogonal DMRS ports**Agreement* Specify to increase the max. number of DMRS ports for PDSCH/PUSCH larger than Rel.15 for CP-OFDM without increasing the DMRS overhead.
	+ Strive to have common design of DMRS enhancement for PDSCH and PUSCH for a given DMRS Type.

Agreement* The maximum number of enhanced DMRS ports in Rel.18 is doubled from Rel.15 DMRS ports:
	+ For DMRS type 1, the max. number of enhanced DMRS ports in Rel.18 for PDSCH/PUSCH is
		- Single symbol DMRS: 8 DMRS ports.
		- Double symbol DMRS: 16 DMRS ports.
	+ For DMRS type 2, the max. number of enhanced DMRS ports in Rel.18 for PDSCH/PUSCH is
		- Single symbol DMRS: 12 DMRS ports.
		- Double symbol DMRS: 24 DMRS ports.

Agreement* To increase the number of DMRS ports for PDSCH/PUSCH, evaluate and, if needed, specify one or more from the following options:
	+ Opt.1 (enhance FD-OCC): Introduce larger FD-OCC length than Rel.15 (e.g. 4 or 6).
		- Study aspect includes potential performance degradation in large delay spread, potential scheduling restriction, backward compatibility.
	+ Opt.2 (enhance TD-OCC): Utilize TD-OCC over non-contiguous DMRS symbols (e.g. TD-OCC across front/additional DMRS symbols)
		- Study aspect includes potential performance degradation in high UE velocity, potential scheduling restriction (e.g. how to apply freq. hopping), potential DMRS configuration restriction (e.g. restriction of the number of additional DMRS), backward compatibility.
	+ Opt.3 (Sparser frequency allocation): increase the number of CDM groups (e.g. larger number of comb/FDM).
		- Study aspect includes potential performance degradation in large delay spread, backward compatibility.
	+ Opt.4 (using TDMed DMRS symbol): reusing additional DMRS symbols to increase orthogonal DMRS ports
		- Study aspect includes potential performance degradation in high UE velocity, potential DMRS configuration restriction (e.g. restriction of the number of additional DMRS), backward compatibility.
	+ Opt.5 TD-OCC over non-contiguous DMRS symbols combined with FD-OCC or FDM: reusing additional DMRS symbol(s) to improve channel estimation performance.
		- Study aspect includes potential performance degradation in high UE velocity, potential scheduling restriction (e.g. how to apply freq. hopping), potential DMRS configuration restriction (e.g. restriction of the number of additional DMRS), backward compatibility.
	+ The same option can be applied to both single symbol DMRS and double symbol DMRS.

Agreement* To increase the max. number of DMRS ports for PDSCH/PUSCH compared to Rel.15 DMRS for CP-OFDM without increasing the DMRS overhead,
	+ Study whether/how to enable MU-MIMO between Rel.15 DMRS ports and Rel.18 DMRS ports, as well as whether/how to enable MU-MIMO among Rel.18 DMRS ports, in the same or different CDM group.

Agreement* To increase the max. number of orthogonal DMRS ports for PDSCH/PUSCH larger than Rel.15
	+ Study whether/how to support DCI-based dynamic antenna ports indication of Rel.18 DMRS ports and/or Rel.15 DMRS ports.
	+ Study whether/how to reuse the antenna port indication table in 38.212 as much as possible for both PDSCH and PUSCH
	+ Study the potential need for MU scheduling restrictions in the design of the enhanced antenna port indication table in 38.212 for DL PDSCH.

**For 8 Tx UL SU-MIMO**Agreement* Study the following potential DMRS enhancement for potential support of more than 4 layers SU-MIMO PUSCH.
	+ Extend DMRS port allocation table for rank 5~8
		- Note: DL DMRS table can be a reference
	+ Enhancement for DMRS to PTRS mapping
* Study whether to utilize Rel.18 DMRS ports for more than 4 layers SU-MIMO PUSCH.
* Note: the above study does not imply more than 4 layers SU-MIMO PUSCH is supported.
* Note: other study for potential DMRS enhancement for potential support of more than 4 layers SU-MIMO PUSCH is not precluded.
 |

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

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| **For increasing orthogonal DMRS ports**Working Assumption* To increase the number of DMRS ports for PDSCH/PUSCH, support at least Opt.1 (introduce larger FD-OCC length than Rel.15 (e.g. 4 or 6)).
	+ FFS: FD-OCC length for Rel.18 DMRS type 1 and type 2.
	+ FFS: Whether it is needed to handle potential performance issues of Opt 1. For example, study if there is performance loss in case of large delay spread scenario. If needed, how (e.g. additionally support other options).

Agreement* For enhanced FD-OCC length for DMRS of PDSCH/PUSCH, support the following FD-OCC length:
	+ For Rel.18 DMRS type 1, down select from the following in RAN1#110bis-e:
		- Opt.1-1: Length 6 FD-OCC is applied to 6 REs of DMRS within a PRB within an CDM group
		- Opt.1-2: Length 4 FD-OCC is applied to 4 REs of DMRS within a PRB or across consecutive PRBs within an CDM group
	+ For Rel.18 DMRS type 2:
		- Length 4 FD-OCC is applied to 4 REs of DMRS within a PRB within an CDM group
		- FFS: Support of length 6 FD-OCC

Agreement* Support MU-MIMO between Rel.15 DMRS ports and Rel.18 DMRS ports.
	+ For MU-MIMO by different CDM groups, no MU-MIMO scheduling restriction of PUSCH/PDSCH (i.e. MU-MIMO between Rel.15 UE and Rel.18 UE is allowed).
	+ For MU-MIMO within a CDM group, study whether and how to support MU-MIMO between Rel.15 DMRS ports and Rel.18 DMRS ports for PDSCH.
		- Note: the study includes MU-MIMO between Rel.15 UE and Rel.18 UE, and between Rel.18 UEs.
	+ Note: PUSCH above is CP-OFDM waveform.

AgreementFor increased DMRS ports for enhanced FD-OCC, study whether/how to support DCI based switching between DMRS port(s) associated with length 2 FD-OCC and DMRS port(s) associated with length M FD-OCC (where M > 2).**For 8 Tx UL SU-MIMO**Agreement* For support of more than 4 layers SU-MIMO PUSCH, study the following potential enhancements for PTRS-DMRS association.
	+ Whether to support more than 2-port UL PTRS.
	+ Whether to increase the DCI size of PTRS-DMRS association field in DCI format 0\_1/0\_2.

AgreementFor > 4 layers PUSCH, support rank = 5,6,7,8 for both DMRS type 1/2, and for both single-symbol/double-symbol DMRS. |