**3GPP TSG RAN WG1 Meeting #100bis-e R1-200xxxx**

**e-Meeting, April 20th –30th, 2020**

**Source: Moderator (NTT DOCOMO)**

**Title: Summary of LS on CSI-RS capabilities (FG 2-33/36/40/41/43)**

**Agenda item: 5**

**Document for:** **Discussion/Decision**

# Introduction

During RAN2#109e, an LS on CSI-RS capabilities (FG 2-33/36/40/41/43) was sent to RAN1 [1]. In this LS, RAN2 asked RAN1 to 3 questions for enhancement of CSI-RS capabilities (FG 2-33/36/40/41/43).

Per chairman’s guidance, this summary is to collect companies’ views on this LS and try to draft the reply based on companies’ input.

[100b-e-LS-07] Email approval of the reply LS for [R1-2001519](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_100b%5CDocs%5CR1-2001519.zip) by 4/24 (DCM, Yuki)

# Discussion

## Answer to Q1

In Q1, RAN2 asked whether to define UE capability of “active Tx ports/resources across multiple slots”.

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| Q1: Definition of CSI-RS ports/resources configured for the TDM case.RAN2 understand that the legacy triplet included in SupportedCSI-RS-Resource is relevant to the following definition in sub-clause 5.2.1.6 of TS 38.214.*In any slot, the UE is not expected to have more active CSI-RS ports or active CSI-RS resources than reported as capability.*RAN2 is wondering if the current running CR to 38.306 describing “active Tx ports/resources across multiple slots” by referring to sub-clause 5.2.1.6 of TS 38.214 is in line with RAN1’s understanding. |

In sub-clause 5.2.1.6 of TS 38.214, counting rule of the number of active CSI-RS is specified, and it is clear that the UE is not expected to have more active CSI-RS ports/resources than reported as UE capability in any slot:

*In any slot, the UE is not expected to have more active CSI-RS ports or active CSI-RS resources than reported as capability. NZP CSI-RS resource is active in a duration of time defined as follows. For aperiodic CSI-RS, starting from the end of the PDCCH containing the request and ending at the end of the PUSCH containing the report associated with this aperiodic CSI-RS. For semi-persistent CSI-RS, starting from the end of when the activation command is applied, and ending at the end of when the deactivation command is applied. For periodic CSI-RS, starting when the periodic CSI-RS is configured by higher layer signalling, and ending when the periodic CSI-RS configuration is released. If a CSI-RS resource is referred by N CSI reporting settings, the CSI-RS resource and the CSI-RS ports within the CSI-RS resource are counted N times.*

However, it is not clear why we should define UE capability of “active Tx ports/resources across multiple slots.

Companies’ views are summarized as below (based on tdocs and input in R1-2002736):

* + Q1: whether “active Tx ports/resources across multiple slots” should be reported?
		- No (“per slot” reporting is enough): ZTE, vivo, DOCOMO, OPPO
		- Yes: Intel(?), Samsung
		- Question from Huawei/HiSilicon (what are definitions of the starting slot and the ending slot of “multiple slots”)
		- Comment from Nokia: Suggest clarifying the specific RAN2 CR referred to in Q1 so that RAN1 can give a consistent answer

From moderator perspective, it is assumed that the Q1 comes from different understanding the under reporting issue between RAN1 and RAN2, and defining “active Tx ports/resources across multiple slots” does not help to solve the under reporting issue.

**Discussion point 1: do you see any necessity of defining UE capability of “active Tx ports/resources across multiple slots”?**

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| Company | Comments |
| DOCOMO | No, current reporting of “active Tx ports/resources per a slot” is enough. |
| Qualcomm | “Active Tx ports/resources across multiple slots” is biased from RAN1 intention. The new per-band and per-BC signalling provides CSI-RS capabilities on a band and a band-combo at any times. So, it is essential to clarify the two capabilities signals as follows:* ***For each codebook, the new UE capability is conveyed jointly by new per-band signalling and new per-BC signalling. New per-band signalling limits the active CSI-RS resources at any time on the corresponding individual band. New per-BC signalling further limits the active CSI-RS resource for a specific codebook at any time across the bands included in the corresponding band combination.***
	+ ***In contrast, current per band signalling does not expect gNB to honour the new per BC signalling when there is active CSI-RS on multiple bands included in the band combination***
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| ZTE | We don’t think we should change the definition of “active ports/resources” to multiple slots. It’s already cleat in the current RAN1 spec that the number of active ports/resources are counted per slot. Further, the change to count the numbers within multiple slot is not relevant with RAN1’s initial intention to introduce the per BC signalling.  |
| Intel | The current definition in RAN1 spec (sub-clause 5.2.1.6 of TS 38.214) is clear and there is no need to change it (“per slot” reporting is enough). |
| Nokia/NSB | No, there is no such definition as “active Tx ports/resources across multiple slots” in subclause 5.2.1.6 of 38.214. The current definition of active ports/resources is given per slot and is enough.After checking RAN2 “running CR to 38.306” in R2-2000689 and the solution to the underreporting problem proposed by RAN2 in R2-2000683, we agree with Qualcomm on the need to clarify the scope of the new capabilities needed to solve the problem:* a new list of triplets, say *supportedCSI-RS-Resource-r16,* in *codebookParameters*, (signalled per-band and for each codebook) with the same description as the current *supportedCSI-RS-Resource,* but intended for a new gNB only, where a UE can indicate more aggressive per-band capabilities and avoid underreporting. This is combined with
* a new list of triplets (these are duplets at the moment) in *CA-ParametersNR* (signalled per-BC and for each codebook). A legacy gNB would simply ignore both these new capabilities and operate as per legacy capabilities in *supportedCSI-RS-Resource*
 |
| Apple | We prefer to stick with “per slot”. We don’t think we will converge on the design even if we start the “per multiple slots” discussion since the definition is not even clear at this moment.  |
| Huawei | There is no need to introduce new description or capability of cross slots since all counting related to the supported codebook is per slot |
| CATT | No, we should keep RAN1 definition of “active Tx ports/resources per a slot”. We also agree with Qualcomm and Nokia to clarify the intention of introducing per BC capability signalling. |
| OPPO | No, the current description in subclause 5.2.1.6 of 38.214 is clear and sufficient.  |
| vivo | No, RAN 1’s understanding is that UE is not expected to have more active CSI-RS ports or active CSI-RS resources than reported as capability in any slot |
| Orange | In TS38.306 the word simultaneously refers to active in any slot as defined in TS38.214 sub-clause 5.2.1.6. From an editorial perspective it would be better to align the terminology between TS38.306 and TS38.214, however we agree that there is no need to define” active across multiple slots”. |
| LG | No, current spec is clear. |
| MediaTek | No, “per slot” report is sufficient. |
| Samsung | Yes, and we suggest to change “active Tx ports/resources across multiple slots” to “total configured Tx ports/resources” for better clarity. We think the new capability is per-band and per-BC extension of the existing capability *supportedCSI-RS-ResourceList* per each CB, which is defined as **the total configurable #**. Defining the capability as **active # of ports/resources per slot** is totally different from above, which seems the extension of *simultaneousCSI-ReportsAllCC* per CB. We haven’t discussed this capability in the original LS to RAN2, nor think this one is necessary. |

**Moderator proposal for reply to Q1: The current definition in RAN1 spec (sub-clause 5.2.1.6 of TS 38.214) is clear and there is no need to change it (i.e. current “per slot” reporting is enough).**

Comments (if any):

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| Company | Comments |
| Moderator-DOCOMO | Most of companies seems fine |
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## Answer to Q2

In Q2, RAN2 asked whether the current maximum value of simultaneous CSI-RS resources and CSI-RS ports are enough.

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| Q2: The maximum value of simultaneous CSI-RS resources and CSI-RS ports.In the existing SupportedCSI-RS-Resource, the maximum value of simultaneous resources is 64 and the one of total Tx ports is 256. RAN2 is wondering if the existing value is enough to address the total capability across all CCs or the larger value is desirable. |

Based on tdocs and input in R1-2002736, no companies raised necessity of changing the maximum values.

* + Whether the current maximum value of simultaneous CSI-RS resources and CSI-RS ports are enough?
		- Yes: ZTE, vivo, Intel, Samsung, DOCOMO, Qualcomm, Huawei/HiSilicon, OPPO, LGE

From moderator perspective, it is assumed that the answer to Q2 is stable. If you have different understanding, please comment it.

**Discussion point 2: Do you think the current maximum value of simultaneous CSI-RS resources and CSI-RS ports are enough?**

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| Company | Comments |
| DOCOMO | Yes, RAN1 has no intention to increase the maximum value of simultaneous CSI-RS resources and CSI-RS ports. |
| Qualcomm | No need to introduce new numbers. 64 resources and 256 total ports are the envelop of CSI engine |
| ZTE | We think the current value range is sufficient. |
| Intel | Current value range is enough. |
| Nokia/NSB | Yes, no need to increase these numbers |
| Apple | We are okay with not increasing the maximum values |
| Huawei | Yes, it is enough.  |
| CATT | Yes, it is enough. |
| OPPO | Yes. |
| vivo | yes |
| LG | Yes, it’s enough. |
| MediaTek | Yes, it’s enough. |
| Samsung | Yes. We think current values are enough. |

**Moderator proposal for reply to Q2: There is no need to increase the maximum value of simultaneous CSI-RS resources and total CSI-RS ports.**

Comments (if any):

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| Company | Comments |
| Moderator-DOCOMO | All of companies seems fine |
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## Answer to Q3

In Q3, RAN2 asked whether to report maxNumberTxPortsPerResource in a per BC.

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| Q3: indication of maxNumberTxPortsPerResource in a per BC manner In the RAN1 LS it is stated that “To address above issue, RAN1 has agreed to recommend to introduce new per band capability signaling and per BC capability signaling for component 1 of FG2-36/2-40/2-41/2-43”. The component 1 of FG2-36/2-40/2-41/2-43 contains maxNumberTxPortsPerResource. Currently RAN2 had no consensus to whether to introduce maxNumberTxPortsPerResource per BC. Without this additional field, the number of ports for each resource would be determined based on the values indicated for the band on which the resource is configured, like in Rel-15 signaling (given in the existing per-band signaling). See Annex A for an example. RAN2 would appreciate if RAN1 could provide feedback if this structure does not serve the intended purpose. |

Companies’ views are following (based on tdocs and input in R1-2002736).

* + Q3: whether to report *maxNumberTxPortsPerResource* per BC?
		- Yes: ZTE, Intel, Qualcomm, Huawei/HiSilicon, OPPO
		- No: vivo, Samsung, DOCOMO, LGE

**Discussion point 3: Do you think maxNumberTxPortsPerResource should be reported per BC?**

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| Company | Comments |
| DOCOMO | No, we think maxNumberTxPortsPerResource per BC is not needed, because it corresponds to the max. number of CSI-RS ports of one CSI-RS resource, and it is reported per each band. If this is reported per BC, that can result in limiting possible number of configurations for per BC CSI processing which of course comes with a higher reporting overhead as well. Let us revisit QC’s example to understand why maxNumberTxPortsPerResource per BC is not necessary. Note that, UE reports its actual per band capability as triplet and per BC capability as {$maxNumberResources, totalNumberTxPorts $}, separately. When NW configures CSI processing for BC, it should adhere to the per band restrictions, {maxNumberTxPortsPerResourcePerBand, $maxNumberResources$ PerBand}. For the given example, this can be clarified as, * NW can configure max. 2 resources each with max. 16 ports in BC configuration
* NW can configure max. 6 resources each with max. 8 ports in BC configuration

Note that, with this, the NW will never configure 3 resources each with 16 ports for BC.With this understanding, let us look at the example. Now, UE reports following as its capability.Band A = {8, 6, 48}, {16, ,2, 32}Band B = {8, 6, 48}, {16, ,2, 32}Band A+B = {6, 48}, {2, 32} Consider {6, 48} for BC now. With that, NW can configure following combinations for CSI processing across two bands (of course with the understanding about per band capability)* (16 x 2) + (8 x 2) = 48;
* (8 x 4) + (8 x 2) = 48
* (8 x 6) = 48
* (8 x 3) + (8 x 3) = 48
* (16 x 1) + (8 x 4) = 48

However, if we impose a restriction on maxNumberTxPortsPerResourceon per BC as {**8**, 6, 48}, NW can configure following combinations only* (8 x 6) = 48
* (8 x 3) + (8 x 3) = 48
* (8 x 4) + (8 x 2) = 48

So, this clearly shows that, imposing a restriction on maxNumberTxPortsPerResourceon per BC will result in limiting possible number of configurations for per BC CSI processing which of course comes with a higher reporting overhead as well.  |
| Qualcomm | We think maxNumberTxPortsPerResource per BC is needed essentially. There are two reasons1. In RAN1 original LS R1-1913276, the intention was to extend the CSI-RS capabilities of G-2-36/40/41/43 to per-BC, so maxNumberTxPortsPerResource should be included.
2. The max number of resources and max number of total ports shall be dependent on maxNumberTxPortsPerResource, regardless of the signalling is per-band or per-BC. Let us consider the following example (the 1st number is number of ports per resource, 2nd number is number of resources):
	* UE’s actual capability on band A: (8,6) (16,2)
	* UE’s actual capability on band B: (8,6) (16,2)
	* UE’s actual capability on band A+B: (8,6) (16,2)

It means that, if there are 8 ports per resource, UE is able to do 6 resources across Band A and B; if there are 16 ports per resource, UE is able to do 2 resources across Band A and B. Then, UE would signal:* For band A, (8,6,48) (16,2,32)
* For band B, (8,6,48) (16,2,32)
* For band A+B, (8,6,48) (16,2,32)

Without signaling maxNumberTxPortsPerResource, UE cannot signal (6,48) for (number of resources, number of total ports), as it includes 3 resources each with 16-ports, which exceeds UE actual capability. So, UE has to underreport as (2,32) for (number of resources, number of total ports). Hence, maxNumberTxPortsPerResource is needed per-BC as it is needed per-band. |
| ZTE | To serve the purpose of avoiding UE under reports these capabilities, maxNumberTxPortsPerResource should also be per BC. The reason is that the complexity of CSI computation does not change linearly with the number of ports per resource. Hence if only the other two numbers are per BC, it is not sufficient to describe the UE complexity in one band combination. |
| Intel | In our view it is preferred to include maxNumberTxPortsPerResource information element for indication of Rel-16 new codebook capabilities corresponding to FG2-36/2-40/2-41/2-43 per BC since it is much simpler to optimise the UE capability signalling according to the actual UE CSI processing capabilities if per band and per BC indication are used together.  |
| Nokia/NSB | We think maxNumberTxPortsPerResource per-BC and per-codebook is needed.As commented in Q1, a solution to the underreporting issue requires a new UE to be able to signal, for each codebook, a new list of triplets (maxNumberTxPortsPerResource, maxNumberResources, totalNumberTxPorts) per-BC together with a new list of triplets per-band (with more aggressive capabilities than the legacy underreported per-band triplets). |
| Apple | We prefer to report *maxNumberTxPortsPerResource* per BC |
| Huawei | We think that a triplet including maxNumberTxPortsPerResource per BC is essential. As we explained in R1-2002673, counting principle for a given codebook shall be common for either per band or per BC, anchoring at the value of maxNumberTxPortsPerResource. Per band or per BC just mean two different restrictions when the UE determine how to report triplets. Triplets per band is associated to band characteristics, e.g. sub-1G, sub-6G or FR2 etc. Triplets per BC is associated to UE implementation for the sharing of CSI processing. All per band and per BC shall be limited by actual UE cap. We also have similar observation as QC. If only {max # of total resources, max # of total ports} is reported per BC, the UE will report {2,32} by assuming 16 ports for band A and band B Always and Simultaneously. It is even worse than Band A or Band B alone.  |
| CATT | Per BC maxNumberTxPortsPerResource is needed. As observed by QC and Huawei, without per BC maxNumberTxPortsPerResource, UE may have to report lower capability than its actual capability.  |
| OPPO | Reporting *maxNumberTxPortsPerResource* per BC is needed to avoid under reporting of UE capability. |
| vivo | In our view reporting maxNumberTxPortsPerResource per BC cannot resolve the issue completely, however given majority views we don’t have strong view. |
| Orange | We think that QC (and Huawei in R1-2002673**)** gave clear examples on why maxNumberTxPortsPerResource parameter is needed. The RAN2 signalling should offer the needed flexibility in order to allow the best usage of UE/chipset implementations. It is beneficial from the network perspective since it can use larger values of maximum number  of  active resources and/or ports per resource per BC  when inter band CA  is enabled. Going back to the QC example, let us assume that the UE report (6,48) per BC and that the maximum of antenna ports per resource configured to be active is 16 across band A+B then the UE must deduce that the maximum number of antenna ports per resource (per BC) is 16. Therefore, the following triplet (16,6,48) assumed by the UE (per BC) likely exceeds the UE capability defined by the set { (16,2,32), (8,6,48)}. This will cause potential under-reporting of per BC signalling when a UE decides actual values of reporting.   |
| LG | In our view, additional maxNumberTxPortsPerResource per BC is not needed due to existing per band signalling. However, if the majority view is introducing maxNumberTxPortsPerResource per BC, we don’t have strong objection on this issue.  |
| MediaTek | We support to report *maxNumberTxPortsPerResource* per BC |
| Samsung | We think signalling *maxNumberTxPortsPerResource* per BC is not necessary. However, we don’t have strong concern on introducing such signalling following the majority view. |

**Moderator proposal for reply to Q3: reporting of maxNumberTxPortsPerResource per BC is needed.**

Comments (if any):

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| Company | Comments |
| Moderator | Majority seem to support the proposal |
| DOCOMO | We have **concern** from signaling overhead perspective. Current overhead of the triplet for CSI codebook is very large, which is problematic to our operation.From NW perspective, there is no meaning for UE to report CSI codebook capability **beyond** NW’s capability. (e.g. if NW supports up to 4 ports, it is no useful for UE to report more than 4 ports)Hence, if we can add following note in the LS, so that RAN2 can discuss how to minimize the signaling overhead, we can accept the moderator proposal:----------------------There was concern from some company to increase of overhead of UE capability signaling. RAN1 suggest RAN2 to consider how to minimize the overhead of UE capability. From RAN1 perspective, there is no meaning for UE to report CSI codebook capability beyond NW’s capability (e.g. if NW has up to 4 ports, there is no useful for UE to report more than 4 ports). One way to enable this is to signal NW’s capability of the number of CSI-RS ports/resources in *UECapabilityEnquiry* information element and UE is not required to report CSI-RS codebook capability beyond the information.----------------------Your feedback is really appreciated. |
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## Others

Some companies mentioned that current FG 2-33 per BC cannot avoid the under reporting issue, and they propose reporting per BC of enhanced FG2-33 (reporting multiple combination of FG2-33), or enhanced triplet (reporting the triplet per BC).

**Discussion point 4: Do you think the current FG2-33 (i.e. single combination of {maxNumberResourcesPerBC, totalNumberTxPortsPerBC} per BC) has an issue of under reporting, and should we inform it to RAN2?**

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| Company | Comments |
| DOCOMO | Yes, the example is shown in our contribution (R1-2002427) |
| Qualcomm | No, there is no issue of FG2-33, it is the whole CSI engine on a band-combo across all codebooks. |
| ZTE | No. With the per codebook type signalling, the under-report issue for different bands in a BC has been solved. For the total number of active ports and resources across codebook types, it is a different issue. There is a discussion on concurrent codebook capability reporting in eMIMO UE feature agenda. We can discuss it there and it’s not related to what RAN2 asked for in this LS. |
| Intel | Similar view as ZTE. It seems that this issue is related to the UE capability reporting for the mixed codebook types which is discussed under eMIMO UE feature agenda.  |
| Nokia/NSB | No, the underreporting issue discussed here does not involve FG2-33. This capability is involved in another ongoing discussion in RAN1, currently handled under the eMIMO UE feature AI, which deals with a different underreporting issue for concurrent codebook configurations with codebooks of different types.  |
| Apple | We believe DCM’s concern is the maximum number of triplets for per BC capability reporting. For example, for per band reporting as of Rel-15, we support a list of maximum 7 triplets. We are fine for discussion and clarification.  |
| Huawei | No, there is no issue of FG2-33 so that no change/discussion is needed for FG 2-33.  |
| CATT | No change/discussion is needed for FG 2-33. |
| OPPO | No, the issue of mixed codebook types can be further discussed in UE feature. |
| vivo | No change is needed for FG2-33 |
| LG | No change is needed for FG2-33. |
| Samsung | No, FG2-33 is the upper bound across all codebooks. |

**Discussion point 5: If the answer of discussion point 4 is yes, do you think we should show the possible enhancement of current signalling?**

[Moderator] So far, following two examples are proposed:

* + - Opt. 1) Enhancement of FG2-33 to enable reporting multiple combinations of max. number of CSI-RS resources and CSI-RS ports per BC per each CSI codebook type
		- Opt.2) A list of supported combinations for each codebook, whereas each combination is a triplet of {maxNumberTxPortsPerResource, maxNumberResources, totalNumberTxPorts}, shall be signaled to gNB with a granularity of per BC

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| Company | Comments |
| DOCOMO | Yes, and we prefer option1.But, we suggest to discuss this after the answer to Q3 becomes stable.  |
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In addition to the above questions, do you figure out any other potential issues? If yes, please provide your detailed comments in the below table.

**Discussion point 6: Any other issue (if any)?**

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| Company | Comments |
| Qualcomm | Clarify intention of new per-band and per-BC signalling as replied in Q1. |
| Nokia/NSB | Similar view as Qualcomm on the need to clarify the intended purpose of the new per-band and per-BC capabilities for each codebook type. |
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# Conclusion

To be updated

# Reference

1. R1-2001519, Reply LS on CSI-RS capabilities (FG 2-33/36/40/41/43), RAN2#109e.
2. R1-2001590 Draft reply LS on UE capabilities of CSI-RS ZTE
3. R1-2001901 Draft reply LS on CSI-RS capabilities (FG 2-33/36/40/41/43) vivo
4. R1-2001980 Draft reply LS on CSI-RS capabilities Intel Corporation
5. R1-2002100 Draft reply to RAN2 LS on CSI-RS capabilities (FG 2-33/36/40/41/43) Samsung
6. R1-2002427 [Draft] Reply LS on CSI-RS capabilities (FG 2-33/36/40/41/43) NTT DOCOMO, INC
7. R1-2002514 Draft response to Reply LS on CSI-RS capabilities Qualcomm Incorporated
8. R1-2002673 Discussion on Reply LS on CSI-RS capabilities (FG 2-33/36/40/41/43) Huawei, HiSilicon
9. R1-2002681 [Draft] Reply LS on CSI-RS capabilities (FG 2-33/36/40/41/43) Huawei, HiSilicon