3GPP TSG RAN WG1 #106-e R1-210xxxx

e-Meeting, August 16th – 27th, 2021

**Agenda item: 8.1.2.1**

**Source:** **Moderator (Nokia, Nokia Shanghai Bell)**

**Title: Summary #3 of Multi-TRP PUCCH and PUSCH Enhancements**

**Document for: Discussion and Decision**

# Introduction

This document is for the phase 1 discussion of M-TRP PUSCH and PUCCH enhancement for Rel-17. Previous FL summary versions can be found in R1-2108298 and R1-2108299.

R1-2108298 Summary#1 of Multi-TRP for PUCCH and PUSCH Moderator (Nokia)

R1-2108299 Summary#2 of Multi-TRP for PUCCH and PUSCH Moderator (Nokia)

Latest proposals are in yellow.

FL Instructions are in red text.

#  Multi-TRP PUCCH transmission

## 2.1 Per-TRP closed loop power control

The following proposal had multiple rounds of discussion. Two issues from ZTE and vivo,

* **Issue #1**: ZTE keep on arguing that we shall discuss a scenario “two same “*closedLoopIndex*” values for multi-TRP repetitions”. Based on the FL reading, the suggestion from ZTE is not in line with the earlier agreements (we had mentioning that per-TRP closed-loop power control valid when closed-loop indexes are different).
* **Issue #2**: vivo is arguing that text in the TS38.213 (see below under their comment), should be valid for the case with two TPC commands are configured in the DCI. In summary, if sTRP mode is active for a given PUCCH transmission, vivo mention that the other TPC command can still be used to determine sum of TPC commands. Based on FL reading, as this two TPC fields are introduced in Rel-17, the text in 38.213 cannot be fully refer to the behavior corresponding to the second TPC field. If RAN1 conclude that the second field is unused, that means the indicated TPC in that field is not considered to determine sum of the TC commands.

**Proposed conclusion 2.1-1:** For per-TRP closed-loop power control,

* When the second TPC field is configured and the indicated PUCCH transmission in DCI formats 1\_1/1\_2 (or PUSCH transmission in DCI formats 0\_1/0\_2) is associated with one “*closedLoopIndex*” value for single TRP transmission [or with two same “closedLoopIndex” values for multi-TRP repetitions], the other TPC field associated with the other “*closedLoopIndex*” value is unused.
* Note: Each TPC field is for each closed-loop index value respectively (i.e., 1st /2nd TPC fields correspond to “*closedLoopIndex*” value = 0 and 1, respectively).

Concerns: vivo and ZTE.

@ZTE, vivo >> please reconsider your opinion.

@Others >> please provide your views on Issue #1 and #2 to convince ZTE and vivo.

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| **Company** | **Comments** |
| **vivo** | First of all, when we reading the current spec in TS38.213-  is a sum of TPC command values in a set  of TPC command values with cardinality  that the UE receives between  symbols before PUCCH transmission occasion  and  symbols before PUCCH transmission occasion  on active UL BWP  of carrier  of primary cell  for PUCCH power control adjustment state, where  is the smallest integer for which  symbols before PUCCH transmission occasion  is earlier than  symbols before PUCCH transmission occasion If there is no spec change on above power control text and two TPC fields have been configured with previous agreements that each TPC field is for each closed-loop index value respectively, do we go to this proposed conclusion 2.1-1? Our interpretation is NO. Because the TPC commands forming the cardinality between  symbols before PUCCH transmission occasion  and  symbols before PUCCH transmission occasion  includes all possible TPC commands.So in our view, if no agreement is made the possible conclusion should be **Proposed conclusion 2.1-1:** For per-TRP closed-loop power control, * When the second TPC field is configured and the indicated PUCCH transmission in DCI formats 1\_1/1\_2 (or PUSCH transmission in DCI formats 0\_1/0\_2) is associated with one “*closedLoopIndex*” value for single TRP transmission,  ~~the other~~ both TPC fields are used ~~associated with the other “~~*~~closedLoopIndex~~*~~” value is unused~~.
* Note: Each TPC field is for each closed-loop index value respectively (i.e., 1st /2nd TPC fields correspond to “*closedLoopIndex*” value = 0 and 1, respectively).

In **Fl Update #3**, FL thought removing the first bullet will not result vivo’s interpretation when there are two TPC fields, which is different from Apple’s interpretation on that. However, our reading on Apple’s point is same as ours.So we’d like ask for the companies’ interpretations and proofs on closed-loop power control when no spec change is adopted. If companies still have the same interpretation as the proposed conclusion given by FL, we think the Proposed conclusion 2.1-1 should be an agreement. |
| **Apple** | **If this is still controversial, we are ok not to agree anyting, since the agreement in last meeting is already completed as follows.****Agreement*** To support per TRP closed-loop power control for PUCCH with DCI formats 1\_1 / 1\_2, a second TPC field can be configured via RRC.
* When the second field is configured by RRC, a second TPC field (similar to the existing TPC field) is added in DCI formats 1\_1 / 1\_2 (option 3).
	+ Each TPC field is for each closed-loop index value respectively
		- FFS: Whether or not the mapping between the TPC field and the PUCCH transmissions is needed
* When the second field is not configured by RRC, a single TPC field (the existing TPC field) is used in DCI formats 1\_1 / 1\_2, and the TPC value applied for the closed loop index(es) for the scheduled PUCCH
* To support per TRP closed-loop power control for PUSCH with DCI formats 0\_1 / 0\_2, adopt the same solution as with M-TRP PUCCH schemes.
	+ FFS: any additional considerations
* Support UE to report the capability on whether it supports the second TPC field
* Note1: Per TRP closed-loop power control is only applicable when the “closedLoopIndex” values are not the same for TRPs.
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| **Lenovo/MotM** | **Thanks for the good discussion. I think the key point is whether the note in proposed conclusion 2.1-1, “**1st /2nd TPC fields correspond to “*closedLoopIndex*” value = 0 and 1, respectively**”, is a common understanding. We prefer to take it as an agreement.** **Based on this common understanding, a single TPC command indicated by the corresponding TPC field shall be applied to PUCCH/PUSCH transmitted to different TRPs regarding ZTE’s scenario, i.e.,** *a same closedLoopIndex*” values for multi-TRP repetitions**.****Regarding issue#2, we share the same view with vivo that if one of the TPC field is unused, it should has spec impact as vivo highlighted, otherwise, the other “unused” TPC field should be included in the** **.****How about the following update on conclusion:** **Proposed conclusion 2.1-1:** For per-TRP closed-loop power control, * When the second TPC field is configured and the indicated PUCCH transmission in DCI formats 1\_1/1\_2 (or PUSCH transmission in DCI formats 0\_1/0\_2) is associated with one “*closedLoopIndex*” value for single TRP transmission, only one TPC command carried by the corresponding TPC filed is applied to the PUCCH transmission ~~the other TPC field associated with the other “closedLoopIndex” value is unused~~.
* Note: Each TPC field is for each closed-loop index value respectively (i.e., 1st /2nd TPC fields correspond to “*closedLoopIndex*” value = 0 and 1, respectively).
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| **ZTE** | **On issue #1:**Regarding the scenario “two same “*closedLoopIndex*” values for multi-TRP repetitions”, as we mentioned many times, we think this case can be possible at least for gNB scheduling flexibility, and its indication is the same as the scenario “one single “*closedLoopIndex*” value for single TRP transmission”.Basically, we respect the previous agreement specifies that “To support per TRP closed-loop power control... second TPC field can be configured via RRC... Note 1: Per TRP closed-loop power control is only applicable when the “*closedLoopIndex*” values are not the same for TRPs.”. However, it should be noted that the above two cases (highlighted as this) can be true and the corresponding indication rules should be clarified.In order to avoid any confusion and to make progress, we suggest using the following revision to try to reach a consensus here:**Proposed conclusion 2.1-1:** For closed-loop power control in Rel-17 MTRP PUCCH repetitions scheme, * When the second TPC field is configured and the indicated PUCCH transmission in DCI formats 1\_1/1\_2 (or PUSCH transmission in DCI formats 0\_1/0\_2) is associated with one “*closedLoopIndex*” value for single TRP transmission or with two same “closedLoopIndex” values for multi-TRP repetitions, the other TPC field associated with the other “*closedLoopIndex*” value is unused.
* Note: Each TPC field is for each closed-loop index value respectively (i.e., 1st /2nd TPC fields correspond to “*closedLoopIndex*” value = 0 and 1, respectively).

@Apple: the part you highlighted in the previous agreement is only valid when two CLI are different, please pay attention to the Note 1 below. Hope that clarifies.@Lenovo: thanks for sharing your view technically, I appreciate we are on the same page now.**On issue #2:**In general, if following the current specification shown by vivo, it can be a valid way to jointly use two TPC fields to indicate one TPC value for a single CLI or two same CLIs, we have also proposed and supported this way before. However, we can compromise to another way ,as FL explained above, to restrict the use of the second TPC field, which at least can ensure that the indications of the above two cases to be clear. |
| **MediaTek** | Our preference is that the other TPC field associated with the other “*closedLoopIndex*” value is unused.We can be fine with ZTE’s update as we fail to find agreements strongly suggesting per-TRP power control is mandatory for M-TRP PUCCH/PUSCH repetition schemes. However, if it is common understanding among companies, then an explicit agreement may be good.On the other hand, if making the proposed conclusion 2.1-1 as agreement can resolve vivo’s concern, we are fine with making it an agreement. |
| **Samsung** | For issue 1, if gNB configures the same closed loop index for both TRPs, gNB doesn’t need to configure ‘twoPUCCH-PC-AdjustmentStates’ for mTRP PUCCH repetition and RRC parameter for two TPC command field in DCI. For issue 2, we cannot see the strong reason why TPC field for the other TRS should be used. This is Rel-17 mTRP enhancement and we are making specification to support mTRP PUCCH repetition. So, FL’s proposed conclusion doesn’t make any problem because the operation is clear. And if gNB wants to update value of closed loop index for the other TRP, gNB can transmit other DCI (e.g. DCI format 2\_2) to update that value.  |

## 2.2 Default beam for PUSCH

LG and intel concerns are not fully technical according to the FL reading. Mainly suggesting that this is not an important issue.

**Proposal 2.2:** If the PUCCH resource with the lowest ID is activated with two spatial relation info, the spatial relation info with lower ID, is used as the default beam for PUSCH scheduled by DCI format 0\_0.

Concerns: LG and Intel

@Intel, LG >> please reconsider your opinion.

@Others >> please provide further justifications than just indicating “support”.

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| **Company** | **Comments** |
| LG | We don’t support. It can be addressed by scheduling restriction without additional issue. The following is our proposal:UE does not expect the PUCCH resource with the lowest ID is activated with two spatial relation info if PUSCH is scheduled by DCI format 0\_0. |
| **Apple** | **OK with either proposal 2.2 or LG’s proposal** |
| **QC** | **We also prefer to close this issue and have a clear behavior or restriction. We are Ok with LG’s Proposal.** |
| **ZTE** | Support proposal 2.2, which can ensure the flexibility on PUCCH resource configuration especially when considering STRP/MTRP dynamic switching. It is unreasonable to restrict the above flexibility from the side of gNB scheduling. |
| **MediaTek** | Same view as Apple. |
| **Samsung** | Support Proposal 2.2. If the clear specification is not defined, other parts of specification for activating spatial relation info. (Single MAC CE based activation, PUCCH resource group activation etc.) can be ambiguous. On the other hand, if the restriction is introduced, we should make some spec impacts according to the restriction (e.g. restriction for PUCCH resource group activation). So, if we make Proposal 2.2 as agreement, we don’t need to make additional spec change except this and make the spec clear and no need to do more discussion for this issue.  |

## 2.3 Frequency hopping

This discussion is extending also without any convergence. Some companies suggest more results to justify the case. FL view is that it is bit late for simulating these further, but there are certain benefits that proponents justified multiple time.

**Proposal 2.3:** When inter-slot frequency hopping is configured with Scheme 1, support the following,

* If sequential mapping pattern is configured, frequency hopping is performed on slot level (as in Rel-15).
* If cyclical mapping pattern is configured, frequency hopping is performed among the repetitions with the same beam.

Concerns: ZTE, vivo, OPPO, HW

@ZTE, vivo, Oppo, HW >> as there is good support on this. RAN1 can support it. Suggest you to reconsider.

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| **Company** | **Comments** |
| **ZTE** | If all other companies can live with proposal 2.3, we can compromise it for progress. |
| **MediaTek** | We do not support Proposal 2.3. The mentioned benefits by proponents are not convincing.To have frequency diversity and spatial diversity, sequential mapping with FH can achieve the same full diversity without additional specification impact.  |

## 2.4 PUCCH grouping

ZTE seems to be the only company with concerns. At least their concern is not clear to the FL.

**Possible Agreement (for comeback)**

For the grouping of PUCCH resources in Rel-17 multi-TRP PUCCH repetition schemes,

* Support MAC-CE activating two spatial relation info’s (for FR2) for a group of PUCCH resources in a CC.
* Support MAC-CE activating two sets of power control parameters (for FR1) for a group of PUCCH resources in a CC.
* When the PUCCH resource is indicated with two spatial relation info’s or two sets of power control parameters, the other PUCCH resources in the group also get updated to have the same two spatial relation info’s or two sets of power control parameters.
* When the PUCCH resource is indicated with one spatial relation info or one set of power control parameters, then the other PUCCH resources in the group also get updated to have the same spatial relation info or the same set of power control parameters.
* The signalling details are up to RAN2 to decide.
* Note: Impacts coming from coverage enhancement work item on associating PUCCH resource with repetition factor can be discussed separately

Concerns: ZTE (support option 3).

@ZTE >> indicate your views such that we can try to resolve them.

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| **Company** | **Comments** |
| **ZTE** | Generally speaking, we understand that the remaining budget in Rel-17 is running out. To make progress, we can compromise option 1.Technically though, our concern of option 1 is actually about the third and fourth bullets, and we have same question as LG ventilated in GTW that it is possible to mix PUCCH resources with one or two spatial relations in one PUCCH group according to option 1. As shown in the following figure, due to the third bullet only indicates the PUCCH resources with two spatial relations in one group can be updated simultaneously, but which of beam#2 and beam#3 can be referred by beam#1 to update? Likewise, the fourth bullet only indicates the PUCCH resources with one spatial relation in one group can be updated simultaneously, but which of beam#2 and beam#3 should be updated with beam#1?To address the above issue, as we discussed in GTW session, the situation of mixing PUCCH resources with one or two spatial relations in one PUCCH group should be avoided. In other words, a PUCCH group for Rel-17 MTRP PUCCH should only includes one type of PUCCH resource (activating with one or two spatial relations). Accordingly, the total number of PUCCH groups of Rel-17 MTRP PUCCH and the respective number of PUCCH groups with PUCCH resources activated with one or two spatial relations only should be discuss additionally. All in all, we suggest:**Possible Agreement (for comeback)**For the grouping of PUCCH resources in Rel-17 multi-TRP PUCCH repetition schemes,* Support MAC-CE activating two spatial relation info’s (for FR2) for a group of PUCCH resources in a CC.
* Support MAC-CE activating two sets of power control parameters (for FR1) for a group of PUCCH resources in a CC.
* When the PUCCH resource is indicated with two spatial relation info’s or two sets of power control parameters, the other PUCCH resources in the group also get updated to have the same two spatial relation info’s or two sets of power control parameters.
* When the PUCCH resource is indicated with one spatial relation info or one set of power control parameters, then the other PUCCH resources in the group also get updated to have the same spatial relation info or the same set of power control parameters.
* The signalling details are up to RAN2 to decide.
* Note: Impacts coming from coverage enhancement work item on associating PUCCH resource with repetition factor can be discussed separately
* Note: PUCCH resources in one PUCCH group should be activated with the same number of spatial relation info’s (for FR2) or sets of power control parameters (for FR1).
* Note: The total number of PUCCH groups can be discussed separately.
	+ FFS: the method on determining the respective number of PUCCH groups with PUCCH resources activated with one or two spatial relations (for FR2)/ sets of power control paramters (for FR1).
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| **MediaTek** | Fine with the possible agreement. |

## 2.5 Scheme 2

FL views that Scheme 2 can be supported as there is not much impact on that for other work. But there are several companies who still not willing to support this. Some companies have valid reasons, but most others have not provided technical views on ‘not supporting’.

**Proposal 2.5:** Support intra-PUCCH resource beam-hopping (Scheme 2):

* Reuse frequency hopping mechanisms for number of symbols in the first / second beam-hops, and number of DMRS symbols and locations.
* The configured value of *secondHopPRB* can be the same as or different than *startingPRB*.

@All >> I copied the older replies (that has some points for discussing). Please do not reply that we can not accept (indicate your technical/procedural comments to justify it).

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| Company | Comments |
| QC | Support the proposal.In the previous meeting, some companies asked for evaluation results and comparing Scheme 2 versus Scheme 3. We have provided detailed evaluations illustrating that PUCCH schemes 2 and 3 have the same performance under both cases of with or without blockage for both RM and polar codes. Only when the UCI payload size becomes large (code rate becomes large) with Polar code and with blockage, PUCCH Scheme 3 is slightly better (1dB) than PUCCH Scheme 2. Critical UCIs (HARQ-Ack) do not have very large payload size.Also, Scheme 2 has multiple important advantages over scheme 3:* With PUCCH repetition (Scheme 1 or 3), UCI multiplexing is not possible, which includes the case of multiplexing different UCIs or multiplexing UCI with PUSCH. However, UCI multiplexing rules for Scheme 2 are much more flexible and those restrictive dropping rules are not needed (similar to existing PUCCH frequency hopping).
* PUCCH scheme 2 has lower latency as the beam hopping is performed within a given PUCCH resource without the need to conform to sub-slot configurations while in PUCCH scheme 3, different repetitions should be in different sub-slots.
* With scheme 2, other PUCCH resources (that do not need mTRP or sub-slot based transmission) can be configured flexibly. With Scheme 3, they have to remain within the sub-slot boundary as in Rel. 16.

The specification impact of Scheme 2 is very small. In our understanding, the proposal above would be enough for the functionality of Scheme 2. |
| Apple | Do not support the proposal. It seems to be redundant since we have agreed intra-slot repetition, and there is not enough time for us to consider a new transmission scheme. |
| QC | Is scheme 2 redundant? No. We explained the benefits of Scheme 2 above. Maybe companies need to explain why they think it is a redundant scheme. I did not see any company questioning the benefits mentioned above.Is there enough time to consider Scheme 2? Yes. The proposal above takes care of the main functionality of Scheme 2. Maybe companies need to explain why there is not enough time.  |
| Ericsson | One challenge on the TRP side with scheme 2 is that the two TRPs have to coordinate within a slot (as PUCCH symbols corresponding to a single PUCCH is split across the two TRPs. This type of coordination is very challenging and hence, we think Scheme 2 can be deprioritized in this release. |
| vivo | Support Scheme 2. The gain is obvious when the PUCCH is transmitted only once which has less resource requirement. Regarding the requirement on TRP coordination, it is up to the network capability to configure Scheme 2 or not. |
| QC | @ Ericsson: In Rel. 16, for PDSCH, we have SDM and FDMSchemeA which are joint encoding / rate matching. Scheme 2 for PUCCH is similar. In fact, this is another reason to have scheme 2 to allow for multiple levels of TRP coordination. The feature can be enabled/disabled depending on the TRP coordination and use case (similar to Rel. 16 MTP discussions). |
| Lenovo/MotM | Do not support. The total UCI can be received when two hops successfully are received since the UCIs are divided into two parts and there are transmitted to different TRPs. If one hop is lost due to the blockage between the UE and one TRP of TRPs, the whole UCI can’t be received. Besides, the multiplexing of PUCCH may be complicated if PUCCH Scheme 2 is supported. |
| vivo | @Lenovo: the decoding can be successful if the code rate is low enough even one hop is completely lost. Besides, Scheme 2 also provide spatial diversity gain. Both QC and us provides the gain of Scheme 2. |
| Xiaomi | We support scheme2. Besides the reasons mentioned by QC and vivo, it’s that scheme 2 can be specified for UEs not implementing sub-slot operations, since Scheme 3 support only sub-slot PUCCH. |
| Ericsson | @Qualcomm: Note that implementation complexities of Rel-16 SDM/FDMSchemeA and MTRP PUCCH scheme 2 are very different things. In the uplink case, it is more challenging because MTRP PUCCH Scheme 2 requires symbol level coordination between TRPs which is very challenging. Such symbol level coordination becomes even more challenging with higher numerologies. Note that we don’t have joint encoding/rate matching support for MTRP PUSCH in Rel-17 because of similar issues. So, we are skeptical whether this scheme is practically deployable from network implementation point of view.Also, given the already high workload in Rel-17, we have concern with adding yet another scheme/option in Rel-17. Note that we should prioritize finalizing the details of the already agreed schemes/options which is much higher priority at this time. So, we do not support Scheme 2.  |
| QC | @ Ericsson: Can you please explain how Rel. 16 SDM/FDMSchemeA does not require symbol-level coordination but PUCCH Scheme 2 does? I do not follow this part. One is about encoding, and the other is about decoding. In both cases in the absence of this coordination, latency will occur: For DL, latency is a result of having to make scheduling decision earlier. For UL, latency is a result of decoding later. In both cases, with backhaul close to ideal (Rel. 16 assumption), there is no additional latency. In addition, mTRP PUCCH in Rel. 17 is not only about non co-located TRPs, it equally applies to multiple panels at the receiver side.As mentioned, Scheme 2 does not have many specification impacts. It is much simpler than Scheme 3 with more benefits. Please also see the FL’s comment above wrt remaining time. We see that most of the issues are already decided and close to be complete. What is more important in our view is the technical benefits of Scheme 2 we mentioned above.  |
| **Ericsson** | @Qualcomm. I think you misunderstood my comment. What I mentioned is that for multi-TRP PUCCH scheme 2, the symbol level coordination between TRPs (over the backhaul) is very challenging. With multi-TRP PUCCH scheme 2, half the symbols of one PUCCH are targeted to TRP1 and the other half the symbols of the PUCCH are targeted to TRP2. In order for the network to perform decoding, one of the TRPs will have to send the baseband data over the backhaul to the other TRP. This will increase the requirement on the backhaul capacity. This is a very challenging network implementation issue which is why we have concerns over Scheme 2.  |
| **QC** | @ Ericsson: I do not follow your comment. “one of the TRPs will have to send the baseband data over the backhaul” is the case also for PUCCH Scheme 3. Do you not count LLRs as “baseband data”?Also, we would like to understand what is more challenging compared to DL Schemes SDM and FDMSchemeA. How joint encoding and rate matching across two TRPs is less channeling than joint decoding and de-rate matching? Furthermore, we would like to understand why the case of co-located panels / TRPs and/or split options 7-8 (lower layer split options) should be excluded from Ericsson’s point of view? If backhaul in a particular deployment is not good enough for PUCCH Scheme 2 or PUCCH scheme 3 or DL SDM scheme/FDMSchemeA (or any other single-DCI based scheme), the feature is not configured. In some other deployments, theses features can be configured. That has been the Rel. 16 principle for supporting both single-DCI and multi-DCI based mTRP models. We miss the point about the real concern here. |
| **Ericsson** | @Qualcomm: Regarding your first question, for MTRP PUCCH Scheme 3, the network implementation can choose to do separate decoding of the repetitions in each TRP. So, there is no need to exchange LLRs over the backhaul between the two TRPs for Scheme 3. But this is not the case with MTRP Scheme 2.Regarding your second question, I am not sure what you are trying to achieve by discussing DL Schemes SDM and FDMSchemeA. Let’s focus the discussion on MTRP PUCCH, and the need to support a third multi-TRP PUCCH scheme in Rel-17 instead.For the third paragraph, whether we should introduce MTRP PUCCH scheme 2 for use cases such as single-TRP with multiple panels, co-located TRPs, etc. I’d like to hear more views from other concerned companies. |
| **Apple** | We still have concern for this proposal. We doubt the feasibility for this issue if there is no gap between two beams. Based on RAN4’s LS, some guard period should be needed. |
| **QC** | @ Ericsson: For the first point: Just to clarify, for PUCCH Scheme 3 with soft combining at the network side, you are also skeptical whether it can be done practically. Is that the right understanding? The reason that I am asking is that it has been the assumption in both design and in most evaluations in this AI (e.g. that was the reason that we did not select different PUCCH resources. Otherwise, it would have been more flexible and still ok with individual decoding).For the second point: I am just trying to understand if Rel. 16 design had the same issue or not in your view.For the third point: In addition to the use cases you mentioned, this would be also applicable to non co-located TRPs with good backhaul (just like single-DCI based mTRP in Rel. 16)@Apple: Isn’t it same as PUSCH Repetition Type B when different beams are back-to-back? Also, with regard to RAN4 LS, please see the answer to Q4:Also, for refence, the RAN4 requirement for freq. hopping is copied below [38.101]:**Question 4**: In particular to multi-TRP intra-slot beam hopping (Scheme 2), can RAN1 assume the same requirement as RB hopping with respect to transient period in current RAN4 requirements, if the two hops have different UL beams in addition to different RBs? **Answer 4**: The current RAN4 requirements for transient period are applicable when RB hopping, or power change is applied. For RB hopping, transient period is defined as 5us for FR2 UE. In case of RB hopping with different UL beams, the transient period depends on different scenarios and it is the same as the answer to Question 1 for FR2 UE.The transmit ON/OFF time mask defines the transient period(s) allowed - between transmit OFF power and transmit ON power symbols (transmit ON/OFF) - between continuous ON-power transmissions when power change or RB hopping is applied. In case of RB hopping, transition period is shared symmetrically. |
| **Samsung** | We can share the same view with Ericsson. For the scheme 3, each repetition can be self-decodable and both TRPs share the result of LLR calculation for combining or just share the CRC result for each repetition when separate decoding is supported. On the other hand, for the scheme 2, each hop is transmitted towards each TRP unlike FDM scheme 2a for PDSCH repetition. One TB is split and both TRPs should exchange the symbol level received signal to calculate LLR. Therefore backhaul capacity can be burdened and more latency to exchange information between two TRPs can be required for non-ideal backhaul. So for this reasons, we think the scheme 3 is enough because we already introduced the scheme 3 that can support both ideal and non-ideal backhaul cases and has similar or (1dB) better performance for all code rate regions and can be self-decodable. |

#  Multi-TRP PUSCH transmission

## Default power control

**For comeback in Week2**

**Alt.1 – QC, MTek, E///, HW, OPPO, Xiaomi, FW**

**Alt.2 – Apple, Intel**

**Alt.3 – LG, Lenovo, DCM, Fujitsu, SS, vivo, CMCC, Nokia, CATT, ZTE, Fraunhofer, Apple (can accept)**

The situation is clear on majority support, we need to pick a solution. Let’s go with majority view.

**Proposal 3.2:** For single-DCI based M-TRP PUSCH repetition schemes, when one SRS resource per SRS resource set is configured (i.e., when two SRI fields are absent in DCI formats 0\_1 / 0\_2), per TRP default P0, alpha, PL-RS, and closed loop index is defined by,

* + If the UE is provided*enablePL-RS-UpdateForPUSCH-SRS*, the first set of values {the first value in *P0-AlphaSet*, the PL-RS corresponding to the first *sri-PUSCH-PowerControl* associated with the first SRS resource set and closed-loop index *l* = 0} is used for TRP1, and the second set of values {the second value in *P0-AlphaSet*, the PL-RS corresponding to the first *sri-PUSCH-PowerControl* associated with the second SRS resource set and closed-loop index *l* = 1 if  *twoPUSCH-PC-AdjustmentStates* is configured, *l*=0 otherwise} is used for TRP2.
	+ Otherwise, the first set of values {the first value in *P0-AlphaSet*, the PL-RS with *PUSCH-PathlossReferenceRS-Id=0* and closed-loop index *l* = 0} can be used for TRP1, and the second set of values {the second value in P0-AlphaSet, the PL-RS with *PUSCH-PathlossReferenceRS-Id*= 1 and closed-loop index *l* = 1 if *twoPUSCH-PC-AdjustmentStates* is configured, *l*=0 otherwise } can be used for TRP2.
	+ Note: How to design the signaling link sri-PUSCH-PowerControl with two SRS resource sets is up to RAN2.

@ **QC, MTek, E///, HW, OPPO, Xiaomi, FW, Intel** >> The situation should be clearer that we shall pick the majority view. Please list objections only if you cannot live with the above. Also, indicate the reasons such that others can help on convincing you.

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| **Company** | **Comments** |
| **QC** | We prefer some GTW discussions on this if possible. We asked the question that what is the true benefit of Alt3 over Alt1 other than RRC overhead optimization, but we did not hear convincing answers. The benefits of Alt1 over Alt3, as explained before, are more flexibility and simplicity.  |
| **LG** | We don’t think Alt 1 is simple because even if Alt 1 is agreed, Alt 3 except for 2nd TRP part should be also implemented for legacy behavior. |
| **Lenovo/MotM** | Support the proposal which is Alt 3 since it’s a straight extensional way of the legacy way to determine power control parameter set if SRI is not present. While Alt 1 does not consider the case when the UE is provided*enablePL-RS-UpdateForPUSCH-SRS*. |
| **ZTE** | Support Alt. 3.@QC, as companies and us elaborated many times, in fact, Alt 3 is the most direct extension of the legacy approach to determine the default power control parameter sets when SRI is not present, which will minimize the spec change/effort. By Alt. 1 or Alt. 2, we fail to see the logical to adopt two different mechanisms among Rel-15/16 and Rel-17. |
| **MediaTek** | We can live with Proposal 3.2. |

## PHR reporting

**Agreement**

For option 4, support the following:

When PHR MAC-CE is reported in slot n, for a CC that is configured with mTRP PUSCH repetition, PHR value(s) are determined as,

* The first PHR value is reported same as Rel. 15/16.
* If the first PHR value is actual PHR (based on Rel. 15/16) corresponding to a repetition among mTRP PUSCH repetitions associated with a given TRP, the second PHR value, select Alt. 1A or Alt. 2A
	+ Alt.1A: Is always actual. When there are more than one repetitions associated with the other TRP, the second PHR is calculated considering on the following repetition,
		- If there are repetition(s) towards the other TRP which transmit after the repetition used to calculate first PHR, the UE select the earliest repetition among them.
		- Otherwise, the UE select the latest repetition which transmitted before the repetition used to calculate first PHR.
	+ Alt.2A: Is actual only when a repetition associated with the other TRP is transmitted in slot n. Otherwise, it is virtual.
		- If there are multiple repetitions associated with the other TRP in slot n, the earliest one in slot n is selected.
* If the first PHR value is actual PHR (based on Rel. 15/16) but not corresponding to a repetition among mTRP PUSCH repetitions (corresponds to sTRP PUSCH), select Alt. 1B or Alt. 2B
	+ Alt1B: a second PHR value is reported as virtual PHR.
	+ Alt2B: a second PHR is not reported
* If the first PHR value is virtual, select Alt. 1C or Alt. 2C
	+ Alt1C: a second PHR value is reported as virtual PHR.
	+ Alt2C: a second PHR is not reported
* When second PHR is virtual, it is calculated based on a set of default power control parameters defined for the other TRP (that is not associated with the first PHR)
* Note: the above is applicable to both single entry and multi-entry PHR reports

RAN1 needs to further agree on exact solution, and the FL suggestions are as below.

**Proposal 3.2-3**

For option 4, support the following:

When PHR MAC-CE is reported in slot n, for a CC that is configured with mTRP PUSCH repetition, second PHR value is determined as,

* If the first PHR value is actual PHR (based on Rel. 15/16) corresponding to a repetition among mTRP PUSCH repetitions associated with a given TRP, the second PHR value, select Alt. 1A or Alt. 2A
	+ Alt.1A: Is always actual. When there are more than one repetitions associated with the other TRP, the second PHR is calculated considering on the following repetition,
		- If there are repetition(s) towards the other TRP which transmit after the repetition used to calculate first PHR, the UE select the earliest repetition among them.
		- Otherwise, the UE select the latest repetition which transmitted before the repetition used to calculate first PHR.
* If the first PHR value is actual PHR (based on Rel. 15/16) but not corresponding to a repetition among mTRP PUSCH repetitions (corresponds to sTRP PUSCH), select Alt. 1B or Alt. 2B
	+ Alt1B: a second PHR value is reported as virtual PHR.
* If the first PHR value is virtual, select Alt. 1C or Alt. 2C
	+ Alt2C: a second PHR is not reported

@All >> Please indicate if you have a big concern on supporting the above alternatives (Alt.1A, Alt. 1B, Alt. 2C). Any small optimizations like Alt. 1C (reporting always two PHRs) should not be a main motivation for objecting the proposal.

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| **Company** | **Comments** |
| **QC** | We do not agree with Alt1A. It results in additional UE complexity for having to calculate power for future slots (computation concern) or for previous slots (memory concerns). We think Alt1B is more aligned with Rel.15/16 principle, and also addresses the mTRP use case as virtual PHR can still be reported. The benefit of actual PHR is all the additional MPR info that gNB gets, but with Alt1A and when PHR is for future, what will actually happen will be different than the reported value as explained before. Then, the benefit of actual PHR is questionable. For the second part (Alt1B versus Alt2B), what is the motivation to change the sTRP behavior? We prefer Alt2B for this part.We are ok with Alt2C. |
| **LG** | On the first bullet: we support Alt2A, which is simple and aligned with legacy principle.On the second bullet: why do we need to consider STRP repetition case? Is there any issue with legacy behavior? From my understanding first and second PHR is related to MTRP operation. On the third bullet: we support Alt1C. it is up to gNB whether/how to use it. |
| **InterDigital** | Support FL proposal (that is based on Alt1A, Alt1B and Alt2C)For Alt.1A, there is no issue for computing the actual PHR values, as the UE already has the grant information (resource and power control parameters) for both TRPs, and hence it can calculate and report both actual PHRs. The incurred complexity is very insignificant.For the second part of the proposal, if the grant is for sTRP, then the grant information does not have any relevance to the second TRP, then UE can report a virtual PHR for the second TRP. Therefore, Alt1B is preferred. |
| **Apple** | Support Alt 2A, 1B and 1C.We have concern for Alt1A. for the “otherwise” part, there may be no signals toward the other TRP before the repetition used to calculate the first PHR.It looks Alt 2B are 2C are not aligned with previous agreement where “2 PHR” are reported. |
| **MediaTek** | Support FL’s proposal 3.2-3. We share the same understanding as InterDigital on Alt. 1A. For Alt.xB and Alt. xC, we can be flexible. |
| **Samsung** | For Alt 2A, the probability to report both PHRs as actual PHR is lower than Alt 1A. We don’t see big problem for computation and memory because PHR calculation is similar to calculation of transmission power and one calculated transmitted power value (with an indicator for MPR) is stored. So, we support Alt 1A.The basic rule of multi-cell PHR is reporting all activated serving cells if PHR is triggered. Even though PUSCH transmission is not scheduled on the certain CC, UE can calculate virtual PHR for the activated serving cell and report it in Rel. 15/16. With similar approach, PHR(s) for TRP that is not scheduled with PUSCH transmission can be reported. Therefore, we support Alt1B and Alt1C to report the current PHR to gNB.  |

## PTRS-DMRS association

**Proposal 3.4:** For single DCI based M-TRP PUSCH Type B repetition, the indication of PTRS-DMRS association for maxRank > 2 is not enhanced (legacy framework, i.e., the same PTRS-DMRS association field is applied to both TRPs (to both sets of repetitions)).

@ ZTE, Apple, E///, LG, vivo, Intel >> Let’s conclude this formally. Not agreeing means also the legacy framework.

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| **Company** | **Comments** |
| **Ericsson** | Our preference is Alt2 in the previous proposal.But if this is the approach everyone wants to take, we can give it a try as long as our following comments are addressed.The first sentence of the proposal says ‘the indication of PTRS-DMRS association for maxRank > 2 is **not enhanced**’. Not enhanced essentially means no spec change. But the part inside the brackets will need specification enhancements. For instance, we’ll have to capture in the spec that the same PTRS-DMRS association field is applied to both TRPs. So, the first sentence of the current proposal contradicts the part inside the brackets.In legacy framework, there is only one TRP, and the PTRS-DMRS association field is applied to the one TRP. To make the proposal more closer to the legacy framework, we suggest to apply the indicated PTRS-DMRS association field to the first TRP. As to what to do with the 2nd TRP, may be a simple solution is to specify a fixed PTRS-DMRS mapping in the spec for the 2nd TRP.Could the following be an acceptable compromise?**Revised Proposal 3.4:** For single DCI based M-TRP PUSCH Type B repetition, the indicated PTRS-DMRS association field is applied to the first TRP (i.e., the first set of repetitions) when maxRank>2. The PTRS-DMRS association for the 2nd TRP is fixed in specifications.~~the indication of PTRS-DMRS association for maxRank > 2 is not enhanced (legacy framework, i.e., the same PTRS-DMRS association field is applied to both TRPs (to both sets of repetitions)).~~  |
| **Apple** | This proposal seems to be the worst solution compared with all the 3 options we have agreed for further down-selection. It seems what we can do is as follows, if we cannot down-select one option among the 3 agreed options.**UE shall not expect to be scheduled M-TRP PUSCH with Rank>2 when PT-RS is transmitted** |
| **ZTE** | As we elaborated in previous rounds, if no agreement here or using the legacy framework, it means the case of rank > 2 is not enhanced. Note that there is no agreement/conclusion saying the number of rank should be limited, it makes no sense to preclude the case of rank > 2. We can compromise and live with Alt. 2 to complete this enhancement.**Alt.2:** For single DCI based M-TRP PUSCH Type B repetition, the indication of PTRS-DMRS association for maxRank > 2, 1-bit MSB is used to indicate PTRS-DMRS association for the first TRP, and 1 bit LSB is used to indicate PTRS-DMRS association for the second TRP* + if *maxNrofPorts* = 1, the 1 bit indicates one of the first two DMRS ports.
	+ if *maxNrofPorts* = 2, the 1 bit indicates one of two DMRS ports sharing the same PTRS port.
 |

## Number of SRS resources

**Proposal 3.6-2:** On the number of SRS resource configured in the two SRS resource sets, select one of the following alternatives,

* Alt.1: Support the same number of SRS resources for both CB and NCB based m-TRP PUSCH repetition.
* Alt.2: Support different number of SRS resources for both CB and NCB based m-TRP PUSCH repetition. The first SRS resource set always have the same or larger number of SRS resources than the second SRS resources set.
	+ The bit width of the 1st SRI field is determined based on maximum number of SRS resources among two resource sets
	+ FFS: How to interpret “SRI field is present or not present”
* Alt.3: Support different number of SRS resources for both CB and NCB based m-TRP PUSCH repetition. The first SRS resource set always have the smaller, same or larger number of SRS resources than the second SRS resources set.
	+ The bit width of the 1st SRI field is determined based on maximum number of SRS resources among two resource sets
	+ FFS: How to interpret “SRI field is present or not present”

**Alt.1** – TCL, ZTE, LG, Xiaomi, E///, OPPO

**Alt.2** – CATT, NEC, Mtek, vivo, SS, HW (?), CMCC

**Alt.3** – Lenovo, Fujitsu, DCM, HW (?)

No discussion needed – Apple

Ok with majority – QC, Nokia

@ All>> Need to conclude this as not agreeing does not mean Alt.3 is supported. If option 3 supported, there are still some work to be finalized. Given that, my suggestion is to take Alt.1.

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| **Company** | **Comments** |
| **Apple** | Open to Alt2 or Alt3 |
| **Lenovo/MotM** | Support Alt.3 since it has no limitation of the number of SRS resources of different SRS resource sets which gives a most flexible solution compared with Alt 1 and Alt 2. |
| **ZTE** | We have discussed this issue through two meetings, it is unnecessary to waste more budget to finish the derivative works of Alt.2 and Alt. 3. We support to take Alt. 1 as way forward. |
| **MediaTek** | We are fine with FL’s suggestion, i.e., Alt. 1. |
| **Samsung** | We can think Alt. 2 is more flexible than Alt.1 and doesn’t require additional spec impact for the definition of two SRI fields (Alt.2 can work with agreed table for dynamic switching). For alt3, total bit width of two SRI fields can be increased because the 1st SRI field is determined based on maximum number of SRS resources among two resource sets (for Alt2, always first SRS resource set has more or same number of SRS resources so there is no issue). |

# Agreements from Phase 0

**Agreement**

When DCI schedules a retransmission of CG-PUSCH for type 1 CG or type 2 CG (DCI with CRC scrambled with CS-RNTI and NDI=1) while the CG configuration is RRC-configured with two fields of power control parameters, apply the same procedure as DCI activation for CG type 2 agreed before, i.e.,

* The first (legacy) RRC-configured fields ‘*p0-PUSCH-Alpha*’ and ‘*powerControlLoopToUse*’ are associated with the first SRS resource set.
* The second (new) RRC-configured fields ‘*p0-PUSCH-Alpha*’ and ‘*powerControlLoopToUse*’ are associated with the second SRS resource set.
* Applying the first, second, or both first and second RRC-configured fields ‘*p0-PUSCH-Alpha*’ and ‘*powerControlLoopToUse*’ is determined from the new DCI field (for dynamic switching) of the activating DCI similar to the case of DG-PUSCH.

**Agreement**

When fallback DCI (DCI format 0\_0) activates a type 2 CG or schedules a retransmission of a type 1 or type 2 CG, and the CG configuration is RRC-configured with 2 sets of power control parameters (two ‘*p0-PUSCH-Alpha*’ and ‘*powerControlLoopToUse*’):

* The UE uses the first set of values for power control (first RRC-configured ‘*p0-PUSCH-Alpha*’ and ‘*powerControlLoopToUse*’).

**Agreement**

When a DCI that includes the new 2-bits DCI field for dynamic switching activates a type 2 CG or schedules a retransmission of a type 1 or type 2 CG, and the CG configuration is RRC-configured with only one set of power control parameters (one ‘*p0-PUSCH-Alpha*’ and ‘*powerControlLoopToUse*’):

* The UE expects the new DCI field for dynamic switching is set to “00”, and all PUSCH repetitions are associated with the first SRS resource set.

**Agreement**

For the new field in DCI for dynamic switching,

* For Codepoint “11”, the 1st SRI/TPMI field associate with the 1st SRS resource set while the 2nd SRI/TPMI field associate with the 2nd SRS resource set. i.e.,

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| **Codepoint** | **SRS resource set(s)** | **SRI (for both CB and NCB)/TPMI (CB only) field(s)** |
| 11 | m-TRP mode with (TRP2,TRP1 order)1st SRI/TPMI field: 1st  SRS resource set2nd SRI/TPMI field: 2nd SRS resource set | Both 1st and 2nd SRI/TPMI fields |

* For Codepoint “11”, the first repetition in time is associated with the second SRS resource set, and the remaining repetitions follow the configured mapping pattern (cyclic or sequential).
* For Codepoint “10”, the first repetition in time is associated with the first SRS resource set, and the remaining repetitions follow the configured mapping pattern (cyclic or sequential).

**Agreement**

For PHR reporting related to M-TRP PUSCH repetition, support Option 4 as UE optional capability for a UE that supports mTRP PUSCH,

* Option 4: Calculate two PHRs (at least corresponding to the CC that applies m-TRP PUSCH repetitions), each associated with a first PUSCH occasion to each TRP, and report two PHRs.

**Agreement**

For SP-CSI report on mTRP PUSCH repetition Type A and B activated by a DCI, support the use of a similar mechanism to A-CSI multiplexing on M-TRP PUSCH without a TB, which includes the following,

* When SP-CSI multiplexed on m-TRP PUSCH, SP-CSI multiplexed on the two repetitions associated with the two TRPs, and the number of repetitions is always assumed to be 2, regardless of the value indicated.
* For mTRP PUSCH repetition Type A, or for the first PUSCH after activation for PUSCH repetition Type B**,** reuse similar conditions to support SP-CSI multiplexing on m-TRP PUSCH as defined in A-CSI multiplexing on M-TRP PUSCH, i.e.,
	+ The UE is expected to follow the above operation for transmitting SP-CSI on two PUSCH repetitions only if
		- For the first PUSCH after activation for PUSCH repetition Type B, the first and second nominal repetitions are expected to be the same as the first and second actual repetitions, respectively (no segmentation).
		- For PUSCH repetition Type A and B, UCIs other than the SP-CSI are not multiplexed on any of the two PUSCH repetitions.
	+ When the UE does not follow the above operation, UE transmits SP-CSI only on the first PUSCH repetition similar to Rel. 15/16.
* For subsequent PUSCHs after activation (without corresponding PDCCH) for PUSCH repetition Type B, use the following criteria,
	+ If the first / second nominal repetition is not the same as the first / second actual repetition, the first / second nominal repetition is dropped
		- If one of the first or second nominal repetitions is not dropped, SP-CSI is multiplexed on that repetition
	+ Else (the first and second nominal repetitions are the same as the first and second actual repetitions)
		- If UCIs other than the SP-CSI are not multiplexed on any of the two PUSCH repetitions, SP-CSI is multiplexed on both repetitions.
		- Otherwise, UE transmits SP-CSI only on the first PUSCH repetition similar to Rel. 15/16 (and the second repetition is dropped)

**Agreement**

For indicating per-TRP OLPC set in DCI format 0\_1/0\_2, if no SRI field presents in the DCI,

* Use the existing field (1 or 2 bits) for OLPC set indication and the second p0-PUSCH-SetList-r16.
	+ if value of the field equals to ‘0’ or ‘00’, the UE determine two values of P0 for two TRPs (one P0 value for each TRP) from the first and the second default P0 values.
		- Note: per TRP default P0 values to be decided in separate discussion (alt.1, alt.2, alt.3 in default power control parameter sets).
	+ if value of the field equals to ‘1’ or ‘01’, the UE determine two values of P0 for two TRPs (one P0 value for each TRP) from the **first value** in the first *P0-PUSCH-Set-r16\_list* and the **first value** in the **second** *P0-PUSCH-Set-r16\_list*.
	+ if value of the field equals to ‘10’ or ‘11’, the UE determine two values of P0 for two TRPs (one P0 value for each TRP) from the **second value** in the first *P0-PUSCH-Set-r16\_list* and the **second value** in the **second** *P0-PUSCH-Set-r16\_list.*

**Agreement**

For RV mapping of type 1 or type 2 CG based multi-TRP PUSCH repetition, support,

* the configured RV sequence (via “repK-RV”) is applied separately for PUSCH repetitions corresponding to the first TRP and the second TRP with a an RV offset for the starting RV corresponding to the second TRP (similar to the case of dynamic multi-TRP PUSCH repetition).
* if startingFromRV0 set to ‘on’, support that the initial transmission of a transport block may start at:
	+ the first RV0 transmission occasion of any TRP if the configured RV sequence is {0 2 3 1},
	+ any of the transmission occasions of the K repetitions that are associated with RV = 0 if the configured RV sequence is {0 3 0 3}, (same as Rel-15/16).
	+ any of the transmission occasions of the K repetitions if the configured RV sequence is {0,0,0,0}, except the last transmission occasion when K≥8. (same as Rel-15/16).
* if startingFromRV0 set to ‘off’, the initial transmission of a transport block may only start at the first transmission occasion of the K repetitions (same as Rel-15/16).

**Agreement 2.1-2:**

For per-TRP closed-loop power control, when the indicated PUCCH transmission in DCI format 1\_0 (fallback DCI) is associated with two “*closedLoopIndex*” values for multi-TRP PUCCH transmission schemes, the single TPC field (the existing TPC field) is applied to both closed loop indices for the scheduled PUCCH.

**Working assumption 3.7:**

For non-codebook based multi-TRP PUSCH repetition, select Alt.2.

* Alt. 2: the actual number of PT-RS ports corresponding to the 1st SRS resource set can be different from the actual number of PT-RS ports corresponding to the 2nd SRS resource set.
* FFS: Whether specification change is needed due to this working assumption

**Agreement**

For option 4, support the following:

When PHR MAC-CE is reported in slot n, for a CC that is configured with mTRP PUSCH repetition, PHR value(s) are determined as,

* The first PHR value is reported same as Rel. 15/16.
* If the first PHR value is actual PHR (based on Rel. 15/16) corresponding to a repetition among mTRP PUSCH repetitions associated with a given TRP, the second PHR value, select Alt. 1A or Alt. 2A
	+ Alt.1A: Is always actual. When there are more than one repetitions associated with the other TRP, the second PHR is calculated considering on the following repetition,
		- If there are repetition(s) towards the other TRP which transmit after the repetition used to calculate first PHR, the UE select the earliest repetition among them.
		- Otherwise, the UE select the latest repetition which transmitted before the repetition used to calculate first PHR.
	+ Alt.2A: Is actual only when a repetition associated with the other TRP is transmitted in slot n. Otherwise, it is virtual.
		- If there are multiple repetitions associated with the other TRP in slot n, the earliest one in slot n is selected.
* If the first PHR value is actual PHR (based on Rel. 15/16) but not corresponding to a repetition among mTRP PUSCH repetitions (corresponds to sTRP PUSCH), select Alt. 1B or Alt. 2B
	+ Alt1B: a second PHR value is reported as virtual PHR.
	+ Alt2B: a second PHR is not reported
* If the first PHR value is virtual, select Alt. 1C or Alt. 2C
	+ Alt1C: a second PHR value is reported as virtual PHR.
	+ Alt2C: a second PHR is not reported
* When second PHR is virtual, it is calculated based on a set of default power control parameters defined for the other TRP (that is not associated with the first PHR)
* Note: the above is applicable to both single entry and multi-entry PHR reports

# Reference

|  |  |  |
| --- | --- | --- |
| [R1-2106464](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106464.zip) | Enhancements on multi-TRP for reliability and robustness in Rel-17 | Huawei, HiSilicon |
| [R1-2106542](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106542.zip) | Multi-TRP enhancements for PDCCH, PUCCH and PUSCH | ZTE |
| [R1-2106572](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106572.zip) | Further discussion on Multi-TRP for PDCCH, PUCCH and PUSCH enhancements | vivo |
| [R1-2106641](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106641.zip) | Discussion on Enhancements for PDCCH, PUCCH, and PUSCH | InterDigital, Inc. |
| [R1-2106667](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106667.zip) | Enhancements on Multi-TRP for PDCCH, PUCCH and PUSCH | Lenovo, Motorola Mobility |
| [R1-2106686](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106686.zip) | Discussion on enhancements on Multi-TRP for PDCCH, PUCCH and PUSCH | Spreadtrum Communications |
| [R1-2106790](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106790.zip) | Considerations on Multi-TRP for PDCCH, PUCCH, PUSCH | Sony |
| [R1-2106866](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106866.zip) | Enhancements on Multi-TRP for PDCCH, PUCCH and PUSCH | Samsung |
| [R1-2106936](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106936.zip) | Enhancements on multi-TRP/panel transmission for PDCCH, PUCCH and PUSCH | CATT |
| [R1-2107030](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107030.zip) | Enhancements on Multi-TRP for PDCCH PUCCH and PUSCH | Fujitsu |
| [R1-2107079](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107079.zip) | Multi-TRP/panel for non-PDSCH | FUTUREWEI |
| [R1-2107144](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107144.zip) | Discussion on multi-TRP for PDCCH, PUCCH and PUSCH | NEC |
| [R1-2107204](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107204.zip) | Enhancements on Multi-TRP for PDCCH, PUCCH and PUSCH | OPPO |
| [R1-2107293](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107293.zip) | Discussion on enhancements on multi-TRP for uplink channels | FGI, Asia Pacific Telecom |
| [R1-2107324](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107324.zip) | Enhancements on Multi-TRP for PDCCH, PUCCH and PUSCH | Qualcomm Incorporated |
| [R1-2107391](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107391.zip) | Enhancements on Multi-TRP for PDCCH, PUCCH and PUSCH | CMCC |
| [R1-2107465](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107465.zip) | On multi-TRP enhancements for PDCCH and PUSCH | Fraunhofer IIS, Fraunhofer HHI |
| [R1-2107486](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107486.zip) | Enhancements on Multi-TRP for PDCCH, PUCCH and PUSCH | MediaTek Inc. |
| [R1-2107571](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107571.zip) | Multi-TRP enhancements for PDCCH, PUCCH and PUSCH | Intel Corporation |
| [R1-2107719](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107719.zip) | Views on Rel-17 multi-TRP reliability enhancement | Apple |
| [R1-2107815](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107815.zip) | Enhancements on Multi-TRP for PDCCH, PUCCH and PUSCH | LG Electronics |
| [R1-2107839](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107839.zip) | Discussion on MTRP for reliability | NTT DOCOMO, INC. |
| [R1-2107894](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107894.zip) | Enhancements on Multi-TRP for PDCCH, PUSCH and PUCCH | Xiaomi |
| [R1-2108020](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2108020.zip) | Enhancements on Multi-TRP for PDCCH, PUCCH and PUSCH | Convida Wireless |
| [R1-2108053](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2108053.zip) | Enhancements for Multi-TRP URLLC schemes | Nokia, Nokia Shanghai Bell |
| [R1-2108072](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2108072.zip) | Enhancements on Multi-TRP for PDCCH, PUCCH and PUSCH | TCL Communication Ltd. |
| [R1-2108074](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2108074.zip) | On PDCCH, PUCCH and PUSCH enhancements for multi-TRP | Ericsson |
| [R1-2108106](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2108106.zip) | Discussion on mTRP PXXCH | ASUSTeK |