**3GPP TSG-RAN WG4 Meeting #98-e R4-210xxxx**

**Electronic Meeting, 25 Jan - 5 Feb, 2021**

**Agenda item:** 15.1

**Source:** Moderator (China Telecom)

**Title:** Email discussion summary for [98e][155] NR\_reply\_LS\_Part\_2

**Document for:** Information

# Introduction

This email thread discusses the response to RAN1 LS R1-2009784 for NR coverage enhancements, including the answers to the three questions requested in the LS:

* Question 1: Under what conditions UE can keep phase continuity cross PUCCH or PUSCH repetitions
* Question 2: Whether back-to-back PUCCH or PUSCH repetitions is one of the conditions required to keep phase continuity cross the repetitions
* Question 3: Under what conditions UE can meet the power control tolerance level cross PUCCH or PUSCH repetitions

List of candidate target of email discussion for 1st round and 2nd round:

* 1st round: Invite companies to review the recommended WF in each sub-topic, and provide comments directly under each issue in section 1.2.1 and 1.2.2.
* 2nd round: prepare and stabilize the WF and reply LS to RAN1.
  + 1 sub-thread on the reply LS, with email title ‘[98e][155] NR\_reply\_LS\_Part\_2 - reply LS R4-2103288’ (led by Qualcomm)
    - Capture the tentative agreements in the 1st round summary, further refine the text in the reply LS and other aspects are not precluded if necessary and agreeable.
  + 1 sub-thread on the WF, with email title ‘[98e][155] NR\_reply\_LS\_Part\_2 - WF R4-2103289’ (led by Huawei)
    - List the aspects for future RAN4 study as recommended in the 1st round summary, mainly for Issue 1-1-4/ 1-1-7/1-2, and other aspects are not precluded if necessary and agreeable.

*Note:* For quick turnaround in responding to comments, it is recommended to send company comments in email body of each sub-thread instead of adding them in the summary document. The moderator will add all the email comments into the summary document.

# Topic #1: Reply LS on PUCCH and PUSCH repetition

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2100159 | InterDigital Communications | Proposal 1: Agree on Q1 answer.  Q1 answer:   * The phase continuity and same power level maintenance are possible for PUCCH and PUSCH repetitions when the same precoding matrix and power level is maintained and no frequency hopping for intra-slot and inter-slot are enabled.   Proposal 2: Agree on Q2 answer.  Q2 answer:   * Yes, for contiguous and uninterrupted back-to-back PUSCH or PUCCH repetitions without hopping, the phase continuity and power level can be maintained.   Proposal 3: Agree on Q3 answer.  Q3 answer:   * To maintain the power level accurate, there shouldn’t be other transmissions in-between contiguous PUSCH or PUCCH repetitions. * The power can be maintained within a defined tolerance between non-contiguous repetitions, occurring at maximum 20ms interval, based on relative power accuracy requirement. For non-contiguous repetitions, the benefits of DMRS bundling shall be investigated by RAN1. |
| R4-2100889 | Qualcomm Incorporated | We discussed the DMRS bundling and repetitions and conditions for phase continuity and made the following observations:  Observation 1: In order to maintain the phase continuity, the transmissions need to be back-to-back  Observation 2: Power change between two transmissions will cause phase to change but it is possible that if power change is small, the phase will change only small amount  Observation 3: Power or PSD change in the transmission can be assumed to break phase continuity between transmissions  Observation 4: Change in RB allocation between transmissions will result in lost phase continuity  And made one proposal for the continuation of the work:  Proposal: Study the amount tolerable phase change between transmission when DMRS bundling still brings benefits |
| R4-2102347 | Ericsson | <Question 1>   * Under what conditions UE can keep phase continuity cross PUCCH or PUSCH repetitions   Proposed answer:  For single transmitter scheme, the conditions to keep the phase continuity across PUCCH and PUSCH repetitions are   1. RB allocation in terms of the length and frequency position should not be changed 2. The output power is kept unchanged.   For multiple transmitter scheme when coherent UL MIMO operation is used, the conditions to keep the phase continuity across PUCCH and PUSCH repetitions are:   1. RB allocation in terms of the length and frequency position should not be changed 2. Each of the transmitter’s output power is kept unchanged. 3. The relative phase change between the transmitter across PUSCH repetitions should be kept low.   <Question 2>   * Whether back-to-back PUCCH or PUSCH repetitions is one of the conditions required to keep phase continuity cross the repetitions   Proposal answer:  Yes, the back-to-back PUCCH or PUSCH repetition is one of conditions required to keep phase continuity cross the repetitions.  <Question 3>   * Under what conditions UE can meet the power control tolerance level cross PUCCH or PUSCH repetitions   Proposal answer:  in TS38.101-1/2, there are specified power control tolerance level and conditions UE shall meet, namely:   * Absolute power tolerance: The absolute power tolerance is the ability of the UE transmitter to set its initial output power to a specific value for the first sub-frame (1 ms) at the start of a contiguous transmission or non-contiguous transmission with a transmission gap larger than 20 ms. The tolerance includes the channel estimation error. * Relative power tolerance: The relative power tolerance is the ability of the UE transmitter to set its output power in a target sub-frame (1 ms) relatively to the power of the most recently transmitted reference sub-frame (1 ms) if the transmission gap between these sub-frames is less than or equal to 20 ms. * Aggregate power tolerance: The aggregate power control tolerance is the ability of the UE transmitter to maintain its power in a sub-frame (1 ms) during non-contiguous transmissions within 21 ms in response to 0 dB commands with respect to the first UE transmission and all other power control parameters as specified in TS 38.213 [8] kept constant |
| R4-2102630 | Huawei, HiSilicon | In this contribution we discussed on phase continuity for PUCCH and PUSCH repetition, according to the analysis, we have the following observations and proposals:  Proposal 1: the conditions UE can keep phase continuity cross PUCCH or PUSCH repetitions are:   * No center frequency change * No frequency hopping intra-slot and inter-slot * No transmission power change including: no RB scheduling change for both position and RB number. No power control parameter specified in TS 38.213 change, and same modulation order * No additional TPC command across PUSCH and PUCCH repetition * No UL/DL switching between 2 UL transmissions * For FR2, there is no beam switching across repetition * If there is un-scheduled UL symbol between 2 UL transmissions, off power requirement is not required for maintaining phase continuity.   Observation 1: If phase continuity conditions are fulfilled, the real transmission power difference between cross PUCCH or PUSCH repetitions is small.  Proposal 2: UE can meet the absolute power control tolerance level cross PUCCH or PUSCH repetitions, the absolute power control tolerance requirements are specified in TS 38.101-1/2. If phase continuity conditions are fulfilled, the real transmission power difference between PUCCH or PUSCH repetitions is small. |

## Open issues summary

### Sub-topic 1-1: Conditions to keep phase continuity cross repetitions (Answers to Q1 and Q2)

**RAN1 Questions related to phase continuity**

* Question 1: Under what conditions UE can keep phase continuity cross PUCCH or PUSCH repetitions
* Question 2: Whether back-to-back PUCCH or PUSCH repetitions is one of the conditions required to keep phase continuity cross the repetitions

**Issue 1-1-1: RB allocation**

* Proposals
  + Option 1: RB allocation in terms of the length and frequency position should not be changed, and no intra-slot and inter-slot frequency hopping within the repetitions (IDC, QC, E///, HW)
* Recommended WF
  + Is option 1 agreeable?

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| **Company** | **Comments** |
| China Telecom | OK with option 1. |
| Huawei | Support option1 |
| IDC | Option 1 is OK. Maybe we can be more precise for the frequency hopping that shall not happen within a repetition bundle.  So maybe the text can be a bit more explicit:  From RAN4 perspective, one of the conditions is that RB allocation in terms of length and frequency position should not be changed, and intra-slot and inter-slot frequency hopping is not enabled within a repetition bundle. |
| MTK | OK with Option 1. |
| Qualcomm | Option 1 |
| Samsung | Option 1 |
| Ericsson | Ok with Option 1. |
| Apple | Agree with Option 1 |

**Issue 1-1-2: Modulation order**

* Proposals
  + Option 1: Keep the same modulation order (E///, HW)
* Recommended WF
  + Is option 1 agreeable?

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| **Company** | **Comments** |
| China Telecom | OK with option 1. |
| Huawei | Support option1 |
| IDC | Support Option 1. |
| MTK | OK with Option 1. |
| Qualcomm | Option 1 |
| Samsung | Option 1 |
| Ericsson | Ok with option 1 |
| Apple | Agree with Option 1 |

**Issue 1-1-3: Transmission power level**

* Proposals
  + Option 1: No change on transmission power level, i.e., no change on the power control parameters specified in TS 38.213 (IDC, QC, E///, HW)
    - Option 1a: It is possible that if power change is small, the phase will change only small amount (QC)
* Recommended WF
  + Is option 1 agreeable?
  + Encourage feedback on option 1a.

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| **Company** | **Comments** |
| China Telecom | OK with option 1. |
| Huawei | Support option 1. Option 1a is not correct, phase continuity is not absolutely associated with power change amount. |
| IDC | Option 1 is agreeable.  For Option 1a:  We have a question:  - How it will be quantified “a small amount in phase change”? |
| MTK | OK with Option 1 with some clarification.  When UE is operating under multiple CCs (CA or DC), the power control on one CC may lead to the power change on another CC. Therefore, we suggest to revise Option 1 as “No change on transmission power level **on all CCs in the same band or different bands**, i.e., no change on the power control parameters specified in TS 38.213” |
| Qualcomm | Option 1 |
| Samsung | Option 1 |
| Ericsson | Ok with option 1. Maybe option 1a can be discussed under **Issue 1-1-7.** |
| Apple | We suggest taking Option 1 as a baseline (i.e. no power change); whether “small” power changes are possible, we suggest further studying and identifying what “small” means |

**Issue 1-1-4: Back-to-back transmission**

* Definition of back-to-back transmission
  + Proposal 1: No transmission of other physical signals/channels in-between PUCCH or PUSCH repetitions from the UE perspective, e.g., no SRS or PUCCH transmission in-between the PUSCH repetition for the UE (IDC, E///)
  + Proposal 2: No downlink transmission in-between the PUSCH or PUCCH repetition. (HW)
  + Proposal 3: No more than *X* un-scheduled OFDM symbols in-between the PUSCH or PUCCH repetition (e.g., *X* = 0, 1, 2, …, 14)
    - Option 3a: OFF power requirement on the un-scheduled symbol cannot be met. Additional time mask requirement is needed. (HW)
* Recommended WF
  + Is it agreeable that the conditions in proposal 1 and 2 should be met to keep phase continuity?
  + Companies are encouraged to discuss whether a non-zero *X* in proposal 3 is possible, and provide feedback on the value of *X* to keep phase continuity. Comments on option 3a are also encouraged.

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| **Company** | **Comments** |
| China Telecom | OK to include proposal 1 and 2 as the conditions to keep phase continuity.  For proposal 3, it is very important to discuss on the non-zero *X* value(s) in RAN4*.* In some cases, the PUSCH or PUCCH repetitions are not strictly back-to-back, e.g., when one symbol in-between the repetitions is used for SRS transmission from other UEs. It is also worth noting that similar discussion has been taken for LTE as approved in [R4-1704089](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_82bis/Docs/R4-1704089.zip) (LS Response on RF impacts related to sPUSCH design), with the following RAN4 answer approved and sent to RAN1:  *Q3: If there is any RF impacts that would degrade sPUSCH demodulation performance when allocating DMRS symbol(s) non-contiguously in time?*  A3: DMRS symbol could be shared in between 2 non-contiguous (in time) sTTI if the gap is equal to up to 2 sTTIs. There should not be any power change and have the same centre frequency, the same RB allocation and the same system bandwidth in between such non-contiguous sTTIs. When such non-contiguous sTTI would be scheduled, BS should indicate UE to keep its PLL ON to limit power consumption impact. |
| Huawei | We support proposal2 and 3a.  For P1, it depends on whether other transmission has impact on phase continuity. |
| IDC | Proposal 1 and 2 are OK. I guess, we need to specify that Proposal 2 is for TDD case.  For Proposal 3: If the PA goes OFF and then is coming ON again the phase continuity may not be there anymore. That will lead us to Option 3a situation, which in our opinion, should be avoided. |
| MTK | Option 1 and 2 (TDD only?) is fine.  Option 3 is highly related to UE implementation. Suggest to have some further study. |
| Qualcomm | Both P1 and P2 need to be satisfied simultaneously. For P3, we see that X=0 is mandatory condition for phase contiguity. On 3a: I do not see it feasible to define “new” OFF power requirement for this purpose. We can explore this but it maybe difficult. |
| Samsung | Proposal 1 and proposal 2 shall be agreed as a package, i.e, no uplink and downlink transmission in-between the PUSCH or PUCCH repetition. For proposal 3, to response LS, 0 un-scheduled OFDM symbols shall be assumed. Based on RAN1 further feature design, RAN4 can further discuss the requirements if needed. |
| Ericsson | Proposal 1 & 2 both says the power should not be changed. Proposal 1 requires no interleaving transmission between repetition to guarantee this. Proposal 2 donot want to turn off PA for downlink receiving (?). For proposal 3, what the PA behavior for the X unscheduled symbols? If PA transmit other power level then the PUSCH/PUCC repetition power, it may have the memory effect and phase continuity will not hold. If the proposal seeks the phase change tolerance corresponding to X unscheduled symbols, this should be discussed under **Issue 1-1-6.** |
| Apple | We agree that P1 and P2 should both be satisfied; similarly to Qualcomm, we see P3 as a potential new OFF power requirement, since the X represents a gap when the UE is neither transmitting or receiving |

**Issue 1-1-5: Precoding matrix for coherent 2Tx transmission**

* Proposals
  + Option 1: The same precoding matrix should be maintained (IDC, [E///])
* Recommended WF
  + Is option 1 agreeable?

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| **Company** | **Comments** |
| China Telecom | OK with option 1. |
| Huawei | Not support. Precoding matrix will not change the signal Phase continuity after PA. This may have impact on whether DMRS bundling can be cross repetition, considering channel estimation may be changed. However, it is not the condition for signal phase continuity. |
| IDC | OK with option 1. |
| MTK | OK with option 1 |
| Qualcomm | Option 1 |
| Samsung | Option 1 |
| Ericsson | Ok with option 1 |

**Issue 1-1-6: Beam switching for FR2**

* Proposals
  + Option 1: No beam switching for FR2 (HW)
* Recommended WF
  + Is option 1 agreeable?

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| **Company** | **Comments** |
| China Telecom | OK with option 1. |
| Huawei | Support option 1 |
| IDC | Support option 1. |
| MTK | OK with option 1 |
| Qualcomm | Option 1 is ok |
| Samsung | Option 1 |
| Ericsson | Ok with option 1. |
| Apple | We agree with Option 1 |

**Issue 1-1-7: Criteria for the phase change**

* Proposals
  + Option 1: Study the amount of phase continuity tolerance between transmissions (QC)
    - QC: Even if all the above mentioned conditions are met, the phase of the tx signal may drift for example only because there is a frequency error in the UE compared to the gNB receiver.
* Recommended WF
  + Is option 1 agreeable? Detailed proposals on the phase continuity tolerance are also encouraged.

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| **Company** | **Comments** |
| China Telecom | We support to discuss the phase continuity tolerance between transmissions, which will be used to define the UE requirements in RAN4, for both FR1 and FR2. |
| Huawei | It is not within the scope of CE WID, and there is no request from RAN1 LS to define new tolerance requirement for phase continuity. |
| IDC | We agree that is a good idea to study the phase continuity tolerance.  However, we need to clarify and agree on the target scenarios. Here are some possible scenarios to study:   1. Phase continuity tolerance within a slot (repetition type B can have multiple repetitions within a slot) 2. Phase continuity tolerance between multiple contiguous slots (DDDSU, where the special slot contains uplink symbols in the end) followed by and U slot in a repetition bundle. 3. Phase continuity tolerance between 2 non-contiguous transmissions/slots.   IDC2: Just to add that we agree with Ericsson that we can ask RAN1 about the target scenarios if we agree to add this question in the LS reply. |
| MTK | We support Option 1. Infra vendor’s input may be also needed in order to know how the phase continuity tolerance may impact the UL reception performance. |
| Qualcomm | Mainly as response to Huawei, this Wi will begin in ran4 later, we can study this then. We do not really understand the notion that RAN1 would need to define the scope of RAN4 work. For now in the context of this LS reply,. We can omit the values but eventually if Ran4 wants to write requirements to this feature, a value is needed. |
| Samsung | Whether RAN4 is going to have explicit phase continuity requirements or reflecting such tolerance in other test cases requires more discussion in RAN4 in later stage once RAN1 complete design |
| Ericsson | Support option 1. Regarding the IDC 3 scenario, the higher priority should be non-contiguous slots and second priority is contiguous slots. The priority is set to benefit the DL heavy TDD and this is scenario with the worst coverage. In the LS reply, such target scenario could be mentioned and ask RAN1 to provide any feedback if any. |
| Apple | We agree that phase continuity tolerance should be studied |

### Sub-topic 1-2: Power control tolerance cross repetitions (Answer to Q3)

**RAN1 Questions related to power control tolerance**

* Question 3: Under what conditions UE can meet the power control tolerance level cross PUCCH or PUSCH repetitions

**Issue 1-2: Answers to RAN1 questions on power control tolerance**

* Proposed answers
  + Option 1 (IDC):
    - To maintain the power level accurate, there shouldn’t be other transmissions in-between contiguous PUSCH or PUCCH repetitions.
    - The power can be maintained within a defined tolerance between non-contiguous repetitions, occurring at maximum 20ms interval, based on relative power accuracy requirement. For non-contiguous repetitions, the benefits of DMRS bundling shall be investigated by RAN1.
  + Option 2 (QC):
    - UE is not able to change its power and maintain phase continuity in full. In some cases, such as if the transmissions are close to max power and power change is small, the phase change is also small and may meet criteria for phase continuity.
  + Option 3 (E///): in TS38.101-1/2, there are specified power control tolerance level and conditions UE shall meet, namely:
    - Absolute power tolerance: The absolute power tolerance is the ability of the UE transmitter to set its initial output power to a specific value for the first sub-frame (1 ms) at the start of a contiguous transmission or non-contiguous transmission with a transmission gap larger than 20 ms. The tolerance includes the channel estimation error.
    - Relative power tolerance: The relative power tolerance is the ability of the UE transmitter to set its output power in a target sub-frame (1 ms) relatively to the power of the most recently transmitted reference sub-frame (1 ms) if the transmission gap between these sub-frames is less than or equal to 20 ms.
    - Aggregate power tolerance: The aggregate power control tolerance is the ability of the UE transmitter to maintain its power in a sub-frame (1 ms) during non-contiguous transmissions within 21 ms in response to 0 dB commands with respect to the first UE transmission and all other power control parameters as specified in TS 38.213 [8] kept constant.
  + Option 4 (HW):
    - HW: UE can meet the absolute power control tolerance level cross PUCCH or PUSCH repetitions, the absolute power control tolerance requirements are specified in TS 38.101-1/2. If phase continuity conditions are fulfilled, the real transmission power difference between PUCCH or PUSCH repetitions is small.
* **Moderator’s observation**
  + Although the descriptions in the answers from companies are different, technically it looks common understanding that:
    - If the conditions for phase continuity cross PUSCH or PUCCH repetitions are fulfilled, the same power level (with certain tolerance level) can also be achieved.
    - The power tolerances specified in TS 38.101-1/2 can be referred.
* Recommended WF
  + Based on the above observation, is the following proposed answer agreeable? Any further suggestion?
    - If the conditions for phase continuity cross PUSCH or PUCCH repetitions are fulfilled, the same power level (with certain tolerance level) can also be achieved.
    - The power tolerances specified in clause 6.3.4 of TS 38.101-1/2 can be referred, in which the following tolerances are defined:
    - Absolute power tolerance: The absolute power tolerance is the ability of the UE transmitter to set its initial output power to a specific value for the first sub-frame (1 ms) at the start of a contiguous transmission or non-contiguous transmission with a transmission gap larger than 20 ms. The tolerance includes the channel estimation error.
    - Relative power tolerance: The relative power tolerance is the ability of the UE transmitter to set its output power in a target sub-frame (1 ms) relatively to the power of the most recently transmitted reference sub-frame (1 ms) if the transmission gap between these sub-frames is less than or equal to 20 ms.
    - Aggregate power tolerance: The aggregate power control tolerance is the ability of the UE transmitter to maintain its power in a sub-frame (1 ms) during non-contiguous transmissions within 21 ms in response to 0 dB commands with respect to the first UE transmission and all other power control parameters as specified in TS 38.213 kept constant.

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| **Company** | **Comments** |
| China Telecom | Support the recommended WF. In our understanding, both phase continuity and power consistency need to be achieved to enable DMRS bundling / joint channel estimation, so we don’t need to re-discuss these conditions for power consistency if they are already included as the conditions for phase continuity in sub-topic 1-1. |
| Huawei | In our understanding, even phase continuity condition is fulfilled, i.e. the configured power in-between the repetition is the same, it does not mean the power received by the gNB is in continuity. Considering absolute power tolerance can be +-9dB for FR1 and higher for FR2, even power tolerance is met between repetition, it may still have impact on DMRS bundling. |
| IDC | The first bullet seems to have a circular logic. Maybe the first bullet needs some adjustments.  The second bullet looks good. |
| MTK | We do not think RAN1 is asking RAN4 about the RF requirements. Similar to Huawei’s comment, what RAN1 cares is the UL decoding performance at the gNB side for cross PUCCH or PUSCH repetitions. Option 2 seems to better address RAN1’s question. Anyhow, RAN4 needs to first clarify the definition of phase continuity tolerance before answer this question. |
| China Telecom 2 | It seems that companies’ understanding on this Q3 for power consistency is slightly different: one view is more focusing on the ‘conditions’ to meet the power consistency, the other one is more focusing on the level of ‘tolerance’. So, in this meeting, we suggest to include the RAN4 answers to both of the two aspects, and the answers can be updated in the future meeting if needed.  On the ‘conditions’:  We discussed the conditions for phase continuity in details in sub-topic #1-1, and it looks that companies are approaching consensuses for the issues excepting the issue on zero/non-zero un-scheduled *X* symbols (i.e., Proposal 3 in Issue 1-1-3), so the first bullet (as below) in the recommended WF seems reasonable, while of course further update on the wording is needed in round 2 discussion.   * + - *If the conditions for phase continuity cross PUSCH or PUCCH repetitions are fulfilled, the same power level (with certain tolerance level) can also be achieved.*   On the level of ‘tolerance’:  We tend to agree with Huawei that ± 9.0 dB in Absolute power tolerance might be too big to utilize joint channel estimation.  So maybe we can inform RAN1 the aggregate power tolerance of ± 2.5 dB/± 3.5 dB for PUCCH/PUSCH, which can be achieved under the conditions that all the power control parameters as specified in TS 38.213 kept constant, and within 21 ms. |
| Samsung | First bullet is sufficient to be included in the response LS. Not sure if we need to refer to RAN4 spec on power tolerance. |
| Ericsson | It is not clear that how to correlate the power control tolerance with the phase continuity tolerance before the phase continuity tolerance is investigated and concluded. For now, maybe the most relevance answer on the power control tolerance in Q3 is the aggregated power control tolerance with 0 TPC command. The ability/tolerance of the UE to hold its output power to a certain level depending on both the output power level and duration of the such requirement. This question answer could relate to the phase continuity tolerance that RAN4 want to investigate further to give RAN1 whole picture. |
| Apple | It would be useful to consider an update to the draft LS text during the second round based on the consensus for the previous issues |

## Companies views’ collection for 1st round

*Provided under each issue in section 1.2*

## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

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|  | **Status summary** |
| **Sub-topic 1-1: Phase continuity** | **Sub-topic 1-1: Conditions to keep phase continuity cross repetitions (Answers to Q1 and Q2)**  *RAN1 Questions related to phase continuity*   * *Question 1: Under what conditions UE can keep phase continuity cross PUCCH or PUSCH repetitions* * *Question 2: Whether back-to-back PUCCH or PUSCH repetitions is one of the conditions required to keep phase continuity cross the repetitions*   **Issue 1-1-1: RB allocation**  *Summary of 1st round discussion:*  In general the following option 1 is agreeable to all companies. IDC provide some wording suggestion, which looks reasonable.   * Option 1: RB allocation in terms of the length and frequency position should not be changed, and no intra-slot and inter-slot frequency hopping within the repetitions (IDC, QC, E///, HW, CTC, MTK, Samsung, Apple)   + IDC: Maybe the text can be a bit more explicit:     - From RAN4 perspective, one of the conditions is that RB allocation in terms of length and frequency position should not be changed, and intra-slot and inter-slot frequency hopping is not enabled within a repetition bundle.   *Tentative agreements:*  Agree option 1 with the updated wording from IDC:   * From RAN4 perspective, one of the conditions is that RB allocation in terms of length and frequency position should not be changed, and intra-slot and inter-slot frequency hopping is not enabled within a repetition bundle.   *Recommendations for 2nd round:*  Capture the discussion outcome in the reply LS.  **Issue 1-1-2: Modulation order**  *Tentative agreements:*  Agree Option 1: Keep the same modulation order (E///, HW, CTC, IDC, MTK, QC, Samsung, Apple)  *Recommendations for 2nd round:*  Capture the discussion outcome in the reply LS.  **Issue 1-1-3: Transmission power level**  *Summary of 1st round discussion:*  In general the following option 1 is agreeable to all companies. MTK suggest to add clarification for UE operating under multiple CCs, which looks reasonable.   * Option 1: No change on transmission power level, i.e., no change on the power control parameters specified in TS 38.213 (IDC, QC, E///, HW, CTC, MTK, Samsung, Apple)   + MTK: When UE is operating under multiple CCs (CA or DC), the power control on one CC may lead to the power change on another CC. Therefore, we suggest to revise Option 1 as “No change on transmission power level **on all CCs in the same band or different bands**, i.e., no change on the power control parameters specified in TS 38.213”   Regarding the option 1a, it can be discussed under Issue 1-1-7 on amount of phase continuity tolerance.   * + Option 1a: It is possible that if power change is small, the phase will change only small amount (QC)   *Tentative agreements:*  Agree option 1 with the additional clarification from MTK:   * No change on transmission power level, i.e., no change on the power control parameters specified in TS 38.213, on all CCs for CA and DC with dynamic power sharing.   *Recommendations for 2nd round:*  Capture the discussion outcome in the reply LS.  **Issue 1-1-4: Back-to-back transmission**  *Summary of 1st round discussion:*  *For proposal 1:*  7 companies support option 1, while 1 company thinks it depends on whether other transmission has impact on phase continuity. To moderator’s understanding, at least different power control parameters are used for different uplink channels/signals, so we can consider that other transmission has impact on the phase continuity.  Therefore, moderator would like to recommend P1 as the tentative agreement.   * Proposal 1: No transmission of other physical signals/channels in-between PUCCH or PUSCH repetitions from the UE perspective, e.g., no SRS or PUCCH transmission in-between the PUSCH repetition for the UE (IDC, E///, CTC, MTK, QC, Samsung, Apple)   + HW: For P1, it depends on whether other transmission has impact on phase continuity.   *For proposal 2:*  In general the following Proposal 2 is agreeable to all companies. IDC and MTK suggest to mention it is for TDD case, which looks reasonable.   * Proposal 2: No downlink transmission in-between the PUSCH or PUCCH repetition. (HW, CTC, IDC, MTK, QC, Samsung, Apple, E///)   + IDC, MTK: Proposal 2 is for TDD case.   Furthermore, several companies mentioned that P1 and P2 both says no uplink and downlink transmission in-between the PUSCH or PUCCH repetition, and need to be satisfied simultaneously, so further work on the wording or merging the two proposals can be done when drafting the reply LS.  *For proposal 3:*  Companies have different views on the value of *X* in Proposal 3.   * Proposal 3: No more than *X* un-scheduled OFDM symbols in-between the PUSCH or PUCCH repetition (e.g., *X* = 0, 1, 2, …, 14)   + View #1: X=0 ([IDC], QC, Samsung)   + View #2: Certain non-zero X values can also be considered to achieve phase contiguity (CTC, HW)   + View #3: Further study is needed (MTK, [E///])   There are also some technical comments on P3 and P3a, which can be taken into account for RAN4 further study:   * QC: I do not see it feasible to define “new” OFF power requirement for this purpose. * E///: For proposal 3, what the PA behavior for the X unscheduled symbols? If PA transmit other power level then the PUSCH/PUCC repetition power, it may have the memory effect and phase continuity will not hold. If the proposal seeks the phase change tolerance corresponding to X unscheduled symbols, this should be discussed under Issue 1-1-7. * Apple: similarly to Qualcomm, we see P3 as a potential new OFF power requirement, since the X represents a gap when the UE is neither transmitting or receiving.   *Tentative agreements:*  Include P1 and updated P2 as two of the conditions to keep phase continuity:   * Proposal 1: No transmission of other physical signals/channels in-between PUCCH or PUSCH repetitions from the UE perspective, e.g., no SRS or PUCCH transmission in-between the PUSCH repetition for the UE. * Updated proposal 2: No downlink transmission in-between the PUSCH or PUCCH repetition for TDD case.   For P3,   * With no un-scheduled OFDM symbol in-between the PUSCH or PUCCH repetition, together with other conditioned identified in RAN4, phase continuity can be maintained. * RAN4 to further study whether phase continuity can be maintained with *X* (*X*>0) un-scheduled OFDM symbols in-between the PUSCH or PUCCH repetition.   *Recommendations for 2nd round:*  For P1 and P2:   * Capture the discussion outcome in the reply LS, and further work on the wording or merging the two proposals if needed.   For P3:   * For the reply LS, capture the RAN4 discussion outcome. * For the WF, list the aspects to be considered for further study on whether non-zero *X* value(s) is possible.   **Issue 1-1-5: Precoding matrix for coherent 2Tx transmission**  *Summary of 1st round discussion:*  6 companies support option 1, while one company does not support. It looks that it depends on whether phase continuity needs to be maintained for DMRS signals after precoding.   * Option 1: The same precoding matrix should be maintained (IDC, E///, CTC, MTK, QC, Samsung)   + HW: Not support. Precoding matrix will not change the signal Phase continuity after PA. This may have impact on whether DMRS bundling can be cross repetition, considering channel estimation may be changed. However, it is not the condition for signal phase continuity.   So moderator would recommend the following updated option 1:  *Tentative agreements:*  The same precoding matrix should be maintained assuming that phase continuity needs to be maintained for DMRS signals after precoding.  *Recommendations for 2nd round:*  Capture the discussion outcome in the reply LS.  **Issue 1-1-6: Beam switching for FR2**  *Tentative agreements:*  Agree Option 1: No beam switching for FR2 (HW, CTC, IDC, MTK, QC, Samsung, E///, Apple)  *Recommendations for 2nd round:*  Capture the discussion outcome in the reply LS.  **Issue 1-1-7: Criteria for the phase change**  *Summary of 1st round discussion:*  6 companies support option 1, and 1 company does not support due to no request from RAN1 LS.   * Option 1: Study the amount of phase continuity tolerance between transmissions (QC, CTC, IDC, MTK, E///, Apple)   + HW: there is no request from RAN1 LS to define new tolerance requirement for phase continuity.   In moderator’s understanding, although the phase continuity tolerance related requirement is not explicitly requested by RAN1, but it is included in the WI scope based on the WID in RP-202928.  Therefore, it is suggested to further study the amount of phase continuity tolerance in RAN4. In addition, the following suggestions can be taken into account for RAN4 further study.   * IDC: we need to clarify and agree on the target scenarios. Here are some possible scenarios to study:  1. Phase continuity tolerance within a slot (repetition type B can have multiple repetitions within a slot) 2. Phase continuity tolerance between multiple contiguous slots (DDDSU, where the special slot contains uplink symbols in the end) followed by and U slot in a repetition bundle. 3. Phase continuity tolerance between 2 non-contiguous transmissions/slots.  * MTK: Infra vendor’s input may be also needed in order to know how the phase continuity tolerance may impact the UL reception performance. * Samsung: Whether RAN4 is going to have explicit phase continuity requirements or reflecting such tolerance in other test cases requires more discussion. * E///: Regarding the IDC 3 scenario, the higher priority should be non-contiguous slots and second priority is contiguous slots. The priority is set to benefit the DL heavy TDD and this is scenario with the worst coverage. * E///, IDC: In the LS reply, such target scenario could be mentioned and ask RAN1 to provide any feedback if any.   *Tentative agreements:*  RAN4 to study the amount of phase continuity tolerance between transmissions, FFS whether RAN4 will have explicit phase continuity requirements or reflecting such tolerance in other test cases.  *Recommendations for 2nd round:*  For reply LS, inform RAN1 the RAN4 plan on the phase continuity tolerance study, and ask RAN1 the target scenarios if needed.  For the WF, list the related scenarios and factors to be considered for further study on the amount of phase continuity tolerance. |
| **Sub-topic 1-2** | **Sub-topic 1-2: Power control tolerance cross repetitions (Answer to Q3)**  *RAN1 Questions related to power control tolerance*   * *Question 3: Under what conditions UE can meet the power control tolerance level cross PUCCH or PUSCH repetitions*   **Issue 1-2: Answers to RAN1 questions on power control tolerance**  *Summary of 1st round discussion:*  Moderator recommended the following answers to RAN1, where the 1st bullet is on the ‘conditions’ to meet the power consistency, and the 2nd bullet is on the level of ‘tolerance’.   * *If the conditions for phase continuity cross PUSCH or PUCCH repetitions are fulfilled, the same power level (with certain tolerance level) can also be achieved.* * *The power tolerances specified in clause 6.3.4 of TS 38.101-1/2 can be referred, in which the following tolerances are defined:*   + *Absolute power tolerance: ….*   + *Relative power tolerance: ….*   + *Aggregate power tolerance: ….*   Companies have slightly different understanding on which bullet is more relevant to RAN1 question. For the power tolerances specified in TS 38.101-1/2, more discussion is needed on which tolerance shall be used or anything new is needed.  To moderator’s understanding, both phase continuity and power consistency are needed to enable joint channel estimation, at least the first bullet on ‘condition’ would be helpful to RAN1; for the amount of power tolerance, further study can be conducted in RAN4.  In addition, the following objective is copied from the WID on NR coverage enhancements in RP-202928, and hopefully we can at least send the ‘conditions’ to keep power consistency to RAN1 in this meeting.   * *Specify mechanism(s) to enable joint channel estimation [RAN1, RAN4]*   + *Mechanism(s) to enable joint channel estimation over multiple PUSCH transmissions, based on the conditions to keep power consistency and phase continuity to be investigated and specified if necessary by RAN4 [RAN1, RAN4]*   + *…*   *Tentative agreements:*  For the reply LS, capture the following bullet:   * If the conditions for phase continuity cross PUSCH or PUCCH repetitions are fulfilled, the same power level (with certain tolerance level) can also be achieved.   For the WF:   * Further discuss any of the existing power tolerance in TS 38.101-1/3 can be applicable, or anything new is needed. |

*Recommendations on WF/LS assignment*

|  |  |  |
| --- | --- | --- |
|  | **WF/LS t-doc Title** | **Assigned Company,**  **WF or LS lead** |
| #1 | Reply LS on PUCCH and PUSCH repetition | Qualcomm Incorporated |
| #2 | WF on phase continuity and power consistency for PUCCH and PUSCH repetition | Huawei, HiSilicon |

## Discussion on 2nd round

### Reply LS

**R4-2103288 Reply LS on PUCCH and PUSCH repetition**

*Type: LS out For: Approval  
 Source: Qualcomm*

**Abstract:**

**Discussion:**

*Moderator’s notes:*

*1) Discussed in the sub-thread titled‘[98e][155] NR\_reply\_LS\_Part\_2 - reply LS R4-2103288’ (led by Qualcomm)*

*2) Interested companies please send your comments in email body instead of adding them in this summary document. Moderator will add all the email comments into this summary document.*

China Telecom: Based on the information from my RAN1 colleague, RAN1 has made the following agreements earlier today.

Agreements: (copied from RAN1 Chairman notes)

* Following potential use cases are considered for joint channel estimation for PUSCH:
  + Use case 1: back-to-back PUSCH transmissions within one slot.
  + Use case 2: non-back-to-back PUSCH transmissions within one slot.
  + Use case 3: back-to-back PUSCH transmissions across consecutive slots.
  + Use case 4: non-back-to-back PUSCH transmissions across consecutive slots.
  + Use case 5: PUSCH transmissions across non-consecutive slots.

Note: RAN1 assumes “back-to-back PUSCH transmission” has zero gap in-between adjacent PUSCH transmissions.

So we would like to check if we can consider this modified version in [R4-2103288 Reply LS on PUCCH and PUSCH repetition\_v1\_CTC.docx](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_98_e/Inbox/Drafts/%5B98e%5D%5B155%5D%20NR_reply_LS_Part_2/2nd%20round/Reply%20LS/R4-2103288%20%20Reply%20LS%20%20on%20PUCCH%20and%20PUSCH%20repetition_v1_CTC.docx). Main updates are:

1) Align the definition of back-to-back and non-back-to-back transmissions with RAN1.

2) Since RAN1 has already identified some potential scenarios at least for PUSCH, maybe we can remove the example scenarios in the reply LS.

China Telecom: We uploaded another version in [R4-2103288 Reply LS on PUCCH and PUSCH repetition\_v1\_CTC2.docx](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_98_e/Inbox/Drafts/%5B98e%5D%5B155%5D%20NR_reply_LS_Part_2/2nd%20round/Reply%20LS/R4-2103288%20%20Reply%20LS%20%20on%20PUCCH%20and%20PUSCH%20repetition_v1_CTC2.docx). The updates include:

1) For the 3rd condition in A1, refine the condition on potential impact by other concurrent CC(s).

2) For A2, our update in the previous email is not accurate. In this revision, we only added the definition of back-to-back and non- back-to-back transmissions assumed in RAN1.

vivo: I made an minor revision on the following description as following:

* + - No transmission of other physical signals/channels in-between PUCCH or PUSCH repetitions from the UE perspective, e.g., no SRS or PUCCH transmission in-between the PUSCH repetition for the UE.
    - No downlink ~~transmission~~ reception in-between the PUSCH or PUCCH repetition for TDD case

The intention is make it further clear the latter condition would not affect any network behavior, and only restrict UE behavior. Sorry for raise this a bit late and hope it could be considered.

E///: I think RAN4 will study the phase discontinuity tolerance from hardware perspective. System simulation on performance is not in RAN4 scope?

For the scenario in Q4, the concern aspects from RAN4 may be needed as some example at least worth to be covered in RAN1 reply.

HW: For precoding matrix, it may have impact on the joint channel estimation with DMRS, but this precoding matrix is added in Baseband and have no impact on phase after upconversion, in my understanding.

We would like to have more discussion on this issue: precoding matrix. May be I can add this one into the WF.

For other physical channel transmitted in-between repetitions, e.g. SRS, we think it needs further evaluation, at least if the transmission power is the same for SRS and the repetitions, phase may be maintained. we would like to make this issue open and further discuss in RAN4.

QC: We can keep the changes and upload DL nears so I cleaned this up and made some minor editorial edits and added “in addition to the conditions under Q1” to the Q2 conditions, I hope everyone agrees.

CTC: Just to remove “on top of those in Q1” since “in addition to the conditions under Q1” has been added.

* + For non-back-to-back transmission with non-zero gap in-between adjacent transmissions, RAN4 concluded that at least following additional condition ~~on top of those in Q1~~ also need to be met in addition to the conditions under Q1:

HW: Can I clarify:

For the scenario: scenario of other physical signals/channels in-between PUCCH or PUSCH repetitions from the UE perspective, e.g., SRS or PUCCH transmission in-between the PUSCH repetition for the UE,

Seems the LS version shows some conflict, could we leave this point for further discuss in the next RAN4 meeting?

HW: Do we have a chance to revise a version to solve the conflict part?

I further revise the LS:  [R4-2103288 Reply LS on PUCCH and PUSCH repetition\_v5\_rev1.docx](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_98_e/Inbox/Drafts/%5B98e%5D%5B155%5D%20NR_reply_LS_Part_2/2nd%20round/Reply%20LS/R4-2103288%20%20Reply%20LS%20%20on%20PUCCH%20and%20PUSCH%20repetition_v5_rev1.docx)

**Recommendation: Agreeable.**

### Way forward

**R4-2103289 Way forward on phase continuity and power consistency for PUCCH and PUSCH repetition**

*Type: other For: Approval  
 Source: Huawei, HiSilicon*

**Abstract:**

*Moderator’s notes:*

*1) Discussed in the sub-thread titled‘[98e][155] NR\_reply\_LS\_Part\_2 - WF R4-2103289’ (led by Huawei)*

*2) Interested companies please send your comments in email body instead of adding them in this summary document. Moderator will add all the email comments into this summary document.*

China Telecom: In the reply LS, RAN4 already answered that the following condition is needed to keep phase continuity and power consistency.

*o       No change on transmission power level, i.e., no change on the power control parameters specified in TS 38.213,…*

So it seems the following part has already covered by the reply LS, and maybe we can remove it from the WF. The other parts of the WF look ok to us.

*Confirm following issues with RAN1, include the questions in the LS:*

* + *Is Path loss RS common used across repetition?*
  + *Is there TPC command transmitted to UE across repetition?*

E///: system simualton involvs simulation assumption discussion and we donot think it is in RAN4 scope.

WF1 tin previous slide covers the phase discontinuity tolerance including this, right?

QC: to E///, it seems you don’t want RAN4 to study the amount of phase discontinuity system can tolerate. I wonder who then does that? I mean you removed it from this WF and also LS as Ran4 facing issue but then we need to ask RAN1 to study it in the LS.

If we only look at the UE implementation, the number will be very big because there is no target or understanding on upper bound.

CTC: We also support to study the performance impact by phase change, which will help us to conclude a reasonable phase continuity tolerance.

In addition, we think link level simulation would be sufficient, and hope this would alleviate the concern on simulation efforts/complexity from Ericsson.

MTK: We share similar view with QC and China Telecom that some study on the phase discontinuity impact to gNB's decoding performance is needed.

Link-level evaluation should be sufficient.

We probably do not want to specify a tolerance requirement that makes the UL signal undecodable at gNB side.

HW: To E///, for the slide 3, the power consistency is a different topic as for phase. Even the configured power is the same, the transmitted power maybe not the same.

I think slide 3 need to be leave there.

QC: And I don’t think we can exclude the receiver aspect (jont chjannel estimation) away from this if we have the UE side there.

HW: Here I clean the notations in the document based on the latest version, hope everyone is OK with this version:

E///: We think the link simulation /system simulation is in RAN1 scope.  This is not a trivial task from agreeing on the simulation assumption till alignment simulation results. If this is not within the WID scope, we donot think RAN4 should study this.

* Study the impact on link level performance of joint channel estimation caused by phase change across repetition

Ericsson not agree with this WF.

HW: Can we say:

Interesting companies could provide analysis on : impact on link level performance of joint channel estimation caused by phase change across repetition

Please Let me know if this is OK for you.

E///: I further checked the [WID](http://www.3gpp.org/ftp/TSG_RAN/TSG_RAN/TSGR_90e/Docs/RP-202928.zip)

* + Specify mechanism(s) to enable joint channel estimation [RAN1, RAN4]
    - Mechanism(s) to enable joint channel estimation over multiple PUSCH transmissions, **based on the conditions to keep power consistency and phase continuity to be investigated and specified if necessary by RAN4** [RAN1, RAN4]
      * Potential optimization of DMRS location/granularity in time domain is not precluded
    - Inter-slot frequency hopping with inter-slot bundling to enable joint channel estimation [RAN1]

I think Ericsson can compromise to:

                       FFS on whether or not RAN4 should study on link level performance of joint channel estimation caused by phase change across repetition

I think this related to work splitting between RAN1 and RAN4 and it may be better that companies can align with RAN1 for the object in WID. At least this can be decided next meeting if companies are hesitate on the interpretation of the WID.

CTC: We think the work split between RAN1 and RAN4 is very clear. The blue text on mechanism(s) is for RAN1, and the green text on conditions is for RAN4. Here the link level performance study is for the purpose of defining reasonable conditions, so for sure it is within RAN4 scope.

* + Specify mechanism(s) to enable joint channel estimation [RAN1, RAN4]
    - Mechanism(s) to enable joint channel estimation over multiple PUSCH transmissions, based on the conditions to keep power consistency and phase continuity to be investigated and specified if necessary by RAN4 [RAN1, RAN4]
      * Potential optimization of DMRS location/granularity in time domain is not precluded
    - Inter-slot frequency hopping with inter-slot bundling to enable joint channel estimation [RAN1]

But we are ok with Qian’s revision as a compromise, i.e.,

*Interesting companies could  provide analysis on : impact on link level performance of joint channel estimation caused by phase change across repetition*

HW: In my understanding, interesting companies is always allowed to provide some analysis, this sentence proposed by me has no harm.

We would like to have some evaluation is because, UE may not keep absolute continuity as 0 degree.

However, from the analysis, you could have the conclusion that the impact is not much. That depends on the receiver somehow.

E///: To CTC:

This is exactly what I am not sure what is the boundary between RAN1 and RAN4 work, in blue text, it mentions the “joint channel estimation” and you say it is for RAN1, then the same text appear in RAN4 work description in your suggested wording at the mail, so I am not sure that is correct decision for now in RAN4.

CTC: The whole bullet is for “joint channel estimation”, RAN1 work is on the “mechanism(s)”, and RAN4 work is on the “condition”. Otherwise, what’s the purpose of discussing the conditions in RAN4?

But if you are not comfortable with that sentence, from our side, the following revision is also acceptable:

* + Amount of Phase continuity tolerance across repetition when all phase continuity conditions agreed by RAN4 is met, following aspects can be considered:
    - Phase drifting from UE implementation aspect:  e.g. frequency error
    - ~~Study the impact on link level performance of joint channel estimation caused by phase change across repetition~~
    - ~~Interesting companies could  provide analysis on : impact on link level performance of joint channel estimation caused by phase change across repetition~~
    - Other aspects, e.g., impact on link level performance, can also be considered if needed ~~are not precluded~~

E///: I guess RAN4 will cover the scope of study lead by rapporteur when there is RAN4 TU in coming meeting. I don’t see the reason to rush the RAN4 scope now without TU allocation in this WID.

Can I ask what the reason to rush the RAN4 scope decision now in this meeting?

E///: To QC

The RAN4 work for this NR\_Cov\_Enh does not start yet.  The question of RAN4 scope in this WID should be formally investigated in the TU allocation.

I donot think what we mean is to deny any potential simulation work but rather we see such discussion should happen when RAN4 formally start. But for general study on the phase discontuity tolerance, we have agreed in LS reply and commit to study as easier agreement on RAN4 scope already before even RAN4 work start. To go beyond on this and discuss sth we need more time to investigate and this is we are not so sure about.

E///: To CTC

I guess RAN4 will cover the scope of study lead by rapporteur when there is RAN4 TU in coming meeting. I don’t see the reason to rush the RAN4 scope now without TU allocation in this WID.

Can I ask what the reason to rush the RAN4 scope decision now in this meeting?

CTC: We don’t think companies are pushing RAN4 scope decision, but just trying to list what RAN4 need to do based on the approved WI scope in RAN plenary.

But if you have strong view, and also considering this is the first meeting for this topic, for now we are fine to remove the sub-bullet on performance study.

* + Amount of Phase continuity tolerance across repetition when all phase continuity conditions agreed by RAN4 is met, following aspects can be considered:
    - Phase drifting from UE implementation aspect:  e.g. frequency error
    - ~~Study the impact on link level performance of joint channel estimation caused by phase change across repetition~~
    - Other aspects are not precluded

E///: We are fine with WF with removal of the sub-bullet for link simulation.

**Recommendation: Revised**

## Summary on 2nd round

*Moderator tries to summarize discussion status for 2nd round and provided recommendation on CRs/TPs/WFs/LSs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP/LS/WF number** | **T-doc Status update recommendation** |
| R4-2103288, Reply LS | *Agreeable*  *Meanwhile, suggest to add the following note in Chairman Notes:*  *RAN4 can further study if phase continuity can be met for the scenario of other physical signals/channels in-between PUCCH or PUSCH repetitions from the UE perspective, e.g., SRS or PUCCH transmission in-between the PUSCH repetition for the UE.* |
| R4-2103289, WF | *to be revised*  *The revision with removal of the sub-bullet for link simulation is agreeable?* |