**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 the WF (if needed) and reply LS to RAN1.

# 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 |

**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 |

**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 |

**Issue 1-1-3: 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. |

**Issue 1-1-4: 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 |

**Issue 1-1-5: 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 |

**Issue 1-1-6: 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. |
| 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. |

### 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. |

## 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** | *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:* |

*Recommendations on WF/LS assignment*

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|  | **WF/LS t-doc Title** | **Assigned Company,**  **WF or LS lead** |
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## Discussion on 2nd round

## Summary on 2nd round

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

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| **CR/TP/LS/WF number** | **T-doc Status update recommendation** |
| XXX | *Based on 2nd round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |
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