**3GPP TSG-RAN WG4 Meeting # 102-e R4-220XXXX**

**Electronic Meeting, Feb 21 - Mar 03, 2022**

**Agenda item:** 10.18.1, 10.18.2

**Source:** Moderator (China Telecom)

**Title:** Email discussion summary for [102-e][136] NR\_cov\_enh

**Document for:** Information

# Introduction

This email thread discusses the UE RF requirements for NR coverage enhancements WI in AI 8.18.1 and 8.18.2, including the following sub-topics:

* Sub-topic #1: Phase continuity tolerance
* Sub-topic #2: Maximum duration for DMRS bundling
* Sub-topic #3: Testing of phase tolerance requirements
* Sub-topic #4: Non-unscheduled gap in-between PUSCH/PUCCH transmissions
* Sub-topic #5: CR and work plan

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

* 1st round:
  + Invite comments on the recommended WF under each issue in section 1.2.
  + Aim to conclude Issue 2-1 (length of maximum duration) and Issue 4-1 (un-scheduled gap for extended CP).
* 2nd round: TBA

# Phase continuity for PUSCH and PUCCH transmissions

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2203818 | China Telecom | Title: Updated RAN4 RF work plan for NR coverage enhancements WI |
| R4-2203819 | China Telecom | Title: Non-zero un-scheduled gap in between PUSCH/PUCCH transmissions  **Proposal 1:** Clarify thatthe power for un-scheduled gap between slots in the same bundle can be either minimum output power (e.g., -40 dBm for small CBW) or some value in between the OFF power and minimum power.   * + Note: not to define new power requirements and just clarifies that the minimum ON power applies.   **Proposal 2:** For extended CP, 11-symbol is the maximum length for the non-zero un-scheduled gap in-between the PUSCH transmission or PUCCH repetition, when UE is required to maintain power consistency and phase continuity. |
| R4-2203820 | China Telecom | Title: On phase continuity tolerance for DMRS bundling  For the phase continuity tolerance:  **Observation 1:** Forphase offset option 1 with [-30, 30] degrees and phase offset option 2 with [-15, 15] degrees, the JCE performance is the same or very similar, in scenario of FR1 15 & 30 kHz SCS with 16 and 32 repetitions, and FR2 60Hz SCS with 16 repetitions.  **Observation 2:** JCE performance based onphase offset option 1 with [-30, 30] degrees is better than that of phase offset option 2 with [-15, 15] degrees, in scenario of FR2 60Hz SCS with 32 repetitions.  So, in general, if it is the truth that phase offset option 2 would better model the real UE behavior, we are fine with either phase offset option 1 or 2.  **Proposal 1:** Selecteither option 1 or option 2 in this meeting:   * + Option 1: [-30, 30] degrees with Phase offset Option 1   + Option 2: [-15, 15] degrees with Phase offset Option 2   For reference point for phase tolerance test:  **Proposal 2:** Selectoption 2 as the reference point for phase tolerance test:   * Option 2: The reference point would be between “Channel estimation” and “equalization”, since the amplitude and phase values can be taken directly from the channel estimation.   **Proposal 3:** For option 2 of the reference point, clarify that it applies to both DFT-s-OFDM and CP-OFDM waveforms, considering that DFT/IDFT is not applied to DMRS.  **Proposal 4:** For option 2 of the reference point, discuss whether only the channel estimation on DMRS symbols in each slot will be used to derive the phase value. |
| R4-2203821 | China Telecom | Title: On maximum duration for DMRS bundling  **Proposal 1:** For maximum duration for DMRS bundling,UE reports the single value per band from a set of 4 values including {5, 8, 16, 32} slots.  **Proposal 2:** Send thefinal values for maximum duration in the first week of this meeting, since the values will impact RAN1’s RRC parameter for TDW as well as the UE capability for maximum duration. |
| R4-2203822 | China Telecom | Title: 38.101-1 CR: UE RF requirements for DMRS bundling |
| R4-2203823 | China Telecom | Title: 38.101-2 CR: UE RF requirements for DMRS bundling |
| R4-2204818 | Huawei, HiSilicon | Title: On phase continuity for multiple transmissions  Observation: Noise has no impact to the test feasibility since it is relative rather than absolute phase offset that will be observed in the test whether non-accumulated or accumulated phase model is applied.  Proposal 1: Remove 32 slots from the max duration set, i.e., UE can report single value from {5, 8, 16} as per band capability of max duration.  Proposal 2: Adopt the following phase variation model:   * For each individual slot k (k=1…n) within the bundle, an independent offset is generated and applied with respect to the slot 0.   Proposal 3: Adopt [-30, 30] degrees for phase continuity tolerance. |
| R4-2204819 | Huawei, HiSilicon | Title: On maximum length for the non-zero un-scheduled gap  Proposal 1: Clarify that 11-symbol for extended CP is the maximum length for the non-zero un-scheduled gap in-between the PUSCH transmission or PUCCH repetition, when UE is required to maintain power consistency and phase continuity.  Proposal 2: Adopt the draft LS reply in Annex. |
| R4-2204820 | Huawei, HiSilicon | Title: Draft CR on UE RF requirements for DMRS bundling |
| R4-2204821 | Huawei, HiSilicon | Title: Draft CR on UE RF requirements for DMRS bundling |
| R4-2205528 | Ericsson | Title: On measurement of the TX coherent transmission  Proposal-1:Consider both DFT-s-OFDM and CP-OFDM in the RF test  Proposal-2:The option 2 should be used for correct test result.   * Option 2: Frequency correction in the JCE test is applied to the whole bundle. * For example, the frequency error is f1, the reference time slot is first time slot and the measured time slot is the second time slots. The first sample in the first symbol of the 2nd time slot need to be correct with f1\* one time slot\* 2pi. |
| R4-2205529 | Ericsson | Title: On JCE phase continuity and power consistency tolerance for PUCCH and PUSCH  Proposal-1: Use the option 1 of phase offset model.   * Phase offset Option 1: for each individual slot k (k=1…n) within the bundle, an independent offset is generated and applied with respect to the slot 0.   Proposal-2:Use the option 1b in the requirement/testing.   * Option 1: for slot #n, define the relative phase tolerance, relative power tolerance explicitly, i.e., separate requirements for phase and power offsets.   + Option 1b: relative to slot #0 and define maximum duration explicitly.   Proposal-3:The rms value should be used in the requirement and measurement   * Difference of relative phase error in RMS is 17 degrees   Proposal-4:Define the measurement interval of 1 time slot.  Proposal-5:Discuss if the [10] bundles should be repeated for the test.  Proposal-6: New TDD pattern of DDSUU is needed for phase continuity tolerance requirement for TDD band.  Proposal-7:RB allocation at the band edge could be exempt from UE phase requirement.  Proposal-8:Add a note on the transmission bandwidths for UE phase continuity tolerance measurement be confined within FUL\_low + 4 MHz to FUL\_high – 4 MHz .  Proposal-9:RAN4 discuss the above requirement text. |
| R4-2205530 | Ericsson | Title: RF impact on non-scheduled gap  Observation 1 RF requirement could be similar for un-scheduled gap and “DL time slot between the repetition”  Observation 2 RAN4 has not discussed the solution of the switching OFF the TX chain during the un-schudeld gap due to non consensus on the phase tolerance.  Proposal-1: LS to Ran1 if no consensus reached within RAN4. |
| R4-2205531 | Ericsson | Title: simulation updated results for phase tolerance for PUSCH repetition  Observation 1 Phase model of option 2 has worse JCE performance compared with phase offset modeling of option 1 for the phase offset range. |
| R4-2205532 | Ericsson | Title: LS reply on DMRS bundling for PUSCH and PUCCH  Proposal: Reply to RAN1 considering the RF requirement discussion for un-scheduled gap and treat 11-symbol extended CP case the same as the 13-symbol normal CP case. |
| R4-2205533 | Ericsson | Title: CR on measurment for DMRS bundling in TS 38.101-1 |
| R4-2205534 | Ericsson | Title: CR on measurment for DMRS bundling in TS 38.101-2 |
| R4-2205535 | Ericsson | Title: CR on phase tolerance for DMRS bundling in TS 38.101-1 |
| R4-2205536 | Ericsson | Title: CR on phase tolerance for DMRS bundling in TS 38.101-2 |
| R4-2205537 | Ericsson | Title: LS reply On maximum duration of phase continuity and power consistency for PUCCH and PUSCH repetition |
| R4-2205882 | Qualcomm Incorporated | Title: Discussion on UE phase discontinuity requirement  Proposal 1: The option 2 with phase of slot n will be referred to slot n-1 when setting the requirements for JCE  Observation 1: Link simulation results should be analysed reflecting the latest agreements how to set the UE requirements  Proposal 2: The requirement for phase discontinuity with the agreed assumptions is +/- 40 deg and phase is referred to the previous slot.  Observation 2: The phase discontinuity test criteria should be agreed, is it based on maximum declared UE capability or something else?  Observation 3: Sum of scheduled PUSCH/PUCCH symbols with number of GAP symbols should equal = 14.  Observation 4: The 11 symbol gap with extended CP is shorter than 13 symbol gap with normal CP.  Proposal 3: Respond to RAN1 that the maximum duration with 11 symbols gap with extended CP is within the agreed maximum duration and maximum gap length agreements. |
| R4-2206014 | Apple | Title: On phase continuity requirement with coverage enhancement  Observation 1: If it can be assumed that no other UL channel is scheduled to be transmitted during the gap, then previous agreements on constant RB allocation, constant output power, and same modulation order over the JCE duration seem to be violated. The simplest way forward seems to preclude network behavior which could configure the UE with such a gap.  Observation 2: In the context of the Option 1 definition of phase continuity tolerance, 3GPP specifications should clearly preclude the suboptimal BS implementation, where DMRS from slot0 is used to demodulate all N of the JCE slots.  Observation 3: In the context of long JCE durations (e.g. 16 and 32 slots), Option 2 might not adequately ensure phase continuity over the entire duration.  Proposal 1: RAN4 should confirm to RAN1 that the length of maximum duration for JCE is a UE capability, with the possible values being {5, 8, 16, 32} slots.  Proposal 2: RAN4 shall not introduce new transmit off power for the non-zero gap in-between PUSCH/PUCCH transmissions, and no requirement applies during the gap  Proposal 3: RAN4 should discuss the impact of Option 1 and 2 together with the tolerance values and JCE duration as a package, and differentiation of the requirement as a function of UE capability on JCE duration should be possible.  Proposal 4: RAN4 should discuss how to capture the above side conditions in the definitions of the applicable requirements. |
| R4-2206131 | MediaTek (Chengdu) Inc. | Title: Coverage enhancements – remaining UE RF requirements aspects  Proposal 1: Agree Option 1. RAN4 do not introduce new transmit off power, i.e., no requirement applies during the non-zero gap.  Proposal 2: Improve the agreement on frequency correction by TE from RAN4#101bis-e, such that “the level of correction required shall be estimated in every slot by the TE”.  Observation 1: There seems to be an “unknown” error component in terms of phase error due to residual frequency error after frequency error correction at the TE. As phase error may increase with time due to frequency error, the magnitude of absolute level of any residual error may increase as bundle size increases.  Proposal 3: There should be no additional restrictions put on UE behaviour regarding frequency adjustments compared to existing specifications.  Proposal 4: Confirmation is required that the TE DL signal frequency shall not change during the JCE test.  Proposal 5: Select Option 2 phase model.  Proposal 6: For Option 2 phase model, agree a phase tolerance of ±20 degrees for bundle sizes of ≤8 slots.  Proposal 7: DL signal timing shall be maintained constant by the TE during the test case.  Observation 2: All of these potential events may occur, and restricting the UE operation may lead to adverse side-effects that counter-act the benefits of JCE.  Proposal 8: Consider exceptions to Gradual Timing Adjustment due to prevention of autonomous changes to UL timing at the UE during a JCE bundle.  Proposal 9: Add a note to the spec to reflect the following: “NOTE: In practical field conditions, the need for the UE to autonomously adjust frequency and power to maintain the radio uplink baseline performance may impact phase continuity in some scenarios. The UE reported capability is not required to take the potential presence of such events into account.”  Proposal 10: Remove at least the value “32” from the list of maximum duration UE capabilities, and preferably also 16 slots. |

## Open issues summary

### Sub-topic #1: Phase continuity tolerance

#### **Issue 1-1: Phase continuity tolerance**

* *RAN4 #101e-bis agreement (in WF R4-2202418)*
  + *Down select between the following two options:*
    - *Option 1: Adopt [-30, 30] degrees if Phase offset Option 1 is agreed.*
      * *Phase offset Option 1: for each individual slot k (k=1…n) within the bundle, an independent offset is generated and applied with respect to the slot 0.*
    - *Option 2: Adopt [-15, 15] degrees if Phase offset Option 2 is agreed.*
      * *Phase offset Option 2: for each individual slot k (k=1…n) within the bundle, an independent offset is generated and applied with respect to the slot k-1. (i.e., the offset is allowed to accumulate).*
* **Proposals** 
  + Option 1: Use phase offset option 1 with the following tolerance (China Telecom, HW, E///)
    - Option 1A: [-30, 30] degrees (China Telecom, HW, E///)
  + Option 2: Use phase offset option 2 with the following tolerance (China Telecom, MTK, QC)
    - Option 2A: [-15, 15] degrees (China Telecom)
    - Option 2B: [-20, 20] degrees for bundle sizes of ≤ 8 slots (MTK)
    - Option 2C: [-40, 40] degrees (Qualcomm)
  + Related issues on the selection of phase offset model
    - Bundle size:
      * Apple: RAN4 should discuss the impact of Option 1 and 2 together with the tolerance values and JCE duration as a package, and differentiation of the requirement as a function of UE capability on JCE duration should be possible.
    - Performance impact:
      * China Telecom: For phase offset option 1 with [-30, 30] degrees and phase offset option 2 with [-15, 15] degrees, the JCE performance is the same or very similar, in scenario of FR1 15 & 30 kHz SCS with 16 and 32 repetitions, and FR2 60Hz SCS with 16 repetitions.
      * E///: Phase model of option 2 has worse JCE performance compared with phase offset modeling of option 1 for the phase offset range.
* **Recommended WF**
  + Further discuss, and compromised proposal with different tolerances for <= 8 slots and > slots is not precluded.

Discussion in GTW:

MTK: we are happy with Option 2, which is the way UE sees the phase error. Need more discussion on the numbers especially on the consecutive slots.

China Telecom: From our simulation results, Option 1A and Option 2A provide the similar performance. In last meeting, we agreed to down-select. We would like to down-select to 1A and 2A. We need to agree on the numbers since it is the last meeting. Majority companies submitted results in January meeting.

Qualcomm:

Apple: consider both options with the tolerance numbers. For larger number of slots, we consider 1A and consider 2A for smaller number of slots. 8 slots should be the boundary.

Huawei: Option 1 is uniform distribution is better than Option 2. The phase noise will be increased if larger slot is used.

Ericsson: We use two options to derive the requirements. We have no measurement to show Option 2 reflects UE behavior better. The randomness of phase behavior is similar to the old behavior. So we still prefer to Option 1.

Qualcomm: We would like to avoid. Option 2 comes from UE behavior. We are assuming the join channel estimation and see the link level simulation. We would like to avoid always using the first slot for channel estimation.

Ericsson: The JCE gain from all of companies over the non-JCE is not the same. The alignment is not good. It is not possible to use 1dB gain loss to set SNR criterion to set the phase tolerance. If you have less JCE gain, you cannot afford more gain loss. This is our understanding that different companies will have different curves and numbers according to their simulation.

Qualcomm: We do not fully understand comment, since we agreed the simulation assumptions.

China Telecom: the Ericsson results are different because of different repetition numbers. Regarding phase offset Option 2, we would like to know what the acceptable number is.

Ericsson: prefer to Apple proposal.

Mediatek: when there is residual of frequency error, if we choose Option 1 the residual phase error would be larger. The other option is to limit the residual phase error.

Qualcomm: if we go with Option1, UE has store the phase in the first slot and then do some correction for the following slots. Option 2 comes from the real UE design.

Ericsson: when we choosing the phase tolerance we should not consider the frequency error. In the last meeting, we agreed that frequency error can be corrected.

**Agreement:**

* Use Option 2 as baseline to define the requirements for repetition number less than or equal to 8
  + Decide the number of phase tolerance according to the <1-dB performance degradation (simulation results with phase tolerance over simulation results without phase tolerance under assumption of JCE at receiver) based on the existing simulation results.
    - The different numbers of phase tolerance will apply depending on the repetition numbers.
* For the larger repetition number (>8), if the repetition number is larger than 8, need deciding on which approach will be taken in this meeting.
  + Alt 1: take Option 1
  + Alt 2: take Option 2
  + Alt 3: take both Option 1 and Option 2

Email discussion after GTW:

* **Recommended WF**
  + Based on the agreements in GTW session, companies are encouraged to provide further inputs in round 1:
    - Phase continuity tolerances and the corresponding performance degradations with phase offset option 2 for the repetition of 5 and 8 slots respectively.
    - For the repetition of 16 slots, the acceptable alternative(s) (i.e., option 1, option 2, or option 1+2) together with the phase continuity tolerance & performance degradation.
  + For the repetition of 32 slots, further discuss pending on the agreement on maximum duration

|  |  |
| --- | --- |
| **Company** | **Comments** |
|  | |  |  |  |  | | --- | --- | --- | --- | | **Number of repetitions** | **Proposed phase continuity tolerance with phase offset option 2** | **SNR degradation w.r.t. no phase offset** | **SNR gain w.r.t. no JCE (Optional)** | | 5 slots |  |  |  | | 8 slots |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Number of repetitions** | **Acceptable alternative(s) (i.e., option 1, option 2, or option 1+2)** | **Proposed phase continuity tolerance** | **SNR degradation w.r.t. no phase offset** | **SNR gain w.r.t. no JCE (Optional)** | | 16 slots | Option 1: acceptable or not? |  |  |  | | Option 2: acceptable or not? |  |  |  | | Option 1+2: acceptable or not? |  |  |  | | [32 slots] | Option 1: acceptable or not? |  |  |  | | Option 2: acceptable or not? |  |  |  | | Option 1+2: acceptable or not? |  |  |  | |
|  | |  |  |  |  | | --- | --- | --- | --- | | **Number of repetitions** | **Proposed phase continuity tolerance with phase offset option 2** | **SNR degradation w.r.t. no phase offset** | **SNR gain w.r.t. no JCE (Optional)** | | 5 slots |  |  |  | | 8 slots |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Number of repetitions** | **Acceptable alternative(s) (i.e., option 1, option 2, or option 1+2)** | **Proposed phase continuity tolerance** | **SNR degradation w.r.t. no phase offset** | **SNR gain w.r.t. no JCE (Optional)** | | 16 slots | Option 1: acceptable or not? |  |  |  | | Option 2: acceptable or not? |  |  |  | | Option 1+2: acceptable or not? |  |  |  | | [32 slots] | Option 1: acceptable or not? |  |  |  | | Option 2: acceptable or not? |  |  |  | | Option 1+2: acceptable or not? |  |  |  | |
| China Telecom | Considering the existing simulation results, for phase offset option 2, we only simulated 16 slots and 32 slots, and the simulation results are as below: (taking 15kHz SCS as example):   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Number of repetitions** | **Acceptable alternative(s) (i.e., option 1, option 2, or option 1+2)** | **Proposed phase continuity tolerance** | **SNR degradation w.r.t. no phase offset** | **SNR gain w.r.t. no JCE (Optional)** | | 16 slots | Option 1: acceptable to us | [-30, 30] or [-40, 40] degrees | 0.7 to 0.8 dB | 2.4 to 2.5 dB | | Option 2: acceptable to us | [-15, 15] or [-20, 20] degrees | 0.7 to 0.8 dB | 2.4 to 2.5 dB | | Option 1+2: seems more complicated compared to only selecting one option |  |  |  | | [32 slots] | Option 1: acceptable to us | [-30, 30] degrees | 0.9 dB | 1.7 dB | | Option 2: acceptable to us | [-15, 15] degrees | 1 dB | 1.6 dB | | Option 1+2: seems more complicated compared to only selecting one option |  |  |  |   Since we need to complete the WI in this meeting, we are trying to provide additional simulation results for 5 and 8 slots with phase offset option 2 during the this week. Will come back to this issue later. |
| Ericsson | According to GTW, it seems the phase tolerance could be specified with <= 8ms and > 8ms & < =32ms. Our understanding on previous WF is that one phase tolerance for any maximum duration <= 32 ms. It seems there is no need to simulate lower maximum duration and requirement could be derived based on what simulation results from companies in simulation results document.  We think it may be easier to continue on such principle from previous meetings and we donot see any harm on this.  For the maximum duration > 8ms case, phase model option 1 is preferred for us. Thus the phase tolerance for the case 16ms, 32ms, is [- 30, 30].  For the maximum duration <= 8ms, we donot see phase model option 2 is worse, thus the phase tolerance can be [-30, 30]. |
| Apple | We think the Moderator's proposal to discuss differentiation of tolerances/options for ≤ 8 slots and > 8 slots is a good starting point. For example, we could consider Option 1 for the case of > 8 slots and Option 2 for the case of ≤ 8 slots. |
| China Telecom 2 | More simulation results for 5 and 8 repetitions added:   |  |  |  |  | | --- | --- | --- | --- | | **Number of repetitions** | **Proposed phase continuity tolerance with phase offset option 2** | **SNR degradation w.r.t. no phase offset** | **SNR gain w.r.t. no JCE (Optional)** | | 5 slots | [-30, 30] degrees | 0.4 dB | 2 dB | | 8 slots | [-25, 25] degrees | 0.8 dB | 2.1 dB | |
| Huawei | For > 8 slots case, prefer to consider the agreed WF in last meeting, which is phase model option 1 with [-30, 30]. As for <= 8 slots case, we can go with option 2 phase model with [-25, 25]. |

#### **Issue 1-1A: Degradation due to UE non-ideality based on Link simulation results**

According to WF R4-2120003:

Agreement in GTW:

* Criterion to derive the tolerance:
  + The degradation of performance for case with phase offset over case without phase offset.
  + The performance gain of using joint channel estimation over not using joint channel estimation when phase offset is modeled.

Options discussed in R4-2205882

* Option 1: 10-1 BLER CINR degradation 1 dB
* Option 2: Other?

Issue 1-1A: Results collection:

* In R4-2205882, with option 2: 40 deg for 8 slots (QC)

Chart

Description automatically generated

* In R4-2203820 (and referring to R4-2200022 submitted in RAN4 #101e-bis) (China Telecom)
  + Observation 1: When option 1 phase offset model is used, the tolerable phase offset is [20, 30] degrees, in scenario of FR1 15 & 30 kHz, FR2 60 kHz, and with 16 and 32 repetitions.
  + Observation 2: When option 2 phase offset model is used, the tolerable phase offset is [10, 15] degrees, in scenario of FR1 15 & 30 kHz with 16 and 32 repetitions, and FR2 60Hz with 16 repetitions.

Table 2. SNR at 2% BLER, **FR1 15 kHz SCS, 16 repetitions**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Phase offset** | | **SNR (dB)** | | | |
| **Phase offset option 1** | | **Phase offset option 2** | |
| **Required SNR** | **Delta SNR** | **Required SNR** | **Delta SNR** |
| Without JCE | | -2.8 | N.A. | -2.8 | N.A. |
| JCE | 0° | -6.0 | Baseline | -6.0 | Baseline |
| 5° |  |  | -5.8 | -0.2 |
| 10° | -5.7 | 0.3 | -5.4 | 0.6 |
| 15° |  |  | -5.3 | 0.7 |
| 20° | -5.5 | 0.5 | -5.2 | 0.8 |
| 30° | -5.3 | 0.7 |  |  |
| 40° | -5.2 | 0.8 |  |  |

Table 3. SNR at 2% BLER, **FR1 15 kHz SCS, 32 repetitions**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Phase offset** | | **SNR (dB)** | | | |
| **Phase offset option 1** | | **Phase offset option 2** | |
| **Required SNR** | **Delta SNR** | **Required SNR** | **Delta SNR** |
| Without JCE | | -6.2 | N.A. | -6.2 | N.A. |
| JCE | 0° | -8.8 | Baseline | -8.8 | Baseline |
| 5° |  |  | -8.3 | 0.5 |
| 10° | -8.8 | 0 | -8 | 0.8 |
| 15° |  |  | -7.8 | 1 |
| 20° | -8.5 | 0.3 | -7.4 | 1.4 |
| 30° | -7.9 | 0.9 |  |  |
| 40° | -7.5 | 1.3 |  |  |

Table 4. SNR at 2% BLER, **FR1 30 kHz SCS, 16 repetitions**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Phase offset** | | **SNR (dB)** | | | |
| **Phase offset option 1** | | **Phase offset option 2** | |
| **Required SNR** | **Delta SNR** | **Required SNR** | **Delta SNR** |
| Without JCE | | -3.1 | N.A. | -3.1 | N.A. |
| JCE | 0° | -6.2 | Baseline | -6.2 | Baseline |
| 5° |  |  | -6.1 | 0.1 |
| 10° | -6 | 0.2 | -5.9 | 0.3 |
| 15° |  |  | -5.6 | 0.6 |
| 20° | -5.8 | 0.4 | -5.4 | 0.8 |
| 30° | -5.6 | 0.6 |  |  |
| 40° | -5.4 | 0.8 |  |  |

Table 5. SNR at 2% BLER, **FR1 30 kHz SCS, 32 repetitions**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Phase offset** | | **SNR (dB)** | | | |
| **Phase offset option 1** | | **Phase offset option 2** | |
| **Required SNR** | **Delta SNR** | **Required SNR** | **Delta SNR** |
| Without JCE | | -6.2 | N.A. | -6.2 | N.A. |
| JCE | 0° | -9.1 | Baseline | -9.1 | Baseline |
| 5° |  |  | -8.7 | 0.4 |
| 10° | -8.9 | 0.2 | -8.6 | 0.5 |
| 15° |  |  | -8.5 | 0.6 |
| 20° | -8.7 | 0.4 | -8.2 | 0.9 |
| 30° | -8.6 | 0.6 |  |  |
| 40° | -8.2 | 0.9 |  |  |

Table 6. SNR at 2% BLER, **FR2 60 kHz SCS, 16 repetitions**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Phase offset** | | **SNR (dB)** | | | |
| **Phase offset option 1** | | **Phase offset option 2** | |
| **Required SNR** | **Delta SNR** | **Required SNR** | **Delta SNR** |
| Without JCE | | -4.7 | N.A. | -4.7 | N.A. |
| JCE | 0° | -5.7 | Baseline | -5.7 | Baseline |
| 5° |  |  | -5.7 | 0 |
| 10° | -5.7 | 0 | -5.6 | 0.1 |
| 15° |  |  | -5.5 | 0.2 |
| 20° | -5.5 | 0.2 | -5.3 | 0.4 |
| 30° | -5.4 | 0.3 |  |  |
| 40° | -5.3 | 0.4 |  |  |

Table 7. SNR at 2% BLER, **FR2 60 kHz SCS, 32 repetitions**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Phase offset** | | **SNR (dB)** | | | |
| **Phase offset option 1** | | **Phase offset option 2** | |
| **Required SNR** | **Delta SNR** | **Required SNR** | **Delta SNR** |
| Without JCE | | -7.8 | N.A. | -7.8 | N.A. |
| JCE | 0° | -7.4 | Baseline | -7.4 | Baseline |
| 5° |  |  | -5.2 | 2 |
| 10° | -7.2 | 0.2 | -3.8 | 3.6 |
| 15° |  |  | -3.6 | 3.8 |
| 20° | -7.2 | 0.2 | -3.5 | 3.9 |
| 30° | -7.1 | 0.3 |  |  |
| 40° | -6.9 | 0.5 |  |  |

* Other proposals based on the simulation results submitted to RAN4 #101e-bis (summarized under Issue 1-2 in RAN4 #101e-bis moderator summary R4-2202330)
* **Proposals on phase continuity tolerance for option 1 phase offset model** 
  + Option 1: [-20, 20] degrees (China Telecom, QC)
  + Option 2: [-30, 30] degrees (China Telecom, Huawei)
  + Option 3: [-35, 35] degrees (E///)
  + Option 4: [-40, 40] degrees (Sony)
* **Proposals on phase continuity tolerance for option 2 phase offset model** 
  + Option 1: [-10, 10] degrees (China Telecom)
  + Option 2: [-15, 15] degrees (China Telecom, [HW])
  + Option 3: [-20, 20] degrees (QC)
  + Option 4: [-35, 35] degrees (E///)
  + Option 5: [-40, 40] degrees (Sony)
* **Recommended WF**
  + Merged with Issue 1-1. No further discussion for Issue 1-1A.

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| **Company** | **Comments** |
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#### **Issue 1-2: RMS average for phase tolerance**

* **Proposals** 
  + Option 1: The rms value should be used for different slots in the bundle, and difference of relative phase error in RMS is 17 degrees (E///)
    - Note: 17 degrees is derived under the assumption of [-30, 30] degrees with phase offset option 1.

**Discussion in GTW:**

MTK: in the simulation, we agreed the uniform distribution. You need a lot of number of samples to come up with the number.

Qualcomm: aligned with MTK. We agreed with uniform value. We would like to go with maximum value.

Apple: How would rms be measured? We agree with MTK and Qualcomm. It is late to consider it.

Huawei: regarding rms value, it is related to sampling numbers, which TE choose. In our understanding, the only value that we can agreed on for the first issue is enough. We do not need rms value.

Ericsson: rms value is providing the good measurement to reflect the good UE performance.

Email discussion after GTW:

* **Recommended WF**
  + Given the situation in Monday GTW session, it is moderator understanding that the RMS average will not be used unless it is acceptable to all companies during round 1 email discussion. Further discussion and clarification are encouraged.

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| **Company** | **Comments** |
| Ericsson | During the GTW, it seems the most companies understanding is to use the maximum value of measurement data set. For example, within one bundle, if the measurement data set is [ -10, -5, 5, 10, 15, 40, 20], the measurement is 40 degree and such UE will fail the requirement if requirement is [-30, 30]. ‘  The key point is for discussion of different metric is that it does not make sense to fail UE if one of measurement point not fulfill the requirement. After all, the phase offset model used in system simulation is the statistical model.  Our view is that to avoid the unnecessary UE test fail a good UE, the requirement itself should measure the statistical characteristic of the measurement data set. Then we think there are different options on the table   1. RMS (standard deviation) 2. Average (mean of the measurement data) 3. CDF pencentitle ( mentioned in GTW ?) 4. Others?   RMS metric has been used in EVM so it is not new thing. As the mean of phase offset modeling is zero so it cannot be used to differentiate two UE performance. We are open to discussion. |
| China Telecom | Thanks E/// for the detailed explanation.  Our understanding is that, for all the samples, the phase delta should be within the specified tolerance. |
| Apple | How would RMS average of phase tolerance be measured? Would test equipment be capable of using all available DMRS in a JCE window for demodulation? |
| Huawei | Still don’t see the need to introduce RMS transform. Only the outcome requirements of Issue 1-1 is enough for test. |
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### Sub-topic #2: Maximum duration for DMRS bundling

#### **Issue 2-1: Length of maximum duration**

* *RAN4 #101e-bis agreement (in RAN4 LS R4-2202368)*
  + *UE reports the single value per band from a set of up to 4 values, and RAN4 does not consider the value more than 32 slots for the capability for maximum duration. Values RAN4 being considered are 5, 8, 16 or 32 slots.*
* **Proposals on the set of values (for per band UE reporting)**
  + Option 1: {5, 8, 16, 32} slots (CTC, Apple)
  + Option 2: {5, 8, 16} slots (HW, MTK)
  + Option 3: {5, 8} slots (MTK)
  + Option 4: 32ms in FDD band and at least 8ms for TDD band (Ericsson)
* **Time to send the values to RAN1**
  + Option 1: Send thefinal values for maximum duration **in the first week of this meeting**, since the values will impact RAN1’s RRC parameter for TDW as well as the UE capability for maximum duration. (CTC)

***Related RAN1 Agreement on RRC parameter***

* + - * The value range of *PUSCH-TimeDomainWindowLength* is INTEGER (2..[32]).
      * The value range of *PUCCH-TimeDomainWindowLength* is INTEGER (2..[8]).

Note: the value shall not exceed the maximum duration.

* **Recommended WF**
  + On the set of values (for per band UE reporting)
    - Agree option 2?

Discussion in GTW:

Apple: keep option 1 alive. 32 slot is valid. 32 slot is only applicable to FDD band.

Qualcomm: prefer to Option 3.

Mediatek: Prefer to Option 3. For TDD, there seems no way to go beyond 8.

Nokia: Go for Option 1. Keep 32 for both TDD and FDD.

China Telecom: Option 2.

Huawei: prefer Option 2.

Ericsson: prefer to separate FDD and TDD. For TDD, {8, 16}, for FDD {5, 8, 16, 32}

Mediatek: people prefer to remove >8 for TDD. UE should reset the phase.

Agreement: For UE capability, the set of values of duration lengths are

* For TDD, {5, 8}
  + FFS: 16
* For FDD, {5, 8, 16, [32]}
  + Time to send the values to RAN1
    - Agree option 1?

Email discussion after GTW:

* **Recommended WF**
  + With the aim to conclude this issue in the first week, moderator proposes to remove the numbers with FFS or [], i.e.,

For per band UE capability on length of maximum duration, the set of values of duration lengths are

* For TDD: {5, 8} slots
* For FDD: {5, 8, 16} slots
  + Meanwhile, proponents of 16 slots for TDD and 32 slots for FDD are highly encouraged to elaborate the motivation as early as possible, so that there would be a chance for companies to further consider it.

NOTE: A sub-thread will be created to discuss this issue in week 1, i.e., companies’ comments to be provided in a dedicated sub-thread instead of this document.

### Sub-topic #3: Testing of phase tolerance requirements

#### **Issue 3-1: Frequency correction for phase tolerance test**

* *RAN4 #101e-bis agreement (in WF R4-2202418)*
  + *The common frequency error of UE should be corrected at test equipment per slot basis in the way similar to that done in EVM testing.*
* Proposals
  + Proposal 1: Improve the agreement on frequency correction by TE from RAN4#101bis-e, such that “the level of correction required shall be estimated in every slot by the TE”. (MTK)
  + Proposal 2: Frequency correction in the JCE test is applied to the whole bundle. (E///)
    - E///: For example, the frequency error is f1, the reference time slot is first time slot and the measured time slot is the second time slots. The first sample in the first symbol of the 2nd time slot need to be correct with f1\* one time slot\* 2pi. (E/// CR in R4-2205533)

Discussion in GTW:

Ericsson: Proposal 1 and 2 do not contradict. We can further discuss it in this meeting.

Qualcomm: Estimation is done in the whole bundling and do correction per slot would not be acceptable way.

Mediatek: agree with Qualcomm. We do not agree with Proposal 2.

R&S: we share the same view as MTK and Qualcomm. Proposal 2 goes against the previous proposal.

Apple: proposal 1 is well aligned with the previous proposal.

Agreement: The level of correction required shall be estimated in every slot by the TE.

* FFS on proposal 2 in this meeting.

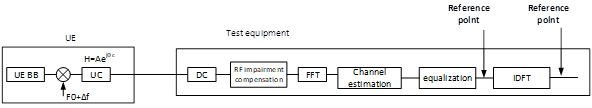
Email discussion after GTW:

* **Recommended WF**
  + Proponent of proposal 2 is encouraged to elaborate the motivation and how it could be reflected in the CR on measurement.

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| **Company** | **Comments** |
| Ericsson | The phase error caused by frequency error is accumulating from the reference time slot to the measurement time slot as the picture shows above. In DMRS bundling phase tolerance test, the phase error caused by frequency error should be corrected not only within the reference time slot but also in measured time slot. This is to make sure the phase error caused by frequency error is fully corrected and not become part of the measured phase offset. A simple way to view this is to defining a “bigger time slot” by concatenating all bundled time slots so there are n\*14 symbols within “this bigger time slot”. Then frequency error correction will be done over n\*14 symbols before the FFT is taken place, namely the frequency error is done in time domain as it is done in legacy EVM testing.  This part is reflected in CR part text below:  *The post-FFT modulated signal before the equalization is modified according to:*  *where*  *is the time domain samples of the signal under test within the bundled time slots.*  *is the RF frequency offset.*  Currently the is the frequency offset as the legacy in one time slot. In case of the MTK proposal 1, this means the frequency offset may be different and the equation above needs to be modified. As the frequency error correction at least related to the measurement time slot and reference time slot, it is then the question how the phase offset is measured? We have discussed two options, relative to the previous time slot or relative to the first time slot, it impacts how the equation should be formulated. Therefore, it needs to discuss these measurement methods to finalize the CR for measurement:   1. relative to slot #n-1. 2. relative to slot #0 |
| China Telecom | Appreciate E/// for the detailed explanation.  We understand the motivation is to mitigate the accumulated phase change (from previous slots in the bundle) due to the frequency error. We think this accumulated phase change need to be mitigated, otherwise the UE can not fulfill the defined phase tolerance requirements. |
| Apple | **Issue 2-1: Length of maximum duration**  We agree with company comments that 32 slots bundling window for TDD bands does not make sense. We are fine to proceed with the agreement captured in GTW. For the sake of progress, we can accept the UE capability as follows:  For TDD, {5, 8, 16}  For FDD, {5, 8, 16, 32}  We also would like to seek a common understanding on the meaning of "bundling window." Referring to the RAN4 LS to RAN1 in R4-2103393, the following is the RAN4 understanding (bold emphasis added):  • Question 1: Under what conditions UE can keep phase continuity cross PUCCH or PUSCH repetitions?  o Modulation order does not change.  o 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.  o **No change on transmission power level** of its own CC, i.e., no change on the power control parameters specified in TS 38.213, and also when own CC is not impacted by other concurrent CC(s) that are configured for inter-band CA or DC for same UE with dynamic power sharing and no change in any configured CC s that are part of configured intra-band uplink CA or DC.  o No UL beam switching for FR2 UE occurs  • Question 2: Whether back-to-back PUCCH or PUSCH repetitions is one of the conditions required to keep phase continuity cross the repetitions.  • RAN4 Answer for question 2:  o For back-to-back transmissions with zero gap in-between adjacent transmissions, the conditions under Q1 need to be met to maintain phase continuity.  o **For non-back-to-back transmission with non-zero gap in-between adjacent transmissions**, RAN4 concluded that at least following additional condition also need to be met in addition to the conditions under Q1:   **No downlink reception in-between the PUSCH or PUCCH repetition in the same band for TDD case**  o In scenario of no more than X un-scheduled OFDM symbols in-between the PUSCH or PUCCH repetition (e.g., X = 0, 1, 2, …, 14), and 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, RAN4 is still discussing if X can be non-zero value and UE can maintain phase continuity  In our understanding, this means that the UE capability of "bundling window" refers only to the number of consecutive UL slots within the UL/DL configuration of the TDD band. For example, if the UL/DL configuration is 7DSUU, and the UE signals support for 5 slots "bundling window," then the network can only utilize the UE capability up to 2 slots, since then the UE would need to switch to DL reception and lower its output power before transmitting two more slots in the next repetition of the UL/DL pattern. Both of these actions violate the conditions RAN4 set down in the aforementioned LS to RAN1. From this perspective, the feasibility of 16 slots for a TDD band "bundling window" seems very remote, although having the capability in the ASN.1 can certainly build in forward compatibility in the specification.  **Issue 3-1: Frequency correction for phase tolerance test**  Last meeting we had agreed the following:  "The common frequency error of UE should be corrected at test equipment per slot basis in the way similar to that done in EVM testing."  We believe that Proposal 1 is well aligned with this agreement. |
| Qualcomm | Issue 3-1: It is unclear why Ericsson wants to define a big slot out of the bundle but then does not want to do channel estimate over the whole bundle. And how would this one frequency correction work since reference time slot changes for every measured slot?  Maybe it would be good to detail the agreement from last meeting as follows:  "The common frequency error of UE should be corrected at test equipment per slot basis based on frequency error estimate from same slot in the way similar to that done in EVM testing." |
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#### **Issue 3-2: Reference point for phase tolerance test**

* *Candidate options in RAN4 #101e-bis (in WF R4-2203818)*
  + *Option 1: Define the reference point for phase/amplitude tolerance requirement in Figure 1 for both options of defining RF requirements in Issue 3-1.*



* + *Option 2: The reference point would be between “Channel estimation” and “equalization”, since the amplitude and phase values can be taken directly from the channel estimation.*
  + *Option 3:* 
    - *For testing phase and power offset: Reference point to calculate the phase continuity and power consistency is after IDFT (time domain).*
    - *For testing EVM: Before IDFT for CP-OFDM case. After IDFT for DFT-s-OFDM case.*
* Proposals
  + Option 2: The reference point would be between “Channel estimation” and “equalization”, since the amplitude and phase values can be taken directly from the channel estimation. (China Telecom, E///)
* **Recommended WF**
  + Agree option 2?

Agreement: agree Option 2.

Email discussion after GTW:

No further discussion, and capture the agreement in the measurement CR.

#### **Issue 3-3: DFT-s-OFDM and CP-OFDM waveforms for testing**

* Proposals
  + Option 1: Test both DFT-s-OFDM and CP-OFDM (China Telecom, E///)
    - China Telecom: For option 2 of the reference point in Issue 3-2, clarify that it applies to both DFT-s-OFDM and CP-OFDM waveforms, considering that DFT/IDFT is not applied to DMRS. (China Telecom)
* **Recommended WF**
  + Agree option 1?

Discussion in GTW:

China Telecom: we can only test CP-OFDM. This is just for testing.

Ericsson: we would like to choose DFT-s-OFDM.

Qualcomm: DFT-s-OFDM is the only meaningful here. We are OK to test both.

Agreement: The core requirement will cover both DFT-s-OFDM and CP-OFDM.

* For the test, only choose DFT-s-OFDM for testing.

Email discussion after GTW:

No further discussion, and capture the agreement in the CRs on requirements and measurement.

#### **Issue 3-4: OFDM symbols for deriving the phase value**

* Proposals:
  + For option 2 of the reference point in Issue 3-2, discuss whether only the channel estimation on DMRS symbols in each slot will be used to derive the phase value. (China Telecom)
    - Option 1: Use the channel estimation on DMRS symbols in each slot (E/// CR in R4-2205533)

Discussion in GTW:

R&S: let us do it as EVM. There is no need to restrict to DMRS. We just reuse the existing procedure.

Ericson: we check that channel estimation is just to use DMRS. On top of that, we have agreed the reference point. If we want to use the data, we force to use other reference point to equalize the data. We may be consistent on the measurement.

China Telecom: tend to agree with Ericsson. We derive the phase based on the estimated channel. No big difference from measurement perspective. DMRS would be enough.

Qualcomm: need clarify what is the intention by saying “channel estimation on DMRS symbols”.

China Telecom: we are talking about using DMRS REs.

R&S: from our perspective, the channel estimation is done for data and DMRS. We prefer the existing approach.

Apple: we want to rephrase the proposal here. We propose the side condition that the network is expected to use all the DMRS symbols within the JCE window to estimation the channel.

Ericsson: the side condition should be for UE side. We are setting the UE requirement.

Tentative agreement: To derive the requirement for phase value, assume that the DMRS REs within the window will be used.

Email discussion after GTW:

* Further check if the above tentative agreement is agreeable.

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| **Company** | **Comments** |
| China Telecom | We are ok with the tentative agreement.  To TE experts:  According to the discussion in GTW, in the existing TE the channel estimation is done for data REs as well. But we think this does not conflict with the tentative agreement. Since in the next step on deriving phase value (after channel estimation), we can just use the estimated channel from the DMRS REs. |
| Rohde & Schwarz | Since this is also part of the Ericsson CR in 5533 we would like to comment on this issue based on what is proposed in the CR:  From our point of view, we can simplify the needed changes in the spec to large degree. From the current spec in Annex F.4 it is already defined how to get the phase response  for a given slot, at  (also this means there is no phaseoffset\_l and phaseoffset\_h as proposed by Ericsson). This is based on data and DMRS symbols and there is no need to redefine this measurement for this requirement as measurement based solely on DMRS.  After determining for each slot (or the 2 slots you want to compare to determine the phase difference) you will then need to determine the difference in phase between those two slots on a subcarrier basis. These results for each subcarrier should then be RMS averaged, to get a result for the whole slot, which can then be compared to the requirement.  We are also currently further reviewing the CR 5533 by Ericsson and try to provide some updates that may better capture what is needed in our point of view. |
| Apple | We recommend rephrasing this issue to capture the assumption on network behavior as follows:  "The network is expected to utilize all DMRS symbols within the JCE window to estimate the channel."  This approach also allows us to define the side conditions for the requirement. |
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#### **Issue 3-5: Measurement interval**

* **Proposals** 
  + Option 1: Define the measurement interval of 1 time slot. Discuss if the [10] bundles should be repeated for the test, i.e., measured Time window is [10] \* Maximum time duration reported by UE. (E///)
* **Recommended WF**
  + Encourage feedback

Discussion: in GTW

Qualcomm: the measurement interval is one slot. TE will average the results over multiple bundles.

Email discussion after GTW:

* Encourage further feedback.

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| **Company** | **Comments** |
| Ericsson | The measurement interval is referencing to the EVM measurement interval. One measurement point is defined corresponding to the one phase offset measurment between the measured time slot and reference time slot. If the measurement interval would be defined within one bundle, it would mean one measurement point is derived from a set of phase offset measurements within the bundled time slots, for example, one bundled time slot is 8ms, there would be 7 measured phase offset values. One option is to use maximum, another option is averaging. Using maximum has the risk that fail a good UE and averaging may not differentiate two UE performance as mean of uniform distribution is zero.  Therefore, we think it may be to consider the measurement interval, number of bundles and RMS metric in requirement as package. We are open to discuss this together with issue 1-2. |
| China Telecom | We are in general ok with the measurement interval of 1 time slot. For the number of bundles from statistics perspective, we agree it is related to whether RMS is used or not. |
| Apple | We encourage feedback from the test equipment vendors to determine how many repetitions of the JCE time window are needed to converge on a stable phase accuracy measurement. |
| Qualcomm | If the specification of the phase is maximum, which is coming from uniform distribution agreed, then for each bundle, the maximum should be found and then if averaging is used, then average of these maximum should be used as criteria.  In terms of requirement writing, it should not be written as in proposal but in the language that e.g. 10 separately measured bundles are used not so that the measured time window is 10 x the bundle since this means requirement is 10 back to back bundles which then is a different requirement. |
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#### **Issue 3-6: Additional side conditions for testing**

* **Proposals** 
  + Proposal 1 (MTK)
    - The TE DL signal frequency shall not change during the JCE test.
    - DL signal timing shall be maintained constant by the TE during the test case.
  + Proposal 2 (MTK)
    - Add a note to the spec to reflect the following:

“NOTE: In practical field conditions, the need for the UE to autonomously adjust frequency and power to maintain the radio uplink baseline performance may impact phase continuity in some scenarios. The UE reported capability is not required to take the potential presence of such events into account.”

* **Recommended WF**
  + Encourage feedback

Apple: support both proposals.

Huawei: additional side condition, the note says the practical field conditions.

Ericsson: share the similar view as Huawei.

China telecom: similar view as Huawei and ericsson

Mediatek: within bundling window is not intention.

R&S: proposal 1 is straightforward.

Agreement in GTW:

* The TE DL signal frequency shall not change during the JCE test.
* DL signal timing shall be maintained constant by the TE during the test case.

Email discussion after GTW:

* **Recommended WF**
  + Capture the GTW agreement in the CRs on requirements.
  + For Proposal 2, it seems not necessary to capture the aspect related to field conditions in RAN4 spec. But proponent can further clarify the intention if needed.

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| **Company** | **Comments** |
| China Telecom | For proposal 2, we don’t agree, since in RAN4 we can focus on defining the requirements under the agreed side conditions. |
| MediaTek | For proposal 2, our intention is to make it clear that there are no restrictions regarding autonomous frequency or power adjustment on the UE, and that the UE does not need to take this into account when reporting its UE capability. This avoids confusion later on. |
| Apple | We are happy to see Proposal 1 agreed in GTW. For proposal 2, we still think that it is valuable to consider including such a note in the RAN4 requirement in order to clarify the applicability of the side conditions which RAN4 will introduce with the requirement. |
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#### **Issue 3-7: RB allocation for testing**

* **Proposals** 
  + Option 1: RB allocation at the band edge could be exempt from UE phase requirement. Add a note on the transmission bandwidths for UE phase continuity tolerance measurement be confined within FUL\_low + 4 MHz to FUL\_high – 4 MHz. (E///)
    - E///: UE may have difficulty to meet the phase tolerance at the band edge when Tx gain changes. Currently in TS 38.101-1, UE is allowed to have 1.5 dB backoff power at band edge. Simulation assumption assumes the same phase offset across 4 RB and this assumption may not be held near the band edge.
* **Recommended WF**
  + Encourage feedback

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| **Company** | **Comments** |
| Ericsson | Currently in system simulation, the phase offset (randomly generated according to phase offset modeling) is added the same on all 4 RBs and this means that the phase response difference at these RBs between one time slot and another time slot is constant. This could be interpreted as a flat group delay across the 4 RBs in different time slots. At the band edge, such assumption may not be held as group delay is big at the band edge. This may make the simulation assumption at band edge invalid.  Another point is that at band edge UE may have difficult to meet the phase tolerance as the phase response is big at the stopband near the cutoff frequency. If the phase response at different time slot would be changed, such changes would be bigger at band edge compared to passband. |
| Apple | This is a valuable observation, and we would like to take some time to check on the offset value; can 4 MHz be placed in square brackets? |
| Qualcomm | There is anyway NZ dB MPR for everything except for DFT-s inner allocations. |
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#### **Issue 3-8: TDD pattern for testing**

* **Proposals** 
  + Option 1: New TDD pattern of DDSUU is needed for TDD band with 15kHz SCS. (E///)
    - Currently the TDD pattern in A.2.1 is as below.

Table A.2.1-1: TDD active uplink slots

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| SCS | Active Uplink slots |
| 15 kHz | 4, 9 |
| 30 kHz | 8, 9, 18, 19 |
| 60 kHz | 16, 17, 18, 19, 36, 37, 38, 39 |

* **Recommended WF**
  + Encourage feedback on the introduction of new TDD pattern, and consider the implications with the UE output power and applicable dutycycles in the test.

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| **Company** | **Comments** |
| China Telecom | Ok two add a new TDD pattern with 2 consecutive UL slots for 15kHz SCS.  For the dutycycle or SAR issue, in our understanding, with TDD pattern like DDSUU, the duty cycle is still below 50%. |
| Apple | The TDD pattern should be selected according to the overall undrestanding of the meaning of "bundling window." As we commented to Issue 2-1, the UE capability of "bundling window" refers only to the number of consecutive UL slots within the UL/DL configuration of the TDD band. If the "bundling window" capability retains all of the fields currently under discussion, then we need TDD patterns which can have up to 32 consecutive active UL slots. Restricting these to FR1 only, then we can target a 50% duty cycle, and the pattern could be 32DS32U, for example. We are open to continue to discuss this further. |
| Qualcomm | New RMC is needed. Care should be taken since right now we are only discussing on adding phase discontinuity requirement, but it would be tested with max output power. If phase discontinuity is to be met at maximum output power level and with 4 RBs as proposed in discussion on Issue 3-7, for DFT-s there are only 1 and 5 RB RMCs and for CP-OFDM 1 and 6 RBs. |
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### Sub-topic #4: Non-unscheduled gap in-between PUSCH/PUCCH transmissions

#### **Issue 4-1: Un-scheduled gap for extended CP**

* *Question in RAN1 LS (in R1-2200*773*)*

*RAN1 respectfully asks RAN4 to provide answer to the following question.*

* *For extended CP, is 11-symbol the maximum length for the non-zero un-scheduled gap in-between the PUSCH transmission or PUCCH repetition, when UE is required to maintain power consistency and phase continuity?*
* **Proposed RAN4 answer**
  + Option 1: Yes, for extended CP, 11-symbol is the maximum length for the non-zero un-scheduled gap in-between the PUSCH transmission or PUCCH repetition, when UE is required to maintain power consistency and phase continuity. (CTC, HW, E///, QC)

**Agreement in GTW**

* + Agree option 1.

Email discussion after GTW:

* **Recommended WF**
  + No further discussion on this issue. Capture the GTW agreement on the reply LS to RAN1 and RAN4 CR on core requirements.

#### **Issue 4-2: Output power for the non-zero gap in-between PUSCH/PUCCH transmissions**

* *RAN4 #101e-bis agreement (in WF R4-2203818)*
  + *Candidate options:*
    - *Option 1: RAN4 do not introduce new transmit off power, i.e., no requirement applies during the gap.*
    - *Option 2: The existing OFF power level of -50dBm apply for less than 1 ms, and FFS whether to and how to introduce measurement uncertainty.*
      * *Option 2a: For option 2, considering to allow the LO leakage power for best spectrum efficiency*
    - *Option 3: The power for un-scheduled gap between slots in the same bundle can be either minimum output power (e.g., -40 dBm for small CBW) or then some value in between the OFF power and minimum power.*
      * *Note: Opiton 3 is not to define new OFF requirements and just clarifies that the minimum ON power applies.*
    - *Option 4: No consensue reached in RAN4, LS back to RAN1.*
  + *WF recommendation:*
    - *Agree on Option 1 or option 4.*
* **Proposals**
  + Option 1: RAN4 do not introduce new transmit off power, i.e., no requirement applies during the gap. (Apple, MTK)
  + Option 3: Clarify that the power for un-scheduled gap between slots in the same bundle can be either minimum output power (e.g., -40 dBm for small CBW) or some value in between the OFF power and minimum power. (China Telecom)
    - Note: not to define new power requirements and just clarifies that the minimum ON power applies.
  + Option 4:LS to Ran1 if no consensus reached within RAN4. (E///)
    - **Moderator’s note:** the RAN1 CR capturing the 13-symbol gap has already been approved in the Dec 2021 RAN plenary meeting.
* **Recommended WF**
  + Further discuss

Qualcomm: prefer to Option 1.

Apple: Option 1.

Mediatek: last meeting we decided not to go with Option 3.

China Telecom: it is very difficult to define the requirement. Network vendor can take into account the possible interference level.

Ericsson: not to define requirement may not be good approach.

Mediatek: the phase continuity assumption is that you basically modify the PA setting and it may impact the phase continuity. It is always problematic from Day 1.

Agreement: RAN4 do not introduce new transmit off power, i.e., no requirement applies during the gap.

* With understanding that there may be co-channel interference to other user in the duration of non-zero gap (< one slot) in-between PUSCH/PUCCH transmissions.
* FFS whether to capture it in the specifications.

Email discussion after GTW:

* **Recommended WF**
  + Companies can further discuss whether to capture the following text in the specifications.
* With understanding that there may be co-channel interference to other user in the duration of non-zero gap (< one slot) in-between PUSCH/PUCCH transmissions.

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| **Company** | **Comments** |
| China Telecom | We are fine to add the text in RAN4 WF, but not in the RAN4 spec. |
| Ericsson | WF will have no one to read later on. Alternatively maybe the Text proposal in TR 38.830 seems more relevant. |
| MediaTek | If we are only capturing requirements and test conditions, this text does not seem so relevant. |
| Apple | We support the agreement from GTW |
| Qualcomm | This is same situation as OFF power currently. If there need to be such informative note then it should be there for every UE. The purpose would be only to help to understand the specification so purpose and priority is questionable. |
| Huawei | We agree with the GTW agreement.  Regardless it is going to capture in WF or spec. We would like to keep it align with the RAN1 statement according to the following RAN1 UE capability:    So we propose the following update to the GTW agreement (only clarification)  Agreement: For the UE indicates capability as supporting DM-RS bundling for non-back-to-back transmission, RAN4 do not introduce new transmit off power, i.e., no requirement applies during the gap.  With understanding that there may be co-channel interference to other user in the duration (< one slot) between the non-back-to-back transmissions of ~~non-zero gap (< one slot)~~ ~~in-between PUSCH/PUCCH transmissions~~. |
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### Sub-topic #5: CR and work plan

#### **Issue 5-1: CRs**

* *CRs submitted to this meeting*
  + *CTC, E/// and HW provided the CRs on the phase tolerance requirements for DMRS bundling to TS 38.101-1/2, and some aspects are summarized below for discussion based on the differences of the CRs.*
  + *E/// provided CRs on measurement for DMRS bundling to TS 38.101-1/2.*

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| R4-2203822 | China Telecom | Title: 38.101-1 CR: UE RF requirements for DMRS bundling |
| R4-2203823 | China Telecom | Title: 38.101-2 CR: UE RF requirements for DMRS bundling |
| R4-2204820 | Huawei, HiSilicon | Title: Draft CR on UE RF requirements for DMRS bundling |
| R4-2204821 | Huawei, HiSilicon | Title: Draft CR on UE RF requirements for DMRS bundling |
| R4-2205533 | Ericsson | Title: CR on measurment for DMRS bundling in TS 38.101-1 |
| R4-2205534 | Ericsson | Title: CR on measurment for DMRS bundling in TS 38.101-2 |
| R4-2205535 | Ericsson | Title: CR on phase tolerance for DMRS bundling in TS 38.101-1 |
| R4-2205536 | Ericsson | Title: CR on phase tolerance for DMRS bundling in TS 38.101-2 |

* **Section number for the requirements**
  + Option 1: new suffix for DMRS bundling requirement (HW, E///)
    - 6.4J Transmit signal quality for DMRS bundling
  + Option 2: new sub-sections under section 6.4.2, 6.4D.2 (for UL-MIMO), 6.4G.2 (for TxD, FR1 only)
    - 6.4.2.5 Phase continuity requirements for DMRS bundling
    - 6.4D.2.5 Phase continuity requirements for DMRS bundling
    - 6.4G.2.5 Phase continuity requirements for DMRS bundling (FR1 only)
* **Testing for the bands capable of UL-MIMO and/or TxD (TxD for FR1 only)**
  + Option 1: (China Telecom)
    - For UL-MIMO, the phase continuity requirements for DMRS bundling apply at [each transmit antenna connector]
    - For TxD in FR1, the phase continuity requirement is derived based on the measurement at each antenna connector according to Annex F.y. (similar to Annex F.8 for TxD EVM)
* **Testing for different modulation orders**
  + Option 1: the requirements are applicable for the modulation orders not higher than QPSK as per previous agreements (HW, E///)

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| PUSCH | Pi/2 BPSK, QPSK |
| PUCCH | Pi/2 BPSK, BPSK, QPSK |

* + Option 2: [the requirements are applicable for the modulation orders not higher than QPSK as per previous agreements], and only consider/specify the reference measurement channels for QPSK in the test. (E///)
* **Testing** **for un-scheduled gap scenario**
  + *RAN4 #101e-bis agreement in WF:* 
    - There is no uplink transmission gap during testing window.
  + Proposal:
    - Option 1: Cover the un-scheduled gap scenario in the core requirements for phase continuity. Meanwhile, only consider no gap scenario in the RMC for test and if needed send LS to RAN5 to clearly recommend not to test the non-zero un-scheduled scenario.
* **Any other comments on the CRs for requirements (R4-2203822/3) and measurements (R4-2205533/4)**
* **Recommended WF**
  + Encourage feedback on the above issues and any other comments.
  + Revise [CTC]’s CRs on the requirements and E///’s CRs on measurement, to reflect any further agreements in this meeting.

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| **Company** | **Comments** |
|  | * Section number for the requirements * Testing for the bands capable of UL-MIMO and/or TxD (TxD for FR1 only) * Testing for different modulation orders * Testing for un-scheduled gap scenario * Any other comments on the CRs for requirements (R4-2203822/3) and measurements (R4-2205533/4) |
| Huawei | We are happy to take the work for requirements CR revision if Moderator and other companies think that is OK. |
| China Telecom | * Section number for the requirements   We prefer option 2, which makes the spec clearer. Also, we can clearly know that the requirements are not applicable to other scenarios like CA, V2X…   * Testing for the bands capable of UL-MIMO and/or TxD (TxD for FR1 only)   We support to clarify how the phase tolerance requirements are applicable to the bands capable of UL-MIMO and/or TxD.  To clarify, this is not add any new requirements, but just clarify the requirement applicability. Otherwise, if one band supports UL-MIMO and/or TxD, and declares the support of DMRS bundling, there are no requirements for testing.   * Testing for different modulation orders   We are ok with option 2 with the [] removed   * + Option 2: the requirements are applicable for the modulation orders not higher than QPSK as per previous agreements, and only consider/specify the reference measurement channels for QPSK in the test. (E///) * Testing for un-scheduled gap scenario   We are ok with option 1.   * + - Option 1: Cover the un-scheduled gap scenario in the core requirements for phase continuity. Meanwhile, only consider no gap scenario in the RMC for test and if needed send LS to RAN5 to clearly recommend not to test the non-zero un-scheduled scenario. * Any other comments on the CRs for requirements (R4-2203822/3) and measurements (R4-2205533/4) |
| Ericsson | * **Section number for the requirements**   DMRS bundling is new feature, Seems option 1 decoupled the other features, may be little difficult for reader to read from specification structure perspective.   * **Testing for the bands capable of UL-MIMO and/or TxD (TxD for FR1 only)**   Currently the system simulation only for 1TxR, (2R for FDD and 4R for TDD). There is no 2 TX or multiple Transmitter is modelled and simulated and this make us not sure about the applicability of the extending the phase tolerance to other features.  On the other hand, we donot see whether DMRS bundling feature work together with TxD or UL MIMO will block the WI finalization.   * Testing for un-scheduled gap scenario   After we agree not set any RF requirement for un-scheduled gap, it seems testing this scenario has no difference with testing consecutive transmitting case. UE can pass the test with consecutive transmitting within the un-scheduled gap. Sad but this is fact. |
| MediaTek | For side conditions I think we need to add that “DL frequency is stable (within the TE tolerance).”  UL MIMO: This was never really discussed. We assume it would be rank 1? Measurement at each antenna at least seems the only feasible approach.  FR2 testing: As this is with OTA testing, we need to consider whether this can be accurately tested. Not sure if a RAN5 or RAN4 discussion. |
| Qualcomm | **Testing for the bands capable of UL-MIMO and/or TxD (TxD for FR1 only):**  For TxD the phase requirement should be for the sum of the power similarly as the every else for TxD.  For UL MIMO, it should per layer as it is for EVM for UL MIMO.  **Testing for different modulation orders**: Prefer option 2  **Testing for un-scheduled gap scenario:** This proposal seems not needed since then it would only record the max length of the gap and this is already [in TS38.214](https://www.3gpp.org/ftp/Specs/archive/38_series/38.214/38214-h00.zip) section 6.1.7: |
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#### **Issue 5-2: Work plan**

* Proposals
  + Updated RAN4 RF work plan for NR coverage enhancements WI in R4-2203818. (CTC)
    - The work plan has been updated to capture the content of the RAN1/4 LS and RAN4 WF approved in the January 2022 meeting.
* Recommended WF
  + Any comments?

Note: the updated work plan is only for information.

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| **Company** | **Comments** |
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## Companies views’ collection for 1st round

*Provided under each issue in section 1.2*

## Summary for 1st round

### Open issues

*Tentative agreements:*

*Candidate options:*

*Recommendations for 2nd round:*

### CRs

*Moderator tries to summarize discussion status for 1st round and provided recommendation on CRs/TPs Status update suggestion*

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| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation** |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |
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## Discussion on 2nd round

1. Recommendations for Tdocs
   1. 1st round

**New tdocs**

|  |  |  |
| --- | --- | --- |
| **Title** | **Source** | **Comments** |
| WF on … | YYY |  |
| LS on … | ZZZ | To: RAN\_X; Cc: RAN\_Y |
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**Existing tdocs**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Tdoc number** | **Title** | **Source** | **Recommendation** | **Comments** |
| R4-210xxxx | CR on … | XXX | Agreeable, Revised, Merged, Postponed, Not Pursued |  |
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Notes:

1. Please include the summary of recommendations for all tdocs across all sub-topics incl. existing and new tdocs.
2. For the Recommendation column please include one of the following:
   1. CRs/TPs: Agreeable, Revised, Merged, Postponed, Not Pursued
   2. Other documents: Agreeable, Revised, Noted
3. For new LS documents, please include information on To/Cc WGs in the comments column
4. Do not include hyper-links in the documents
   1. 2nd round

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| **Tdoc number** | **Title** | **Source** | **Recommendation** | **Comments** |
| R4-210xxxx | CR on … | XXX | Agreeable, Revised, Merged, Postponed, Not Pursued |  |
| R4-210xxxx | WF on … | YYY | Agreeable, Revised, Noted |  |
| R4-210xxxx | LS on … | ZZZ | Agreeable, Revised, Noted |  |
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Notes:

1. Please include the summary of recommendations for all tdocs across all sub-topics.
2. For the Recommendation column please include one of the following:
   1. CRs/TPs: Agreeable, Revised, Merged, Postponed, Not Pursued
   2. Other documents: Agreeable, Revised, Noted
3. Do not include hyper-links in the documents

# Annex

Contact information

|  |  |  |
| --- | --- | --- |
| **Company** | **Name** | **Email address** |
|  |  |  |

Note:

1. Please add your contact information in above table once you make comments on this email thread.
2. If multiple delegates from the same company make comments on single email thread, please add you name as suffix after company name when make comments i.e. Company A (XX, XX)