**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

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| **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 bundlingFor 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 transmissionsObservation: 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 gapProposal 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 transmissionProposal-1:Consider both DFT-s-OFDM and CP-OFDM in the RF testProposal-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.
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| R4-2205529 | Ericsson | Title: On JCE phase continuity and power consistency tolerance for PUCCH and PUSCHProposal-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 gapObservation 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 repetitionObservation 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 PUCCHProposal: 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 requirementProposal 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 requirementsProposal 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 enhancementObservation 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 gapProposal 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 aspectsProposal 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.

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| **Company** | **Comments** |
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#### **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)



* 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**

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| --- | --- |
| **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**
	+ Since majority companies did not re-submit the simulation results to this meeting, companies can comment on the above results.

NOTE: a summary of companies’ simulation results to this meeting and the previous meetings are put in a separate document named “CovEnh simulation results for phase tolerance”

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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.
* **Recommended WF**
	+ Encourage feedback on whether to use RMS average for the phase tolerance requirements.
	+ Note that the RMS average may be different for different max durations if phase offset option 2 is used.

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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 table1. 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. |
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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?
	+ Time to send the values to RAN1
		- Agree option 1?

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| **Company** | **Comments** |
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### 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)
* **Recommended WF**
	+ In moderator’s understanding, Proposal 3 already reflects the agreement in the last meeting, not sure whether further discussion is needed.

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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
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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?

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| **Company** | **Comments** |
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#### **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?

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| **Company** | **Comments** |
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#### **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)
* **Recommended WF**
	+ Encourage feedback

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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

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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. |
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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

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| **Company** | **Comments** |
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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.  |
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#### **Issue 3-6: 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

|  |  |
| --- | --- |
| 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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### 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)
* **Recommended WF**
	+ Agree option 1.

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| **Company** | **Comments** |
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#### **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

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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)
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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

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| **Company** | **Name** | **Email address** |
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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)