**3GPP TSG-RAN WG4 Meeting # 109 R4-2318148**

**Chicago, USA, November 13 – November 17, 2023**

**Agenda item:** 8.29.5

**Source:** Moderator (Samsung)

**Title:** Topic summary for [109][142] NR\_MIMO\_evo\_DL\_UL\_UERF

**Document for:** Information

# Introduction

*Briefly introduce background, the scope of this email discussion (e.g. list of treated agenda items) and provide some guidelines for email discussion if necessary.*

At its latest meeting, RAN4 approved a WF on STxMP UE RF requirements to capture the agreements, and to summarize the discussion status. As agreed in the WF, RAN4 is expected to conclude the discussion on the configured transmitted power for STxMP with other relevant requirements.

Also, RAN4 recieved an LS from RAN1 on coherence between PUSCH and 8-ports SRS with partial dropping. Although RAN4 already excluded the 8Tx discussion from Rel-18 MIMO as they are now focused on 4Tx in other RAN4 WI, it is expected to have an initial discussion in this thread based on input contributions.

# Topic #1: STxMP

*Main technical topic overview. The structure can be done based on sub-agenda basis.*

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2318096 | InterDigital, Inc. | *Observation 1: Rel-17 supports two uplink transmissions in TDM mode with two power control loops and thus, the Pumax reflects this approach meaning one Pumax per beam.*  *Proposal 1: Introduce PUMAX f,c,k**corresponding to PCMAX f,c,*k *defined for each active TCI state.*  *Proposal 2: If not addressed in Rel-18, agree to treat the beam overlapping case for mDCI STxMP during Rel-18 maintenance (TEI) or Rel-19.*  *Proposal 3: For non-overlapping beams k, k={0,1}, a common MPR can be used MPR f,c,k = Max{* MPRf,c,0 , MPRf,c,1 *) corresponding UL grant 0 and UL grant 1 corresponding to indicated TCI 0 and 1 states, respectively.*  *Proposal 4:* *The extra relaxation ΔTSTxMP may be used in the future, thus we propose to keep it.*  *Observation 2: The inter-cell case works as intended by using* P-MPRf,c,k *per beam in MPE reporting, and PHR . No changes are required.*  *Observation 3: The intra-cell case can maintain* P-MPRf,c,k *per beam but leave it for UE implementation.*  *Proposal 5: Agree to keep the* P-MPRf,c,k *parameter in the Pcmax equation.*  *Proposal 6: We propose the following text for the Pcmax definition changes that are specific to STxMP capability:* |
| R4-2318490 | Nokia, Nokia Shanghai Bell | 1. The listed option 1 and option 2 only allows for equal relaxation on each indicated TCI state. 2. Support option 2a i.e., MAX(X, MPRf,c, A- MPRf,c,), where X is 10\*log (number of UL TCI-states indicated for STxMP) dB. 3. If uneven split shall be supported, we suggest leaving the additional relaxation, ∆TSTxMP,k, outside of MAX(MPR) to the lower bound. 4. Support WF i.e., the applied P-MPR value is up to the UE implementation for MPE compliance. |
| R4-2318682 | Apple | *Proposal 1: Relaxation factor in the per-TCI state configured power formulation is needed to account for RF impairments or design constraints.*  *Proposal 2: Option 2 for MPR/A-MPR can be a starting point, i.e., MAX(X, MPRf,c,k, A-MPRf,c,k), X = 10\*log10(number of UL TCI-states indicated for [STxMP]) dB in lower bound, subject to further checking of whether MPR is gated by EVM/IBE/OOBE, and further investigation of interaction between the two active panels.*  *Observation 1: Option 1 is workable, but may lead to unnecessarily lower TX power.* |
| R4-2318768 | Qualcomm Incorporated | Observation 1: PCMax needs to only be maintained for 2 TCI states at a time.  Proposal 1: As a package, a per TCI-state MPR is defined along with a per power-class relaxation ‘∆TSTxMP’. The MPR is MAX(X, MPRf,c,k, A- MPRf,c,k), X = 10\*log10(number of UL TCI-states indicated for [STxMP]) dB. ‘∆TSTxMP’ is defined with the power class for STxMP.  Proposal 2: From the perspective of specifying STxMP operation in the core requirement, no special feasibility work is necessary for measuring per TCI-state EIRP.  Proposal 3: RAN4 to attempt early agreement on the configured power framework so RAN1 can complete their task during the concurrent RAN1 meeting. |
| R4-2318952 | vivo | Definition of MPRf,c,k/A-MPRf,c,k  Observation 1: There exists other limiting factors, that make *MAX(X, MPRf,c, A- MPRf,c,)* not satisfying requirements, and *MAX(MPRf,c, A- MPRf,c,) + X dB* is a safer choice, especially when lacking in-depth analysis and simulations as currently it is .  Proposal 1: Incorporate Option 1 *MAX(MPRf,c, A- MPRf,c,) + X dB* for MPR part*.*  Definition of ΔTSTxMP  Observation 2: ΔTSTxMP is needed and conceptually different from previous MPR part, but the requirements may be not easy to reach consensus in short notice.  Proposal 2: Introduce additional relaxation ΔTSTxMP outside MPR part, but leave the requirements of this parameter to the next release.  The need of PCMAX,f,c  Observation 3: There is currently no clear need for a Pcmax,f,c definition for STxMP. This potential concept also have do not have clear mapping problems with other concepts including Pcmax,f,c,k, Pumax,f,c,k, and Pumax,f,c.    Proposal 3: Avoid defining Pcmax,f,c for STxMP, and sending RAN1 LS about this issue if needed.  Others  Proposal 4: Adding previously agreed EIRP definition of STxMP to the spec:  *“For STxMP, the EIRP defined refer to total EIRP which is the aggregated EIRP of all beams in one direction.”* |
| R4-2319443 | ZTE Corporation | Observation 1: Both MAX(MPRf,c, A-MPRf,c)+X and MAX(X, MPRf,c, A-MPRf,c) can guarantee the EIRP and TRP power regulatory requirements.  Observation 2: MAX(MPRf,c, A-MPRf,c)+X may cause unnecessary power reduction in some cases, while MAX(X, MPRf,c, A-MPRf,c) does not.  Observation 3: Considering the interaction of multiple beams, existing MPRf,c/A-MPRf,c for single panel transmission may not be enough to satisfy the signal quality requirements for each panel in STxMP.  Proposal 1: For the derivation of MPRf,c,k/A-MPRf,c,k, MAX(X, MPRf,c, A-MPRf,c) is preferred, but an additional backoff ΔMPRSTxMP is needed to handle the increased MPRf,c and A-MPRf,c caused by the interaction of multiple panels, expressed as MAX(X, MPRf,c, A-MPRf,c)+ΔMPRSTxMP.  Proposal 2: The value of the additional backoff ΔMPRSTxMP is challenging to be determined currently, which needs further discussion. |
| R4-2319638 | Samsung | Observation 1: Existing MPR/A-MPR requirements applied to the single panel transmission can also apply to the ‘per-panel’ MPR/A-MPR for STxMP, respectively, by adding some specific rules for certain cases.  Observation 2: All the regulatory requirements should be considered and kept to comply with the existing limit, which is ‘per-UE’ requirements such as max EIRP and/or max TRP depending on the region.  Observation 3: A relaxation value can be applied not only for the regulatory and/or TRP-based requirements, but also for the future discussion with other constraints of the multi-panel transmission.  Proposal 1: Both performance benefit under mDCI case and the least impact should be considered to define the final lower limit of PUMAX for STxMP.  Observation 4: RAN4 has to consider the association between a UE panel (Tx) and a TRP (Rx) for STxMP operations in order to define the ‘per-panel, k’ of PCMAX,f,c,k because the most important target of the PCMAX is to determine the transmission power of UL channels defined in RAN1.  Observation 5: RAN4 agreed and confirmed RAN1 in that the number of PCMAX,f,c,k is two, and ‘k(k=0,1)’ corresponds to the first and second indicated joint/UL TCI states, respectively.  Observation 6: Two ‘per-panel’ PCMAX,f,c,k values will be set as ‘k (k=0,1)’, and they will CORRESPOND to the first and second indicated joint/UL TCI states (per-panel), but it does not mean that two PCMAX,f,c,k values will be picked/calculated out of 128 PCMAX,f,c,k of 128 UL TCI states (per-beam).  Observation 7: What RAN4 has agreed is to have two values ‘per-panel’ PCMAX, but not to have/store/calculate different PCMAX for the different TCI state.  Observation 8: RAN1 also closed the discussion based on the RAN4 agreement and LS while keeping the existing UL power control formula without any change since the only different thing between simultaneous transmission and original single panel transmission is to add one more PCMAX(i), but has not introduced the brand new ‘per-beam’ PCMAX like ‘PCMAX(qd)’  Observation 9: It should be noted that not every TCI state can have different pathloss RSs.  Proposal 2: The pathloss RS in the TCI state field should not be the motivation for the PCMAX per TCI state.  Observation 10: UE does not change/choose/calculate PCMAX whenever the TCI state changes from the specification and implementation point of view.  Observation 11: The activated TCI states (panel i) correspond to the first and second indicated joint/UL TCI states (TRP j), so that PCMAX,f,c,k can be stayed, and nothing to do with TCI state change as PCMAX(i) and the legacy single panel transmission.  Proposal 3: ‘Activated TCI states’ or ‘a group of TCI states’ for a TRP can represent a panel in the spec word.  Proposal 4: New suffix, e.g., K, can be considered to introduce the configured transmitted power of STxMP considering potential following up discussion in the future. |
| R4-2319639 | Samsung | CR to introduce configured transmitted power for STxMP |
| R4-2320083 | Huawei, HiSilicon | *Proposal 1: For STxMP operation, clarify that the overall output power capability would still be what can be achieved by the advertised power class considering all legacy transmitter RF requirements for single band operation as defined in TS 38.101-2 clause 6.*  *Observation 1: While* *reusing legacy MPR for each TCI state inherits the margin for meeting EVM and IBE (EIRP metric) and provides more flexibility for the case that per TCI state configured with different MCS, additional 3dB MPR per TCI state is not superfluous for UE to meet ACLR and SEM (TRP metric) under STxMP.*  *Observation 2: The total TRP relaxation with per panel MPR=MAX(MPRlegacy, 3dB)* *can be 3dB only when the legacy MPR requirement equals to 0dB.*  *Proposal 2: If RAN4 further defines per panel MPR/A-MPR and PUMAX in Rel-18, the following definition should be considered.*   * *Reuse the legacy MPRf, c/A-MPRf, c for single band operation for per panel MPR/A-MPR respectively and introduce additional 3dB relaxation into the lower bound for PUMAX, f, c, k.* |
| R4-2320243 | Google Inc. | Proposal 1: It is proposed to introduce PUMAX,f,c,k for STxMP in the following equation based on MPRf,c,k/A-MPRf,c,k as MAX(MPRf,c, A- MPRf,c,) + X dB with ‘k (k=0,1)’ corresponds to the first and second indicated joint/UL TCI states, where X can be 3dB or 10\*log (number of UL TCI-states indicated for STxMP) dB, and PUMAX,f,c,k and PTMAX,f,c,k in dB scale are assumed.  PPowerclass + DPIBE – MAX(MAX(MPRf,c, A- MPRf,c,) + X + ΔMBP,n, P-MPRf,c) – MAX{T(MAX(MPRf,c, A- MPRf,c,) + X), T(P-MPRf,c)} ≤ PUMAX,f,c ≤ EIRPmax  With the constraint is that  PUMAX,f,c = 10\*log10{Σk[10^(PUMAX,f,c,k/10)]} and PTMAX,f,c = 10\*log10{Σk[10^(PTMAX,f,c,k/10)]} ≤ TRPmax  Proposal 2: If proposal 1 is not agreed, it is proposed to introduce PUMAX,f,c,k and ΔTSTxMP for STxMP in the following equation based on MPRf,c,k/A-MPRf,c,k as MAX(X, MPRf,c, A- MPRf,c,) with ‘k (k=0,1)’ corresponds to the first and second indicated joint/UL TCI states, where X can be 3dB or 10\*log (number of UL TCI-states indicated for STxMP) dB and ΔTSTxMP = [TBD], and PUMAX,f,c,k and PTMAX,f,c,k in dB scale are assumed.  PPowerclass + DPIBE – MAX(MAX(X,MPRf,c, A- MPRf,c) + ΔTSTxMP + ΔMBP,n, P-MPRf,c) – MAX{T(MAX(MAX(X,MPRf,c, A- MPRf,c) + ΔTSTxMP), T(P-MPRf,c)} ≤ PUMAX,f,c ≤ EIRPmax  With the constraint is that  PUMAX,f,c = 10\*log10{Σk[10^(PUMAX,f,c,k/10)]} and PTMAX,f,c = 10\*log10{Σk[10^(PTMAX,f,c,k/10)]} ≤ TRPmax |
| R4-2320821 | Ericsson India Private Limited | Proposal 1: The MPR/A-MPR per TCI state can be set using the relevant information in DCI and the power control specified for TCI state and any other common signalling, like NS value.  Proposal 2: There is no need to introduce an additional relaxation factor ΔTSTxMP if the purpose of both MPRf,c,k/A-MPRf,c,k and P-MPRf,c,k per TCI state ‘k’ is clearly defined and the UE can meet all the requirements by applying those.  Proposal 3: The text proposal for the introduction of configured maximum output power for STxMP (in clause 6.2D.4 of TS38.101-2) is provided in Section 2.2 of the contribution. |

## Open issues summary

*Before Meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions.*

### Sub-topic 1-1: MPRf,c,k/A-MPRf,c,k

*Sub-topic description:*

MPRf,c,k/A-MPRf,c,k is the most important and only remaining topic needs to be concluded in this meeting. Two options are carried forward from the last meeting.

MAX(MAX([Option 2], MPRf,c,k, A- MPRf,c,k,) + [Option 1] + ΔMBP,n, P-MPRf,c,k)

Moderator added one more issue to discuss a proper symbol for the temporary term ’X’.

*Open issues and candidate options before meeting:*

**Issue 1-1-1: Remaining options for MPRf,c,k/A-MPRf,c,k**

* Proposals
  + Option 1: MAX(MPRf,c,k, A- MPRf,c,k,) + X dB, where X is
    - Option 1a: 10\*log (number of UL TCI-states indicated for STxMP) dB
    - Option 1b: 3 dB if two TCI states are indicated, and 0 dB otherwise
    - Option 1c: [TBD]
  + Option 2: MAX(X, MPRf,c,k, A- MPRf,c,k,), where X is
    - Option 2a: 10\*log (number of UL TCI-states indicated for STxMP) dB
    - Option 2b: 3 dB if two TCI states are indicated, and 0 dB otherwise
* Recommended WF
  + (Majority view) Option 2
  + (Moderator) Decision required between Option 1 and 2 (Sub-options can be discussed with CR work)

**Issue 1-1-2: New symbol for ‘X’**

* Proposals
  + Option 1: Keep ‘X’ for MPR per TCI state
  + Option 2: Use ‘ΔTSTxMP’ for MPR per TCI state WITHOUT additional relaxation (Sub-topic 1-2)
  + Option 3: Others to differentiate with ΔTSTxMP (e.g., ΔMPRSTxMP)
* Recommended WF
  + (Moderator) Option 3

### Sub-topic 1-2: Additional relaxation, ΔTSTxMP

*Sub-topic description:*

In addition to the MPRf,c,k, there has been proposals to leave a relaxation factor for the lower bound as a placeholder to make up for any RF impairments to be discussed later. It should be decided whether to leave the relaxation without a requirement for Rel-18.

… – MAX{T(MAX(MPRf,c,k, A- MPRf,c,k,)), T(P-MPRf,c,k)} – [ΔTSTxMP] ≤ PUMAX,f,c,k ≤ EIRPmax

*Open issues and candidate options before meeting:*

**Issue 1-2: Whether or not to leave ΔTSTxMP on the lower bound for future discussions**

* Proposals
  + Option 1: Yes
    - Option 1a: Per power class
  + Option 2: No
* Recommended WF
  + (Majority view) Option 1
  + (Moderator) Even though Option 1 is agreed, there would be no requirement for ΔTSTxMP

### Sub-topic 1-3: ’Per-panel, k’ definition

*Sub-topic description*

RAN4 informed RAN1 that RAN4 will introduce PCMAX,f,c,k for STxMP where ‘k (k=0,1)’ corresponds to the first and second indicated joint/UL TCI states as a spec word of ‘per-panel’, respectively. One company proposed a different view with ‘k = TCI state’ for spec wording. It needs to be resolved before the CR work.

*Open issues and candidate options before meeting:*

**Issue 1-3-1: UEs can configure its maximum output power for [what]? (introduction of the clause)**

* Proposals
  + Option 1: for each UL TCI state k, k= {0,1}
  + Option 2: for each UL TCI-state indicated for simultaneous mTRP transmission
  + Option 3: for activated TCI states applies for a TRP as specified in TS 38.321
* Recommended WF
  + (Moderator) Option 2

**Issue 1-3-2: What is the spec word of ‘per-panel, k (k=0,1)’?**

* Proposals
  + Option 1: TCI state k
  + Option 2: Each of the active TCI states k
  + Option 3: Corresponding to the first and second indicated joint/UL TCI states
* Recommended WF
  + (Moderator) Option 2

### Sub-topic 1-4: PUMAX,f,c

*Sub-topic description:*

One company suggests not to define PUMAX,f,c under STxMP while putting previous agreement on the aggregated EIRP limitation somewhere in the spec.

*Open issues and candidate options before meeting:*

**Issue 1-4: Is PUMAX,f,c still necessary?**

* Proposals
  + Option 1: Yes
    - Option 1a: with ‘over all [indicated/active] TCI states’
    - Option 1b: with 10\*log10{Σk[10^(PUMAX,f,c,k/10)]}
  + Option 2: No (but capture previous agreement into the spec)
    - “*For STxMP, the EIRP defined refer to total EIRP which is the aggregated EIRP of all beams in one direction.*”
  + Option 3: Send an LS to RAN1 for checking
* Recommended WF
  + (Majority view) Option 1
  + (Moderator) Understanding of both options would be the same, but the issue is where to put the understanding

### Sub-topic 1-5: Spec structuring

*Sub-topic description*

Original plan discussed in the last meeting was to add sub-clause under suffix D, UL-MIMO. New proposal to share new suffix K with multi-Rx requirements is suggested to this meeting. For example, clause 6 for STxMP and clause 7 for multi-Rx requirements.

*Open issues and candidate options before meeting:*

**Issue 1-5: Target clause affected**

* Proposals
  + Option 1: Add new suffix K (sharing with multi-Rx)
  + Option 2: Reuse existing suffix D (UL-MIMO)
* Recommended WF
  + (Moderator) Option 1

# Topic #2: LS on coherence between PUSCH and 8-ports SRS with partial dropping

*Main technical topic overview. The structure can be done based on sub-agenda basis.*

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2318040 | Nokia, Nokia Shanghai Bell | **Observation 1:** The current requirements for coherent MIMO do not request the UE to maintain the phase and power of each port during 20 ms, but rather they request the UE to maintain the difference of power and phase difference of two ports in a symbol and those of the two ports in another symbol within certain threshold, e.g., 4 dB for difference of relative power error, during 20 ms.  **Observation 2: Observation 1** furhter means that the RAN4 requirements allow e.g., power and/or phase of port 0 in slot n to drastically change in slot, e.g., n+20. Hence, if the 1st symbol@ SRS transmission occasion 1 in slot n is dropped, the 2nd symbol@ SRS transmission occasion 1 alone cannot ensure that full coherent transmission is possible in 20 ms from the occasion 1. The same applies to the 1st symbol@ SRS transmission occasion 2.  **Observation 3:** From **observation 1 and 2,** even if the UE meets the current RAN4 requirements, there is no guarantee that full coherency is maintained under this scenario. |
| R4-2318235 | Qualcomm Incorporated | **Proposal 1: Coherence across ports for the following PUSCH transmissions can be assumed when SRS symbols for different ports are scheduled and transmitted in consecutive symbols.**  **Proposal 2: Coherence can not be assumed across ports for the following PUSCH transmissions when SRS symbols to the different ports are scheduled and transmitted in different SRS occasions (TDM’d SRS).**  **Proposal 3: Only actually transmitted symbols are considered as reference for UL MIMO coherence.**  **Proposal 4: RAN4 will reply according to the provide draft LS [2]** |
| R4-2318236 | Qualcomm Incorporated | **[DRAFT] Reply LS on coherence between PUSCH and 8-ports SRS with partial dropping** |
| R4-2318739 | InterDigital, Inc. | ***Observation 1:*** *The main challenge for RAN1 has been in interpretation of existing RAN4 requirements for coherency. Therefore, establishing a clear understanding of the “coherence” term should be the first step towards a clear answer to RAN1 LS.*  ***Proposal 1:*** *To avoid any ambiguity, clarify the wording of the coherence requirement in subclause 6.4D.4 as follows:*  *“For coherent UL MIMO, Table 6.4D.4-1 lists the maximum allowable difference between the measured relative power and phase errors between any pair of ~~different~~ antenna connectors…”.* |
| R4-2318741 | InterDigital, Inc. | Draft CR for 8Tx UL MIMO coherence requirement |
| R4-2318955 | vivo | [Draft] Reply LS on coherence between PUSCH and 8-ports SRS with partial dropping |
| R4-2319444 | ZTE Corporation | ***Observation 1:*** *In existing RAN4 specification, we have a consideration that the relative phase error is small between signals at different antenna ports, which should be ideally 0. This is a premise for the coherence among all the ports.*  ***Observation 2:*** *For the coherence, we require that the difference of relative phase and power errors in a given slot compared to those measured at last SRS transmitted should not exceed the threshold in Table 2-1, and the premise is Observation 1.*  ***Observation 3****: For Question 3, first, any operations that disrupt the transmission continuity are not permitted at least, such as UL/DL transmission switching. Second, the time interval between the two SRS transmission occasions should not be too long and need to be limited considering the risk of phase shifting. The length of the time interval required needs further discussion.*  ***Proposal 1:*** *Further discuss the length of the time interval required between the two SRS transmission occasions for the UE to meet the relative phase and power error requirements among the 8 SRS ports between the last SRS transmission and the PUSCH transmission over the defined time window.* |
| R4-2320083 | Huawei, HiSilicon | ***Observation 3: The coherent UL MIMO RF requirement was introduced in Rel-15 by assuming 2Tx, while it has been reviewed only for 4Tx in Rel-18.***  ***Observation 4: For the 8Tx-related coherent UL MIMO scenario mentioned in R1-23106456, it is not clear whether new UE behaviour accompanied with specific RF requirement and verification are needed, while RAN1 have already agreed no additional specification impact will be introduced*** ***rather than pending on RAN4 feedback.***  ***Proposal 3: RAN4 should not resume 8Tx discussion e.g., seeking answers to the questions in R1-2310645, until dedicated RAN4 WI for 8Tx could be established.*** |

## Open issues summary

*Before Meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions.*

Figures in R1-2310645

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| *Figure 1 PUSCH transmission following 2 partial SRS dropping in different slots*    *Figure 2 PUSCH transmission following partial SRS dropping in one slot configured with SRS repetition* |

### Sub-topic 2-1: Discussion on each question

*Sub-topic description*

Given that it is agreed by RAN1 that no RAN1 spec impact will be expected rather than pending on RAN4 feedback, an immediate reply may not necessary. However, although any concrete answer cannot be derived, it would be beneficial for RAN4 to have initial discussion on each question based on the input contributions.

*Open issues and candidate options before meeting:*

**Issue 2-1-1: Answer to Q1**

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| *Question 1: For a coherent 8Tx PUSCH transmission, can a UE meet the relative phase and power error requirements (defined in RAN 4 specifications) among the 8 SRS ports between the last SRS transmission and the PUSCH transmission over the defined time window, when the SRS is configured with or without TDM and no SRS symbol is dropped?* |

* Proposals
  + Option 1: Yes, as long as UE reports its capability for supporting coherent 8TX UL and 8TX TDMed SRS transmission (Nokia, ZTE)
  + Option 2: Yes, as long as the time windows can be maintained (vivo)
  + Option 3: Yes, for non-TDMed SRS case only. More discussion is needed for TDMed SRS (QC)
* Recommended WF
  + (Moderator) All the answers are yes, but different condition slightly

**Issue 2-1-2: Answer to Q2**

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| *Question 2: For a coherent 8Tx PUSCH transmission, can a UE meet the relative phase and power error requirements (defined in RAN 4 specifications) among the 8 SRS ports between the last SRS transmission and the PUSCH transmission over the defined time window, when the SRS is configured with TDM and part of the SRS symbols is dropped, for example as shown in Figure 1 and Figure 2?* |

* Proposals
  + Option 1: No
    - Option 1a: Even if the UE meets the current RAN4 requirements, there is no guarantee that full coherency is maintained under this scenario. (Nokia)
    - Option 1b: No, UE cannot meet the relative phase and power error requirements when the SRS is configured with TDM and part of the SRS symbols is dropped. (QC)
  + Option 2: When the SRS is configured with TDM and part of the SRS symbols is dropped, the examples in Figure 1 and Figure 2 may be different. (vivo)
    - Difficult for Figure 1, but not much worse for Figure 2 than legacy case
  + Option 3: If the phase and power consistency between two SRS symbols can be guaranteed, it is available for the UE to meet the relative phase and power error requirements among the 8 ports. (ZTE)
* Recommended WF
  + (Moderator) Diverse views

**Issue 2-1-3: Answer to Q3**

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| *Question 3: What are the conditions a UE has to satisfy to meet the relative phase and power error requirements among the 8 SRS ports between the last SRS transmission and the PUSCH transmission over the defined time window, in the scenario as described in questions 1 and 2?* |

* Proposals
  + Option 1: Nothing yet. One possible additional requirement is that UE shall maintain power and phase in each port for a certain duration. (Nokia)
  + Option 2: Nothing yet. There is no way UE can maintain phase and power coherence from two different SRS transmission occasions to a succeeding PUSCH. (QC)
  + Option 3: Nothing yet (vivo)
  + Option 4: Nothing yet. Further discussions are required on the length of the time interval required (ZTE)
* Recommended WF
  + All options need more discussions on the requirement and feasibility in RAN4

**Issue 2-1-4: Answer to Q4**

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| *Question 4: For the scenarios as described in question 2, if a UE cannot meet the relative phase and power error requirements among the 8 SRS ports, can UE meet the relative phase and power error requirements among a subset of SRS ports, such as among {1000, 1001, 1004, 1005} or among {1002, 1003, 1006, 1007}?* |

* Proposals
  + Option 1: If the question assumes that a UE passed the expected requirements for 8Tx coherency in Question 1, but the UE faces a situation that part of SRS symbols is dropped, the answer is yes. (Nokia)
  + Option 2: Yes, UE can meet the relative phase and power error requirements among a subset of SRS ports which are sounded in a same OFDM symbol. (QC)
  + Option 3: RAN4 may need further study for these scenarios before giving more concrete answer. As a preliminary answer, it seems possible for SRS ports {1000, 1001, 1004, 1005} in SRS transmission occasion 2 in Figure 1, if it can ensure a time gap smaller than 20ms between SRS and PUSCH. (vivo)
  + Option 4: The subset of SRS ports {1000, 1001, 1004, 1005} or {1002, 1003, 1006, 1007} is transmitted on the same OFDM symbol. For the dropping cases in Question 2, if the coherence among all the 8 ports is not required, it is available to satisfy the coherence of each subset separately. (ZTE)
* Recommended WF
  + All proposed options say “yes” among a subset of SRS ports

### Sub-topic 2-2: Others

*Sub-topic description:*

Considering that this is the last meeting of the WI, there are two different proposals if it is necessary to send the reply LS to RAN1 with initial view in this meeting. We have three draft reply LSs for this meeting.

*Open issues and candidate options before meeting:*

**Issue 2-2-1: Whether or not to send LS in this meeting**

* Proposals
  + Option 1: Yes, with initial thinking of companies
  + Option 2: No, nothing affected
* Recommended WF
  + (Majority view) Option 1
  + (Moderator) All companies have a common understanding that RAN4 needs further discussions

**Issue 2-2-2: CR to change wording for coherent UL MIMO requirement application**

* Proposals
  + Option 1: Yes, so the requirement becomes applicable between any pair of antenna connectors
    - … between ~~different~~ any pair of antenna connectors… (R4-2318236)
  + Option 2: No, need more discussion
* Recommended WF
  + (Moderator) No direct relation to reply LS

# ANNEX

*Main technical topic overview. The structure can be done based on sub-agenda basis.*

## Proposed text for STxMP

(R4-2315275, InterDigital)

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| 6.2D.4.1 Configured transmitted power for STxMP The UE can configure its maximum output power for each UL TCI state k, k= {0,1}. The configured UE maximum output power PCMAX,f,c,k for TCI state k of carrier f and serving cell c is defined as that available to the reference point of a given transmitter branch that corresponds to the reference point of the higher-layer filtered RSRP measurement as specified in TS 38.215 [11].  The configured UE maximum output power PCMAX,f,c,k shall be set such that the corresponding measured peak EIRP PUMAX,f,c,k for each active TCI,k state indicated for STxMP is within the following bounds  PPowerclass + DPIBE – MAX(MAX(MPRf,c,k, A- MPRf,c,k) +∆TSTxMP + ΔMBP,n, P-MPRf,c,k) – MAX{T(MAX(MPRf,c,k, A- MPRf,c,k,)), T(P-MPRf,c,k)} ≤ PUMAX,f,c,k ≤ EIRPmax  While the MPRf,c,k and A- MPRf,c,k are the maximum between the related legacy MPRs and A-MPRs for the k= {0,1}corresponding mDCI received UL grants.  The corresponding measured peak EIRP for carrier *f* of a serving cell *c,* over each active UL TCI states configured for STxMP*,* PUMAX,f,c,k satisfies  PUMAX,f,c,k ≤ EIRPmax  When the UE signals STxMP overlapping beams then ∆TSTxMP  = 3dB, otherwise ∆TSTxMP  = 0.  The corresponding measured total radiated power PTMAX,f,c is always bounded by  PTMAX,f,c ≤ TRPmax |

(R4-2318768, Qualcomm)

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| 6.2K.4 Configured transmitted power for simultaneous mTRP transmission The UE can configure its maximum output power for each UL TCI-state indicated for simultaneous mTRP transmission. The configured UE maximum output power PCMAX,f,c, k for TCI state *k* of carrier *f* and serving cell *c* defined as that available to the reference point of a given transmitter branch that corresponds to the reference point of the higher-layer filtered RSRP measurement for TCI state *k* as specified in TS 38.215 [11].  The configured UE maximum output power PCMAX,f,c,k shall be set such that the corresponding measured peak EIRP PUMAX,f,c,k for each of the active TCI states *k* indicated for simultaneous mTRP transmission is within the following bounds  PPowerclass + DPIBE – MAX(MAX(X, MPRf,c,k, A- MPRf,c,k) + ΔMBP,n, P-MPRf,c,k) – MAX{T(MAX(X, MPRf,c,k, A- MPRf,c,k)), T(P-MPRf,c,k } -[∆TSTxMP] ≤ PUMAX,f,c,k ≤ EIRPmax  and the corresponding measured peak EIRP for carrier *f* of a serving cell *c,* over all active TCI states indicated for [STxMP]*,* PUMAX,f,c satisfies  PUMAX,f,c ≤ EIRPmax  while the corresponding measured total radiated power over all active TCI states indicated for simultaneous mTRP transmission*,* PTMAX,f,c is bounded by  PTMAX,f,c ≤ TRPmax  Where,  X = 10\*log10(number of UL TCI-states indicated for simultaneous mTRP transmission) dB is the per TCI state relaxation to comply with the PTMAX,f,c inequality above  ∆TSTxMP is a relaxation specific to simultaneous mTRP transmission defined in sections 6.2K.x,  PPowerclass the UE minimum peak EIRP as specified in sub-clause 6.2.1, EIRPmax the applicable maximum EIRP as specified in sub-clause 6.2.1, MPRf,c,k, and A-MPRf,c,k the MPR and A-MPR respectively for UL associated with TCI state *k* as specified in sub-clauses 6.2.2 and 6.2.3  *…..(other parts left out due to trivial nature of changes)* |

(R4-2319639, Samsung)

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| 6.2K.4 Configured transmitted power for [Multiple AoA/AoD]  A UE configured for simultaneous transmission with multi-panel (STxMP) can configure its maximum output power for activated TCI states applies for a TRP as specified in TS 38.321. The configured UE maximum output power PCMAX,f,c,k where k (k=0,1) corresponds to the first and second indicated joint/UL TCI states for carrier f and serving cell c is defined as that available to the reference point of a given transmitter branch that corresponds to the reference point of the higher-layer filtered RSRP measurement as specified in TS 38.215 [11].  The configured UE maximum output power PCMAX,f,c,k shall be set such that the corresponding measured peak EIRP PUMAX,f,c,k is within the following bounds  PPowerclass + PIBE – MAX(MAX([ΔTSTxMP,] MPRf,c,k, A- MPRf,c,k,) + ΔMBP,n, P-MPRf,c,k) – MAX{T(MAX(MPRf,c,k, A- MPRf,c,k,)), T(P-MPRf,c,k)} [– ΔTSTxMP] ≤ PUMAX,f,c,k ≤ EIRPmax  while the corresponding measured peak EIRP for carrier *f* of a serving cell *c,* over all indicated joint/UL TCI states for STxMP*,* PCMAX,f,c satisfies  PCMAX,f,c ≤ EIRPmax  while the corresponding measured total radiated power PTMAX,f,c is bounded by  PTMAX,f,c ≤ TRPmax  with PPowerclass the UE minimum peak EIRP as specified in sub-clause 6.2K.1, EIRPmax the applicable maximum EIRP as specified in sub-clause 6.2.1, MPRf,c,k as specified in sub-clause 6.2K.2 , A-MPRf,c,k as specified in sub-clause 6.2K.3, ΔMBP,n the peak EIRP relaxation as specified in clause 6.2.1 and TRPmax the maximum TRP for the UE power class as specified in sub-clause 6.2.1. PIBE is 1.0 dB if UE declares support for *mpr-PowerBoost-FR2-r16*, UL transmission is QPSK, MPRf,c = 0 and when NS\_200 applies and the network configures the UE to operate with *mpr-PowerBoost-FR2-r16*otherwisePIBE is 0.0 dB. UE The requirement is verified in beam peak direction.  [ΔTSTxMP is 3 dB if both the first and second TCI states are indicated, and 0 dB if either of the first or second TCI state is indicated for STxMP.]  P-MPRf,c,k is the power management maximum output power reduction P-MPRf,c of each indicated joint/UL TCI state. P-MPRf,c is defined in clause 6.2.4.  The tolerance T(∆P) for applicable values of ∆P (values in dB) is specified in Tables 6.2.4-1 and 6.2.4-2. |

(R4-2320821, Ericsson)

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| 6.2D.4 Configured transmitted power for UL MIMO  For UEs configured for 2-layer transmission as well as UEs configured for single layer uplink full power transmission (ULFPTx), the configured maximum output power PCMAX,c for serving cell c is defined as sum of all streams and is bound by limits set in clause 6.2.4.  For operation with multiple TCI states, the configured UE maximum output power PCMAX,f,c,k corresponding to TCI state *k* of carrier *f* of a serving cell *c* is defined as that available to the reference point of a given transmitter branch that corresponds to the reference point of the higher-layer filtered RSRP measurement as specified in TS 38.215 [11] for the TCI state *k*. The configured UE maximum output power PCMAX,f,c,k for a TCI state *k* of carrier *f* of a serving cell *c* shall be set such that the corresponding measured peak EIRP PUMAX,f,c,k is within the following bounds  PPowerclass + DPIBE – MAX(MAX(MPRf,c,k, A- MPRf,c,k) + ΔMBP,n, P-MPRf,c,k) – MAX{T(MAX(MPRf,c,k, A- MPRf,c,k,)), T(P-MPRf,c,k)} ≤ PUMAX,f,c,k ≤ EIRPmax  while the total corresponding measured peak EIRP in any direction across all TCI states is bounded by  PUMAX,f,c ≤ EIRPmax  with PPowerclass the UE minimum peak EIRP as specified in sub-clause 6.2.1, EIRPmax the applicable maximum EIRP as specified in sub-clause 6.2.1 [or as determined by local exposure requirements], MPRf,c,k for each TCI state *k* as specified in sub-clause 6.2.2 using corresponding information in the DCI, A-MPRf,c,k for each TCI state *k* as specified in sub-clause 6.2.3, ΔMBP,n the peak EIRP relaxation as specified in clause 6.2.1. DPIBE is 1.0 dB if UE declares support for *mpr-PowerBoost-FR2-r16*, UL transmission is QPSK, MPRf,c,k = 0 and when NS\_200 applies and the network configures the UE to operate with *mpr-PowerBoost-FR2-r16* otherwise DPIBE is 0.0 dB. The requirement is verified in beam peak direction.  *maxUplinkDutyCycle-FR2,* as defined in TS 38.306 [14], is a UE capability to facilitate electromagnetic power density exposure requirements. This UE capability is applicable to all FR2 power classes.  If the field of UE capability *maxUplinkDutyCycle-FR2* is present and the percentage of uplink symbols transmitted within any 1 s evaluation period is larger than *maxUplinkDutyCycle-FR2*, the UE follows the uplink scheduling and can apply P-MPRf,c,k.  If the field of UE capability *maxUplinkDutyCycle-FR2* is absent, the compliance to electromagnetic power density exposure requirements are ensured by means of scaling down the power density or by other means.  P-MPRf,c,k is the power management maximum output power reduction. The UE shall apply P-MPRf,c,k for a TCI state *k* of carrier *f* of a serving cell *c* only for the cases described below. For UE conformance testing P-MPRf,c,k shall be 0 dB.  a) ensuring compliance with applicable electromagnetic power density exposure requirements and addressing unwanted emissions / self desense requirements in case of simultaneous transmissions on multiple RAT(s) for scenarios not in scope of 3GPP RAN specifications;  b) ensuring compliance with applicable electromagnetic power density exposure requirements in case of proximity detection is used to address such requirements that require a lower maximum output power.  NOTE 1: P-MPRf,c,k was introduced in the PCMAX,f,c,k equation such that the UE can report to the gNB the available maximum output transmit power. This information can be used by the gNB for scheduling decisions.  NOTE 2: P-MPRf,c,k and *maxUplinkDutyCycle-FR2* may impact the maximum uplink performance for the selected UL transmission path.  NOTE 3: MPE P-MPR Reporting capability *tdd-MPE-P-MPR-Reporting-r16*, as defined in TS 38.306 [14], is used to report P-MPRf,c,k when the reporting conditions configured by gNB are met. This UE capability is applicable to all FR2 power classes.  The tolerance T(∆P) for applicable values of ∆P (values in dB) is specified in Table 6.2.4-1.  **Table 6.2.4-1: PUMAX,f,c,k tolerance**   |  |  |  | | --- | --- | --- | | **Operating Band** | **∆P (dB)** | **Tolerance T(∆P)**  **(dB)** | | n257, n258, n259, n260, n261 | P = 0 | 0 | |  | 0 < P ≤ 2 | 1.5 | |  | 2 < P ≤ 3 | 2.0 | |  | 3 < P ≤ 4 | 3.0 | |  | 4 < P ≤ 5 | 4.0 | |  | 5 < P ≤ 10 | 5.0 | |  | 10 < P ≤ 15 | 7.0 | |  | 15 < P ≤ X | 8.0 | | NOTE: X is the value such that Pumax,f,c lower bound, PPowerclass - P – T(P) = minimum output power specified in clause 6.3.1 | | | |

## Proposed reply LSs for 8Tx

(R4-2318040, Nokia)

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| RAN4 discussed the question included in R1-2310645 and would like to share the answer as follows.   * Question 1: For a coherent 8Tx PUSCH transmission, can a UE meet the relative phase and power error requirements (defined in RAN 4 specifications) among the 8 SRS ports between the last SRS transmission and the PUSCH transmission over the defined time window, when the SRS is configured with or without TDM and no SRS symbol is dropped? * A: Without SRS symbol dropping, as long as UE reports its capability for supporting coherent 8TX UL and 8TX TDMed SRS transmission, UE can meet the requirement for the coherent transmission. * Question 2: For a coherent 8Tx PUSCH transmission, can a UE meet the relative phase and power error requirements (defined in RAN 4 specifications) among the 8 SRS ports between the last SRS transmission and the PUSCH transmission over the defined time window, when the SRS is configured with TDM and part of the SRS symbols is dropped, for example as shown in Figure 1 and Figure 2? * A: Even if the UE meets the current RAN4 requirements, there is no guarantee that full coherency is maintained under this scenario.. * Question 3: What are the conditions a UE has to satisfy to meet the relative phase and power error requirements among the 8 SRS ports between the last SRS transmission and the PUSCH transmission over the defined time window, in the scenario as described in questions 1 and 2? * A: This requires further study given that RAN4 hasn’t completed requirements for 4Tx coherency. One possible additional requirement is that UE shall maintain power and phase in each port for a certain duration. For example, in Figure 2 in R1-2310645, if the UE can maintain the power and phase of the 1st symbol over the four symbols including the 1st symbol on top of the existing requirement, i.e., between any two ports out of the scheduled eight ports across four symbols, then, the UE would be able to keep the coherency. However, any errors on the above additional condition breaks the coherency. Hence, the feasibility as well as the exact requirement needs more study * Question 4: For the scenarios as described in question 2, if a UE cannot meet the relative phase and power error requirements among the 8 SRS ports, can UE meet the relative phase and power error requirements among a subset of SRS ports, such as among {1000, 1001, 1004, 1005} or among {1002, 1003, 1006, 1007}? * A: If the question assumes that a UE passed the expected requirements for 8Tx coherency in Question 1, but the UE faces a situation that part of SRS symbols is dropped, the answer is yes. |

(R4-2318236, Qualcomm)

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| In summary, RAN4 answers as follows to the questions to RAN1.  **RAN1 Question 1:** For a coherent 8Tx PUSCH transmission, can a UE meet the relative phase and power error requirements (defined in RAN 4 specifications) among the 8 SRS ports between the last SRS transmission and the PUSCH transmission over the defined time window, when the SRS is configured with or without TDM and no SRS symbol is dropped?  **RAN4 Answer**: For non-TDM’d SRS and without SRS symbol dropping, the answer is yes.  For TDM’d SRS and without SRS dropping, more RAN4 study might be needed to answer this question. The reason is because TDM’d SRS would require UE to remember phase and power difference of ports cross two different OFDM symbols and reproduce that difference on PUSCH in a same OFDM symbol. This is a new aspect that RAN4 has not studied yet. In RAN4’s understanding, for a same UE, there are two levels of coherence with or without TDM’d SRS. A UE might be coherence across all 8 Tx ports without TDM’d SRS (without SRS dropping), while being partially coherent within 4 Tx ports such as across {1000, 1001, 1004, 1005} or across {1002, 1003, 1006, 1007} with TDM’d SRS, as full coherence across all 8 Tx ports with TDM’d SRS (without SRS dropping) might impose new requirement for UE implementation.  **RAN1 Question 2:** For a coherent 8Tx PUSCH transmission, can a UE meet the relative phase and power error requirements (defined in RAN4 specifications) among the 8 SRS ports between the last SRS transmission and the PUSCH transmission over the defined time window, when the SRS is configured with TDM and part of the SRS symbols is dropped, for example as shown in Figure 1 and Figure 2?  **RAN4 Answer:** No, UE cannot meet the relative phase and power error requirements when the SRS is configured with TDM and part of the SRS symbols is dropped.  **RAN1 Question 3:** What are the conditions a UE has to satisfy to meet the relative phase and power error requirements among the 8 SRS ports between the last SRS transmission and the PUSCH transmission over the defined time window, in the scenario as described in questions 1 and 2?  **RAN4 Answer:** There is causality issue with SRS dropping. For example, UE does not know the SRS in future slot n+20 will be dropped, thus UE may have changed physical antenna to port mapping between slot n and slot n+20. UE cannot revert the antenna mapping back when SRS dropping occurs in slot n+20. Therefore, due to this causality issue, there is no way UE can maintain phase and power coherence from two different SRS transmission occasions to a succeeding PUSCH.  **Question 4:** For the scenarios as described in question 2, if a UE cannot meet the relative phase and power error requirements among the 8 SRS ports, can UE meet the relative phase and power error requirements among a subset of SRS ports, such as among {1000, 1001, 1004, 1005} or among {1002, 1003, 1006, 1007}?  **RAN4 Answer:**  Yes, UE can meet the relative phase and power error requirements among a subset of SRS ports which are sounded in a same OFDM symbol. |

(R4-2318955, vivo)

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| RAN4 thanks RAN1 for the LS on coherence between PUSCH and 8-ports SRS with partial dropping.  Before answering questions, RAN4 would like to first make some clarifications on the UL MIMO coherence requirements to avoid misunderstandings by referencing some contents from R4-1805132 which is the last WF before the requirements were introduced:  Way Forward   * *For UL MIMO, relative power and phase difference between the two chains is of importance.* * *The goal of the spec is to ensure that UE can maintain a power and phase error within a bound for a period of time after every SRS transmitted.* * *Power and phase error shall be measured as:*   + *A delta between the power and phase difference between the two chains computed at the last SRS and at any other time after that within the time window specified.* * *The time window specified is a guide to the gNB to determine the SRS periodicity for UL MIMO UE*   RAN4 discussed the question below and would like to provide the answers:  **Question 1:** For a coherent 8Tx PUSCH transmission, can a UE meet the relative phase and power error requirements (defined in RAN 4 specifications) among the 8 SRS ports between the last SRS transmission and the PUSCH transmission over the defined time window, when the SRS is configured with or without TDM and no SRS symbol is dropped?  **Answer:** Currently there the case of 8 SRS ports has not been formally discussed in RAN4 yet. As a preliminary answer, if similar implementation with 2Tx/4Tx is assumed, with the condition that the SRS is configured with or without TDM and no SRS symbol is dropped, it seems similar requirements can be met between any two ports, as long as the time windows can be maintained.  **Question 2:** For a coherent 8Tx PUSCH transmission, can a UE meet the relative phase and power error requirements (defined in RAN 4 specifications) among the 8 SRS ports between the last SRS transmission and the PUSCH transmission over the defined time window, when the SRS is configured with TDM and part of the SRS symbols is dropped, for example as shown in Figure 1 and Figure 2?  **Answer:** When the SRS is configured with TDM and part of the SRS symbols is dropped, the examples in Figure 1 and Figure 2 may be different.  For Figure 1, the 2nd symbol of SRS transmission in occasion 1 is more than 20ms away from PUSCH transmission, which is beyond the current 20ms time window specified, this may cause larger drift for those ports which are carried by 2nd symbol, thus bring more difficulty to meet the current coherence requirements.  For Figure 2, since the different SRS symbols with different ports are still in the same slot, it seems meeting current requirements, which is not more difficult compared to legacy case.  **Question 3:** What are the conditions a UE has to satisfy to meet the relative phase and power error requirements among the 8 SRS ports between the last SRS transmission and the PUSCH transmission over the defined time window, in the scenario as described in questions 1 and 2?  **Answer:** For the case in Figure 1, since this scenario has not been formally discussed in RAN4, RAN4 may need further study before giving more concrete answer.  **Question 4:** For the scenarios as described in question 2, if a UE cannot meet the relative phase and power error requirements among the 8 SRS ports, can UE meet the relative phase and power error requirements among a subset of SRS ports, such as among {1000, 1001, 1004, 1005} or among {1002, 1003, 1006, 1007}?  **Answer:** RAN4 may need further study for these scenarios before giving more concrete answer. As a preliminary answer, it seems possible for SRS ports {1000, 1001, 1004, 1005} in SRS transmission occasion 2 in Figure 1, if it can ensure a time gap smaller than 20ms between SRS and PUSCH. |