**3GPP TSG-RAN WG4 Meeting # 111 R4-2408932**

**Fukuoka, Japan, May 20 - 24, 2024**

**Agenda item:** 7.17.3

**Source:** Moderator (Huawei, HiSilicon)

**Title:** Topic summary for [110bis][121] NR\_cov\_enh2\_R18

**Document for:** Information

# Introduction

This contribution summarizes the documents that are submitted to agenda 7.17.1.1 and 7.17.1.2 for RAN4#111 and targeting below aspects.

* Topic #1: Concluding work on DPC reporting, hopefully
* Topic #2: Remaining issue for Rel-18 power boosting feature applicability

# Topic #1: Concluding work on DPC reporting, hopefully

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2407686 | Huawei, HiSilicon | **CR for TS 38.101-1**  To correct UE capability name for dpc-Reporting-FR1. |
| R4-2407687 | Huawei, HiSilicon | **CR for TS 38.101-3**  To correct UE capability name for dpc-Reporting-FR1. |

## Open issues summary

### Sub-topic 1-1: On the proposed CR for UE capability name update

**Issue 1-1: Whether to approve the CR for UE capability name correction**

* Proposals
  + Option 1: Approve the CR R4-2407686/7687. (Huawei)

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| Moderator: One example from R4-2407686 |

* + Option 2: Others
* Recommended WF
  + Check if Option 1 can be acceptable.

# Topic #2: Remaining issue for Rel-18 power boosting feature applicability

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2407068 | Apple | ***Observation1: Power boosting combined with UL CA cases using more than single UL CC can have IMD and harmonic falling into own Rx. Due to the boosting the increased power of IMD and harmonics are expected to create stronger de-sense of own Rx. MSD allowance might not be sufficient and would be subject to re-evaluation.***  ***Observation 2: The only exception seems to be FR1+FR2 UL CA. Having single UL CC in FR1 and UL in FR2 would not interfere with the boosting as those frequency ranges can be considered orthogonal.***  ***Proposal 1: Keep the focus on UL CA Case A and continue the discussion on solving the remaining issues.***  ***Observation 3: Not specifying receiver requirements for boosting leaves the performance undefined. The only safeguard is that performance has been evaluated under non-boosting condition. Having clear requirements provides valuable guidelines for UE design. Defining specific requirements under boosting better reflects the typical RAN4 approach. It is common procedure to define requirements specific to PC3 and PC2 UL CA combos, separately. This is done via basket approach where interested companies can propose new band combinations which are then implemented after evaluation. This concept can be used to enable boosting for all relevant combinations.***  ***Proposal 2: Define specific requirements for boosting by choosing Option 2.*** |
| R4-2408037 | Qualcomm | ***Observation 1: In trying to generalize applicability of power-boosting to CA scenarios, RAN4 should focus on requirement set completion and applicability to common deployment scenarios.***  ***Proposal 1: No new MSD test cases are introduced to reflect Rel-18 power boosting. In this case, the Rel-18 power boosting feature can be automatically extended to DLCA with single uplink CC used for Tx***  ***Observation 2: There is both, technical justification as well as need for consistency in the standard to include boosting in 2-band ULCA operation.***  ***Proposal 2: Extend the power boosting feature to the following scenarios:***   * ***Case B: Inter-band UL CA, at least one indicated band supports the power boosting, where a single CC is used for transmission in each power boosted uplink band.*** * ***Case C: FR1+FR2 UL CA, FR1+FR2 DC, FR1+FR1 DC, power boosting feature is supported in an FR1 NR band, where a single CC is configured in this uplink band.***   ***Observation 3: Boosting is also possible with Rel-18 and older intra-band CA, but only when signalling for IE dualPA-Architecture is present.***  ***Proposal 3: Extend the power boosting feature to intra-band CA for all scenarios where the single CC MPR applies. Make the configured power requirement consistent with the single CC MPR requirement that references boosting.***  ***Observation 4: The configured power requirements for ULMIMO (D), Intra-band NC CA (A) and inter-band CA (A) are inconsistent with the redirection to single CC MPR for those cases.***  ***Proposal 4: For Intra-band NC CA, to remove the inconsistency in Tx configured power when redirected to single CC MPR, add clarification that the single CC Tx configured power (6.2.4) also applies at the same time as single CC MPR (6.2.2).***  ***Proposal 5: For the configured Tx power requirement for ULMIMO, replicate wording for 6.2G.4 for consistency.***    ***Proposal 6: For the configured Tx power requirement for inter-band ULCA, use proposals of R4-2409110 and R4-2409111 as a baseline.*** |
| R4-2408130 | vivo | ***Observation 1: The higher input power will increase the MSD value, especially for UL harmonic product.***  ***Proposal 1: If the new test points with boosting need be verified, the current MSD requirements should not be reused.***  ***Proposal2：For case A, MSD would only be tested in the cases without power boosting applied, and the new MSD of power boosting cases does not need to be specified and tested again at this stage and could be discussed in Rel-19 if necessary.***  ***Proposal 3: Case B and C are not to be considered in Rel-18 discussion.*** |
| R4-2408613 | Intel | **Proposal #1: Enable power boosting enhancements/features for FR1 CA/DC scenarios with single configured UL CC including FR1 intra-band / inter-band CA and DC scenarios.**  **Proposal #2: Enable power boosting enhancements/features for FR1 CA/DC scenarios with inter-band UL CA with at least one indicated band supporting the power boosting, where a single CC is used for transmission in each power boosted uplink band.**  **Proposal #3: Further discuss applicability power boosting enhancements/features for FR1 CA/DC scenarios with intra-band UL CA under assumption of a single UL CC used for transmissions (based on scheduling restrictions or for single active CC case).**  **Proposal #4: Enable power boosting enhancements/features for FR1-FR2 CA/DC scenarios with at least one indicated FR1 band supporting the power boosting, where a single FR1 UL CC is used for transmission in uplink FR1 band.** |
| R4-2409109 | Ericsson | **Observation 1 The power class which the power boosting feature should be based on is up to the indicated power class by UE.**  **Observation 2 The network may decide whether to configure power boosting in the uplink by observing if the uplink is a coverage bottleneck.**  **Observation 3 HigherPowerLimit feature does not consider the additional MSD.**  **Observation 4 for NE-DC and EN-DC for FR1 + FR1 DC case , power boosting feature cannot apply for now**  **Proposal-1: No need to consider MSD impact when network enable the power boosting feature.**  **Proposal-2: Support the power boosting feature also in case B and case C.**  **Proposal-3: Consider an LS to RAN2 with a further update on the feature list as shown below:**   |  | | --- | | Apart from the feature support for the single band band combination where single CC is configured in this band.  This feature is applicable to the following multiple carrier scenarios in addition to single carrier scenarios:  Case A: FR1 inter-band DL CA with a single uplink CC configured.  Case B: FR1 inter-band UL CA, where at least one indicated band supports the power boosting, where a single CC is configured in each power boosted uplink band.  Case C: FR1+FR2 UL CA, FR1+FR2 DC, and FR1+FR1 DC, the power boosting feature is supported in an FR1 NR band, where a single CC is configured in this uplink band | |
| R4-2409110 | Ericsson, Qualcomm, Intel | **Draft CR for TS 38.101-1**  Adding power boosting feature [41-2] and [41-3] suppport for inter-band CA case in clause 6.2A.4.1.3. |
| R4-2409111 | Ericsson, Qualcomm, Intel | **Draft CR for TS 38.101-3**  Adding power boosting feature [41-2] and [41-3] suppport for FR1+FR2 inter-band CA and FR1+FR2 DC. |
| R4-2409168 | Huawei, HiSilicon | ***Proposal 1: No new MSD requirements will be specified due to enabling Rel-18 power boosting for FR1 DL CA configured with single uplink CC.***   * ***UE will be verified with MSDs defined for the reported power class and corresponding power configurations in current spec.***   ***Proposal 2: Do not consider extending Rel-18 power boosting to inter-band UL CA and FR1+FR1 DC.*** |

## Open issues summary

### Sub-topic 2-1: Preference on applicability

*Sub-topic description:*

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| *According to WF R4-2403885, whether Rel-18 power boosting can be applied to CA is still FFS.*   * *RAN4 is still discussing the applicable scenarios.*   + *The common understanding in RAN4 is that power boosting is only supported for single CC UL at least in Rel-18.*     - *UL CA is not supported for this feature in Rel-18.*   *As in WF R4-2406713, DL CA with single UL CC configured can be the case for extension.*  ***Issue 1: which applicable power class should be based on for CA configuration***  *Applicable power class type, configured output power requirements and criteria for the band activated with power boosting for the case*   * *The power class indication for the single uplink CC, which is the basic to enable power boosting, is subject to the discussion outcome of NR\_power\_class thread.*   ***Issue 2: MSD impact due the enabling of the power boosting feature for case A***   * *Proposals*   + *Option 1: No new MSD requirements due to the Rel-18 power boosting feature will be specified in RAN4 specification.*      - *UE will be verified with MSDs defined for the reported power class and corresponding power configurations in current spec*     - *how to capture this in RAN4 specification is FFS*   + *Option 2: MSD can be specified after justification of new test cases*     - *enable combinations which shall be subject to power boost case by case. Basket approach is used similar to the basket approach used for introducing new band combinations. Requirements can be checked.*   *The following two cases are FFS.*   * + *Case B: FR1 inter-band UL CA, at least one indicated band supports the power boosting, where a single CC is used for transmission in each power boosted uplink band.*   + *Case C: FR1+FR2 UL CA, FR1+FR2 DC, FR1+FR1 DC, power boosting feature is supported in an FR1 NR band, where a single CC is configured in this uplink band.* |

**Issue 2-1: How to handle MSD for Rel-18 power boosting extension**

* Proposals
  + Proposal 1: For any CA/DC Rel-18 power boosting extension, MSD should be specified after justification of new test cases. (Apple)
    - Enable combinations which shall be subject to power boost case by case. Basket approach is used similar to the basket approach used for introducing new band combinations. Requirements can be checked.
  + Proposal 2: If the new test points with boosting need be verified, the current MSD requirements should not be reused. (vivo)
  + Proposal 3: For FR1 DL CA configured with single uplink CC, MSD would only be tested in the cases without power boosting applied, and the new MSD of power boosting cases does not need to be specified and tested again. (vivo, Huawei)
  + Proposal 4: No new MSD test cases are introduced to reflect Rel-18 power boosting. (QC)
    - No need to consider MSD impact when network enable the power boosting feature. (Ericsson)
* Recommended WF
  + TBA.

**Ericsson: This is a generic issue. We could discuss them together for case A, B, C. This feature targets at the legacy hardware. This MSD has been tested. Here we are talking about the additional MSD. We do not change the hardware and so we do not need to specify.**

**OPPO: For this issue, we had agreements. MSD will be only tested in lower power class.**

**Qualcomm: No new test case for MSD will be specified. Keep the existing ones.**

**Intel: To OPPO, there is no agreement. Agree with Ericsson that no new requirement of MSD.**

**Apple: Same comment. We would like to see the certain agreement to exclude any requirement. RAN5 does not introduce the tests.**

**Mediatek: MSD is discussed for reporting power class. There is no new information for power boosting feature.**

**Vivo: There is on-going discussions how to handle MSD. Maybe we verify the lower power classes.**

**Samsung: for this issue, in future, we can only define the MSD for lowest reported power class. Alternatively, companies can develop the equation or looking-up table.**

**Agreement:**

* No new MSD test cases are introduced to reflect Rel-18 power boosting.

**Issue 2-2: Whether Rel-18 power boosting can be further extended to Case B and C**

* Proposals
  + Option 1: Do not consider this extension in Rel-18. (vivo, Huawei, Apple, Mediatek, Spectrum)
  + Option 2: This extension can be considered. (Ericsson, QC, Intel, Verizon)
  + Option 3: Others.
* Recommended WF
  + TBA.

**Mediatek: in our view, if case B and case C were introduced, there will be some implementation issues that the power class cannot fulfil some regulation requirements. We agree with option 1.**

**Apple: Agree with Mediatek.**

**Ericsson: for FR1+FR2, we have less design pressure. At least this combination would be more acceptable.**

**OPPO: Tend to agree with Option 1. For Case C, FR1+FR2 may be more acceptable.**

**Qualcomm: we agree that there are considerable implementation challenges. At least we have associate it with implementation. This feature is optional per band per band combination. It does not mandate UE to do something. In early phase, only a few band combinations support it. Our focus should be on finishing the framework.**

**Intel: Share the same understanding as Qualcomm. Case B and Case C should be separately discussed.**

**Verizon: we should focus on the framework. This is optional feature.**

**Spectrum: We agree with option 1.**

**Ericsson: in the real network deployment, CA configuration will be very general configuration in the field. If it is not enabled, it is useless feature. This has already been flexible enough.**

**Verizon: Support option 2. We can use this feature for region of US for example. Can we put the wording that the features are optional.**

**Apple: we are not fine that UE reporting boosting for one band needs support it for all the band combination.**

**Intel: the signaling should be be per feature set. It is per band per band combination.**

**Qualcomm: there is no intend to make it be mandatorily supported by UE. There is no mandatory requirements changed because of this feature.**

**OPPO: Not sure how UE report if it support band A but not support for Band A+B.**

**Qualcomm: the band combination signalling is flexible. This feature is per band per band combination.**

**Mediatek: to Qualcomm, in case that Case B and Case C includes multiple uplink carriers, which are different from Case A.**

**Qualcomm: regional regulation does not compromise for this feature.**

**Tentative Agreement:**

* **Rel-18 power boosting can be supported for Case A**
* **Rel-18 power boosting can be supported for Case B and Case C**
  + **No new RAN4 requirement will be specified**
  + **No signalling needs be changed in RAN2**
  + **UE can independently indicate support of Case A, B or/and C**

**Issue 2-3: Whether Rel-18 power boosting can be further extended to intra-band UL CA case**

* Proposals
  + Proposal 1: Extend the power boosting feature to intra-band CA for all scenarios where the single CC MPR applies. (QC)
    - *Boosting is also possible with Rel-18 and older intra-band CA, but only when signalling for IE dualPA-Architecture is present*
  + Proposal 2: Further discuss applicability power boosting enhancements/features for FR1 CA/DC scenarios with intra-band UL CA under assumption of a single UL CC used for transmissions (based on scheduling restrictions or for single active CC case). (Intel)
* Recommended WF
  + TBA.

**Issue 2-4: Inconsistency fix for intra-band NC CA**

* Proposals
  + Proposal 1: For Intra-band NC CA, to remove the inconsistency in Tx configured power when redirected to single CC MPR, add clarification that the single CC Tx configured power (6.2.4) also applies at the same time as single CC MPR (6.2.2). (QC)

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| 6.2A.2.2.0 General For intra-band non-contiguous CA, the allowed Maximum Power Reduction (MPR) for the maximum output power is specified into 2 types: MPR to meet -30dBm/MHz and -13dBm/MHz. The UE determins the MPR type as follows:  For UE indicating *dualPA-Architecture* supported  If OR (LCRB1 = 0, LCRB2 = 0)  MPR defined in Table 6.2.2-1 and Table 6.2.2-2 for PC3 and PC2 UE respectively and the Tx configured power requirement of 6.2.4 applies  Else If AND( FIM3,low\_block,low > SEM-13,low , FIM3,high\_block,high < SEM-13,high )  MPR defined in Clause 6.2A.2.2.2.1 and Clause 6.2A.2.2.2.2 for PC3 and PC2 UE respectively.  Else  MPR defined in Clause 6.2A.2.2.1.1 and Clause 6.2A.2.2.1.2 for PC3 and PC2 UE respectively.  For UE without indicating *dualPA-Architecture* supported  If OR( LCRB1 = 0, LCRB2 = 0 )  For PC3 UE, MPR defined in Table 6.2.2-1, except for B < 9 MHz where 5.5 dB MPR is used and the Tx configured power requirement of 6.2.4 applies;  For PC2 UE without indicating *TxD*, MPR defined in Table 6.2.2-2 is used, except for B < 11.52 MHz where 6.5 dB MPR is used and the Tx configured power requirement of 6.2.4 applies; |

* Recommended WF
  + Discuss the above TP and check if there is any conflict with the ongoing discussion in *NR\_power\_class* thread.

**Issue 2-5: Inconsistency fix for UL MIMO**

* Proposals
  + Proposal 1: For the configured Tx power requirement for ULMIMO, replicate wording for 6.2G.4 for consistency. (QC)

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| 6.2D.4 Configured transmitted power for UL MIMO For UE supporting UL MIMO, the transmitted power is configured per each UE.  The definitions of configured maximum output power PCMAX,*c*, the lower bound PCMAX\_L,*c*, and the higher bound PCMAX\_H,*c* specified in clause 6.2.4 shall apply to UE supporting UL MIMO, where  - PPowerClass, ΔPPowerClass+ΔPPowerBoost and ∆TC,c are specified in clause 6.2.4 unless otherwise stated;  - MPRc is specified in clause 6.2D.2;  - A-MPRc is specified in clause 6.2D.3. |

* Recommended WF
  + If the intention is aligned, this is already fixed in the latest version of TS 38.101-1.

**Issue 2-6: Proposed CR R4-2409110 for TS 38.101-1**

* Proposals
  + Proposal 1: *For Case A*.

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| 6.2A.4.1.3 Configured transmitted power for Inter-band CA For uplink carrier aggregation the UE is allowed to set its configured maximum output power PCMAX,*c* for serving cell *c* and its total configured maximum output power PCMAX.  The configured maximum output power PCMAX,*c* on serving cell *c* shall be set as specified in clause 6.2.4, except that the UE power class for serving cell *c* on the specific operating band shall be determined by the *ue-PowerClassPerBandPerBC-r17* IE [7] as indicated for the band combination if signalled.  For downlink inter-band carrier aggregation with a single uplink component carrier configured, when the IE [powerBoostPi2BPSKRel18] or [powerBoostQPSKRel18] is set to 1 for a UE supporting the capability of [powerBoostTSRel18] or [powerBoostRel18], the configured maximum output power PCMAX,c on serving cell c shall be set as specified for PCMAX,f,c in clause 6.2.4.  For uplink inter-band carrier aggregation, MPR*c* and A-MPR*c* apply per serving cell *c* and are specified in clause 6.2.2 and clause 6.2.3, respectively. P-MPR*c* accounts for power management for serving cell *c*. PCMAX,*c* is calculated under the assumption that the transmit power is increased independently on all component carriers.  The total configured maximum output power PCMAX shall be set within the following bounds: |

* + Proposal 2: *Combine Rel-17 highpowerLimit with Rel-18 power boosting for inter-band CA.*

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| For uplink inter-band carrier aggregation with one serving cell c per operating band when same slot symbol pattern is used in all aggregated serving cells,  PCMAX\_L = MIN {10log10∑ MIN [ pEMAX,c/(tC,c), pPowerClass.c/(MAX(mprc·∆mprc, a-mprc)·tC,c ·tIB,c·tRxSRS,c), pPowerClass,c/pmprc], PEMAX,CA, PPowerClass,CA-ΔPPowerClass, CA}  PCMAX\_H = MIN{10 log10 ∑ pEMAX,c , PEMAX,CA, PPowerClass,CA-ΔPPowerClass, CA}  where  - pEMAX,c is the linear value of PEMAX, *c* which is given by IE *P-Max* for serving cell *c* in [7];  - PPowerClass,CA is the maximum UE power specified in Table 6.2A.1.3-1 without taking into account the tolerance specified in the Table 6.2A.1.3-1; If the UE indicates *higherPowerLimit-r17* for an eligible CA configuration as specified in Table 6.2A.1.3-1 and ΔPPowerClass, CA = 0, PPowerClass,CA is replaced by 10 log10 ∑ pPowerClass,c.  - pPowerClass,c is the linear value of the maximum UE power for serving cell *c* specified in Table 6.2.1-1 according to *ue-PowerClassPerBandPerBC-r17* if indicated or ue-PowerClass otherwise without taking into account the tolerance; For uplink inter-band carrier aggregation with a single uplink component carrier configured in any band where the IE [powerBoostPi2BPSKRel18] or [powerBoostQPSKRel18] is set to 1 for a UE supporting the capability of [powerBoostTSRel18] or [powerBoostRel18] and supporting *higherPowerLimit-r17* for an eligible CA configuration as specified in Table 6.2A.1.3, ΔPPowerClass, CA = 0, PPowerClass,CA is replaced by 10 log10 ∑ pPowerClass,c ∙ ∆pPowerBoost,c, where ∆pPowerBoost,c is linear value of ΔPPowerBoost.c as specified in 6.2.4.  - ΔPPowerClass,CA = 3 dB for a power class 2 UE when the requirements of default power class are applied as specified in sub-clause 6.2.A.1.3; otherwise ΔPPowerClass, CA = 0 dB; |

* Recommended WF
  + For Proposal 1, discuss the above change and check if there is any conflict with the ongoing discussion in NR\_power\_class thread.
  + For Proposal 2, TBA.

**Issue 2-7: Proposed CR R4-2409111 for TS 38.101-3**

* Proposals
  + Proposal 1: *For inter-band FR1+FR2 UL CA case*.

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| 6.2A.4 Configured output power for CA6.2A.4.1 Configured output power level For inter-band NR CA between FR1 and FR2, UE configured output power specified in TS 38.101-1 [2] and TS 38.101-2 [3] apply for each frequency range respectively.  For inter-band NR CA between FR1 and FR2 with a single uplink component carrier configured in FR1, when the IE [powerBoostPi2BPSKRel18] or [powerBoostQPSKRel18] is set to 1 for a UE supporting the capability of [powerBoostTSRel18] or [powerBoostRel18], the configured maximum output power PCMAX,c on serving cell c shall be set as specified for PCMAX,f,c in clause 6.2.4. |

* + Proposal 2: *For inter-band FR1+FR2 NR-DC case*.

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| 6.2B.5.1.1 Inter-band NR-DC between FR1 and FR2 For both synchronous and non-synchronous inter-band NR-DC [12] with MCG in FR1 and SCG in FR2 combined with one uplink serving cell per CG, the UE is allowed to set its configured maximum output power PCMAX,*c(i),i* for serving cell *c(i)* of CG *i, i = 1,2* as specified in clause 6.2.4 of TS 38.101-1 [2] and clause 6.2.4 TS 38.101-2 [3] independently.  For inter-band NR-DC between FR1 and FR2 with a single uplink component carrier configured in FR1, when the IE [powerBoostPi2BPSKRel18] or [powerBoostQPSKRel18] is set to 1 for a UE supporting the capability of [powerBoostTSRel18] or [powerBoostRel18], the configured maximum output power PCMAX,c on serving cell c shall be set as specified for PCMAX,f,c in clause 6.2.4. |

* Recommended WF
  + TBA.