**3GPP TSG-RAN WG4 Meeting #110-bis R4-2405282**

**Changsha, China, April 15 – 19, 2024**

**Agenda item:** 9.1.5

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

**Title:** Topic summary for [110bis][129] NR\_ENDC\_RF\_Ph4\_Part1

**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.*

Thread [129] includes following topics:

1. Topic #1: Workplan
2. Topic #2: High power UE (HPUE) for CA in terrestrial network (TN)
3. Topic #3: Power boosting and/or MPR reduction
4. Topic #4: 6Rx for handheld and FWA UE

# Topic #1: Workplan

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

## Companies’ contributions summary

|  |  |  |  |
| --- | --- | --- | --- |
| **T-doc number** | **T-doc name** | **Company** | **Proposals / Observations** |
| [**R4-2405486**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2405486.zip) | Work plan for Rel-19 UE RF enhancements | Huawei, HiSilicon, AT&T | *Work plan for 3 main objectives** *HPUE for CA/DC*
* *Power boosting and/or MPR reduction*
* *6Rx for handheld and FWA UE*
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## 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: Workplan for Rel-19 UE RF enhancements

Workplan in [**R4-2405486**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2405486.zip)

* Proposals

|  |  |  |  |
| --- | --- | --- | --- |
| **Meeting** | **High power UE (HPUE) for CA** | **Power boosting and/or MPR reduction** | **6Rx for handheld and FWA UE** |
| #110bis | 1. Initial discussion on general requirements for **PC1.5 in intra-band UL contiguous CA and non-contiguous UL CA** with 2Tx, mainly focus on **MPR/A-MPR and SAR solution**2. Initial discussion on **general requirements** for **PC1.5 two-band inter-band UL CA** w/ 2Tx and/or 3Tx for handheld and FWA UE as well as **PC2 and PC1.5 two-band EN-DC** w/ 2Tx and/or 3Tx for handheld and FWA UE, mainly focus on **SAR solutions**3. Initial discussion on **study of increasing power limit** for inter-band UL CA and EN-DC with different power classes4. Alignment of understanding of scope for HPUE for CA/DC based on the WID objectives. If needed, WID could be clarified in next RAN meeting. | 1. Initial discussion on **scenarios for power domain enhancement** with relaxation of applicable requirements, including both (e)RedCap UE (only PC3) and non-RedCap UE with scenarios of* when there is no adjacent in-band/out-of-band co-existence issue
* when a UE uses a narrower channel bandwidth within a wider BS bandwidth

2. Initial discussion on **MPR applicability** based on the **UL CCs with activated cells** for NR intra-band UL CA configuration3. Alignment of understanding of scope for power booting and/or MPR reduction based on the WID objectives. If needed, WID could be clarified in next RAN meeting. | 1. Initial discussion on 6Rx for example bands n41, n77/n78, n79, n1042. **Identify the RF requirements** for UE supporting 6Rx3. Initial discussion on supported MIMO layers4. Initial discussion on study for the issue of SRS IL imbalance  |
| #111 | 1. Continue discussion on MPR/A-MPR requirements as well as SAR solutions for PC1.5 intra-band UL contiguous and non-contiguous UL CA* Agree on the simulation/measurement evaluation assumptions for MPR/A-MPR requirements

2. **Conclude on identified general requirements** to be considered for PC 1.5 inter-band UL CA with 2Tx and/or 3Tx, and PC1.5 and PC2 inter-band EN-DC with 2Tx and/or 3Tx* **Agree on the cases**, e.g. supported TDD/FDD combinations with different power classes, to be considered for SAR solutions for inter-band CA and EN-DC with 2Tx and/or 3Tx

3. **Conclude on feasibility of increasing power limit** for inter-band CA/EN-DC with different power classes  | 1. Continue discussion on scenarios for power domain enhancement with relaxation of applicable requirements* Agree on simulation/evaluation assumptions for determined scenarios

2. Continue discussion on **MPR applicability** based on the UL CCs with activated cells for NR intra-band UL CA configuration for **FR1 and FR2** including both contiguous and non-contiguous UL CA 3. Discuss **MPR improvement** for intra-band UL contiguous CA for **FR2*** Evaluate MPR impact due to consideration of DL CCs
* Agree on the new simulation/measurement evaluation assumptions for MPR improvement if needed
 | 1. Agree on the **Rx requirements for 6Rx** based example bands2. Continue discussion on **SRS antenna switching** requirements3. Continue discussion on supported MIMO layers4. Continue discussion on **study for the issue of SRS IL imbalance** |
| #112 | 1. Continue discussion on MPR/A-MPR requirements as well as SAR solution for PC1.5 intra-band UL contiguous and non-contiguous UL CA2. Continue discussion on identified general requirements for PC 1.5 inter-band UL CA with 2Tx and/or 3Tx, and PC1.5 and PC2 inter-band EN-DC with 2Tx and/or 3Tx3. Continue discussion on increasing power limit for inter-band CA/EN-DC with different power classes | 1. Try to **conclude on feasible scenarios** for power domain enhancement with relaxation of applicable requirements, and continue discussion on requirements to enable power domain enhancement via MPR reduction and/or power boosting2. Continue discussion on MPR applicability based on the UL CCs with activated cells for NR intra-band UL CA configuration for both FR1 and FR2; 3. Continue discussion on MPR improvement for intra-band UL contiguous CA for FR2 | 1. **Agree on SRS antenna switching requirements** for 6Rx for t1r6, t2r6, t3r6, t4r62. Conclude on supported MIMO layers in RF session3. Conclude on the issue of SRS IL imbalance and discuss candidate solutions 4. Initial discussion on RRM impact5. Initial review of the CR framework for better spec structure |
| #112bis | Continue discussion on remaining requirements and signalling if needed to support HPUE enhancements for CA/EN-DC | 1. Continue discussion on requirements to enable power domain enhancement via MPR reduction and/or power boosting based on identified feasible scenarios2. Continue discussion on MPR applicability based on the UL CCs with activated cells for NR intra-band UL CA configuration for both FR1 and FR2; 3. Continue discussion on MPR improvement for intra-band UL contiguous CA for FR2 | 1. Continue discussion of CR framework if needed2. Try to agree on the draft CR for RF requirements for 6Rx3. If justified, continue the discussion of down selection of candidate solutions |
| #113 | Continue discussion on remaining requirements and signalling if needed to support HPUE enhancements for CA/EN-DC | 1. Continue discussion on requirements to enable power domain enhancement via MPR reduction and/or power boosting2. **Try to conclude on MPR applicability** based on the UL CCs with activated cells for NR intra-band UL CA configuration for both FR1 and FR2 3. Continue discussion on MPR improvement for intra-band UL contiguous CA for FR2 | 1. **Endorse the draft big CR** for RF requirements for 6Rx2. Continue the discussion the solution of SRS IL imbalance, if needed3. Try to conclude on RRM impact |
| #114 | 1. Continue discussion on remaining requirements and signalling if needed to support HPUE enhancements for CA/EN-DC2. Initial review of the CR framework for better spec structure | 1. Continue discussion on remaining issues for power boosting and/or MPR reduction enhancements2. Initial review of the CR framework for better spec structure | **Try to conclude the solution** **of SRS IL imbalance**, if needed |
| #114bis | 1. Continue discussion on remaining requirements and signalling if needed to support HPUE enhancements for CA/EN-DC2. Continue discussion of CR framework if needed | 1. Continue discussion on remaining issues for power boosting and/or MPR reduction enhancements2. Continue discussion of CR framework if needed | make conclusion for the study of SRS reporting, i.e. support or not support in Rel-19 |
| #115 | Endorse big CR for aspects supporting HPUE for CA/EN-DC enhancements | Endorse big CR for aspects supporting power boosting and/or MPR reduction enhancements | Finalize **big CR for 6Rx** |
| #116 | 1. Finalize the **big CR for HPUE enhancements for CA/EN-DC**2. Agree on the release independent CR for TS **38.307 for HPUE enhancements for CA/EN-DC** if needed | 1. Finalize the **big CR for power boosting and/or MPR reduction**2. Agree on the release independent CR for TS **38.307 for power boosting and/or MPR reduction** if needed |  |

* Recommended WF
	+ Approve the workplan.

# Topic #2: High power UE (HPUE) for CA in terrestrial network (TN)

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

## Companies’ contributions summary

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| --- | --- | --- | --- |
| **T-doc number** | **T-doc name** | **Company** | **Proposals / Observations** |
| [**R4-2404184**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2404184.zip) | On Rel-19 HPUE for CA and DC | Apple | *Observation 1: For mobile handheld UE, PC1.5 for single carrier can only be supported with 2Tx via either Tx diversity or UL MIMO.**Observation 2: For mobile handheld UE, only up to 2Tx can be supported for any single band.**Observation 3: For intra-band contiguous UL CA with UL MIMO, dualPA-Architecture would not be feasible.**Observation 4: For intra-band contiguous UL CA without UL MIMO, dualPA-Architecture is only feasible for UL configurations with equal bandwidth between the two carriers.****Proposal 1: For intra-band contiguous UL CA with and without UL MIMO, the general requirements are specified without dualPA-Architecture.****Observation 5: For intra-band non-contiguous UL CA without UL MIMO, dualPA-Architecture is only feasible for UL configurations with equal bandwidth between the two carriers.**Observation 6: For intra-band non-contiguous UL CA without UL MIMO, the benefit of using dualPA-Architecture is that the supported frequency separation between the two carriers can be up to the full-band range.**Observation 7: For intra-band non-contiguous UL CA without using dualPA-Architecture, the supported frequency separation between the two carriers (outer edge to outer edge) is only up to 200MHz.****Proposal 2: Deprioritize the specifications development for PC1.5 intra-band non-contiguous UL CA with simultaneous UL transmission and introduce UL Tx switching to intra-band non-contiguous UL CA with UL MIMO as an alternative.****Observation 8: For the 2-band 3Tx UE RF requirements already specified for FWA, there is no compelling reason that the same requirements could not be applied to handheld UE.****Proposal 3: For PC1.5 2-band inter-band UL CA with 2Tx or 3Tx, only define one set of UE RF requirements for both handheld UE and FWA.****Observation 9: For inter-band UL CA with 3Tx configurations, the UL combinations shall be captured in either sub-clause 6.2H.3.1 or sub-clause 6.2L.3.1 or both, while for 2Tx UL configurations, the UL combinations are to be captured in sub-clause 6.2A.1.3.**Observation 10: Though PC1.5 is a new feature for inter-band EN-DC, it does not require new Tx general requirement as PCMAX range has already been specified up to 33 dBm.****Proposal 4: For PC2 and PC1.5 2-band inter-band EN-DC with 2Tx or 3Tx, only define one set of UE RF requirements for both handheld UE and FWA.****Observation 11: For PC2 2-band inter-band EN-DC with 2Tx or 3Tx, no new general requirement needs to be developed.**Observation 12: For inter-band EN-DC with 3Tx configurations, the UL combinations shall be captured in either sub-clause 6.2H.1.3 or sub-clause 6.2L.1.3 or both, while for 2Tx UL configurations, the UL combinations are to be captured in sub-clause 6.2B.1.3.****Proposal 5: For UL configurations of PC1.5 inter-band UL CA and PC1.5 inter-band EN-DC which require new MSD framework, an example band combination for each UL configuration shall be selected to complete the requirements before other combinations of the same UL configuration can be proposed to the basket WID.****Observation 13: For UL configurations consist of at least one FDD band, it may be subject to 2UL IMD interference issue. If PCMAX for each constituent UL band would be applied to evaluate MSD requirements, new MSD framework would be needed for these UL configurations.****Proposal 6: RAN4 shall be mindful on defining MSD requirements for the new UL configurations supporting “Increasing UE power high limit for CA and DC” feature.*** |
| [**R4-2404208**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2404208.zip) | High power UE for CA in terrestrial networks | Qualcomm Technologies Int | ***Proposal 1: Add a lower BW band combination like CA\_41B for completeness to the list of example band combinations for the 2Tx HPUE PC1.5 contiguous intra-band CA objective.******Proposal 2: Add a lower frequency band combination like CA\_41(2A) to the list of example band combinations for the 2Tx HPUE PC1.5 non-contiguous intra-band CA objective.*** *Observation 1: A practical way to enable generalized applicability of higherPowerLimit-r17 across different power-class aggregations is to minimize the definition of new MSD test cases for new power-class aggregations.****Proposal 3: For Rel-19, RAN4 to identify the additional conditions that must also be met before a new MSD test case is justified in context of a new power class aggregation for an already specified ULCA inter-band combination. For example, if an MSD test case exists for a PC1.5 CA power class UE comprising a PC3 UL band and a PC1.5 UL band, does a new case need to be defined when the same band combination is enabled for PC2 + PC1.5 UL?*** |
| [**R4-2404455**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2404455.zip) | Initial consideration on HPUE for CA in terrestrial network (TN) | CATT | ***Proposal 1: In Rel-19 HPUE works, RAN4 to enhance the specifications concerning the power class capability of band combinations in a manner that eliminates dispersion and redundancy, avoids inconvenience, ensures conciseness, and eases maintenance challenges.*** |
| [**R4-2404485**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2404485.zip) | On SAR Solution of R19 HPUE for CA | E-surfing Digital | ***Proposal1: For PC1.5 HPUE for two bands CA with 2Tx*** ***and/or 3Tx, the general SAR solution framework and the threshold of average percentage of uplink symbols should both refer to PC2 UE for CA and PC1.5 UE for single CC.******Proposal2:*** ***For PC1.5 HPUE for two bands CA with 2Tx*** ***and/or 3Tx, if power class of one or both of the bands within the band combination is power class 1.5, the default value of maxDutyNR,x/y should be 25%.*** |
| [**R4-2404541**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2404541.zip) | High power UE for intra/inter-band CA/DC including 2Tx/3Tx in TN | Meta Ireland | ***Proposal 1: RAN4 considers separate PA (2x26dBm) and separate antenna RF architecture for Power class 1.5 to derive the MPR/A-MPR requirements for the intra-band contiguous CA UE.******Proposal 2: RAN4 can reuse the max uplink duty cycle limitation of the single carrier SAR solution for PC 1.5 intra-band contiguous CA UE.******Proposal 3: RAN4 can consider 2x26dBm PA (2LO) and separate antenna RF architecture as baseline to derive the MPR/A-MPR requirements for the intra-band non-contiguous CA UE.******Proposal 4: RAN4 can reuse the max uplink duty cycle limitation of the single carrier SAR solution for PC 1.5 intra-band non-contiguous CA combinations UE.******Proposal 5: RAN4 can define the above high power inter-band CA/DC band combinations with 2Tx/3Tx in the related Basket WIs in Rel-19. In the Rel-19 UE RF enhancement WI, RAN4 only focuses on general RF requirements for high power inter-band CA/DC UE.******Proposal 6: RAN4 can define some new power classes to support total accumulated power for inter-band CA/DC band combinations UE in Rel-19.******Proposal 7: The power class information of high-power inter-band CA/DC UE with 2Tx/3Tx will be reported per band and per band combinations.******Proposal 8: For the SAR regulation requirements of high power inter-band CA/DC UE, RAN4 can consider both duty cycle limitation and P-MPR approach from Rel-19 as same in FR2 MPE solutions.*** |
| [**R4-2404551**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2404551.zip) | Discussion on PC1.5 TDD intra-band CA | Xiaomi | ***Proposal 1: Two RF architectures as shown in table 1 could be considered when developing Tx requirements for both PC1.5 intra-band contiguous CA and non-contiguous CA. For intra-band contiguous CA with UL MIMO, the RF architecture #1 is considered.****Table 1, the possible RF architecture for PC1.5 intra-band CA*

|  |  |  |
| --- | --- | --- |
| ***Architecture*** | ***Description*** | ***Applicability of UL MIMO***  |
| *#1* | *2x26dBm PA+2LO with 100MHz BW* | *Not supported* |
| *#2* | *2x26dBm PA+1LO with 200MHz BW* | *supported* |

***Proposal 2: the tolerance +2/-3 could as baseline for PC1.5 intra-band CA in Band n41,n77,n78 and n79.******Proposal 3: To mitigate the SAR issue, the following is proposed for PC1.5 intra-band CA.**** ***P-MPR is available for the UE for SAR mitigation method***
* ***Duty cycle based SAR solution: Reuse the capability for single carrier case, i.e. maxUplinkDutyCycle-PC2-FR1, maxUplinkDutyCycle-PC1dot5-MPE-FR1***
* ***Fallback behavior: same fallback behavior as single carrier PC1.5. i.e. fallback to the corresponding PC3 or PC2 intra-band non-contiguous CA in case of the dutycycle condition is not met.***
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| [**R4-2404552**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2404552.zip) | Discussion on PC1.5 UE for two band NR inter-band uplink CA | Xiaomi | ***Proposal 1: For PC1.5 UE for two band NR inter-band uplink CA with 2Tx and/or 3Tx, the existing SAR mitigation solution for PC1.5 with 3Tx in Ts 38.101-1 could be reused.******Proposal 2: the SAR solution as follow is proposed for PC1.5 inter-band EN-DC with 2Tx and 3Tx case.*** |
| [**R4-2404553**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2404553.zip) | Discussion on increasing high power limit for inter-band CA DC with 2Tx and or 3Tx | Xiaomi | ***Proposal 1: the following power class configuration could be considered in Rel 19 for UE increasing high power limit.****PC3 (TDD/FDD) +PC1.5**PC2 (TDD with TxD) +PC3 (TDD/FDD)**PC2 (TDD) +PC5* |
| [**R4-2404605**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2404605.zip) | Discussion on HPUE for CA and EN-DC | LG Electronics | ***For PC1.5 UE supporting NR TDD intra-band UL contiguous and non-contiguous CA with 2Tx,******Proposal 1: For PC1.5 UE supporting NR TDD intra-band UL contiguous and non-contiguous CA with 2Tx, consider dual Tx (2x26dBm) for MPR/A-MPR.******Proposal 2: For PC1.5 UE supporting NR TDD intra-band UL contiguous and non-contiguous CA with 2Tx, consider SAR solution similar to PC1.5 in a single carrier.******For PC1.5 UE supporting NR inter-band UL CA with 2Tx,*** ***Proposal 3: For PC1.5 UE supporting NR inter-band UL CA with 2Tx, decide which case(s) is supported.*** *- Case 1 : PC2 NR FDD + PC2 NR TDD* *- Case 2 : PC2 NR TDD + PC2 NR TDD* ***Proposal 4: For PC1.5 UE supporting NR inter-band UL CA with 2Tx, update the existing SAR solution of PC2.******For PC1.5 UE supporting NR inter-band UL CA with 3Tx,*** ***Proposal 5: For PC1.5 UE supporting NR inter-band UL CA with 3Tx, decide which case(s) is supported additionally.*** *- Case 2 : PC2 NR FDD + PC1.5 NR TDD (UL-MIMO or Tx Diversity)**- Case 3 : PC2 NR FDD + PC2 NR TDD (UL-MIMO or Tx Diversity)**- Case 4 : PC3 NR TDD + PC1.5 NR TDD (UL-MIMO or Tx Diversity)**- Case 5 : PC2 NR TDD + PC1.5 NR TDD (UL-MIMO or Tx Diversity)**- Case 6 : PC2 NR TDD + PC2 NR TDD (UL-MIMO or Tx Diversity)****Proposal 6: For PC1.5 UE supporting NR inter-band UL CA with 3Tx, consider impact the existing SAR solution when higherPowerLimit is configured.******For PC2 UE supporting two band EN-DC with 2Tx,*** ***Proposal 7: For PC2 UE supporting two band EN-DC with 2Tx, decide which case(s) is supported additionally.*** *- Case 5 : PC3 E-UTRA FDD + PC3 NR FDD* *- Case 6 : PC3 E-UTRA FDD + PC2 NR FDD* *- Case 7 : PC2 E-UTRA TDD + PC3 NR TDD* ***Proposal 8: Specify the SAR solution considering the possible E-UTRA TDD uplink-downlink configurations and the percentage of maximum E-UTRA/NR uplink transmission if additional case(s) is agreed in P7.******For PC1.5 UE supporting two band EN-DC with 2Tx,*** ***Proposal 9: For PC1.5 UE supporting two band EN-DC with 2Tx, decide whether to support the following case.****- Case 1 : PC2 E-UTRA TDD + PC2 NR TDD* ***Proposal 10: Specify the SAR solution considering the possible E-UTRA TDD uplink-downlink configurations and the percentage of maximum E-UTRA/NR uplink transmission if Case 1 is agreed in P9.******For PC2 UE supporting two band EN-DC with 3Tx,*** ***Proposal 11: For PC2 UE supporting two band EN-DC with 3Tx, decide which case(s) is supported additionally.*** ***- Case 5 : PC3 E-UTRA FDD + PC3 NR FDD (UL-MIMO or*** *Tx diversity)**- Case 6 : PC3 E-UTRA FDD + PC2 NR FDD (UL-MIMO or Tx diversity)**- Case 7 : PC2 E-UTRA TDD + PC3 NR TDD (UL-MIMO or Tx diversity)****Proposal 12: Specify the SAR solution considering the possible E-UTRA TDD uplink-downlink configurations and the percentage of maximum E-UTRA/NR uplink transmission if additional case(s) is agreed in P11.******For PC1.5 UE supporting two band EN-DC with 3Tx,*** ***Proposal 13: For PC1.5 UE supporting two band EN-DC with 3Tx, decide whether to support the following cases.****- Case 1 : PC3 E-UTRA FDD + PC1.5 NR TDD (UL-MIMO or Tx diversity)**- Case 2 : PC3 E-UTRA TDD + PC1.5 NR TDD (UL-MIMO or Tx diversity)**- Case 3 : PC2 E-UTRA TDD + PC1.5 NR TDD (UL-MIMO or Tx diversity)**- Case 4 : PC2 E-UTRA TDD + PC2 NR TDD (UL-MIMO or Tx diversity)****Proposal 14: Specify the SAR solution considering the possible E-UTRA TDD uplink-downlink configurations and the percentage of maximum E-UTRA/NR uplink transmission if additional case(s) is agreed in P13.*** |
| [**R4-2404623**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2404623.zip) | PC 1.5 for band combinations and the general framework for high power classes | Ericsson | ***For PC 1.5 band combinations and the general framework for higher power we observe that****Observation 1: there is no need to focus on the SAR solution for the objectives of the Rel-19 WID for the PC1.5 UE for any CA configurations to be considered; the SAR solution can be provided by the “P-MPR method”, no need to consider further duty-cycle reporting for PC1.5 capable UEs.****Proposal 1: conductive MSD conformance tests for UL CA configurations are not necessary for all possible higher power classes like PC1.5 in case the UE meets the exception for the default power class. An exception is still needed in case the standard REFSENS requirement can be met for the default power class but not for the higher power class.****Observation 2: the UE must meet regulatory transmitter requirements for any supported band combination and power class, while it may be sufficient to justify compliance with regulatory receiver requirements by compliance with REFSENS and selectivity requirements for the default power classes of the bands of the BC.****For PC1.5 inter-band combinations with 3Tx, we observe that****Observation 3: for two-band inter-band combinations with UL-MIMO in one band implemented with 3Tx, the UL-MIMO power class is the same as the per-band power class regardless of transmissions in the other band, exposure limits allowing.* *and regardless of the number of Tx**Observation 4: the per-BC power class may be ambiguous when the higherPowerLimit is present for the BC regardless of the number of Tx and power class supported, the gNB not aware if the UE is in power-capability fallback due to SAR; the higherPowerLimit indication replaces the powerClass only when the UE is not in power-capability fallback.****For PC1.5 intra-band combinations with 2Tx,*** *Observation 5: for a PC1.5 UE supporting DL-only intra-band CA or UL contiguous or non-contiguous CA cases with the CCs combined in baseband, it is business as usual, no change of the MPR framework.****whereas****Observation 6: for a PC1.5 UE supporting UL non-contiguous CA cases with each CC transmitted by a separate Tx, the MPR framework must be changed: each CC can only transmit up to 26 dBm and the PC1.5 UE would not need prioritize UL power.* |
| [**R4-2404665**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2404665.zip) | Discussion on high power UE for CA in terrestrial network | vivo | ***Observation 1.*** *Based on the state-of-art technology, it is difficult to use one single PA to support PC1.5 29dBm for handheld/FWA UE.****Observation 2:*** *The Intra-band CA for PC1.5 would need multiple Tx, thus need to be considered in MPR derivation.****Observation 3:*** *Other RF requirements is easily to be extended to PC1.5 considering PC2 history and PC1.5 single carrier requirement.****Observation 4:*** *The scenarios for Rel-18 can be categorized as:** *Group 1: (FWA done in R18)*
* *PC2 NR inter-band UL CA/EN-DC with 3Tx for handheld*
* *PC1.5 NR inter-band UL CA/EN-DC with 3Tx for handheld*
* *Group 2: (No UE type done in R18)*
* *PC1.5 NR inter-band UL CA/EN-DC with 2Tx for handheld and FWA*

***Observation 5:*** *For EN-DC with 2Tx, if LTE is in FDD band, UE cannot support PC1.5.* ***Observation 6:*** *Other issues can be discussed with the progress of the previous scopes.* ***Proposal 1:*** *It is suggested to use two 26dBm PA architecture to achieve PC 1.5 UL contiguous and non-contiguous CA. The baseline architecture is proposed to be:* * *Non-Contiguous CA: Option 1 (2x26 dBm, 100MHz, 2LOs)*
* *Contiguous CA: Option 2 (2x26 dBm, 200MHz, 1LO)*

***Proposal 2:*** *Discuss more detailed framework for MPR/A-MPR after reference architecture discussion.****Proposal 3:*** *Considering agreeing the following RF requirements for both intra-band contiguous and non-contiguous CA at least as starting point:** *Define tolerance as：26dBm +2/-3dB*
* *ACLR requirement: 31dB*
* *Emission requirement: reuse SEM, general spurious, ASEM, ASE and UE-to-UE coexistence requirements defined for PC3 and PC2 (for contiguous and non-contiguous CA respectively)*
* *UL/DL configuration: adopt the same UL/DL configuration between CCs*
* *Capability of MaxUplinkDutyCycle, maxUplinkDutyCycle-PC1dot5-MPE-FR1: Reuse the capability for single carrier case*

***Proposal 4:*** *For scenarios discussed and defined in Rel-18 for FWA, discuss the applicable requirements for handheld and use the conclusions for FWA as baseline, e.g. reuse or apply some relaxations.****Proposal 5:*** *For PC 1.5 UL inter-band CA/EN-DC with 2Tx, use two 26dBm PA architecture with two LOs and discuss the requirements, and reuse the SAR solutions as for PC1.5 3Tx.* |
| [**R4-2404745**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2404745.zip) | Discussions on TDD intra-band CA HPUE | China Unicom | ***Proposal 1: Keep the power class definition consistent by reusing PC1.5 values for NR single carrier MOP for NR TDD Intra-band UL CA, i.e. 29dBm maximum power and +2/-3dB tolerance.******Proposal 2: Reuse the existing duty cycle reporting as optional SAR solution for PC1.5 TDD Intra-band CA HPUE, and revisit the default duty cycle value if needed to ensure SAR is not violated on PC1.5.*** |
| [**R4-2404885**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2404885.zip) | Initial consideration on R19 UE RF enh for HPUE in TN | Huawei, HiSilicon | *PC1.5 UE for NR TDD intra-band UL CA with 2Tx****Proposal 1-1: For both C/NC CA, dual-Tx (two CCs in one PA) and dualPA-Architecture (one CC one PA) architectures should be considered.******Proposal 1-2: It is proposed to discuss whether down scope the RF architectures for specifying the requirements in terms of contiguous UL CA and/or non-contiguous UL CA.******Proposal 1-3: Due to similar UE architecture (2x26dBm PA) compared to Rel-17 PC2 assumption, it is proposed to evaluate the net power gain of PC1.5 intra-band C/NC CA compared to PC2.****Observation 1-1: For PC3 and PC2, the same intra-band CA power class applies to all UL component carriers.****Proposal 1-4: Discuss how to treat PC1.5 with dualPA-architecture for intra-band CA, since the MOP of an individual CC is 26dBm instead of 29dBm.******Proposal 1-5: P Power class issue relevant to intra-band UL CA, if needed, is considered in Rel-18 maintenance part or power boosting and/or MPR reduction part (applicability of MPR) instead of HPUE for CA/DC.*** ***Proposal 1-6: It is proposed to clarify the WI scope if the understandings of the objectives are diversified.******Proposal 1-7: Study and if necessary, specify the MPR requirements for both small and large form factor UEs, i.e. minimum antenna isolation = 10 or 20dB.******Proposal 1-8: Consider reusing the evaluation assumptions for PC1.5 single-carrier UL.******Proposal 1-9: Large measurement campaign is needed for evaluating the PC1.5 MPR requirements for intra-band UL CA including all applicable waveforms and modulation formats.******Proposal 1-10: UE implemented P-MPR is considered as baseline SAR solution, upon that, only duty-cycle based SAR solution is considered in Rel-19****Observation #1-2: The duty-cycle based SAR solution for PC2 and PC1.5 intra-band CA can be unified based on the current structure of the SAR solution for PC2. And there is no difference of the SAR solution between intra-band contiguous and non-contiguous CA.**HPUE for NR inter-band UL CA and EN-DC with 2Tx and/or 3Tx****Proposal 2-1: Based on operators’ demand, the applicable combinations of duplex modes (FDD/TDD) as well as power configurations for the WI can be further clarified.******Proposal 2-2: The Rel-18 3Tx WI (4Rx\_low\_NR\_band\_handheld\_3Tx\_NR\_CA\_ENDC) has defined the general RF requirements for PC2 and PC1.5 3Tx inter-band CA/EN-DC for FWA, which can be extended for 3Tx handheld UEs.******Proposal 2-3: Update to the existing clauses of RF requirements are needed for adding PC1.5 inter-band UL CA with 2Tx for handheld and FWA, i.e. PC2 1Tx + PC2 1Tx.******Proposal 2-4: For HPUE CA/DC, no BC-specific MSD discussion in this non-spectrum WI, but generic MSD model for deriving PC1.5/PC2 MSD requirements based on existing PC2/PC3 MSD could be considered.****Observation 2-1: The duty-cycle based SAR solution for intra-band CA in PC2 and PC1.5 can be unified based on the current structure of the SAR solution for PC2 without differentiation of duplex mode. The SAR solutions specified for PC1.5 inter-band CA with 2Tx can be unified with that for 3Tx.**Observation 2-2: The SAR solution to inter-band EN-DC with PC3 FDD+ PC3 FDD may need to be supported in Rel-19.**Observation 2-3: A duty cycle capability for 2Tx FDD+FDD inter-band EN-DC band combination with PC2 may need to be introduced in Rel-19.**Observation 2-4: The 2Tx inter-band EN-DC with PC2 TDD+ PC2 TDD in PC1.5 and the corresponding SAR solution may need to be supported in Rel-19.**Observation 2-5: It is not necessary to further consider SAR solution to 3Tx inter-band EN-DC with PC2/PC1.5 in Rel-19, given that no new demand different from that in Rel-18 from operators until now.****Proposal 2-5: The SAR solutions required in Rel-19 HPUE are listed in the following table.***

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | ***PC2*** | ***PC1.5*** |
| ***Intra-band CA*** | ***contiguous*** |  | ***SAR solution is required*** |
| ***non-contiguous*** |
| ***Inter-band CA*** | ***2Tx*** |  | ***SAR solution is required*** |
| ***3Tx*** |
| ***Inter-band EN-DC*** | ***FDD + FDD*** | ***SAR solution is required*** |  |
| ***TDD + TDD*** |  | ***SAR solution is required*** |

***Proposal 2-6: If no consensus on the SAR solution, leave the issue to UE implementation****Increasing UE transmission power limit for NR inter-band UL CA and EN-DC**Observation 3-1: The WI scope is to study UL bands with different existing power classes.****Proposal 3-1: Consider alternatives to the Rel-17 higherPowerLimit feature to enable higher power limit for inter-band CA/DC if they’re better.******Proposal 3-2: Avoid NBC issues for legacy networks when designing new solutions for increasing UE Tx power limit.******Proposal 3-3: Consider impact to the duty-cycle based SAR solution when the total Tx power exceeds the MOP of the conventional CA power class.******Proposal 3-4: Consider whether to increase the total Tx power limit beyond PC1.5 for handheld UEs.******Proposal 3-5: Consider impact to the MSD requirements, e.g., whether to define MSD requirements for various combinations of per-band power classes such as PC1.5+PC2/3/5, PC2+PC5, etc.*** |
| [**R4-2404901**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2404901.zip) | On architecture aspects for PC1p5 intra-band ULCA support | Skyworks Solutions Inc. | ***Proposal: To support the mandatory 1CC fall back, a UE supporting contiguous or non-contiguous PC1.5 ULCA must support single CC PC1.5 in the same band and thus, support 2Tx with TxD as a minimum feature and UL MIMO optionally.******Proposal: the intra-band PC1.5 ULCA R19 work focusses on UE implementing intra-band ULCA PC1.5 this two 26dBm PAs.******Proposal on intra-band contiguous PC1.5 ULCA architecture:*** * ***Only the two 26dBm PA architecture using 2Tx as already needed for the 1CC fall back is specified.***
* ***Each PA must support the two CCs and TxD is default and UL MIMO is optional.***
* ***This has no restriction in terms of supporting the 200MHz maximum aggregated BW or allocation BW in each CC.***

***Proposal on intra-band non-contiguous PC1.5 ULCA architecture:*** * ***Only the two 26dBm PA architecture using one PA per CC is specified.***
* ***A specific MPR term is added to account for the case where there is an imbalance between the two CC allocated RB BW and PC1.5 maximum power cannot be reached for large RX BW imbalances***
* ***This has no restriction in terms of supporting 600MHz maximum separation BW or gap sizes.***
* ***UL MIMO cannot be supported.***

***Proposal: for R19 PC1.5 intra-band non-contiguous ULCA with two 26dBm PAs and one PA per CC, the 29dBm PCmax is modified as follows to account for RB BW imbalances:*** ***PCmax=10\*log(10^(26/10)+10^((26-10\*log(LCRB1\*SCS1/LCRB2\*SCS2))/10))*** |
| [**R4-2404986**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2404986.zip) | Views on HPUE | Samsung | For 3.1 PC1.5 for intra-band contiguous UL CA w/o UL MIMO***Proposal 1: PC2 for UL CA n79C should be specified as well, can be done in this WI.******Proposal 2: MOP tolerance can be +2/-3 dB, in addition adding the following note into MOP table for PC1.5.**** ***Note X: Achieved via dual Tx***

*Observation 1: The description for SAR mechanism would be present in which clause should be TBD, depending on the outcome of “power class’ relevant discussion. We can first discuss the applicableΔPPowerClass,CA* *and its condition.****Proposal 3:*****For a PC1.5 UE:****ΔPPowerClass,CA = 6dB*** **When 10 log10 ∑ pEMAX,c or PEMAX,CA which defined in clause 6.2A.4.1.1 is 23 dBm or lower;**
* **or when the field of UE capability *maxUplinkDutyCycle-PC2-FR1* is absent and the field of UE capability *maxUplinkDutyCycle-PC1dot5-MPE-FR1* is absent and the percentage of uplink symbols transmitted in a certain evaluation period is larger than 50%;**
* **or when the field of UE capability *maxUplinkDutyCycle-PC2-FR1* is not absent and the percentage of uplink symbols transmitted in a certain evaluation period is larger than *maxUplinkDutyCycle-PC2-FR1* as defined in TS 38.306 ;**
* **or when the field of UE capability *maxUplinkDutyCycle-PC1dot5-MPE-FR1* is not absent and half the percentage of uplink symbols transmitted in a certain evaluation period is larger than *maxUplinkDutyCycle-PC1dot5-MPE-FR1* as defined in TS 38.306.**

**ΔPPowerClass,CA = 3dB*** **When 10 log10 ∑ pEMAX,c or PEMAX,CA which defined in clause 6.2A.4.1.1 is between 23 dBm and 26dBm;**
* **or when the field of UE capability *maxUplinkDutyCycle-PC2-FR1* is absent and the field of UE capability *maxUplinkDutyCycle-PC1dot5-MPE-FR1* is absent and the percentage of uplink symbols transmitted in a certain evaluation period is between 25% and 50%;**
* **or when the field of UE capability *maxUplinkDutyCycle-PC2-FR1* is not absent and the percentage of uplink symbols transmitted in a certain evaluation period is between 0.5\**maxUplinkDutyCycle-PC2-FR1* and *maxUplinkDutyCycle-PC2-FR1* as defined in TS 38.306;**
* **or when the field of UE capability *maxUplinkDutyCycle-PC1dot5-MPE-FR1* is not absent and the percentage of uplink symbols transmitted in a certain evaluation period is larger than *maxUplinkDutyCycle-PC1dot5-MPE-FR1* but less than 2\* *maxUplinkDutyCycle-PC1dot5-MPE-FR1* as defined in TS 38.306.**

**ΔPPowerClass,CA = 0dB otherwise*****Note: The exact evaluation period is no less than one radio frame.******Proposal 4: Consider the following architectures for MPR evaluation.******- 2 Lo +2 PA (dualPA-Architecture is indicated)******- 1 Lo +2 PA (TxD support is indicated)******Proposal 5: PCMAX tolerance for PC1.5 intra-band contiguous UL CA without UL MIMO:**** ***TLOW=3dB***
* ***THIGH=2dB***

***Proposal 6：For PC 1.5, NR ALCR as 31dB, UTRA ALCR not needed for the example combos.***For 3.2 PC1.5 for intra-band contiguous ULCA with UL MIMO***Proposal 7: PC2 and PC3 for UL CA n77C with UL MIMO, ULCA n79C with UL MIMO should be specified, can be done in this WI.******Proposal 8: MOP tolerance can be +2/-3 dB, in addition adding the following note into MOP table for PC1.5.**** ***Note X: Achieved via dual Tx***

***Proposal 9: The applicable ΔPPowerClass,CA and its conditions for PC1.5 intra-band contiguous CA w/o UL MIMO can be reused for PC1.5 intra-band contiguous CA w/ UL MIMO.******Proposal 10: For PC1.5, intra-band contiguous ULCA with UL MIMO can reuse the MPR requirements of intra-band contiguous ULCA without UL MIMO and with dual Tx(TxD).******Proposal 11: PCMAX tolerance for PC1.5 intra-band contiguous UL CA with UL MIMO can be:**** ***TLOW=3dB***
* ***THIGH=2dB***

For 3.3 PC1.5 for intra-band NC ULCA w/o UL MIMO***Proposal 12: MOP tolerance can be +2/-3, in addition adding the following note into MOP table for PC1.5.**** ***Note X: Achieved via dual Tx***

***Proposal 13:*****For a PC1.5 UE:****ΔPPowerClass,CA = 6dB*** **When 10 log10 ∑ pEMAX,c or PEMAX,CA which defined in clause 6.2A.4.1.2 is 23 dBm or lower;**
* **or when the field of UE capability *maxUplinkDutyCycle-PC2-FR1* is absent and the field of UE capability *maxUplinkDutyCycle-PC1dot5-MPE-FR1* is absent and the percentage of uplink symbols transmitted in a certain evaluation period is larger than 50%;**
* **or when the field of UE capability *maxUplinkDutyCycle-PC2-FR1* is not absent and the percentage of uplink symbols transmitted in a certain evaluation period is larger than *maxUplinkDutyCycle-PC2-FR1* as defined in TS 38.306 ;**
* **or when the field of UE capability *maxUplinkDutyCycle-PC1dot5-MPE-FR1* is not absent and half the percentage of uplink symbols transmitted in a certain evaluation period is larger than *maxUplinkDutyCycle-PC1dot5-MPE-FR1* as defined in TS 38.306.**

**ΔPPowerClass,CA = 3dB*** **When 10 log10 ∑ pEMAX,c or PEMAX,CA which defined in clause 6.2A.4.1.2 is between 23 dBm and 26dBm;**
* **or when the field of UE capability *maxUplinkDutyCycle-PC2-FR1* is absent and the field of UE capability *maxUplinkDutyCycle-PC1dot5-MPE-FR1* is absent and the percentage of uplink symbols transmitted in a certain evaluation period is between 25% and 50%;**
* **or when the field of UE capability *maxUplinkDutyCycle-PC2-FR1* is not absent and the percentage of uplink symbols transmitted in a certain evaluation period is between 0.5\**maxUplinkDutyCycle-PC2-FR1* and *maxUplinkDutyCycle-PC2-FR1* as defined in TS 38.306;**
* **or when the field of UE capability *maxUplinkDutyCycle-PC1dot5-MPE-FR1* is not absent and the percentage of uplink symbols transmitted in a certain evaluation period is larger than *maxUplinkDutyCycle-PC1dot5-MPE-FR1* but less than 2\* *maxUplinkDutyCycle-PC1dot5-MPE-FR1* as defined in TS 38.306.**

**ΔPPowerClass,CA = 0dB otherwise*****Note: The exact evaluation period is no less than one radio frame.******Proposal 14: Consider the following architectures for MPR discussion.******- 2 Lo +2 PA (dualPA-Architecture is indicated)******- 1 Lo +2 PA (TxD support is indicated)******Proposal 15: PCMAX tolerance for PC1.5 intra-band non-contiguous UL CA without UL MIMO**** ***TLOW=3dB***
* ***THIGH=2dB***

***Proposal 16：For PC1.5, NR ALCR as 31dB, UTRA ALCR not needed for the example combos.***For 3.4 PC1.5 for 2-band Inter-band UL NR-CA***Proposal 17: Same requirements of 3Tx FWA are applicable to 3Tx handheld UE, and to support 3Tx operation for handheld UE in Rel-19, remove the following limitation in clause 4.3 of TS 38.101-1.******“****For a terminal that supports inter-band Carrier Aggregation (CA) with UL MIMO or Tx diversity operation, the requirements are targeted for FWA form factor in current version of specification.****”******Proposal 18: For Rel-19 3Tx operation, the scenarios can be the same with Rel-18 scenarios unless new requests/scenarios raised from operators. Depending on the new requests/scenarios, some general requirements including the Note in MOP table and SAR requirements can be updated if needed.******Proposal 19: For 2Tx PC1.5 MOP tolerance, reuse the 3Tx PC1.5 MOP tolerance, i.e., +2/-3dB.******Proposal 20: For 2Tx PC1.5 IMD, it is suggested to introduce a new MSD table assuming min (+26dBm, PCMAX\_L,f,c) for each band for MSD evaluation.*** ***Proposal 21: For 2Tx PCMAX tolerance, it was already automatically specified when 3Tx PC1.5 was introduced in Rel-18, since 3Tx configured transmitted power clause refer to 2Tx configured transmitted power clause.******Proposal 22: For 2Tx PC1.5 SAR compliance, 3Tx PC1.5 SAR methodology can be referred while the restriction on the scenarios needs to be removed/updated.***For PC1.5 and PC2 for two-band EN-DC***Proposal 23: Same requirements of 3Tx FWA are applicable to 3Tx handheld UE, and to support 3Tx operation for handheld UE in Rel-19, remove the following limitation in clause 4.2 of TS 38.101-3.****“For a terminal that supports inter-band Dual-Connectivity (DC) with UL MIMO or Tx diversity operation, the requirements are targeted for FWA form factor in current specification.”****Proposal 24: For Rel-19 3Tx PC2/PC1.5 EN-DC, It is suggested to first collect the demand/request on the following aspects before specifying the requirements.*** * ***PC1.5 scenarios***
* ***PC2 scenarios, Whether there is new scenarios to be considered in Rel-19 compared with the Rel-18 scenarios***

For 3.6 Increasing UE transmission power***Observation 2: The following table summarize the specified scenarios of increasing high power limit feature in Rel-17/18.***

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Indicated PC for A-B****(2Tx in total)** | **PC for band A of A-B** | **PC for band B of A-B** | **From which release increasing high power limit feature supported** | **Note** |
| PC2 | PC3 | PC2 | Support from Rel-17  | One CC per band |
| PC3 | PC5(NRU band) | PC3 | Support from Rel-18 | One CC per band; One CC on band B, 2CC on band A(NRU band) |

***Proposal 25: For 2Tx, if based on existing specified combos, there seems no new scenarios to be considered so far.******Proposal 26: For 3Tx, the following scenarios may could be considered.******(Note the analysis is based on the specified combos and the combos/scenarios would certainly be specified within Rel-19)***

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Indicated PC for A-B****(3Tx in total)** | **PC for band A of A-B****(1Tx)** | **PC for band B of A-B****(2Tx)** | **The total power****(dBm)** | **Note** |
| PC2 | PC3 | PC2 | 27.8 | One CC per band  |
| PC1.5 | PC3 | PC1.5 | 30.8 | One CC per band; For FWA only |

 |
| [**R4-2405059**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2405059.zip) | Initial discussion on Rel-19 High power UE (HPUE) support for EN-DC | CHTTL | ***Proposal 1: The 3Tx EN-DC configurations and the corresponding requirements defined in Rel.18 are applicable for handheld UE in Rel.19.******Proposal 2: At least the following scenarios of EN-DC for handheld and FWA are considered in Rel.19.**** ***PC2 with total 2Tx: LTE FDD + NR FDD with PC3+PC3 & PC3+PC2 configurations***
* ***PC2 with total 3Tx: LTE FDD + NR FDD with 1Tx PC3 + 2Tx PC3 or PC2 configurations***
* ***PC1.5 with total 3Tx: LTE FDD + NR TDD with 1Tx PC3 + 2Tx PC1.5 configuration***

***Proposal 3: Regarding the SAR mitigation solution for PC1.5 LTE FDD + NR TDD EN-DC, the UE-implementation based methods (i.e. P-MPR) is applied by default, and re-using the PC2 duty cycle signalling with some scaling for PC1.5 can be further considered as an additional method.******Proposal 4: Regarding the SAR mitigation solution for PC2 LTE FDD + NR FDD EN-DC, the UE-implementation based methods (i.e. P-MPR) is applied by default, and whether to introduce duty cycle method can be further investigated.*** |
| [**R4-2405182**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2405182.zip) | R19 3Tx inter-band enh | OPPO | ***Proposal 1: Remove the UE type limitation for 3Tx (inter-band CA with UL MIMO or Tx Diversity).****Observation 1: Current spec restrict 3Tx to some specific power and MIMO configurations, which should be removed in Rel-19 to fully enable 3Tx power capabilities.**Observation 2: To remove the 3Tx power/MIMO configuration restrictions, some general principles might be needed on the MSD application, e.g. whether MSDs are differentiated by power/MIMO configurations for each band combination.****Proposal 2: Discuss and decide whether only one set of MSDs are defined for a 3Tx band combination regardless of power/MIMO configurations of each band in the band combination.******Proposal 3: Define 3Tx power class only by the total transmitted power, and no further restriction on the power/MIMO configurations of each band in the band combination (as 2Tx band combinations have defined).*** |
| [**R4-2405226**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2405226.zip) | Discussion on R19 FR1 TN HPUE requirements | ZTE Corporation | **2Tx PC1.5 for NR TDD intra-band UL contiguous and non-contiguous CA***Observation 1: Rx RF requirements are not impacted.**Observation 2: The following Tx RF requirements are needed to be updated/defined due to the introduction of PC1.5 intra-band UL CA.*1. *UE MOP for CA*
2. *Pcmax/SAR*
3. *MPR/A-MPR*
4. *SEM/SE/ACLR*

***Proposal 1: PC2 CA\_n79C with or without UL-MIMO and PC2 CA\_n77C with UL-MIMO should be introduced accordingly, the MOP requirements for CA\_n79C and CA\_n77C are 26dBm with tolerance +2/-3dB.******Proposal 2: The MOP requirements for PC1.5 CA\_n41C, CA\_n77C, CA\_n78C, CA\_n79C, CA\_n77(2A) and CA\_n78(2A) are 29dBm with tolerance +2/-3dB, achieved via dual Tx.******Proposal 3: For PC1.5 NR TDD intra-band UL non-contiguous CA, only the MPR for UE indicating IE dualPA-Architecture shall be defined as the band combination agnostic manner.****Observation 3: For n78, there are no CA\_NS\_XX or CA\_NC\_NS\_XX values for intra-band CA, and for n77, general CA\_NC\_NS\_01 is used for intra-band non-contiguous CA but no CA\_NS\_XX value defined for intra-band contiguous CA. For n41, CA\_NS\_04 and CA\_NC\_NS\_04 are used to for PC2/PC3 n41C and n41(2A),****Proposal 4: No A-MPR requirements are defined for PC1.5 n77/n78 intra-band CA, while the A-MPR requirements are needed to be revisited for PC1.5 n41 intra-band CA.******Proposal 5: Use the PC1.5 single CC capability for PC1.5 TDD UL intra-band contiguous and non-contiguous CA.******Proposal 6: Pcmax requirement with ΔPPowerClass =3/6associated with the descriptions related to duty cycle are needed to be defined for PC1.5 TDD UL intra-band contiguous and non-contiguous CA******Proposal 7: For Spectrum emission mask and spurious emission, the descriptions of existing intra-band contiguous CA are needed to be updated to include 2Tx PC1.5 UL intra-band contiguous CA.******Proposal 8: Same requirement for PC1.5 single carrier (i.e. CA ACLR=31dB) is re-used for PC1.5 intra-band UL contiguous and non-contiguous CA*****Handheld and/or FWA UE related HPUE band combination***Observation 4: For 2Tx PC2 NR inter-band CA band combination, only PC3 on FDD band is considered in Rel-18, and in Rel-19, it seems only PC3 on FDD band is considered as well.****Proposal 9. At least PC2(TDD) + PC2(TDD) band combination could be included for 2Tx PC1.5 inter-band UL CA, the duty cycle (related to SAR) requirements Pcmax updates are needed accordingly.**** ***Example band combination: PC2 n41+PC2 n79***

***Proposal 10: To consider PC2(TDD)+PC1.5(TDD) band 2Tx (UL MIMO and TxD) for 3Tx PC1.5 inter-band CA/ENDC.******Proposal 11: For 3Tx band combination, FWA UE requirements can be applied to handheld UE.*****Increasing UE transmission power limit***Observation 5: Same R17 approach is reused for R18 to enable increase higher power limit feature, i.e. the PPowerClass,CA is replaced by the sum of the linear value of the maximum UE power according to the reported* power class per band.***Proposal 12. By reusing the same approaches as Rel-17/18, it is feasible to support increasing UE transmission power limit up to the sum of maximum output power per band for NR inter-band uplink CA and EN-DC HPUE with the different existing power classes which have already been specified******Proposal 13. To consider the following eligible inter-band CA/ENDC band combination to enable increase higher power limit feature in Rel-19:******For PC2 2Tx inter-band NR CA and ENDC:**** ***Inter-band with intra-band UL CA in one of the band***

***For HPUE 3Tx inter-band NR CA and ENDC:**** ***PC2 band combination of PC3+PC2 with single carrier in each band.***
* ***PC1.5 band combination of PC3+PC1.5 with single carrier in each band.***
* ***PC1.5 band combination of PC2+PC1.5 with single carrier in each band.***

***Note: Only PC3 is considered for LTE FDD in EN-DC*** |
| [**R4-2405409**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2405409.zip) | Discussion on PC 1.5 EN-DC | Nokia | *When in June RAN4 spectrum items are discussed having a basket LTE PC2 CA including also FDD bands should be considered. At the moment there are no LTE FDD TDD bands as ul-duty-cycle-feature is not implemented for LTE and SAR can be an issue. P-MPR is however possible for LTE FDD leaving it to UE to make sure that SAR is met, this is anyway how it is also for TDD bands. Even with P-MPR solution benefits for DL/UL coverage extension are possible even though the benefits for UL throughput may not be that evident. FWA use cases do not have any restrictions due to SAR.**Even though PC2 LTE bands are out scoped from UE RF enhancements for NR FR1/FR2 and EN-DC, Phase 4 WI it does not mean that new PC1.5 EN-DC combinations could not be specified as pending SAR issues can be handled with P-MPR or use case is FWA.* |
| [**R4-2405497**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2405497.zip) | Discussion and overview on Rel-19 UE RF HPUE enhancements | MediaTek Inc. | ***For PC1.5 NR TDD intra-band UL CCA/NCCA:****Observation 1: For single band PC1.5 NR TDD intra-band UL CCA with or without UL-MIMO and intra-band UL non-contiguous CA without UL-MIMO, the existing PC2 framework is also applicable****Proposal 1: The SAR solution for existing PC1.5 non-CA single TDD band can be considered as starting point of PC1.5 NR TDD intra-band UL CCA with or without UL-MIMO and intra-band UL non-contiguous CA without UL-MIMO*** ***For PC1.5 2-band NR inter-band UL CA with 2Tx and/or 3Tx and 2-band EN-DC with 2Tx and/or 3Tx:****Observation 2: In Rel-19, a 3Tx capable UE would be possible to support UL CA with UL MIMO in any one of the bands****Proposal 2: The framework of Rel-18 3Tx can be further extended for Rel-19 UE RF enhancement for UE supporting UL CA with UL MIMO in any one of the bands with necessary modification. Tx requirements are also applicable for Rel-19 UE RF enhancement with proper modification, i.e., the clauses in the specification suffix H and L in 38.101-1/3 can be updated in more generic way to accommodate Rel-19 UE RF enhancements.******Proposal 3: Existing Rx requirements framework such as MSD specification for different aggressor mechanisms are applicable for Rel-19 UE RF enhancements.******Proposal 4: The following configurations are to be considered in Rel-19, details can be further discussed:******For NR UL Inter-band CA:**** ***Power Class 1.5:***
* ***PC2 FDD 1/2Tx + PC2 TDD 1/2Tx, the maximum number of Tx chain is up to three.***
* ***PC2 FDD 1Tx + PC1.5 TDD 2Tx***

***For EN-DC:**** ***Power Class 2:***
* ***PC3 LTE FDD 1Tx + PC2/3 NR FDD/TDD 1/2 Tx***
* ***PC3/2 LTE TDD 1/2Tx + PC2/3 NR FDD/TDD 1/2 Tx, the maximum number of Tx chain is up to three***
* ***PC3 LTE FDD 1Tx + PC2 NR FDD/TDD 1/2Tx***
* ***Power Class 1.5:***
* ***PC3 LTE FDD 1Tx + PC1.5 NR TDD 2 Tx***
* ***PC2 LTE TDD 1/2Tx + PC2 NR FDD/TDD 1/2 Tx, the maximum Tx chain is up to three***
* ***PC2 LTE TDD 1/2Tx + PC1.5 NR TDD 1/2 Tx, the maximum Tx chain is up to three***
 |
| [**R4-2405964**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2405964.zip) | Initial views on UL CA and EN-DC with 3Tx for handheld UE | NTT DOCOMO INC. | *Observation 1: In Rel-19, RAN4 will discuss introducing the 3Tx requirements for handheld UE. It is very valuable because UE can enable UL MIMO and UL CA/EN-DC simultaneously.****Proposal 1: The below power class configurations for inter-band UL CA/EN-DC with 3Tx for FWA introduced in Rel-18 are reused as a starting point for the scope of power class configurations for inter-band UL CA/EN-DC with 3Tx for handheld UE in Rel-19.***

|  |
| --- |
| *In each band only 1CC included. The Tx capability considered is 1Tx in one band, and 2Tx in the other band**The following power class configurations will be considered** *CA power class or EN-DC power class is PC2*
	+ *PC3 FDD band 1Tx + PC2 TDD band 2Tx (UL MIMO and TxD)*
	+ *PC3 FDD band 1Tx + PC3 TDD band 2Tx (UL MIMO and TxD)*
	+ *PC3 TDD band 1Tx + PC2 TDD band 2Tx (UL MIMO and TxD)*
* *CA power class or EN-DC power class is PC1.5*
	+ *PC3 FDD band 1Tx + PC1.5 TDD band 2Tx (UL MIMO and TxD)*
 |

***Proposal 2: For both FWA and handheld UE, at least, the increasing UE power high limit feature should be introduced for 3Tx UL CA/EN-DC configured with PC3 band and PC2 band. Other power class configurations can also be discussed******if they are included in the scope of 3Tx in Rel-19 WI.****Observation 2: If the increasing UE power high limit feature can be introduced for 3Tx, it is applicable within the existing power limits indicated by IE P-Max, p-UE-FR1, p-NR-FR1, or p-MaxEUTRA. Independent power control on each CC should not be allowed.* |

## 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 2-1: PC1.5 for intra-band contiguous and non-contiguous UL CA

*Sub-topic description*

**NOTE 1**: Intra-band contiguous UL CA includes cases with and without UL MIMO, Intra-band non-contiguous UL CA includes only w/o UL MIMO

**NOTE 2:** Unless otherwise stated, the issues discussed below are applicable for both contiguous and non-contiguous CA

*Open issues and candidate options before meeting:*

#### **Issue 2-1-1: New proposed BC configurations which are not included in the WI objectives**

* Proposals for intra-band contiguous CA
	+ Proposal 1: PC2 and PC3 for UL CA n77C with UL MIMO, UL CA n79C w/ and w/o UL MIMO should be specified, can be done in this WI. (Samsung, ZTE)
	+ Proposal 2: Add a lower BW band combination like CA\_41B for completeness to the list of example band combinations for the 2Tx HPUE PC1.5 contiguous intra-band CA objective. (Qualcomm)
* Proposals for intra-band non-contiguous CA
	+ Proposal 3: Add a lower frequency band combination like CA\_41(2A) to the list of example band combinations for the 2Tx HPUE PC1.5 non-contiguous intra-band CA objective. (Qualcomm)
* Recommended WF
	+ Discuss whether the above proposed BC configurations could be considered in this WI.

#### **Issue 2-1-1: SAR solution**

* Proposals
	+ Proposal 1: UE implemented P-MPR is considered as baseline SAR solution, upon that, duty-cycle based SAR solution is considered in Rel-19.
	+ Proposal 2: For Duty-cycle based SAR solution, reuse the capability for single carrier case, i.e. *maxUplinkDutyCycle-PC2-FR1*, *maxUplinkDutyCycle-PC1dot5-MPE-FR1*
	+ Proposal 3: Same fallback behaviour as single carrier PC1.5. i.e. fallback to the corresponding PC3 or PC2 intra-band contiguous or non-contiguous CA in case of the dutycycle condition is not met.
	+ Proposal 4: Due to ongoing discussion for where to present the description of duty-cycle based SAR mechanism, first discuss the applicableΔPPowerClass,CA and its condition.
	+ Proposal 5: The applicable ΔPPowerClass,CA and its conditions for PC1.5 intra-band contiguous CA w/o UL MIMO can be reused for PC1.5 intra-band contiguous CA w/ UL MIMO.
* Recommended WF
	+ Discuss the details of duty-cycle based SAR solution for intra-band UL CA based on above proposals.

#### **Issue 2-1-2: Assumed UE architectures for MPR/A-MPR evaluation**

* Proposals
	+ Option 1: (Xiaomi, Samsung, Huawei)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Architecture** | **Description** | **Indicated capability** | **Support UL MIMO** | **Applicable cases** |
| #1 | 2x26 dBm PA + 2 LO with 100MHz BW | *dualPA-Architecture* | No | C/NC CA |
| #2 | 2x26 dBm PA + 1 LO with 200MHz BW | *TxD* | Yes | C/NC CA |

NOTE: support UL MIMO here doesn’t mean UE has to support the feature, it depends on UE capability reporting

* + Option 2: (Apple, vivo, Skyworks, Meta)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Architecture** | **Description** | **Indicated capability** | **Support UL MIMO** | **Applicable cases** |
| #1 | 2x26 dBm PA + 2 LO with 100MHz BW | *dualPA-Architecture* | No | NC CA |
| #2 | 2x26 dBm PA + 1 LO with 200MHz BW | *TxD* | Yes | Contiguous CA |

* Recommended WF
	+ To discuss whether down selection of the UE architecture for specifying MPR for intra-band contiguous CA w/ and w/o UL MIMO, and for intra-band non-contiguous CA w/o UL MIMO

#### **Issue 2-1-3: General consideration for the MPR requirements**

* Proposals
	+ Proposal 1: For PC1.5, intra-band contiguous ULCA with UL MIMO can reuse the MPR requirements of intra-band contiguous ULCA without UL MIMO and with dual Tx (TxD). (Samsung)
	+ Proposal 2: Study and if necessary, specify the MPR requirements for both small and large form factor UEs, i.e. minimum antenna isolation = 10 or 20dB. (Huawei)
	+ Proposal 3: Consider reusing the evaluation assumptions for PC1.5 single-carrier UL. (Huawei)
	+ Proposal 4: Due to similar UE architecture (2x26dBm PA) compared to Rel-17 PC2 assumption, it is proposed to evaluate the net power gain of PC1.5 intra-band C/NC CA compared to PC2. (Huawei)
	+ Proposal 5: Deprioritize the specifications development for PC1.5 intra-band non-contiguous UL CA with simultaneous UL transmission and introduce UL Tx switching to intra-band non-contiguous UL CA with UL MIMO as an alternative. (Apple)
* Recommended WF
	+ Agree with proposal 1~3.
	+ FFS whether to deprioritize some specific cases for specifying MPR requirement with proposal 4~5
	+ Tx switching for UL NC CA has been discussed in RAN meeting, since it is not included in the current WID, no further discussion for this aspect unless WID updated with such objective

#### **Issue 2-1-4: MOP tolerance**

* Proposals
	+ MOP tolerance can be +2/-3 dB, in addition adding the following note into MOP table for PC1.5. (Samsung,
		- Note X: Achieved via dual Tx
* Recommended WF
	+ Agree with the proposal.

#### **Issue 2-1-5: PCMAX**

* Proposals
	+ Option 1: for R19 PC1.5 intra-band **non-contiguous** ULCA with two 26dBm PAs and one PA per CC, the 29dBm PCmax is modified as follows to account for RB BW imbalances: (Skyworks)
		- PCmax=10\*log(10^(26/10) + 10^((26-10\*log(LCRB1\*SCS1/LCRB2\*SCS2))/10))
	+ Option 2: Other
* Recommended WF
	+ TBA.

#### **Issue 2-1-5: PCMAX tolerance**

* Proposals
	+ PCMAX tolerance for PC1.5 intra-band C/NC UL CA can be: (Samsung, vivo, ZTE, China Unicom, Xiaomi)
		- TLOW=3dB
		- THIGH=2dB
* Recommended WF
	+ Agree with the proposal.

#### **Issue 2-1-6: ACLR**

* Proposals
	+ For PC 1.5, NR ALCR as 31dB, UTRA ALCR not needed for the example combos. (Samsung, vivo, ZTE)
* Recommended WF
	+ Agree with the proposal.

### Sub-topic 2-2: PC1.5 for 2-band Inter-band UL NR-CA

*Sub-topic description*

*Open issues and candidate options before meeting:*

#### **Issue 2-2-1: Applicability of 3Tx requirements for FWA and handheld UE**

* Proposals
	+ Option 1: The Rel-18 3Tx WI (4Rx\_low\_NR\_band\_handheld\_3Tx\_NR\_CA\_ENDC) has defined the general RF requirements for PC2 and PC1.5 3Tx inter-band CA/EN-DC for FWA, which can be extended for 3Tx handheld UEs. (Huawei, Samsung, OPPO, Apple, ZTE)
		- To support 3Tx operation for handheld UE in Rel-19, remove the following limitation in clause 4.3 of TS 38.101-1. *For a terminal that supports inter-band Carrier Aggregation (CA) with UL MIMO or Tx diversity operation, the requirements are targeted for FWA form factor in current version of specification.* (Samsung, OPPO)
	+ Option 2: For scenarios discussed and defined in Rel-18 for FWA, discuss the applicable requirements for handheld and use the conclusions for FWA as baseline, e.g. reuse or apply some relaxations. (vivo)
* Recommended WF
	+ Option 1. Further discuss the details of the spec impact.

#### **Issue 2-2-2: RF requirements for PC1.5 inter-band UL CA with 2Tx for handheld and FWA**

* Proposals
	+ Proposal 1: Update to the existing clauses of RF requirements are needed for adding PC1.5 inter-band UL CA with 2Tx for handheld and FWA, i.e. PC2 1Tx + PC2 1Tx. (Huawei)
	+ Proposal 2: For Rel-19 3Tx operation, the scenarios can be the same with Rel-18 scenarios unless new requests/scenarios raised from operators. Depending on the new requests/scenarios, some general requirements including the Note in MOP table and SAR requirements can be updated if needed. (Samsung)
	+ Proposal 3: For 2Tx PC1.5 MOP tolerance, reuse the 3Tx PC1.5 MOP tolerance, i.e., +2/-3dB. (Samsung)
	+ Proposal 4: For 2Tx PC1.5 IMD, it is suggested to introduce a new MSD table assuming min (+26dBm, PCMAX\_L,f,c) for each band for MSD evaluation. (Samsung)
	+ Proposal 5: For 2Tx PCMAX tolerance, it was already automatically specified when 3Tx PC1.5 was introduced in Rel-18, since 3Tx configured transmitted power clause refer to 2Tx configured transmitted power clause. (Samsung)
	+ Proposal 6: Define 3Tx power class only by the total transmitted power, and no further restriction on the power/MIMO configurations of each band in the band combination (as 2Tx band combinations have defined). (OPPO)
* Recommended WF
	+ In general, the above proposals are agreeable.

#### **Issue 2-2-3: SAR solution**

* Proposals
	+ Option 1: For 2Tx PC1.5 SAR compliance, 3Tx PC1.5 SAR methodology can be referred while the restriction on the scenarios needs to be removed/updated. (Samsung, Huawei, CTC, vivo)
	+ Option 2: the SAR solution can be provided by the “P-MPR method”, no need to consider further duty-cycle reporting for PC1.5 capable UEs (Ericsson)
* Recommended WF
	+ Option 1. It is suggested to consider a unified duty-cycle based solution covering both 3Tx and 2Tx

#### **Issue 2-2-4: BC cases to be considered in the WI for specifying requirements and/or SAR solution**

* Proposals
	+ Proposal 1: For Rel-19 3Tx operation, the scenarios can be the same with Rel-18 scenarios unless new requests/scenarios raised from operators. (Samsung, DCM)
	+ Proposal 2: To consider PC2(TDD)+PC1.5(TDD) band 2Tx (UL MIMO and TxD) for 3Tx PC1.5 inter-band CA/ENDC. (ZTE)
	+ Proposal 3: At least PC2(TDD) + PC2(TDD) band combination could be included for 2Tx PC1.5 inter-band UL CA, the duty cycle (related to SAR) requirements Pcmax updates are needed accordingly. (ZTE)
	+ Proposal 4: for PC1.5 (MTK)
		- PC2 FDD 1/2Tx + PC2 TDD 1/2Tx, the maximum number of Tx chain is up to three
		- PC2 FDD 1Tx + PC1.5 TDD 2Tx
* Recommended WF
	+ Check whether proposal 1 and proposal 3 can be considered as baseline for specifying the generic requirements and/or SAR solution

#### **Issue 2-2-5: On MSD requirements (not BC specific discussion)**

* Proposals
	+ Proposal 1: For HPUE CA/DC, no BC-specific MSD discussion in this non-spectrum WI, but generic MSD model for deriving PC1.5/PC2 MSD requirements based on existing PC2/PC3 MSD could be considered. (Huawei)
	+ Proposal 2: For UL configurations of PC1.5 inter-band UL CA and PC1.5 inter-band EN-DC which require new MSD framework, an example band combination for each UL configuration shall be selected to complete the requirements before other combinations of the same UL configuration can be proposed to the basket WID. (Apple)
	+ Proposal 3: Discuss and decide whether only one set of MSDs are defined for a 3Tx band combination regardless of power/MIMO configurations of each band in the band combination. (OPPO)
	+ Proposal 4: conductive MSD conformance tests for UL CA configurations are not necessary for all possible higher power classes like PC1.5 in case the UE meets the exception for the default power class. An exception is still needed in case the standard REFSENS requirement can be met for the default power class but not for the higher power class. (Ericsson)
* Recommended WF
	+ No BC specific MSD would be discussed in this WI.
	+ FFS whether generic rules could be applied for HPUE band combinations on top of existing MSD requirements to avoid BC specific MSD study
	+ Note that the general considerations on MSD for PC1.5 CA are also applicable for PC1.5 EN-DC

#### **Issue 2-2-6: Others**

* Proposals
	+ Proposal 1: To support total accumulated power for inter-band CA/DC band combinations UE, RAN4 can define some new power classes in Rel-19. (Meta)
	+ Proposal 2: The power class information of high-power inter-band CA/DC UE with 2Tx/3Tx will be reported per band and per band combinations. (Meta)
* Recommended WF
	+ TBA

### Sub-topic 2-3: PC1.5 and PC2 for two-band EN-DC

*Sub-topic description*

*Open issues and candidate options before meeting:*

#### **Issue 2-3-1: Applicability of 3Tx requirements for FWA and handheld UE**

* Proposals
	+ Option 1: Same requirements of 3Tx FWA are applicable to 3Tx handheld UE, and to support 3Tx operation for handheld UE in Rel-19, remove the following limitation in clause 4.2 of TS 38.101-3. (Samsung)
		- *For a terminal that supports inter-band Dual-Connectivity (DC) with UL MIMO or Tx diversity operation, the requirements are targeted for FWA form factor in current specification*
	+ Option 2: For scenarios discussed and defined in Rel-18 for FWA, discuss the applicable requirements for handheld and use the conclusions for FWA as baseline, e.g. reuse or apply some relaxations. (vivo)
* Recommended WF
	+ Option 1

#### **Issue 2-3-2: SAR solution**

* Proposals
	+ Option 1: SAR solution considered for following scenarios: (CHTTL)
		- Proposal 1: Regarding the SAR mitigation solution for PC1.5 LTE FDD + NR TDD EN-DC, the UE-implementation based methods (i.e. P-MPR) is applied by default, and re-using the PC2 duty cycle signalling with some scaling for PC1.5 can be further considered as an additional method.
		- Proposal 2: Regarding the SAR mitigation solution for PC2 LTE FDD + NR FDD EN-DC, the UE-implementation based methods (i.e. P-MPR) is applied by default, and whether to introduce duty cycle method can be further investigated. (CHTTL)
	+ Option 2: SAR solution considered for following scenarios: (Huawei)

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | **PC2** | **PC1.5** |
| **Inter-band EN-DC** | **FDD + FDD** | **SAR solution is required** |  |
| **TDD + TDD** |  | **SAR solution is required** |

* Recommended WF
	+ The two options are similar, only difference is whether to introduce duty-cycle based SAR solution for PC2 FDD+FDD case.
	+ Check whether more generic option 2 can be considered as baseline for further discussion.

#### **Issue 2-3-3: BC cases to be considered in the WI for specifying requirements and/or SAR solution**

* Proposals
	+ Option 1: For Rel-19 3Tx PC2/PC1.5 EN-DC, it is suggested to first collect the demand/request on the following aspects before specifying the requirements. (Samsung)
		- PC1.5 scenarios
		- PC2 scenarios, whether there are new scenarios to be considered in Rel-19 compared with the Rel-18 scenarios
	+ Option 2: At least the following scenarios of EN-DC for handheld and FWA are considered in Rel.19. (CHTTL)
		- PC2 with total 2Tx: LTE FDD + NR FDD with PC3+PC3 & PC3+PC2 configurations
		- PC2 with total 3Tx: LTE FDD + NR FDD with 1Tx PC3 + 2Tx PC3 or PC2 configurations
		- PC1.5 with total 3Tx: LTE FDD + NR TDD with 1Tx PC3 + 2Tx PC1.5 configuration
	+ Option 3: power class configurations for inter-band UL CA/EN-DC with 3Tx for FWA introduced in Rel-18 are reused as a starting point for the scope of power class configurations for inter-band UL CA/EN-DC with 3Tx for handheld UE in Rel-19 (DCM)

Power Class 2:

* + - PC3 FDD band 1Tx + PC2 TDD band 2Tx (UL MIMO and TxD)
		- PC3 FDD band 1Tx + PC3 TDD band 2Tx (UL MIMO and TxD)
		- PC3 TDD band 1Tx + PC2 TDD band 2Tx (UL MIMO and TxD)

Power Class 1.5:

* + - PC3 FDD band 1Tx + PC1.5 TDD band 2Tx (UL MIMO and TxD)
	+ Option 4: To consider PC2(TDD)+PC1.5(TDD) band 2Tx (UL MIMO and TxD) for 3Tx PC1.5 inter-band CA/ENDC. (ZTE)
	+ Option 5: The following configurations are to be considered in Rel-19, details can be further discussed (MTK)

Power Class 2:

* + - PC3 LTE FDD 1Tx + PC2/3 NR FDD/TDD 1/2 Tx
		- PC3/2 LTE TDD 1/2Tx + PC2/3 NR FDD/TDD 1/2 Tx, the maximum number of Tx chain is up to three
		- PC3 LTE FDD 1Tx + PC2 NR FDD/TDD 1/2Tx

Power Class 1.5:

* + - PC3 LTE FDD 1Tx + PC1.5 NR TDD 2 Tx
		- PC2 LTE TDD 1/2Tx + PC2 NR FDD/TDD 1/2 Tx, the maximum Tx chain is up to three
		- PC2 LTE TDD 1/2Tx + PC1.5 NR TDD 1/2 Tx, the maximum Tx chain is up to three
* Recommended WF
	+ Discuss whether specific power class configurations are needed for specifying the generic requirements and/or SAR solution
		- Option 1: specific power class configuration as well as TDD/FDD info are determined based on operators’ input
		- Option 2: generic requirements and/or SAR solution are applicable for all possible power class configurations, and leave the specific configurations to basket WI based on inputs from operators’ demand

### Sub-topic 2-4: Increasing UE transmission power

*Sub-topic description*

*Open issues and candidate options before meeting:*

#### **Issue 2-4-1: Scenarios to be considered in Rel-19**

* Proposals
	+ Option 1: For 2Tx, if based on existing specified combos, there seems no new scenarios to be considered so far. For 3Tx, the following scenarios may could be considered. (Samsung)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Indicated PC for A-B****(3Tx in total)** | **PC for band A of A-B****(1Tx)** | **PC for band B of A-B****(2Tx)** | **The total power****(dBm)** | **Note** |
| PC2 | PC3 | PC2 | 27.8 | One CC per band  |
| PC1.5 | PC3 | PC1.5 | 30.8 | One CC per band; For FWA only |

* + Option 2: the following power class configuration could be considered in Rel 19 for UE increasing high power limit. (Xiaomi)
		- PC3 (TDD/FDD) +PC1.5
		- PC2 (TDD with TxD) +PC3 (TDD/FDD)
		- PC2 (TDD) +PC5
	+ Option 3: To consider the following eligible inter-band CA/ENDC band combination to enable increase higher power limit feature in Rel-19 (ZTE)
		- For PC2 2Tx inter-band NR CA and ENDC:
			* Inter-band with intra-band UL CA in one of the bands
		- For HPUE 3Tx inter-band NR CA and ENDC:
			* PC2 band combination of PC3+PC2 with single carrier in each band.
			* PC1.5 band combination of PC3+PC1.5 with single carrier in each band.
			* PC1.5 band combination of PC2+PC1.5 with single carrier in each band.
			* Note: Only PC3 is considered for LTE FDD in EN-DC
	+ Option 4: For both FWA and handheld UE, at least, the increasing UE power high limit feature should be introduced for 3Tx UL CA/EN-DC configured with PC3 band and PC2 band. Other power class configurations can also be discussed if they are included in the scope of 3Tx in Rel-19 WI. (DOCOMO)
* Recommended WF
	+ Option 1 as baseline.

#### **Issue 2-4-2: General considerations on increasing power limit**

* Proposals
	+ Proposal 1: Consider alternatives to the Rel-17 *higherPowerLimit* feature to enable higher power limit for inter-band CA/DC if they’re better (Huawei)
	+ Proposal 2: Avoid NBC issues for legacy networks when designing new solutions for increasing UE Tx power limit. (Huawei)
	+ Proposal 3: Consider whether to increase the total Tx power limit beyond PC1.5 for handheld UEs. (Huawei)
* Recommended WF
	+ Check the above proposals one by one

#### **Issue 2-4-3: On MSD impact**

* Proposals
	+ Proposal 1: Consider impact to the MSD requirements, e.g., whether to define MSD requirements for various combinations of per-band power classes such as PC1.5+PC2/3/5, PC2+PC5, etc. (Huawei)
	+ Proposal 2: RAN4 shall be mindful on defining MSD requirements for the new UL configurations supporting “Increasing UE power high limit for CA and DC” feature. (Apple)
	+ Proposal 3: For Rel-19, RAN4 to identify the additional conditions that must also be met before a new MSD test case is justified in context of a new power class aggregation for an already specified ULCA inter-band combination. For example, if an MSD test case exists for a PC1.5 CA power class UE comprising a PC3 UL band and a PC1.5 UL band, does a new case need to be defined when the same band combination is enabled for PC2 + PC1.5 UL? (Qualcomm)
* Recommended WF
	+ Discuss whether generic rules could be applied for HPUE band combinations on top of existing MSD requirements to avoid BC specific MSD study

#### **Issue 2-4-4: On SAR compliance issue**

* Proposals
	+ Option 1: Consider impact to the duty-cycle based SAR solution when the total Tx power exceeds the MOP of the conventional CA power class. (Huawei)
	+ Option 2: Others
* Recommended WF
	+ For UE supporting feature of increasing power limit, discuss whether to just use P-MPR solution to comply with SAR limits when the duty-cycle based SAR solution with the per BC power class is not valid anymore.

# Topic #3: Power boosting and/or MPR reduction

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

## Companies’ contributions summary

|  |  |  |  |
| --- | --- | --- | --- |
| **T-doc number** | **T-doc name** | **Company** | **Proposals / Observations** |
| [**R4-2404194**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2404194.zip) | On power domain enhancement for NR | Apple | *Observation: The WID description is highly ambitious to guarantee a useful MPR reduction scheme. The WID states that NR single carrier shall be investigated as well as UL CA. For both configurations several scenarios are assumed. Modulations are QPSK and 16QAM. Additionally, RedCap devices are included. This leads to a multitude of evaluations throughout the Rel-19 time frame. Due to the ambitious workload it seems to be adviceable that RAN4 tackles the individual aspects step-by-step. This approach would guarantee that every meeting enough results from different companies are present to allow meaningful decisions or/and agreements.****Proposal: For the initial stage RAN4 could evaluate the performance gains of single carrier and the interference on other devices. As second step UL CA could be analysed.*** |
| [**R4-2404209**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2404209.zip) | Power boosting and MPR reduction | Qualcomm Technologies Int | ***Proposal 1: Define a complete list of MPR reduction scenarios by FR that will be considered for MPR reduction study. Also, define the maximum allowable degradation in ACLR, SEM and spurious emissions that is permissible.******Proposal 2: Determine whether MPR reduction is limited to MPR=0 dB or whether power boost is also possible****For MPR applicability for configured/activated UL CCs for intra-band UL CA configurations for following observations and proposals are made:****Observation 1:*** *Some FR2 UEs need a back-off allowance that depends on CABW, while other UEs can get by with a back-off that depends on UL BWchannel\_CA.****Observation 2:*** *A new FR2 UE capability can indicate to the network that it can support, CA MPR reduction by changing the BW basis of the CA MPR table from cumulative aggregated channel BW (CABW) to UL BWchannel\_CA.****Observation 3:*** *Allowing the UE capability to depend on UL CA configuration rather than activation status will encourage more UEs to support a low MPR scheme, owing to less challenging timelines.****Proposal 3: To encourage UEs to support the enhancements in FR2, define a first level of enhancements based on CA configuration, and then a second level of enhancements based on CC activation.*** ***Proposal 4: For FR2, define a UE capability that changes the BW basis of the CA MPR table from cumulative aggregated channel BW (CABW) to UL BWchannel\_CA (configuration based)******Observation4:*** *For an FR2 UE that supports lower CA MPRs based on UL CCs , the benefit is constrained by unavailability of CA MPR values for BW basis less than 400 MHz* ***Proposal 5: RAN4 to define lower FR2 CA MPR for UL BWchannel\_CA <400 MHz. The CA MPR values for these new BWs can be reproduced from the single CC MPR tables of equivalent channel BW.*** ***Proposal 6: For FR2, enhance the case of intra-CA configured with single CC UL by making the single CC MPR table applicable for a supporting UE.*** |
| [**R4-2404270**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2404270.zip) | Views on MPR reduction | Sony | *Observation 1: The required MPR to meet the out-of-band emission limits can be reduced when the UE is allocated at the inner RB allocation of an operator’s spectrum block.**Observation 2: From the network aspect, allocating a device with narrow bandwidth towards the inner location within an operator’s spectrum block may not be a common scenario in real life since this may create spectrum fragmentation.**Observation 3: The frequency bands are usually small in FDD bands in sub 1 GHz, which makes it not being feasible to move the UE away from the edge of the band.* *Observation 4: Depending on the UE RF front implementations and UE bandwidth, the required MPR to meet each out-of-band emission is different with different RB allocations. In addition, it is also different at different frequency bands due to the spurious emission limit for the co-existence.* ***Proposal 1: it is not feasible to allow the out-of-band emission limits outside the operator spectrum block to be relaxed even if the adjacent spectrum is not used.*** ***Proposal 2: RAN4 shall focus on the scenario when a UE uses a narrower channel bandwidth within a wider operator spectrum block for the MPR reduction in Rel-19.******Proposal 3: RAN4 shall examine if the proposed MPR reduction scheme can be enabled for all types of UEs, including TDD and FDD, as well as normal UE, Redcap, and eRedcap UEs.*** ***Proposal 4: If any reduction of MPR would be specified in the end, it should be an optional feature with per band per UE capability*** |
| [**R4-2404456**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2404456.zip) | Initial consideration on power domain enhancement for single carrier operation | CATT | ***Proposal 1: RAN4 needs to clarify whether it intends to specify MPR requirements in this WID for intra-band non-contiguous UL CA with a dual PA architecture.*** |
| [**R4-2404546**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2404546.zip) | Discussion on power domain enhancement | Xiaomi | ***Proposal 1: RAN4 can research whether ACLR can be modified based on co-existence study, firstly.******Proposal 2: RAN4 can research how to modify the requirements of SEM since the SEM was defined based on regional regulation.******Proposal 3: RAN4 need further confirm whether it is helpful to reduce MPR through improving IQ image and carrier leakage by MPR simulation.******Proposal 4: For inner RB allocations, RAN4 can consider whether can define a new inner RB allocation that is retracted from the legacy inner RB allocations.******Proposal 5: Using previous MPR simulation assumptions to evaluate the MPR reduction as the starting point:**** ***PA model calibration***
	+ ***DFT-s-OFDM QPSK 20MHz***
	+ ***100RB0***
	+ ***4dB post PA loss***
	+ ***1dB MP***
* ***Carrier Leakage: 28dB***
* ***IQ Image: 28dBc***
* ***CIM3: 60dBc***
* ***EVM: 17.5%***
* ***For a PC3 PA the calibration point is 30dB ACLR and for a PC2 PA the calibration point is 31dB ACLR***

***Proposal 6: For intra-band UL contiguous CA, RAN4 need research whether the MPR of single carrier for PC2 and PC3 can be applied to contiguous RB allocation for CA bandwidth class B and bandwidth class C when LCRB1 = 0 or LCRB2 = 0 (that is, only one CC with activated cell).******Proposal 7: For intra-band UL non-contiguous CA, RAN4 don’t need to specify the MPR applicability for only one CC with active cell, since it has specified that the MPR of single carrier for PC2 and PC3 will apply to intra-band UL non-contiguous CA if LCRB1 = 0 or LCRB2 = 0 (that is, only one CC with activated cell) in current Spec.******Proposal 8: RAN4 need research two issues for FR2 intra-band UL CA configuration:**** ***Whether the MPR for intra-band UL contiguous CA can be defined based on the channel bandwidth class of intra-band UL contiguous CA.***

***Whether the MPR of single carrier can be applied to contiguous RB allocation for intra-band UL contiguous CA when only one CC with activated cell or single UL with intra-band DL contiguous CA*** |
| [**R4-2404588**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2404588.zip) | Discussion on MPR reduction for FR1 and FR2 | Samsung | ***Observation 1: It is reasonable to focus on*** ***QSPK and 16QAM for FR1 single UL carrier when*** ***applying ACLR/SEM relaxation to reduce MPR.****Observation 2: Regulator always have additional SE requirements and could be more stringent when it comes to certification.**Observation 3: SE also serves the purpose of protecting of remote frequency spectrum, relaxing SE has more risk of interfering the deployment of other operators.****Proposal 1: It needs to be justified if it is meaningful and feasible to relax general SE requirements for MPR reduction, SE requirements should not be relaxed in lack of justification.******Proposal 2: In terms of relaxing ACLR/SEM, it needs to be discussed whether only general requirements are under discussion, or both general and additional requirements are taken into account.****Observation 4: In case the in-band co-existence issues can be resolved by the operator with considerate scheduling, or the in-band co-existence issues is acceptable by this operator, ACLR/SEM can be relaxed to allow MPR reduction.* *Observation 5: When a UE is configured with a narrower channel bandwidth within a wider BS channel bandwidth, and the OOB boundary is within the BS channel bandwidth, ACLR/SEM can be relaxed; in other words, ACLR/SEM outside the BS channel bandwidth should not be relaxed.****Proposal 3: In terms of QPSK and 16QAM, it is feasible to relax*** ***ACLR/SEM with BS indication for sake of MPR reduction, with following conditions:******- The in-band co-existence issues can be resolved by the operator with considerate scheduling or the in-band co-existence issues is acceptable to this operator******- ACLR/SEM outside the BS channel bandwidth is not relaxed****Observation 6: It is reasonable to include both RedCap UE (only PC3) and non-RedCap UE.**Observation 7: It might be beneficial for some scenarios to assume the applicable requirements are according to the activated CC(s).**Observation 8: For FR1 intra-band contiguous UL CA with only one UL CC activated, MPR reduction in Rel-19 is limited to applicability change instead of introducing new MPR values according to the WID, which would also significantly reduce the workload.****Proposal 4:*** ***For PC3, the single CC MPR requirements (Table 6.2.2-1) can be applied to FR1 intra-band contiguous UL CA with only one UL CC activated.******For PC2, the single CC MPR requirements can be applied to FR1 intra-band contiguous UL CA with only one UL CC activated. If TxD is indicated for this intra-band contiguous ULCA, single CC with TxD MPR (Table 6.2D.2-1) should apply; if TxD is not indicated for this intra-band contiguous ULCA, single CC without TxD MPR (Table 6.2.2-2) should apply.******Proposal 5: A new optional UE capability should be introduced to indicate if single CC MPR requirements are applicable for FR1 intra-band contiguous UL CA with single UL CC activated.******Proposal 6: This MPR enhanced feature should not be release-independent.****Observation 9: There is significant difference between the MPR requirements for FR1 intra-band NC UL CA and single CC operation.****Proposal 7: More study needs be conducted on whether single CC MPR requirements can be applicable for intra-band NC CA with single UL CC activated, given the significant difference between them.*** *Observation 10: FR2 MPR enhancement in Rel-19 applies only to specific UE implementation.* ***Proposal 8: FR2 MPR enhancement in Rel-19 should be an optional feature and should not be release independent.*** *Observation 11: FR2 MPR enhancement in Rel-19 is limited to applicability change instead of MPR value change, and MPR simulation is not necessary.****Proposal 9: For intra-band UL contiguous CA for FR2, the applicable MPR values should be changed from DL CABW dependent to UL CABW dependent for UE supporting the enhanced MPR capability; for intra-band DL contiguous CA with single UL for FR2, the applicable MPR values should be changed from DL CABW dependent to reusing single carrier MPR requirements for UE supporting the enhanced MPR capability.*** |
| [**R4-2404616**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2404616.zip) | Initiatory discussion on power domain enhancement | E-surfing Digital | ***Proposal1: Further study the MPR reduction with more general solution.*** ***Proposal2: Extend the scenarios of MPR reduction to UL CA, and specify the corresponding requirements.*** ***Proposal3: Study and confirm the resource range of inner and outer for MPR reduction under some mechanisms as untransparent scheme.*** |
| [**R4-2404624**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2404624.zip) | MPR reductions for UE-specific bandwidths and for UL intra-band CA | Ericsson | ***Proposal 1: increasing UE output power by allowing relaxed ACLR and SEM by (NS) network signaling is not pursued as this as there is no guarantee that the NS indication is not used between an aggressor and victim operator at the operator block edge of the aggressor.****Relaxing the ACLR requirements outside the UE channel bandwidth for the non-CA case is more feasible for unwanted emissions within the carrier:****Proposal 2: MPR reductions are specified for the case of a narrow UE-specific CHBW within a wider BS CHBW for the non-CA case.****that also appears feasible from an implementation viewpoint for* ***Observation 1:*** *the UE is aware of the carrier resource grid (indicated by SIB1) and can then use the corresponding CHBW or any smaller supported CHBW to derive the MPR based on the allocations contained within the UE-specific CHBW.**and the UE must support transmissions without MPR for some allocations within the UE-specific CHBW at any rate.* *Furthermore, for UL intra-band CA in fragmented operator spectrum,****Proposal 2: introduce additional requirements for DL/UL intra-band non-contiguous CA (1Tx or 2Tx) in fragmented spectrum**** ***single UL cell scheduled/active: by reducing MPR to that of non-CA for UL transmissions confined within one of the two cells also for UEs not indicating dualPA-Architecture at least when one of the cells is deactivated;***
* ***dual NC UL cells scheduled: by reducing MPR for concurrent transmissions for FDD and TDD regardless of PA architecture with additional side-conditions (LO leakage etc) if needed;***
* ***up to 100 MHz carrier separation (intraBandFreqSeparationUL-AggBW-GapBW-r16 class I) as supported by a single TX/PA and RX chain, and up to 50 MHz carrier separation for FDD;***
* ***enhancements subject to UE capability.***
 |
| [**R4-2404642**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2404642.zip) | Discussion on MPR reduction for NR single carrier and NR intra-band UL CA | vivo | ***MPR reduction with relaxed emission requirements on a single carrier******Observation 1:*** *ACLR mainly affects the outer RB allocations, well SEM mainly affects the inner RB allocations close to the edge of BW and outer RB allocations with lower RB numbers.****Proposal 1: ACLR relaxation could be studied from outer region.******Observation 2:*** *If SEM is also considered to relax, the RB allocation area where output power can be boosted would be larger.****Observation 3:*** *QPSK and 16QAM would be more severely affected by ACLR than higher modulation mode.****Observation 4:*** *PC2 is more susceptible to SEM than PC3 when RB number is small.****Observation 5:*** *Whether spurious emission can/need be relaxed needs further discussion.****Proposal 2: When there are no out-of-band co-existence issues, the ACLR can be omitted in MPR evaluation.*** ***Proposal 3: When the BW of the UE is smaller than the BS, the ACLR of being outside the UE CBW but within the BS CBW could be relaxed to IBE, and ACLR requirement should be applied from the edge of the BS.******Proposal 4: There are two mechanisms of the NW to indicate the UE behavior, and option1 could be studied as the baseline.*** * *Option1: NW decides whether the OOBE requirement can be relaxed and sends signaling to UE, then UE improves the MPR or performs power boosting.*
* *Option2: NW indicates the relative positions of the UE CBW to the BS CBW, and the UE decides the MPR based on the position information.*

***Features of single CC scheduling in contiguous UL CA******Observation 6:*** *For intra-band contiguous UL CA, when only one component carrier is scheduled or allocated, the MPR requirement could approach or be lower that of a single carrier in some cases.****Observation 7:*** *For intra-band contiguous CA, MPR values should be evaluated based on different architectures when scheduling or configuring only one component carrier.****Proposal 5: The 2-LO architecture of intra-band contiguous UL CA could be the baseline architecture for MPR reduction when only 1 CC is scheduled.*** ***Observation 8:*** *The typical 1-LO architecture of in-band contiguous UL CA will create more IQ image interference when switching from 2CC to 1CC, this problem can be alleviated if the LO can be switched to the center of the scheduled CC at the same time.****Proposal 6: The following architectures could be the baseline for MPR reduction in UL contiguous CA:****Architecture 1: 2PA+1LO, each PA supports up to 200MHz.**Architecture 2: 2PA+2LO, each PA supports up to 100MHz.****Proposal 7:*** *For FR2 if the independent LO for UL is feasible, the MPR can be only based on the UL aggregated BW.****Proposal 8:*** *For FR2, a new UE capability should be introduced to indicate the UE with independent LO in UL.* |
| [**R4-2404936**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2404936.zip) | FR2 MPR requirements improvement for single carrier or intra band CA | NTT DOCOMO, INC. | *Observation 1: With the current specifications, the FR2 CA MPR is based on CABW, which may prevent the NW from fully utilizing the terminal's performance.****Proposal 1: Study, as one of the improved MPR solution, whether MPR for FR2 single carrier UL or intra band UL CA with DL intra band CA can be defined based on only UL CBW (i.e., independent from DL CBW). Other solutions are not precluded.******Proposal 2: Target band combination is CA n257I if needed.*** |
| [**R4-2405064**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2405064.zip) | Discussion on power boosting and/or MPR reduction | ZTE Corporation | ***Proposal 1: We propose to focus on the modification of SEM or ACLR for FR1 on a single UL carrier.****Observation 1: From our simulation results, it can be observed that MPR reduction is about 0.3 - 0.4 dB for QPSK/ 16QAM for DFT-s-OFDM/ CP-OFDM when ACLR relaxes 1 dB. MPR reduction can reach 0.7 - 0.8 dB for QPSK/ 16QAM for DFT-s-OFDM/ CP-OFDM when ACLR is relaxed by 2 dB.****Proposal 2: Relax UE ACLR/SEM requirement can be further MPR boosting, how much ACLR/SEM can be relaxed needs more discussions such as co-existence study.******Proposal 3: For FR1, there are two scenarios should be considered: relaxing one side starting point of ACLR, SEM domain, and relaxing both sides.*** ***Proposal 4: It is proposed that for intra-band UL CA without indicating dualPA-Architecture support, the MPR requirements of single CC operation for PC 2 and PC 3 can be followed when the UL Scell is deactivated.******Proposal 5: It is feasible for intra-band UL CA with TxD supported, when the UL Scell is deactivated, to follow the MPR/A-MPR requirements specified for the corresponding bands with txDiversity-r16 capability.******Proposal 6: To enhance the MPR requirement, it is feasible to define the MPR for FR2 intra-band CA based on UL BW.******Proposal 7: For DL CA only for FR2 intra-band CA, reuse the MPR requirements defined for UL single carrier.******Proposal 8: For UL intra-band CA, when the Scells are deactivated to make CABW group switched, then the MPR requirements in the switched CABW group can be re-used.*** |
| [**R4-2405306**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2405306.zip) | Discussion on enhanced MPR scenarios | CMCC | ***Observation 1:*** *following three scenarios are the potential scenarios that may lead to relaxation of ACLR/SEM emission requirements.** *Scenario 1: One individual operator* ***share the whole operation band****, i.e. no operators in the same area using the adjacent(s) carriers*
* *Scenario 2:* ***when several operators share the same operation band****, there is enough guard spectrum at each side of operator’s spectrum edge*
	+ *For example, there is reserved spectrum between two operators’ spectrum in the same area*
	+ *ACLR is symmetrical at both sides of carrier edges, only one side relaxation will not contribute to final ACLR relaxation*
* *Scenario 3: The UE bandwidth is less than gNB bandwidth, then equivalent ACLR falling into adjacent gNB bandwidth may be less than current ACLR requirements.*
	+ *Sub-scenario 3-1: instead of ACLR 1, ACLR 2 or even higher order ACLR may apply due to less UE bandwidth.*
		- *Note: this is due to the flexible UE bandwidth location within gNB bandwidth*
	+ *Sub-scenario 3-2: Equivalent ACLR due to unequal aggressor and victim bandwidth for adjacent carrier co-existence scenario*
		- *Note: this is due to less UE aggressor bandwidth compared with gNB victim bandwidth*

***Observation 2:*** *whether the ACLR/SEM requirement applies or not should consider both the adjacent carrier interference and adjacent operation band interference case. Besides, since ACLR/SEM requirement relaxation is BS indication basis, the spatial isolation factor for actual deployment scenario should also be taken into consideration.****Proposal 1: for scenario 1, the ACLR and SEM may not be needed when taken spatial isolation factor into consideration.******Proposal 2: RAN4 further discuss whether the ACLR relaxation is allowed for the case when there is guard band but the guard band is less than CBW assumption for ACL******Proposal 3: usually regulatory agency will not reserve spectrum between two operators to avoid spectrum fragment. But still suggest to wait for companies input to further identify whether scenario 2 is the corner case or not.*** ***Proposal 4: RAN4 needs to discuss whether there is any relaxation for higher order ACLR for the scenario when UE bandwidth is less than gNB bandwidth.******Proposal 5: RAN4 further discuss whether the ACLR with narrower aggressor BW than victim BW still equals to the legacy value or not.******Proposal 6: it’s suggested to study the extent of ACLR/SEM relaxation at first with limited number of relaxation values to reduce further MPR reduction analysis workload.*** |
| [**R4-2405606**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2405606.zip) | Discussion on MPR reduction for power domain enhancement | LG Electronics UK | ***Proposal 1:*** *it is necessary to discuss what information should be included in the BS indication.* ***Proposal 2:*** *it is necessary to clarify whether this discussion exclude or includes FDSS filter in Rel-19.* ***Proposal 3:*** *The method of single carrier operation for power domain enhancement can be reused to intra-band contiguous CA contiguous RB allocation for power domain enhancement.* |
| [**R4-2405614**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2405614.zip) | On power domain enhancement for NR single carrier and NR intra-band UL CA for PC2 and PC3 | Huawei, HiSilicon | *Observation 1: Real world UL traffic proves the necessity of power domain enhancement for large RB number allocation.**Observation 2: ACLR is derived from co-existence study to ensure that the transmitter does not cause excessive interference to the adjacent channels between different operators.**Observation 3: SEM has connection with ACLR but with different emphasis:** *ACLR considers the average power leaked into adjacent channels by using the channel bandwidth as the measurement bandwidth. It reflects the transmitter’s “noise floor” in adjacent channel, while SEM captures out-of-specification points within narrower measurement bandwidths in adjacent channel, emphasizing “unwanted emissions based on the noise floor.”*

*Observation 4: Spurious are related to regulations and represents “noise floor” far from the edge of the channel bandwidth.**Observation 5: The interference measured by the ACLR has different absolute values corresponding to different power classes and the absolute value of ACLR would be a reasonable metric for ACLR relaxation.**Observation 6: UE CBW could be different from the NW CBW, and the RF requirements are specified based on UE CBW.**Observation 7: For FR1* *intra-band non-contiguous UL CA, the single carrier MPR would be applied when only one component carrier is scheduled after configuration and activation (except for smaller RB allocation on that component carrier where larger MPR needs to be utilised instead).****Proposal 1: UE in a channel without any adjacent channels of different operators can be allowed not to meet the existing ACLR requirement, and further consider*** * ***whether SEM can be relaxed***
* ***RSD for FDD band***

***Proposal 2: For the scenario: UE CBW=BS CBW, several UE indicted by BS in a channel with adjacent channels may be allowed to meet relaxed ACLR requirement, which the feasibility need to be further evaluated:**** ***Two deployments including the same site or different sites.***
* ***Whether SEM can be relaxed***

***Proposal 3: For the scenario: UE CBW<BS CBW and the frequency offset between the edge of UE CBW and the edge of BS CBW is wider than or equal to UE CBW, UE in a channel with adjacent channels of different operators can be allowed not to meet the existing ACLR requirement, and further consider*** * ***whether SEM can be relaxed***
* ***RSD for FDD band***

***Proposal 4: For the scenario: UE CBW<BS CBW and the frequency offset between the edge of UE CBW and the edge of BS CBW is narrower than UE CBW, UE in a channel with adjacent channels of different operators may be allowed to meet relaxed ACLR requirement, which the feasibility need to be further evaluated.**** ***Two deployments including the same site or different sites***
* ***Whether SEM can be relaxed***

***Proposal 5: For the scenario: UE CBW<BS CBW, UE in a channel with adjacent channels of different operators may be allowed to meet relaxed ACLR requirement, which the feasibility need to be further evaluated.**** ***Two deployments including the same site or different sites.***
* ***Whether SEM can be relaxed.***

***Proposal 6: BWP-based ACLR/SEM/Spurious emission requirements should be excluded from WID.******Proposal 7: For the MPR applicability study for FR1 intra-band contiguous UL CA, the terminology “activation/deactivation” should be interpreted as the existing MAC CE based serving cell activation/deactivation mechanism.***  ***Proposal 8: Since the WID objective is to specify MPR applicability, the power class should remain the same as the CA power class when activated cell number is changed.**** ***For example, if a UE indicates PC1.5 for band n78 and PC2 for n78C, the intention is to study whether PC2 MPR for single band operation can be applied assuming power class would still be PC2 instead of PC1.5 when only PCell is activated.***

***Proposal 9: In Rel-19, the applicable MPR for FR1*** ***intra-band non-contiguous UL CA doesn’t need further enhancement.******Proposal 10: For FR2, check if only PC3 UE will be considered for Rel-19 study.******Proposal 11: For FR2 intra-band UL contiguous CA and intra-band DL contiguous CA with single UL**** ***MPR applicability and/or potential reduction can be considered***
* ***Both simulation and measurement should be considered***
* ***Common Rx/Tx LO architecture should not be precluded as architecture assumption***
 |
| [**R4-2405619**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2405619.zip) | Discussion on power domain enhancement for NR single carrier | MediaTek (Wuhan) Inc. | *Observation 1: It is feasible and useful for RedCap UE to apply Tx emissions requirements relaxation inside a spectrum block >20MHz if MPR reduction can be achieved.**Observation 2: For a non-RedCap UE operating in a spectrum block <100MHz, there is some flexibility today to enable relaxed emissions and tighter MPR via existing functions and requirements framework. However, some clarification would be useful in relation to BWP and CBW and applicability of requirements.* *Observation 3: For a non-RedCap UE operating in a spectrum block >100MHz, emissions requirements relaxation appears to be feasible if sufficient to enable MPR reduction.**Observation 4: In cases where adjacent spectrum outside of a block is not designated for other users/services, then it may be feasible to apply emission relaxation, subject to the specific regulatory requirements for that deployment.**Observation 5: For coordinated deployments such as site/network sharing, initial results suggest that relaxed UE Tx emissions requirements could be enabled whilst providing acceptable inter-operator coexistence. However regulatory aspects have not yet been considered.**Observation 6: Network to UE signalling would be required to allow UE Tx emissions relaxations and applicable corresponding MPR improvement.**Observation 7: It is feasible to allow operators to apply controlled relaxations to UE ACLR if there are no impacts to other operators, at least when operator’s own spectrum is immediately adjacent.**Observation 8: It is feasible to allow operators to apply controlled relaxations to UE SEM if there are no impacts to other operators, at least when operator’s own spectrum is immediately adjacent. ITU recommendations are not restrictive even outside of the operator’s spectrum block.**Observation 9: Relaxation of UE spurious emission requirement is likely needed if other Tx emission requirements such as ACLR or SEM are relaxed, and this is feasible whilst still adhering to ITU REC SM.329.**Observation 10: Shifting the starting frequency (channel edge) for Tx emissions requirements away from the first or last allocated RB by a sufficient amount can enable an Outer RB allocation to become equivalent to an Inner RB allocation from MPR perspective.**Observation 11: Relaxing ACLR without relaxing SEM/Spurious emissions will likely have smaller MPR reduction, more RAN4 effort, more complex MPR rules, and more complex real-time derivation of MPR by UE.**Observation 12: 1dB – 1.5dB MPR reduction for Outer RB allocations is achievable with sufficient Tx emission requirements relaxations, depending on waveform (DFT-S-OFDM or CP-OFDM) and modulation scheme (QPSK or 16QAM).* *Observation 13: Aiming to reduce MPR lower than that of the inner RB allocation will lead to much more RAN4 work to identify the requirement bottlenecks and would fully or partially repeat the Rel-18 effort.****Proposal 1: Further clarify the Tx emissions requirements applicability in relation to BWP and Channel Bandwidth, in particular when no dedicated UE channel bandwidth is configured to the UE.******Proposal 2: Prioritize study on reduction of Outer RB allocation MPR to similar level as Inner RB allocation MPR without increasing reference UE complexity (particularly hardware), by appropriate Tx emission requirement relaxation in the identified operating scenarios.******Proposal 3: Endorse a Tx emission requirements relaxation approach of shifting the Tx emissions requirements “channel edge” (ΔfOOB = 0 MHz) away from real channel edge to create sufficient guardband from the UE channel bandwidth edge, to enable ACLR, SEM, and Spurious Emission relaxation. “Extension of” IBE or equivalent to apply from first/last allocated RB to new Tx emission requirements “channel edge”.******Proposal 3a: Agree to further analyse the Wider CBW Tx emission requirements framework as one option to enable Outer RB allocation MPR reduction, for RedCap and non-RedCap UE. Also further study the Spurious Emission requirement issue as described for this approach.******Proposal 3b: Agree to further analyse the Shifted Channel Edge with “Same CBW” Tx emission requirements framework as one option to enable Outer RB allocation MPR reduction for RedCap and non-RedCap UE.******Proposal 3c: Agree to further analyse the “One-Sided” Shifted Channel Edge enhancement to 3a and 3b approaches as one option to enable Outer RB allocation MPR reduction for RedCap and non-RedCap UE, when UE channel bandwidth is at one edge of the operator’s spectrum block. The actual maximum RB allocation in this case can be further discussed.******Proposal 4: For the non-RedCap UE, study further the following aspects for the shifted channel edge approach:**** ***Which Tx emissions requirements framework would apply for Wider Channel Bandwidth >100MHz?***
* ***Whether the CBW/2 shift from the channel edge proposed for RedCap also scales in exactly the same way for larger UE channel bandwidths such as 80-100MHz.***
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## 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 3-1: Clarificaion on scope of power domain enhancements for single carrier

*Sub-topic description*

*Open issues and candidate options before meeting:*

* Proposals
	+ Proposal 1: For the initial stage RAN4 could evaluate the performance gains of single carrier and the interference on other devices. As second step UL CA could be analysed. (Apple)
	+ Proposal2: Extend the scenarios of MPR reduction to UL CA, and specify the corresponding requirements. (China Telecom)
	+ Proposal 3: The method of single carrier operation for power domain enhancement can be reused to intra-band contiguous CA contiguous RB allocation for power domain enhancement. (LGE)
* Recommended WF
	+ Refrain the discussion to SC scenario for the time being. Whether the scope could be extended to CA should be discussed in RAN plenary meeting based on RAN4 progress.

### Sub-topic 3-2: Scenarios for power domain enhancements for singel carrier

*Sub-topic description*

*Open issues and candidate options before meeting:*

#### **Issue 3-2-1: Scenarios for power domain enhancements for single carrier**

* Proposals
	+ **Scenario 1-1**: Scenario with no adjacent in-band/out-of-band co-existence issue (single operator)
		- One individual operator share the whole operation band, i.e. no operators in the same area using the adjacent(s) carriers (CMCC)
	+ **Scenario 1-2**: Scenario with no adjacent in-band/out-of-band co-existence issue (adjacent operators)
		- when several operators share the same operation band, there is enough guard spectrum at each side of operator’s spectrum edge (CMCC)
		- adjacent operators with coordinated deployments, such as in multi-operator site/network sharing scenarios (MTK)
		- RAN4 can research whether ACLR can be modified based on co-existence study, firstly. (Xiaomi)
		- increasing UE output power by allowing relaxed ACLR and SEM by (NS) network signaling is not pursued as this as there is no guarantee that the NS indication is not used between an aggressor and victim operator at the operator block edge of the aggressor. (Ericsson)
	+ **Scenario 2**: Narrower UE channel BW within wider BS bandwidth
		- Proposal 1: The UE bandwidth is less than gNB bandwidth, then equivalent ACLR falling into adjacent gNB bandwidth may be less than current ACLR requirements. (CMCC)
		- Proposal 2: Shifted Channel Edge via “wider CBW” emissions framework. (MTK)



* + - Proposal 3: Shifted channel edge with “same CBW” emissions framework (MTK)



* + - Proposal 4: One-sided emissions relaxation framework (MTK)



* + - Proposal 5: the “One-Sided” Shifted Channel Edge enhancement to Proposal 3 and Proposal 4 approaches as one option to enable Outer RB allocation MPR reduction for RedCap and non-RedCap UE, when UE channel bandwidth is at one edge of the operator’s spectrum block (MTK)
		- Proposal 6: UE CBW<BS CBW and the frequency offset between the edge of UE CBW and the edge of BS CBW is wider than or equal to UE CBW (Huawei)
		- Proposal 7: UE CBW<BS CBW and the frequency offset between the edge of UE CBW and the edge of BS CBW is narrower than UE CBW (Huawei)
* Recommended WF
	+ Focus on scenario 1-1 and 2, no need to perform co-existence study for the co-ordinated scenario 1-2 given diversified views
	+ Further discussion on sub-scenarios to be evaluated for scenario 2

#### **Issue 3-2-2: On relaxed requirements from co-existence / regulation perspective**

* Proposals
	+ Proposal 1: It needs to be justified if it is meaningful and feasible to relax general SE requirements for MPR reduction, SE requirements should not be relaxed in lack of justification. (Samsung)
	+ Proposal 2: In terms of QPSK and 16QAM, it is feasible to relax ACLR/SEM with BS indication for sake of MPR reduction, with following conditions: (Samsung)
		- The in-band co-existence issues can be resolved by the operator with considerate scheduling or the in-band co-existence issues is acceptable to this operator
		- ACLR/SEM outside the BS channel bandwidth is not relaxed
	+ Observation 1: It is feasible to allow operators to apply controlled relaxations to UE ACLR if there are no impacts to other operators, at least when operator’s own spectrum is immediately adjacent. (MTK)
	+ Observation 2: It is feasible to allow operators to apply controlled relaxations to UE SEM if there are no impacts to other operators, at least when operator’s own spectrum is immediately adjacent. ITU recommendations are not restrictive even outside of the operator’s spectrum block. (MTK)
	+ Observation 3: Relaxation of UE spurious emission requirement is likely needed if other Tx emission requirements such as ACLR or SEM are relaxed, and this is feasible whilst still adhering to ITU REC SM.329. (MTK)
* Recommended WF
	+ Further discuss whether there could be some limitations for relaxed ACLR/SEM/SE to comply with the regulatory requirements, especially for SE requirement

### Sub-topic 3-3: Evaluation consideration on power domain enhancements for singel carrier with relaxed requirements

*Sub-topic description*

*Open issues and candidate options before meeting:*

#### **Issue 3-3-1: General considreations for power domain enhancements**

* Proposals
	+ Proposal 1: RAN4 need further confirm whether it is helpful to reduce MPR through improving IQ image and carrier leakage by MPR simulation. (Xiaomi)
	+ Proposal 2: Further clarify the Tx emissions requirements applicability in relation to BWP and Channel Bandwidth, in particular when no dedicated UE channel bandwidth is configured to the UE. (MTK)
	+ Proposal 3: BWP-based ACLR/SEM/Spurious emission requirements should be excluded from WID. (Huawei)
	+ Proposal 4: In terms of relaxing ACLR/SEM, it needs to be discussed whether only general requirements are under discussion, or both general and additional requirements are taken into account. (Samsung)
	+ Proposal 5: RAN4 shall examine if the proposed MPR reduction scheme can be enabled for all types of UEs, including TDD and FDD, as well as normal UE, Redcap, and eRedcap UEs. (Sony)
	+ Proposal 6: Study and confirm the resource range of inner and outer for MPR reduction under some mechanisms as untransparent scheme. (China Telecom)
	+ Proposal 7: it is necessary to clarify whether this discussion exclude or includes FDSS filter in Rel-19. (LGE)
* Recommended WF
	+ The above proposals should be discussed one by one, as they have impact on the following evaluation

#### **Issue 3-3-2: On evaluation of applicable ACLR/SEM/spurious emission modification with BS indication**

* Proposals on evaluation cases with relaxed requirements
	+ Proposal 1: When there are no out-of-band co-existence issues, the ACLR can be omitted in MPR evaluation. (vivo)
	+ Proposal 2: ACLR relaxation could be studied from outer region (vivo)
	+ Proposal 3: When the BW of the UE is smaller than the BS, the ACLR of being outside the UE CBW but within the BS CBW could be relaxed to IBE, and ACLR requirement should be applied from the edge of the BS. (vivo)
	+ Proposal 4: For FR1, there are two scenarios should be considered: relaxing one side starting point of ACLR, SEM domain, and relaxing both sides. (ZTE)
	+ Proposal 5: RAN4 further discuss whether the ACLR relaxation is allowed for the case when there is guard band but the guard band is less than CBW assumption for ACLR (CMCC)
	+ Proposal 6: RAN4 needs to discuss whether there is any relaxation for higher order ACLR for the scenario when UE bandwidth is less than gNB bandwidth. (CMCC)
	+ Proposal 7: RAN4 further discuss whether the ACLR with narrower aggressor BW than victim BW still equals to the legacy value or not. (CMCC)
	+ Proposal 8: Endorse a Tx emission requirements relaxation approach of shifting the Tx emissions requirements “channel edge” (ΔfOOB = 0 MHz) away from real channel edge to create sufficient guardband from the UE channel bandwidth edge, to enable ACLR, SEM, and Spurious Emission relaxation. “Extension of” IBE or equivalent to apply from first/last allocated RB to new Tx emission requirements “channel edge”. (MTK)
	+ Proposal 9a: Agree to further analyse the Wider CBW Tx emission requirements framework as one option to enable Outer RB allocation MPR reduction, for RedCap and non-RedCap UE. Also further study the Spurious Emission requirement issue as described for this approach. (MTK)
	+ Proposal 9b: Agree to further analyse the Shifted Channel Edge with “Same CBW” Tx emission requirements framework as one option to enable Outer RB allocation MPR reduction for RedCap and non-RedCap UE. (MTK)
	+ Proposal 10: Agree to further analyse the “One-Sided” Shifted Channel Edge enhancement to 9a and 9b approaches as one option to enable Outer RB allocation MPR reduction for RedCap and non-RedCap UE, when UE channel bandwidth is at one edge of the operator’s spectrum block. The actual maximum RB allocation in this case can be further discussed. (MTK)
	+ Proposal 11: For the non-RedCap UE, study further the following aspects for the shifted channel edge approach: (MTK)
		- Which Tx emissions requirements framework would apply for Wider Channel Bandwidth >100MHz?
		- Whether the CBW/2 shift from the channel edge proposed for RedCap also scales in exactly the same way for larger UE channel bandwidths such as 80-100MHz.
	+ Proposal 12: UE in a channel without any adjacent channels of different operators (Huawei)
		- whether SEM can be relaxed
		- Consider RSD for FDD band
	+ Proposal 13: UE CBW<BS CBW and the frequency offset between the edge of UE CBW and the edge of BS CBW is wider than or equal to UE CBW (Huawei)
	+ Proposal 14: UE CBW<BS CBW and the frequency offset between the edge of UE CBW and the edge of BS CBW is narrower than UE CBW (Huawei)
* Proposals relevant on how to specify possible requirements
	+ Proposal 15: Define a complete list of MPR reduction scenarios by FR that will be considered for MPR reduction study. Also, define the maximum allowable degradation in ACLR, SEM and spurious emissions that is permissible. (Qualcomm)
	+ Proposal 16: Determine whether MPR reduction is limited to MPR=0 dB or whether power boost is also possible (Qualcomm)
	+ Proposal 17: For inner RB allocations, RAN4 can consider whether can define a new inner RB allocation that is retracted from the legacy inner RB allocations (Xiaomi)
	+ Proposal 18: Prioritize study on reduction of Outer RB allocation MPR to similar level as Inner RB allocation MPR without increasing reference UE complexity (particularly hardware), by appropriate Tx emission requirement relaxation in the identified operating scenarios. (MTK)
	+ Proposal 19: Relax UE ACLR/SEM requirement can be further MPR boosting, how much ACLR/SEM can be relaxed needs more discussions such as co-existence study. (ZTE)
	+ Proposal 20: it’s suggested to study the extent of ACLR/SEM relaxation at first with limited number of relaxation values to reduce further MPR reduction analysis workload. (CMCC)
* Recommended WF
	+ FFS the relaxed ACLR/SEM/SE for power boosting and/or MPR reduction with above proposals as initial inputs.

#### **Issue 3-3-3: Simulation assumption for power boosting and/or MPR reduction**

* Proposals
	+ Proposal 1: Using previous MPR simulation assumptions to evaluate the MPR reduction as the starting point. (Xiaomi)
		- PA model calibration
			* DFT-s-OFDM QPSK 20MHz
			* 100RB0
			* 4dB post PA loss
			* 1dB MP
		- Carrier Leakage: 28dB
		- IQ Image: 28dBc
		- CIM3: 60dBc
		- EVM: 17.5%
		- For a PC3 PA the calibration point is 30dB ACLR and for a PC2 PA the calibration point is 31dB ACLR
* Recommended WF
	+ Agree with the above preliminary simulation assumptions for following evaluation. Assumptions are subject to revisions with further study.

#### **Issue 3-3-4: Signaling aspects**

* Proposals
	+ Proposal 1: it is necessary to discuss what information should be included in the BS indication. (LGE)
	+ Proposal 2: If any reduction of MPR would be specified in the end, it should be an optional feature with per band per UE capability (Sony)
	+ Proposal 3: There are two mechanisms of the NW to indicate the UE behavior, and option1 could be studied as the baseline. (vivo)
		- Option1: NW decides whether the OOBE requirement can be relaxed and sends signaling to UE, then UE improves the MPR or performs power boosting.
		- Option2: NW indicates the relative positions of the UE CBW to the BS CBW, and the UE decides the MPR based on the position information.
* Recommended WF
	+ To discuss the signalling aspects after sufficient evaluation of power boosting and/or MPR reduction in terms of relaxed requirements.

### Sub-topic 3-4: MPR applicablility based on the UL CCs with activated cells for FR1 intra-band UL CA

*Sub-topic description*

*Open issues and candidate options before meeting:*

#### **Issue 3-4-1: Clarifications of concept and pre-conditions for FR1 MPR applicability enhcnacements for UL CA**

* Proposals
	+ Proposal 1: For the MPR applicability study for FR1 intra-band contiguous UL CA, the terminology “activation/deactivation” should be interpreted as the existing MAC CE based serving cell activation/deactivation mechanism. (Huawei)
	+ Proposal 2: Since the WID objective is to specify MPR applicability, the power class should remain the same as the CA power class when activated cell number is changed. (Huawei)
		- For example, if a UE indicates PC1.5 for band n78 and PC2 for n78C, the intention is to study whether PC2 MPR for single band operation can be applied assuming power class would still be PC2 instead of PC1.5 when only PCell is activated.
* Recommended WF
	+ Discuss whether above proposals are agreeable

#### **Issue 3-4-2: Applicable MPR for FR1 intra-band contiguous UL CA based on the UL CCs with activated cells**

* Proposals
	+ Proposal 1: For PC3, the single CC MPR requirements (Table 6.2.2-1) can be applied to FR1 intra-band contiguous UL CA with only one UL CC activated. (Samsung)
	+ Proposal 2: For PC2, the single CC MPR requirements can be applied to FR1 intra-band contiguous UL CA with only one UL CC activated. If TxD is indicated for this intra-band contiguous ULCA, single CC with TxD MPR (Table 6.2D.2-1) should apply; if TxD is not indicated for this intra-band contiguous ULCA, single CC without TxD MPR (Table 6.2.2-2) should apply. (Samsung)
	+ Proposal 3: A new optional UE capability should be introduced to indicate if single CC MPR requirements are applicable for FR1 intra-band contiguous UL CA with single UL CC activated. (Samsung)
	+ Proposal 4: For intra-band UL contiguous CA, RAN4 need research whether the MPR of single carrier for PC2 and PC3 can be applied to contiguous RB allocation for CA bandwidth class B and bandwidth class C when LCRB1 = 0 or LCRB2 = 0 (that is, only one CC with activated cell). (Xiaomi)
	+ Proposal 5: The 2-LO architecture of intra-band contiguous UL CA could be the baseline architecture for MPR reduction when only 1 CC is scheduled. (vivo)
	+ Proposal 6: The following architectures could be the baseline for MPR reduction in UL contiguous CA: (vivo)
		- Architecture 1: 2PA+1LO, each PA supports up to 200MHz.
		- Architecture 2: 2PA+2LO, each PA supports up to 100MHz.
	+ Proposal 7: It is proposed that for intra-band UL CA without indicating dualPA-Architecture support, the MPR requirements of single CC operation for PC 2 and PC 3 can be followed when the UL Scell is deactivated. (ZTE)
	+ Proposal 8: It is feasible for intra-band UL CA with TxD supported, when the UL Scell is deactivated, to follow the MPR/A-MPR requirements specified for the corresponding bands with txDiversity-r16 capability (ZTE)
* Recommended WF
	+ Applicable MPR values with UE capability in proposal 1, 2 are considered as baseline
		- FFS the details of UE capability
		- Discuss whether different UE architectures need to be considered

#### **Issue 3-4-3: Release independent issue**

* Proposals
	+ Proposal 1: FR2 MPR enhancement in Rel-19 should be an optional feature and should not be release independent. (Samsung)
* Recommended WF
	+ TBA after conclusion of MPR requirements

### Sub-topic 3-5: MPR applicablility based on the UL CCs with activated cells for FR1 intra-band UL non-contiguous CA

*Sub-topic description*

*Open issues and candidate options before meeting:*

#### **Issue 3-5-1: Applicable MPR for FR1 intra-band non-contiguous UL CA based on the UL CCs with activated cells**

* Proposals
	+ Proposal 1: For intra-band UL non-contiguous CA, RAN4 don’t need to specify the MPR applicability for only one CC with active cell, since it has specified that the MPR of single carrier for PC2 and PC3 will apply to intra-band UL non-contiguous CA if LCRB1 = 0 or LCRB2 = 0 (that is, only one CC with activated cell) in current Spec. (Xiaomi)
	+ Proposal 2: In Rel-19, the applicable MPR for FR1 intra-band non-contiguous UL CA doesn’t need further enhancement. (Huawei)
		- It is observed that the single CC MPR would apply when there is no scheduling after configuration and activation on any one of the two component carriers (except for those “corner cases” with smaller RB allocation where larger MPR would be utilized)
	+ Proposal 3: More study needs be conducted on whether single CC MPR requirements can be applicable for intra-band NC CA with single UL CC activated, given the significant difference between them. (Samsung)
	+ Proposal 4: RAN4 needs to clarify whether it intends to specify MPR requirements in this WID for intra-band non-contiguous UL CA with a dual PA architecture. (CATT)
	+ Proposal 5: introduce additional requirements for DL/UL intra-band non-contiguous CA (1Tx or 2Tx) in fragmented spectrum (Ericsson)
		- single UL cell scheduled/active: by reducing MPR to that of non-CA for UL transmissions confined within one of the two cells also for UEs not indicating *dualPA-Architecture* at least when one of the cells is deactivated;
		- dual NC UL cells scheduled: by reducing MPR for concurrent transmissions for FDD and TDD regardless of PA architecture with additional side-conditions (LO leakage etc) if needed;
		- up to 100 MHz carrier separation (intraBandFreqSeparationUL-AggBW-GapBW-r16 class I) as supported by a single TX/PA and RX chain, and up to 50 MHz carrier separation for FDD;

enhancements subject to UE capability.

* Recommended WF
	+ Check whether proposal 1 and proposal 2 are agreeable, i.e. no further enhancement for MPR applicability based on the UL CCs with activated cells for FR1 intra-band UL non-contiguous CA, since current requirement is already scheduling based.
	+ MPR enhancement for concurrent transmission is not included in the current WI objective for the time being, which may need further discussion in Dec RAN plenary meeting.

### Sub-topic 3-6: MPR applicablility based on the UL CCs with activated cells for FR2 intra-band UL CA

#### **Issue 3-6-1: Clarifications of concept and pre-conditions for FR2 MPR applicability enhcnacements for UL CA**

* Proposals
	+ Proposal 1: For FR2, check if only PC3 UE will be considered for Rel-19 study. (Huawei)
* Recommended WF
	+ TBA

#### **Issue 3-6-2: Applicable MPR for FR2 single carrier UL with DL intra band CA**

* Proposals
	+ Proposal 1: For DL CA only for FR2 intra-band CA, reuse the MPR requirements defined for UL single carrier. (ZTE)
	+ Proposal 2: For FR2, enhance the case of intra-CA configured with single CC UL by making the single CC MPR table applicable for a supporting UE. (Qualcomm)
		- Some FR2 UEs need a back-off allowance that depends on CABW, while other UEs can get by with a back-off that depends on UL BWchannel\_CA*.*
	+ Proposal 3: for intra-band DL contiguous CA with single UL for FR2, the applicable MPR values should be changed from DL CABW dependent to reusing single carrier MPR requirements for UE supporting the enhanced MPR capability (Samsung)
	+ Proposal 4: Study, as one of the improved MPR solution, whether MPR for FR2 single carrier UL or intra band UL CA with DL intra band CA can be defined based on only UL CBW (i.e., independent from DL CBW). Other solutions are not precluded (DCM)
	+ Proposal 5: For FR2 intra-band UL contiguous CA and intra-band DL contiguous CA with single UL (Huawei)
		- MPR applicability and/or potential reduction can be considered
		- Both simulation and measurement should be considered
		- Common Rx/Tx LO architecture should not be precluded as architecture assumption
	+ Proposal 6: For FR2 if the independent LO for UL is feasible, the MPR can be only based on the UL aggregated BW. (vivo)
	+ Proposal 7: For FR2, a new UE capability should be introduced to indicate the UE with independent LO in UL. (vivo)
	+ Proposal 8: RAN4 need research two issues for FR2 intra-band UL CA configuration: (Xiaomi)
		- Whether the MPR for intra-band UL contiguous CA can be defined based on the channel bandwidth class of intra-band UL contiguous CA.
		- Whether the MPR of single carrier can be applied to contiguous RB allocation for intra-band UL contiguous CA when only one CC with activated cell or single UL with intra-band DL contiguous CA
* Recommended WF
	+ Apply the single CC MPR table for the case of FR2 single carrier UL with DL intra band CA with UE capability
		- It is noted that some UE may still need to apply the MPR based on cumulative aggregated channel BW (CABW)
		- FFS the details of the UE capability

#### **Issue 3-6-3: Enhanced MPR for FR2 UL CA with DL intra band CA (configuration based)**

* Proposals
	+ Proposal 1: For FR2, define a UE capability that changes the BW basis of the CA MPR table from cumulative aggregated channel BW (CABW) to UL BWchannel\_CA (configuration based). (Qualcomm)
	+ Proposal 2: For intra-band UL contiguous CA for FR2, the applicable MPR values should be changed from DL CABW dependent to UL CABW dependent for UE supporting the enhanced MPR capability (Samsung)
	+ Proposal 3: For FR2 intra-band UL contiguous CA and intra-band DL contiguous CA with single UL (Huawei)
		- MPR applicability and/or potential reduction can be considered
		- Both simulation and measurement should be considered
		- Common Rx/Tx LO architecture should not be precluded as architecture assumption
	+ Proposal 4: For FR2 if the independent LO for UL is feasible, the MPR can be only based on the UL aggregated BW. (vivo)
	+ Proposal 5: For FR2, a new UE capability should be introduced to indicate the UE with independent LO in UL. (vivo)
* Recommended WF
	+ Enhanced MPR is applied for FR2 UL CA with DL intra band CA (configuration based) with UE capability
		- FFS the details of the UE capability
	+ Enhance MPR (configuration based) is based on simulation or measurement campaign
		- FFS simulation/measurement assumptions

#### **Issue 3-6-4: Enhanced MPR for FR2 UL CA with DL intra band CA (CC activation based)**

* Proposals
	+ Proposal 1: To encourage UEs to support the enhancements in FR2, define a first level of enhancements based on CA configuration, and then a second level of enhancements based on CC activation. (Qualcomm)
	+ Proposal 2: RAN4 to define lower FR2 CA MPR for UL BWchannel\_CA <400 MHz. The CA MPR values for these new BWs can be reproduced from the single CC MPR tables of equivalent channel BW. (Qualcomm)
	+ Proposal 3: For UL intra-band CA, when the Scells are deactivated to make CABW group switched, then the MPR requirements in the switched CABW group can be re-used. (ZTE)
* Recommended WF
	+ Consider enhanced MPR with UE capability for FR2 UL CA with DL intra band CA (CC activation based) as second level compared to configuration-based case
		- FFS the details of UE capability
	+ Enhance MPR (CC activation based) is based on simulation of measurement campaign
		- FFS simulation/measurement assumptions

#### **Issue 3-6-5: Release independent issue**

* Proposals
	+ Proposal 1: FR2 MPR enhancement in Rel-19 should be an optional feature and should not be release independent. (Samsung)
* Recommended WF
	+ TBA after conclusion of MPR requirements

# Topic #4: 6Rx for handheld and FWA UE

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

## Companies’ contributions summary

|  |  |  |  |
| --- | --- | --- | --- |
| **T-doc number** | **T-doc name** | **Company** | **Proposals / Observations** |
| [**R4-2404178**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2404178.zip) | Views on 6Rx for handheld UEs | Apple | ***Observation#1***: *The value of* ***∆TRxSRS*** *relaxation will be higher for 6Rx compared to 4Rx due to the increase in UE integration complexity when more Rx paths are added.* ***Observation#2:*** *IL pre-compensation could be effective when the UE is not Tx power limited but could be sub-optimal in power limited situations*.***Observation #3****: Implementing IL pre-compensation would require UE factory calibration. As a result, UE test time and cost will increase.****Proposal #1:*** *The performance benefits of SRS antenna switching for 6Rx in handled UEs will have to be well understood and quantified. This feature should remain optional if those benefits do not clearly outweigh the implementation challenges and the increase in UE cost.****Observation #4****: Due to limited area to accommodate more antennas, achieving low antenna correlation for 6Rx will be challenging.****Observation #5****: FR1 conducted requirements are performed at the antenna port level, under which a suitable channel environment is applied via test equipment as per demodulation requirements definition.****Proposal #2:*** *The antenna correlation assumptions need to be thoroughly studied and understood since the decision of whether 6 MIMO Layers is beneficial will strongly depend on simulation results based on this decision.****Proposal #3:*** *During the discussion of this work item, interested companies should propose concrete antenna correlation analysis based on antenna spacing and other physical considerations.****Proposal #4:*** *The viability of 6 MIMO Layers should be analyzed and understood during RAN4 demodulation performance discussions, along with the discussion of what demodulation requirements should be determined.****Proposal #5:*** *The performance benefits of 6 MIMO Layers vs 4 MIMO Layers will have to be well understood and quantified. In general, we propose this feature should remain optional if those benefits do not clearly outweigh the implementation and UE cost challenges.****Observation #6:*** *Due to limited area to accommodate more antennas, achieving good REFSENS for 6Rx will be challenging due to sub-optimal component placement, poor isolation at HB and UHB frequencies, and RF coupling between the Rx paths.* ***Proposal #6:*** *RF isolation at HB and UHB frequencies and antenna placement should be well studied and understood because of their impact on REFSENS for 6Rx handheld UEs.* |
| [**R4-2404539**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2404539.zip) | Discussion on 6Rx initial consideration points for single carrier | Meta Ireland | ***Proposal 1: Based on the 2Rx REFSENS requirements, the 6Rx REFSENS levels will be specified with ΔRIB,6R  as follow**** + - * ΔRIB,6R is [- 3.0] dB forn77, n78, n79 and n104
			* ΔRIB,6R is [- 3.3] dB for n41

***Proposal 2: If RAN4 agree to specify the REFSENS based on REFSEN equation, then we are also fine to make consensus with the diversity gain of 6Rx and other parameters such as IM level.******Proposal 3: RAN4 can define the detailed ΔTRxSRS values according to the possible SRS antenna configuration.******Proposal 4: RAN4 will specify detailed Rx core requirements for 6Rx HHUE and 6Rx feature can be supported as release independent manner from Release 17.*** |
| [**R4-2404544**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2404544.zip) | Discussion on NR 6Rx UE | Xiaomi | *Observation 1: The diversity gain between 4Rx and 6Rx is lower than that between 2Rx and 4Rx for the same UE type.****Proposal 1: RAN4 needs to determine whether to define different ΔRIB, 6R value for handheld UE and FWA separately.******Proposal 2:******For 6Rx UE, RAN4 follows the same consensus that not to remove ΔPPowerClass applied for PCMAX\_H,f,c for a PC2 capable UE with txDiversity-r16 and 1TxR capabilities.******Proposal 3: RAN4 to analyse the ∆TRxSRS for xT6R AS-SRS IL.*** |
| [**R4-2404587**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2404587.zip) | Discussion on 6RX for handheld UE and FWA | Spreadtrum Communications | ***Proposal 1: Adopt the value of ΔRIB,6R in Table1 1for n41/n77/n78/n79/n104 for handheld UE and FWA.*****Table1: Six antenna port reference sensitivity allowance ΔRIB,6R**

|  |  |
| --- | --- |
| **Operating band** | **ΔRIB,6R (dB)** |
| n41 | -3.61, -3.32 |
| n77, n78, n79,n104 | -3.21, -3.02 |
| NOTE 1: When 6 Rx operation is supported by FWA form factor.NOTE 2: When 6 Rx operation is supported by handheld UE. |

***Proposal 2: Adopt the value of ΔTRXSRS in Table 2 for 1T6R, 2T6R, 4T6R for PC3 in Table 2.*****Table2: ΔTRXSRS for 1T6R, 2T6R, 4T6R for PC3**

|  |  |  |
| --- | --- | --- |
| UE capability | Bands whose FUL\_high is lower than the FUL\_low of n79 (dB） | Bands whose FUL\_high is higher than the FUL\_low of n79 (dB） |
| 1T6R/1T6R-2T6R/1T6R-4T6R/2T6R-4T6R | 3.5 | 5 |
| 2T6R/4T6R | 3 | 4.5 |
| 1T6R-2T6R-4T6R | 4 | 5.5 |

***Proposal 3: Supporting that UE reports on the actual SRS insertion loss to NW.*** |
| [**R4-2404666**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2404666.zip) | Discussion on 6Rx for handheld and FWA UE | vivo | ***Proposal 1：****Define Delta\_RIB,6R for 6 Rx FWA and Handheld UE REFSENS considering:** *Define one delta value for all CBWs*
* *Do not consider PDCCH Aggregation Level in the RF spec*
* *Consider different requirements for different bands*
* *Handheld and FWA UE requirements differentiation can be further discussed*

***Proposal 2：****Preclude t3r6 and t4r6 SRS antenna switching configuration for 6Rx in Rel-19 and update the WID objective in the next plenary.****Proposal 3:*** *Discuss ΔTRxSRS based on typical RF architectures.****Proposal 4:*** *Discuss a framework to study the gain and feasibility of 6 layers compared to 4 layers for 6Rx, probably including a reference antenna correlation based on implementation for 6Rx to facilitate simulation.****Proposal 5:*** *Study the issues of insertion loss imbalance across SRS ports.****Proposal 6:*** *Specify 6Rx release independent from Rel-17 or Rel-18.* |
| [**R4-2404793**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2404793.zip) | Discussion for 6 Rx | LG Electronics France | ***Observation 1****: The frequency range of 4Rx high band (n48, n77, n78, n79 and n104) is quite broad, around 3800 MHz. In the case of 4 Rx, the n104 band could be considered a high band because the high frequency performance degradation of 4Rx UEs is less than 6Rx or 8Rx UEs.The complexity of UEs for 6Rx or 8Rx can be greather than 4Rx UEs, which may result in a higher potential for highfrequency performance degradation.****Observation 2****: The ideal value of ΔRIB,4R is -3 dB and ΔRIB,4R is currently defined in TS38.101-1 with a relaxation of 0.3 to 0.8 dB depeding on the operating frequency band, duplexing type and UE types (handheld or non-handheld).****Observation 3****: The ideal value of ΔRIB,8R is -6 dB and ΔRIB,8R is currently defiend in TS38.101-1 with a relaxation of 1.5 to 2 dB depeding on the operating frequency band and duplexing type.****Observation 4****: The 6Rx UEs are more complex than 4Rx but less complex than 8Rx, therefore the Relaxation6Rx can be considered to be larger than Relaxation4Rx(0.3~0.8 dB)and smaller than Relaxation8Rx(1.5~2 dB) .****Proposal 1****: It is necessary to study whether or not band n104 could be included in the high band(n77, n78 and n79) category for 6Rx case.****Proposal 2****: ΔRIB,6R can be defined using below equation.**ΔRIB,6R = -4.77 (ideal ΔRIB,6R) + Relaxation6Rx**[0.3 ~0.8] dB< Relaxation6Rx<[1.5~2] dB****Proposal 3****: To specify the ∆TRxSRS for 6Rx, it is necessary to analyse the 6Rx SRS antenna switching IL below scenarios.** *t1r6*
* *t2r6*
* *t4r6*
* *t1r6-t2r6*
* *t1r6-t2r6-t4r6*
* *t2r6-t4r6*
* *t1r6-t4r6*
 |
| [**R4-2404930**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2404930.zip) | Views on SRS insertion loss compensation and reporting enhancements | Intel Corporation | ***Proposal #1: Further discuss SRS IL for 6RX type of devices taking into consideration:**** ***SRS insertion loss requirements for 6RX UEs***
* ***SRS IL impact on performance***
* ***SRS insertion loss compensation***
* ***UE assistance on SRS insertion loss (power imbalance)***

***Proposal #2: Specify UE behavior and requirements for scenarios, when UE has sufficient power to compensate the power imbalance (Case 2) and require UE to perform SRS IL compensation up to the maximum power capabilities.*** ***Proposal #3: Further discuss the mechanisms for UE assistance mechanisms to inform network on the actual SRS transmission power imbalance among TX chains. The methods in WF R4-2317621 can be used as the basis for further analysis.*** |
| [**R4-2404935**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2404935.zip) | Views on 6Rx for handheld and FWA UE | Samsung | *Observation 1: There are two objectives having conditions, which are seeking for feasibility/justification in the WID.****Proposal 1: RAN4 should have more discussion to investigate both issues on the 6 layers and SRS insertion loss imbalance from a practical point of view before having further decisions for the solution.****Observation 2: It would be a different story between ‘any space for more antennas’ and ‘enough space for more layers’ for handheld UEs.**Observation 3: It would be not easy for handheld UEs to get the full technical benefit from the 6 MIMO layers, while it rather have a significant impact on the existing 4 Rx performance.****Proposal 2: 6 MIMO layers can be considered restricted to FWA UEs only unless RAN4 identifies the better performance than 4 MIMO layers given the practical smartphone form factors.****Observation 4: Similar discussion happened in Rel-18 both in RAN4 and RAN1 having no outcome due to the lack of a clear or workable solution considering the practical deployment between UE and network.**Observation 5: RAN4 first needs to justify what the issue is regarding the IL imbalance across SRS ports as there is a lot of sources affects both downlink and uplink performance related to the multiple SRS ports.**Observation 6: In our measurement, it have not been seen the meaningful performance degradation even from the large imbalance gap between antennas under various scenarios with various networks.**Observation 7: Introducing new capability for IL imbalance reporting would be a meaningless solution for improving accuracy of the downlink channel estimation.****Proposal 3: At the current stage, the SRS IL imbalance does not affect the practical system performance, nor any enhancement to resolve the issue would work effectively.*** |
| [**R4-2405083**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2405083.zip) | UE SRS IL imbalance for 6Rx UE | Shanghai Chen Si Electronics | *Observation 1: It seems feasible for a UE implementation to compensate for additional insertion loss on additional antenna Tx ports relative to primary Tx ports where it has sufficient remaining power available to perform such compensation.**Observation 2: When the UE does not have sufficient remaining Tx power available, it can be expected that there may be some SRS power imbalance**Observation 3: Results from [4] show that at mid-high CNR, relying on gNB SRS power imbalance compensation via signalled power offsets is inferior in terms of improving DL performance compared to the “zero imbalance” scenario. In this scenario we assume that the UE would likely have Tx power available to compensate potential SRS power imbalance by itself.**Observation 4: Results from [4] show that, at low CNR, the benefit of gNB SRS power imbalance compensation via signalled power offsets is negligible in terms of benefit to DL performance.**Observation 5: Results show that, there is no DL performance benefit in the UE reporting SRS offset values and gNB performing compensation of IL compared to the UE performing IL compensation alone.**Observation 6: Results show that, for UEs operating at low SINR and Tx power limited cases, Type 1 CSI-RS based CSI reporting enables superior DL performance when compared to SRS-based CSI reporting when the Tx port contains IL.****Proposal 1: RAN4 does not pursue specifying reporting of SRS IL offsets due to IL imbalance.*** |
| [**R4-2405183**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2405183.zip) | R19 6Rx delta RIB | OPPO | ***Proposal 1: Define 6Rx delta RIB for n41 as 3.6dB, and for n78/n77/n79/n104 as 3.2dB.*** |
| [**R4-2405227**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2405227.zip) | Discussion on NR 6Rx requirement | ZTE Corporation | ***Proposal 1. ΔRIB,6R = [-3.5dB] for band n41, and ΔRIB,6R = [-3dB] for n77/n78/n79/n104.*** ***Observation: t3r6 and t4r6 SRS antenna switching are not included in the existing srs-AntennaSwitchingBeyond4RX-r17.******Proposal 2. Apply 4.5dB for n41/n77/n78 and 5.5dB for n79 for t1r6 ∆TRxSRS requirements.******Proposal 3. Apply 4dB for n41/n77/n78 and 5dB for n79 for t2r6 ∆TRxSRS requirements.******Proposal 4. Apply 5dB for n41/n77/n78 and 6dB for n79 for t1r6-t2r6 ∆TRxSRS requirements.******Proposal 5. Static reporting is up to UE implementation, and UE needs to indicate the power compensation behaviour to NW if UE reports statically.******Proposal 6. Dynamic reporting for actual SRS IL reporting for each SRS-TxSwitch pattern, and several threshold associated with capability class for the actual SRS IL reporting can be considered.******Proposal 7. The SRS IL imbalance reporting mechanism should be also specified for 2Rx, 4Rx and 8Rx.*** |
| [**R4-2405615**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2405615.zip) | On RF requirements for 6Rx smartphone | Huawei, HiSilicon | ***Observation 1: SLS shows that the probability of DL 6 layer scheduling, is quite low:**** ***Taking 4 Rx (then of course the maximum of DL layer is 4) as the baseline, system can harvest the diversity gain from 6 Rx;***
* ***When 6 layer scheduling is allowed, the UE with qualified channel condition to support 6 layer transmission is very limited.***

***Observation 2: LLS shows that the demodulation performance degradation due to non-ideal antenna isolation will become severe when MCS becomes larger since error floor is occurred:**** ***When MCS=13, there is ~1dB incensement on the demodulation threshold for rank 6 DL reception;***
* ***When MCS=20~23, degradation on the maximum achievable throughputs for rank 6 is severe, while rank 4 can still achieve corresponding maximum throughputs as expected.***

***Observation 3: From UE capability indication perspective, it is clear that both 3T6R and 4T6R are not supported.******Observation 4: Unlike antenna switching SRS transmission, DL reception would not require Rx switching. Consequently, IL of each Rx path should be within the same level given that it can be realized by similar PCB trace pattern and RF component selection.******Observation 5: RAN4 has never discussed about per branch REFSENS since no exceptional but reasonable RF implementation can be provided to prove the necessity of it.******Proposal 1: To specify -3dB as ΔRIB,6R for the example bands n41, n77/n78, n79, n104 and it is applicable to both FWA and handheld UE.******Proposal 2: Hold on the discussion on 6 Rx RF requirements for CA/DC until that for single band operation is finished.**** ***Similar handling as 8 Rx for CA/DC in Rel-18 can be considered if no specific issue can be identified.***

***Proposal 3: Clarify the support of 6 Rx as follows.**** ***For single band operation, the support of 6 Rx is optional.***
* ***If a UE indicates the support of 6 Rx for a band under single band operation, then it is optional to support 6 Rx for the same band under CA/DC operation.***

***Proposal 4: Only consider 4 DL MIMO layers in Rel-19.******Proposal 5: Preclude 3T6R AS-SRS from 6 Rx ∆TRxSRS requirements discussion in Rel-19.*** * ***The WID shall be revised accordingly.***

***Proposal 6: Inform RAN1 to start the work on enabling 4T6R AS-SRS, while RAN2 can wait for future inputs from RAN1 and RAN4.******Proposal 7: RAN4 discussion on 6 Rx ∆TRxSRS requirements should focus on 1T6R and 2T6R before RAN1 conclusion on how to support 4T6R can be available.******Proposal 8: Adopt the following ∆TRxSRS requirements.**** ***When antenna switching SRS capability is indicated as 't1r6' or ‘t2r6’:***
	+ ***The value of ∆TRxSRS is 5.5 dB for bands whose FUL\_high is higher than the FUL\_low of n79 and 4.0 dB for bands whose FUL\_high is lower than the FUL\_low of n79 when the device is capable of power class 3 or power class 5 or power class 1.5 in the band, or when the device is capable of power class 2 in the band and ΔPPowerClass = 3 dB, or when UE indicating txDiversity-r16.***
* ***When antenna switching SRS capability is indicated as 't1r6-t2r6':***
	+ ***The value of ∆TRxSRS is 6 dB for bands whose FUL\_high is higher than the FUL\_low of n79 and 4.5 dB for bands whose FUL\_high is lower than the FUL\_low of n79 when the device is capable of power class 3 or power class 5 or power class 1.5 in the band, or when the device is capable of power class 2 in the band and ΔPPowerClass = 3 dB, or when UE indicating txDiversity-r16.***

***Note: this is inherited from TS 38.101-1 v18.4 without any intention to revert the change in TS 38.101-1 v18.5.******Proposal 9: Rx-Rx imbalance should not be considered for the discussion on insertion loss imbalance across SRS ports.******Proposal 10: For clarification:*** * ***RAN1 specification on power control doesn’t require or imply that UE shall apply the same PCMAX for all AS-SRS transmission occasions.***
* ***Under the minimum requirement ∆TRxSRS defined in RAN4 specification, it is up to UE implementation whether to apply exact value for corresponding AS-SRS transmission occasions.***

***Proposal 11:*** ***RAN4 should carry on this leftover Rel-18 work and find solution to mitigate the network performance degradation caused by AS-SRS IL imbalance,*** ***at least for the UE that can merely meet the minimum requirement on ∆TRxSRS.******Proposal 12: Do not consider 6 Rx as release independent.*** |
| [**R4-2405616**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2405616.zip) | LS on 4T6R AS-SRS | Huawei, HiSilicon | ***ACTION: RAN4 respectfully asks RAN2 to consider necessary signaling design to support 4T6R AS-SRS depending on future inputs from RAN1 and RAN4.*** |
| [**R4-2405689**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2405689.zip) | Initial considerations on 6RX | Qualcomm France | ***• At least REFSENS, Other RF RX requirements, SRS antenna switching requirements and SRS IL Imbalance issue should be discussed in RF room******• Companies should, independent of their view, provide constructive technical inputs on SRS TX power imbalance topic******• Release independence and at least number of MIMO layers should be discussed in Demod room while also inputs from RF perspective are welcomed*** |
| [**R4-2405727**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2405727.zip) | Initial considerations on 6RX | Qualcomm France | *Duplicated with above contribution* |
| [**R4-2405933**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_110bis/Docs/R4-2405933.zip) | Initial discussion on SRS insertion loss imbalance reporting and 6Rx requirements | Ericsson India Private Limited | [*Observation 1 Whether or not to specify two values of ΔRIB,6R for handheld and FWA UE depends on whether these two types of UE lead to a significant difference.*](#_Toc163511213)[*Observation 2 For ΔRIB,4R requirement and for the example bands of this WI, there is no difference between the handheld and FWA devices.*](#_Toc163511214)[*Observation 3 Existing ΔRIB requirements for 4Rx and 8Rx can be used as a starting point to study the performance of ΔRIB for 6Rx considering the form factor of handheld and FWA UE and other impact factors.*](#_Toc163511215)[*Observation 4 ΔTRxSRS value for the given txr6 AS capability should be specified as an average between the different architectures relevant in practice, which include typical insertion losses of the included antenna switches and PCB traces.*](#_Toc163511216)[*Observation 5 Support of 6 layers should consider the likelyhood to get a rank 6 channel given the limited antenna area on the device and the handheld UE processing requirement and overhead to support 6 layers in the baseband.*](#_Toc163511217)*Based on the discussion in the previous sections we propose the following:*[*Proposal 1 Introduce a solution for the SRS insertion loss imbalance issue in Rel-19 which should be applicable to all 2Rx/4Rx/6Rx/8Rx.*](#_Toc163511218)[*Proposal 2 IL imbalance reporting mechanism for SRS AS should include both the configured maximum output power per SRS resource and the power headroom per SRS resource.*](#_Toc163511219)[*Proposal 3 The PH used for the SRS resource can be a Type 3 but used for a new MAC-CE “SRS resource power report” and can be used also for a carrier configured for PUSCH transmission.*](#_Toc163511220)[*Proposal 4 ΔTRxSRS for the bands whose FUL\_high is higher than the FUL\_low of n79 (n79 and n104 among the exemplary bands) should be higher by 1.5dB compared with the bands whose FUL\_high is lower than the FUL\_low of n79 (n41, n77, n78).*](#_Toc163511221) |

## 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 4-1: REFSENS (delta RIB,6R)

*Sub-topic description*

*Open issues and candidate options before meeting:*

#### **Issue 4-1-1: General considreations for specifying ΔRIB, 6R value**

* Proposals
	+ Proposal 1: Define one delta value for all CBWs (vivo)
	+ Proposal 2: Do not consider PDCCH Aggregation Level in the RF spec (vivo)
	+ Proposal 3: Consider different requirements for different bands (vivo)
	+ Proposal 4: It is necessary to study whether or not band n104 could be included in the high band (n77, n78 and n79) category for 6Rx case. (LGE)
	+ Proposal 5: RF isolation at HB and UHB frequencies and antenna placement should be well studied and understood because of their impact on REFSENS for 6Rx handheld UEs (Apple)
* Recommended WF
	+ In general, agree with proposal 1~3
	+ Discuss proposal 4, 5

#### **Issue 4-1-2: Whether same ΔRIB, 6R value for handheld UE and FWA**

* Proposals
	+ Option 1: RAN4 needs to determine whether to define different ΔRIB, 6R value for handheld UE and FWA separately. (Xiaomi, vivo)
	+ Option 2: Same value for handheld UE and FWA (Meta, ZTE, OPPO, Huawei, LGE)
	+ Option 3: Different value for handheld UE and FWA (Spreadtrum)
* Recommended WF
	+ Option 2.

#### **Issue 4-1-3: Proposed ΔRIB, 6R values for handheld UE and FWA**

* Proposals
	+ Option 1: Based on the 2Rx REFSENS requirements, the 6Rx REFSENS levels will be specified with ΔRIB,6R as follow. (Meta)
		- ΔRIB,6R is [- 3.0] dB for n77, n78, n79 and n104
		- ΔRIB,6R is [- 3.3] dB for n41
	+ Option 2: Adopt the value of ΔRIB,6R in Table below for n41/n77/n78/n79/n104 for handheld UE and FWA. (Spreadtrum)

|  |  |
| --- | --- |
| **Operating band** | **ΔRIB,6R (dB)** |
| n41 | -3.61, -3.32 |
| n77, n78, n79, n104 | -3.21, -3.02 |
| NOTE 1: When 6 Rx operation is supported by FWA form factor.NOTE 2: When 6 Rx operation is supported by handheld UE. |

* + Option 3: ΔRIB,6R can be defined using below equation. (LGE)
		- ΔRIB,6R = -4.77 (ideal ΔRIB,6R) + Relaxation6Rx
		- [0.3 ~0.8] dB< Relaxation6Rx<[1.5~2] dB
	+ Option 4: Define 6Rx delta RIB for n41 as 3.6dB, and for n78/n77/n79/n104 as 3.2dB (OPPO)
	+ Option 5: ΔRIB,6R = [-3.5dB] for band n41, and ΔRIB,6R = [-3dB] for n77/n78/n79/n104. (ZTE)
	+ Option 6: To specify -3dB as ΔRIB,6R for the example bands n41, n77/n78, n79, n104 and it is applicable to both FWA and handheld UE (Huawei)
* Recommended WF
	+ TBA.

### Sub-topic 4-2: SRS antenna switching and ΔTRxSRS

*Sub-topic description*

*Open issues and candidate options before meeting:*

#### **Issue 4-2-1: SRS antenna switching configurations**

* Proposals
	+ Option 1: Preclude t3r6 and t4r6 SRS antenna switching configuration for 6Rx in Rel-19 and update the WID objective in the next plenary. (vivo, ZTE)
	+ Option 2: Preclude 3T6R AS-SRS from 6 Rx ∆TRxSRS requirements discussion in Rel-19 and update the WID, while inform RAN1 to start the work on enabling 4T6R AS-SRS, while RAN2 can wait for future inputs from RAN1 and RAN4. (Huawei)
	+ Option 3: RAN4 discussion on 6 Rx ∆TRxSRS requirements should focus on 1T6R and 2T6R before RAN1 conclusion on how to support 4T6R can be available. (Huawei)
	+ Option 4: To specify the ∆TRxSRS for 6Rx, it is necessary to analyse the 6Rx SRS antenna switching IL below scenarios. (LGE)
		- t1r6
		- t2r6
		- t4r6
		- t1r6-t2r6
		- t1r6-t2r6-t4r6
		- t2r6-t4r6
		- t1r6-t4r6
* Recommended WF
	+ Preclude t3r6 AS-SRS and update the WID in next RAN
	+ Discuss whether to preclude t4r6 and/or request RAN1 to continue their work for t4r6
	+ Before conclusion on t4r6, RAN4 focus on the discussion for 1T6R and 2T6R

#### **Issue 4-2-2: Delta TRxSRS values**

* Proposals
	+ Option 1: Adopt the following ∆TRxSRS requirements. (Huawei)
		- When antenna switching SRS capability is indicated as 't1r6' or ‘t2r6’:
			* The value of ∆TRxSRS is 5.5 dB for bands whose FUL\_high is higher than the FUL\_low of n79 and 4.0 dB for bands whose FUL\_high is lower than the FUL\_low of n79 when the device is capable of power class 3 or power class 5 or power class 1.5 in the band, or when the device is capable of power class 2 in the band and ΔPPowerClass = 3 dB, or when UE indicating txDiversity-r16.
		- When antenna switching SRS capability is indicated as 't1r6-t2r6':
			* The value of ∆TRxSRS is 6 dB for bands whose FUL\_high is higher than the FUL\_low of n79 and 4.5 dB for bands whose FUL\_high is lower than the FUL\_low of n79 when the device is capable of power class 3 or power class 5 or power class 1.5 in the band, or when the device is capable of power class 2 in the band and ΔPPowerClass = 3 dB, or when UE indicating txDiversity-r16.
	+ Option 2: ΔTRxSRS for the bands whose FUL\_high is higher than the FUL\_low of n79 (n79 and n104 among the exemplary bands) should be higher by 1.5dB compared with the bands whose FUL\_high is lower than the FUL\_low of n79 (n41, n77, n78). (Ericsson)
	+ Option 3: Apply 4.5dB for n41/n77/n78 and 5.5dB for n79 for t1r6 ∆TRxSRS requirements. Apply 4dB for n41/n77/n78 and 5dB for n79 for t2r6 ∆TRxSRS requirements. Apply 5dB for n41/n77/n78 and 6dB for n79 for t1r6-t2r6 ∆TRxSRS requirements. (ZTE)
	+ Option 4: Adopt the value of ΔTRXSRS in Table below for 1T6R, 2T6R, 4T6R for PC3 (Spreadtrum)

|  |  |  |
| --- | --- | --- |
| UE capability | Bands whose FUL\_high is lower than the FUL\_low of n79 (dB） | Bands whose FUL\_high is higher than the FUL\_low of n79 (dB） |
| 1T6R/1T6R-2T6R/1T6R-4T6R/2T6R-4T6R | 3.5 | 5 |
| 2T6R/4T6R | 3 | 4.5 |
| 1T6R-2T6R-4T6R | 4 | 5.5 |

* Recommended WF
	+ TBA with consideration of Issue 4-2-1

### Sub-topic 4-3: MIMO layers

* Proposals
	+ Option 1: Only consider 4 DL MIMO layers in Rel-19. (Huawei)
	+ Option 2: Number of MIMO layers should be discussed in Demod room while also inputs from RF perspective are welcomed (Qualcomm)
	+ Option 3: 6 MIMO layers can be considered restricted to FWA UEs only unless RAN4 identifies the better performance than 4 MIMO layers given the practical smartphone form factors. (Samsung)
	+ Option 4: The antenna correlation assumptions need to be thoroughly studied and understood since the decision of whether 6 MIMO Layers is beneficial will strongly depend on simulation results based on this decision. (Apple)
		- During the discussion of this work item, interested companies should propose concrete antenna correlation analysis based on antenna spacing and other physical considerations.
		- The viability of 6 MIMO Layers should be analyzed and understood during RAN4 demodulation performance discussions, along with the discussion of what demodulation requirements should be determined.
		- The performance benefits of 6 MIMO Layers vs 4 MIMO Layers will have to be well understood and quantified. In general, we propose this feature should remain optional if those benefits do not clearly outweigh the implementation and UE cost challenges
	+ Option 5: Discuss a framework to study the gain and feasibility of 6 layers compared to 4 layers for 6Rx, probably including a reference antenna correlation based on implementation for 6Rx to facilitate simulation. (vivo)
* Recommended WF
	+ Determine firstly issue MIMO layers to be discussed in RF or Demod session
	+ Discuss whether 6 MIMO layers could be restricted to FWA UE only
	+ Whether 6 MIMO layers can be supported to handheld depends on further study, could include the following aspects
		- reference antenna correlation analysis
		- performance simulation in comparison with 4 MIMO layer considering possible implementation constraints

### Sub-topic 4-4: SRS IL imbalance issue

*Sub-topic description*

*Open issues and candidate options before meeting:*

#### **Issue 4-4-1: General considreations for SRS IL imbalance issue**

* Proposals
	+ Proposal 1: Study the issues of insertion loss imbalance across SRS ports. (vivo)
	+ Proposal 2: Further discuss SRS IL for 6RX type of devices taking into consideration: (Intel)
		- SRS insertion loss requirements for 6RX UEs
		- SRS IL impact on performance
		- SRS insertion loss compensation
		- UE assistance on SRS insertion loss (power imbalance)
	+ Proposal 3: Some clarifications according the RAN1 and RAN4 specs (Huawei)
		- RAN1 specification on power control doesn’t require or imply that UE shall apply the same PCMAX for all AS-SRS transmission occasions
		- Under the minimum requirement ∆TRxSRS defined in RAN4 specification, it is up to UE implementation whether to apply exact value for corresponding AS-SRS transmission occasions
	+ Proposal 4: Companies should, independent of their view, provide constructive technical inputs on SRS TX power imbalance topic (Qualcomm)
* Recommended WF
	+ In general, agree with above proposals for further study of SRS IL imbalance issues. Whether a solution is agreeable, depends on further discussion of the following candidate solutions and/or identified issues.

#### **Issue 4-4-2: Candidate solutions for the SRS IL imbalance issue**

* Proposals
	+ Option 1: **Specify UE behavior and requirements** for scenarios, when UE has sufficient power to compensate the power imbalance (Case 2) and require UE to perform SRS IL compensation up to the maximum power capabilities. (Intel)
		- **Case 1 (non near max Tx power)**: In this scenario the SRS transmission power (PSRS) is below PCMAX\_L,f,c. Based on TS 38.213 the UE is required to compensate any insertion loss and no further changes in the specification are needed. Per discussion during RAN4 meetings there seem to be no clear understanding whether all existing UEs do perform the SRS IL compensation under these conditions. So, it is recommended to consider specific requirements / conformance requirements in future to guarantee proper UE implementations.
		- **Case 2 (near max Tx power)**: In this scenario the actual required SRS transmission power is higher than PCMAX\_L,f,c, but is still below the max transmission power PCMAX\_H,f,c. Based on the interpretation of TS 38.101-1 above, in this case the UE behavior is undefined and UE may or may not perform SRS IL compensation.
		- **Case 3 (max Tx power)**: In this scenario the actual required SRS transmission power is equal to PCMAX\_H,f,c. (i.e. hypothetical scenario). In this case UE is not capable to perform any SRS IL compensation.



* + Option 2: At the current stage, the SRS IL imbalance does not affect the practical system performance, nor any enhancement to resolve the issue would work effectively. (Samsung)
	+ Option 3: Not specifying reporting of SRS IL offsets due to IL imbalance. (MTK)
	+ Option 4: IL imbalance reporting mechanism for SRS AS including both static reporting and dynamic reporting (ZTE)
		- Static reporting is up to UE implementation, and UE needs to indicate the power compensation behaviour to NW if UE reports statically.
		- Dynamic reporting for actual SRS IL reporting for each *SRS-TxSwitch* pattern, and several threshold associated with capability class for the actual SRS IL reporting can be considered.
	+ Option 5: IL imbalance reporting mechanism for SRS AS including both the configured maximum output power per SRS resource and the power headroom per SRS resource (Ericsson)
		- The PH used for the SRS resource can be a Type 3 but used for a new MAC-CE “SRS resource power report” and can be used also for a carrier configured for PUSCH transmission.
* Recommended WF
	+ Discuss firstly of the UE behaviour in terms of the IL imbalance compensation
		- Whether UE can compensate the IL imbalance for AS-SRS for all power levels
		- Whether NW and UE have the consistent understanding for the possible compensation
	+ Further consider whether a solution around the UE behaviour could be considered

#### **Issue 4-4-3: Extention of the solution, if agreeable, to other cases**

* Proposals
	+ Option 1: Introduce a solution for the SRS insertion loss imbalance issue in Rel-19 which should be applicable to all 2Rx/4Rx/6Rx/8Rx. (ZTE, Ericsson)
* Recommended WF
	+ TBA, based on conclusion of discussion of candidate solutions.

### Sub-topic 4-5: On 6Rx CA requirements

* Proposals
	+ Proposal 1: Hold on the discussion on 6 Rx RF requirements for CA/DC until that for single band operation is finished. (Huawei)
		- Similar handling as 8 Rx for CA/DC in Rel-18 can be considered if no specific issue can be identified
	+ Proposal 2: For single band operation, the support of 6 Rx is optional. If a UE indicates the support of 6 Rx for a band under single band operation, then it is optional to support 6 Rx for the same band under CA/DC operation. (Huawei)
* Recommended WF
	+ In general, agree with the above proposals

### Sub-topic 4-6: Release independent

* Proposals
	+ Option 1: Release independent from Rel-17. (Meta, vivo)
	+ Option 2: Release independent from Rel-18. (vivo)
	+ Option 3: Do not consider 6 Rx as release independent, i.e. supporting 6Rx is from Rel-19. (Huawei)
	+ Option 4: Release independence and at least number of MIMO layers should be discussed in Demod room while also inputs from RF perspective are welcomed (Qualcomm)
* Recommended WF
	+ TBA, based on conclusion of requirements specified

### Sub-topic 4-7: Others

* Proposals
	+ Proposal 1: For 6Rx UE, RAN4 follows the same consensus that not to remove ΔPPowerClass applied for PCMAX\_H,f,c for a PC2 capable UE with txDiversity-r16 and 1TxR capabilities. (Xiaomi)
* Recommended WF
	+ Agree with the above proposal