**3GPP TSG-RAN WG4 Meeting #112 R4-2414285**

**Maastricht, Netherlands, August 19 – August 23, 2024**

**Title:** WF on 6Rx UE requirements

**Agenda Item:** 8.1.3

**Source:** AT&T

**Document for:** Approval

# Topic 1: REFSENS (delta RIB,6R)

## Sub-topic 1-1: General considerations for specifying ΔRIB,6R value

**Issue 1-1-1: Whether band n104 should be included in the high band (n77, n78 and n79) category for 6Rx case**

**Agreement**: Include n104 in the high band (n77, n78, n79) category.

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

**Way Forward**: Further discuss the following options.

- Option 1: Defer decision until relaxation value(s) are decided

- Option 2: Same value for handheld UE and FWA

- Option 3: Different value for handheld UE and FWA

**Issue 1-1-3: Verification of 6Rx receiver requirements**

**Way Forward**: Companies encouraged to provide their views on the ZTE proposal in Proposal 5 in R4-2411883 and any further positions on verification of 6Rx receiver requirements at future meetings after ΔRIB,6R value is defined.

## Sub-topic 1-2: ΔRIB,6R values for handheld UE and FWA

**Issue 1-2-1: Proposed ΔRIB,6R values for handheld UE and FWA**

**Way Forward**: Further discuss the following options for the ΔRIB,6R values. Ultimately, the decision to specify separate or same requirements for handheld UE and FWA will be dependent on outcome of Issue 1-1-2.

- Option 1: Adopt the average value of ΔRIB,6R for handheld UE from company proposals (updated to include company proposals from RAN4#111) and specify it for handheld UE devices.

**Table: Averaged values for handheld UE based on proposals**

|  |  |  |
| --- | --- | --- |
|  | Operating Bands | ΔRIB,6R (dB) |
| MediaTek | Band n41 | -3.4 |
| Band n77, n78, n79, n104 | -3.1 |
| Xiaomi | Band n41 | -3.2 |
| Band n77, n78, n79, n104 | -3.0 |
| LGE | Band n41 | -3.5 |
| Band n77, n78, n79, n104 | -3.0 |
| Spreadtrum | Band n41 | -3.3 |
| Band n77, n78, n79, n104 | -3.0 |
| Meta | Band n41 | -3.5 |
| Band n77, n78, n79, n104 | -3.1 |
| vivo #1 | Band n41 | -3.0 |
| Band n77, n78, n79, n104 | -3.0 |
| vivo #2 | Band n41 | -3.2 |
| Band n77, n78, n79, n104 | -3.0 |
| ZTE | Band n41 | -3.5 |
| Band n77, n78, n79, n104 | -3.0 |
| Ericsson | Band n41 | -3.6 |
| Band n77, n78, n79, n104 | -3.2 |
| Google | Band n41 | -3.4 |
| Band n77, n78, n79 | -3.0 |
| Huawei | Band n41 | -3.3 |
| Band n77, n78, n79, n104 | -3.0 |
| Qualcomm | Band n41 | -3.4 |
| Band n77, n78, n79, n104 | -3.0 |
| Apple (R4-2407071) | Band n41 | -3.3 |
| Band n77, n78, n79, n104 | -3.0 |
| OPPO (R4-2408759) | Band n41 | -3.6 |
| Band n77, n78, n79, n104 | -3.2 |
| **Average** | Band n41 | **-3.4** |
| Band n77, n78, n79, n104 | **-3.0** |

- Option 2: Adopt the average value of ΔRIB,6R for FWA UE from company proposals indicating different FWA UE values from handheld UE values and specify it for FWA UE devices.

**Table: Averaged values for FWA UE based on proposals**

|  |  |  |
| --- | --- | --- |
|  | Operating Bands | ΔRIB,6R (dB) |
| LGE | Band n41 | -3.7 |
| Band n77, n78, n79, n104 | -3.4 |
| Spreadtrum | Band n41 | -3.6 |
| Band n77, n78, n79, n104 | -3.2 |
| vivo | Band n41 | -3.4 |
| Band n77, n78, n79, n104 | -3.2 |
| Google | Band n41 | -3.7 |
| Band n77, n78, n79 | -3.3 |
| Nokia | Band n41 | -4.0 |
| Band n77, n78, n79, n104 | -3.4 |
| **Average** | Band n41 | **-3.7** |
| Band n77, n78, n79, n104 | **-3.3** |

- Option 3: Adopt the average value of ΔRIB,6R for handheld UE from company proposals in Option 1 and specify it for FWA and handheld UE devices.

# Topic 2: SRS antenna switching and ΔTRxSRS

## Sub-topic 2-1: General considerations for SRS antenna switching and ΔTRxSRS

**Issue 2-1-1: Whether to consider an additional breakpoint for bands whose FUL\_high is higher than the FUL\_low of n104**

**Way forward**: Further discuss the following options.

Option 1: Do not consider an additional breakpoint for bands whose FUL\_high is higher than the FUL\_low of n104

Option 2: Consider additional breakpoint for bands whose FUL\_high is higher than the FUL\_low of n104

**Issue 2-1-2: Whether to consider separate ∆TRxSRS values when the device is power class 2 in the band and ΔPPowerClass = 0dB and not indicating Tx diversity capability**

**Way forward**: Have additional 3dB for power class 2 when ΔPPowerClass = 0dB and not indicating Tx diversity capability.

## Sub-topic 2-2: ΔTRxSRS values

**Issue 2-2-1: Proposed ∆TRxSRS values**

**Agreement**: Take option 10 and option 11 as the starting point and further discuss the values.

- Option 10: Adopt the average values from companies as summarized below and specify the values for ΔTRxSRS without considering an additional breakpoint for bands whose FUL\_high is higher than the FUL\_low of n104.

**Table: Averaged values based on proposals**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Operating Bands | ΔTRxSRS t1r6 (dB) | ΔTRxSRS t2r6 (dB) | ΔTRxSRS t1r6-t2r6 (dB) |
| **Average** | Band n41, n77, n78 | **3.9** | **3.5** | **4.5** |
| Band n79, n104 | **5.3** | **4.8** | **5.9** |

- Option 11: Adopt the average values from companies as summarized below and specify the values for ΔTRxSRS considering an additional breakpoint for bands whose FUL\_high is higher than the FUL\_low of n104.

**Table: Averaged values based on proposals**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Operating Bands | ΔTRxSRS t1r6 (dB) | ΔTRxSRS t2r6 (dB) | ΔTRxSRS t1r6-t2r6 (dB) |
| **Average** | Band n41, n77, n78 | **3.9** | **3.5** | **4.5** |
| Band n79 | **5.3** | **4.8** | **5.9** |
| Band n104 | **5.7** | **5.0** | **6.3** |

# Topic 3: MIMO layer evaluation for 6Rx UE

## Sub-topic 3-1: General considerations for MIMO layer evaluation for 6Rx UE

**Issue 3-1-1: Tightening BS EVM requirement**

**Agreement**:

- Do not tighten the minimum requirements of BS Tx EVM

- Further discuss the assumption of Tx EVM for 6-layer performance evaluation.

**Issue 3-1-2: 6-Layer Performance Evaluation Assumptions**

The following list of options are not necessarily mutually exclusive.

* Proposals
  + Option 1: RAN4 to consider the baseline PDSCH simulation assumptions in Table 1 in R4-2411393 (Apple).
  + Option 2: Performance evaluation campaign for HHUE and FWA depending on the medium/high correlation of ULA and cross polarized MIMO matrices (i.e., 1x6, 2x6 and 6x6 cases compared to 1x4, 2x4 and 4x4 cases) in Dense urban micro (UMi) cellular deployment scenarios. (Meta).
  + Option 3: Consider correlation values with correlation coefficient between pairs of antennas to be less than 0.1 for a handheld device (Qualcomm).
  + Option 4: RAN4 to further discuss the system-level simulation assumptions for the feasibility study of 6-layer MIMO for 6Rx handheld UEs (MediaTek).
  + Option 5: RAN4 to use link adaption without OLLA for evaluation as baseline. RAN4 shall not tighten the BS EVM requirements for 6 MIMO layers feasibility study. Companies can start with providing reasonable antenna correlation based on e.g. measurement and run the simulation accordingly. RAN4 to use low correlation (α=0) at BS side. RAN4 to consider 10dB MIMO isolation when evaluating the 6 MIMO layers feasibility (Huawei, HiSilicon).
  + Option 6: Use TDLA30-10 as the propagation condition and cross polarized (XP/X-pol) antennas correlation modelling with low and medium correlation as the correlation configuration for the starting point. Use MCS4, MCS13, and MCS19 with different modulation orders as the beginning (Samsung).
  + Option 7: Support of MIMO 6 layers should be evaluated considering the impact of antenna correlation and the feasibility and probability of achieving a rank 6 channel in the deployment scenario (Ericsson).
  + Option 8: Others.

**Way Forward**: Further discuss the following options.

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**Issue 3-1-4: Performance requirements for 6Rx**

**Agreement**: RAN4 to defer decision after evaluation of 6 MIMO layer performance for handheld and FWA devices.

## Sub-topic 3-2: 6-layer Support

**Issue 3-2-1: 6-layer Support**

**Way Forward**: Further discuss the following options.

- Option 1: 6-layer support is feasible for handheld and FWA based on some company evaluations considering realistic antenna correlation assumptions and deployment scenarios.

- Option 2: 6-layer support is feasible for FWA devices.

- Option 3: Define a common set of simulation assumptions to evaluate feasibility.

**Issue 3-2-2: 6-layer Support as optional feature**

**Way Forward**: RAN4 to further discuss if 6-Layer support should be considered an optional feature.

- Option 1: Introduce 6 MIMO layers support as an optional feature.

# Topic 4: SRS IL imbalance issue

## Sub-topic 4-1: General considerations for SRS IL imbalance issue

**Issue 4-1-1: Whether to solve SRS IL imbalance issue in Rel-19**

**Way Forward**: RAN4 to further discuss the following options.

- Option 1: RAN4 should not continue the discussion on how to solve the SRS IL imbalance issue.

- Option 2: Continue to pursue a solution to the SRS IL imbalance issue dependent on the outcome of Issue 4-1-2 in the approved WF in R4-2410751.

**Issue 4-1-2: Initial Considerations for SRS IL imbalance issue**

* Proposals
  + Proposal 1: Whether the UE perform power imbalance self-compensation depends on UE implementation. The compensation of gNB is necessary when UE cannot keep SRS power balanced (Spreadtrum).
  + Proposal 2: To handle the SRS IL issue, RAN4 should take UE self-compensation as the baseline solution, when UE haven’t reached its Tx power limit (MediaTek)
  + Proposal 3: RAN4 to further discuss a solution when UE cannot fully compensate the SRS IL (MediaTek)
  + Proposal 4: UE power compensation is up to UE implementation, and UE needs to indicate the power compensation behaviour to NW (ZTE, Sanechips).
  + Proposal 5: Dynamic reporting for actual SRS IL reporting for each SRS‑TxSwitch pattern, and several thresholds associated with capability class for the actual SRS IL reporting can be considered (ZTE, Sanechips).
  + Proposal 6: Discuss some general understandings may be helpful to make progress considering the following, e.g.: (vivo)
    - Widely used Dynamic antenna switching have to be considered.
    - Currently there is no “mandatory compensation” requirement or behaviour for UE.
    - Tx-Rx imbalance still need further consideration.
  + Proposal 7: RAN4 should avoid RAN1 impact as much as possible, and should not conclude a scheme with RAN1 impact without confirmation from RAN/RAN1 (vivo)
  + Proposal 8: Do not consider UE self-compensation and UE reporting IL loss at the same time, if reporting is considered (vivo)
  + Proposal 9: RAN4 should discuss and conclude whether the IL imbalance issue needs to be handled in the specification based on the real network check and measurements before moving forward to the solutions (Samsung).
  + Proposal 10: Specify solutions, UE behavior and requirements for scenarios, when UE has sufficient power to compensate the power imbalance and require UE to perform SRS IL compensation up to the maximum power capabilities (Intel).
  + Proposal 11: Further discuss the mechanisms for UE assistance mechanisms to inform network on the actual SRS transmission power imbalance among TX chains and modifications to the configured transmit power equations to require UE to perform at partial SRS IL compensation (Intel)
  + Proposal 12: UE should indicate to NW whether it support insertion loss compensation ability. From complexity point, the static reporting is more feasible. But if we want more accurate report, dynamic method should be considered (China Telecom).
  + Proposal 13: Clarify that for PSRS calculation as defined in TS 38.213, PCMAX is a value determined by UE according to the definition in TS 38.101-1, where ∆TRxSRS has already been counted respective to each SRS occasion, but not the range [PCMAX, L, PCMAX, H] itself. (Huawei, HiSilicon)
  + Proposal 14: Tx/Rx-Rx imbalance should not be considered for the discussion on SRS IL reporting (Huawei, HiSilicon)
  + Proposal 15: The introduced solution for the SRS insertion loss imbalance issue and SRS IL imbalance reporting mechanism should be specified for 2Rx, 4Rx, 6Rx, and 8Rx (Apple, ZTE, Sanechips, Ericsson).
  + Proposal 16: Introduce reporting for the SRS insertion loss imbalance issue in Rel-19 (Ericsson).

**Way forward**: Given the different views amongst companies, RAN4 to further discuss the set of initial considerations which will allow companies to have a common understanding for the study including existing UE behavior for SRS transmissions in case of SRS IL.

- Companies are encouraged to bring analysis on the existing UE behavior and achievable power imbalance for SRS transmissions based on current specification and UE implementations in case of SRS IL.

- Companies are encouraged to analyse the impact of SRS IL imbalance on NW performance degradation.

## Sub-topic 4-2: SRS IL imbalance issue solutions

**Issue 4-2-1: Candidate solutions for the SRS IL imbalance issue**

* Proposals
  + Proposal 1: Solution for IL imbalance issue based on power pre-compensation and reporting for two specific cases. For Case#1 (PCMAX\_SRSi ≤ PCMAX\_SRSmin), the UE has enough power headroom and can perform pre-compensation on the SRS ports. For Case #2 (PCMAX\_SRSi ≥ PCMAX\_SRSmin), the UE does not have enough headroom to perform pre-compensation. The UE should report to the NW the amount of power back-off (PCMAX\_SRSi - PCMAX\_SRSmin) for each SRS port. The reporting mechanism is triggered when the configured power at each SRS resource reaches PCMAX\_SRSmin. (Apple).
  + Proposal 2: Solution for IL imbalance issue as identified below (Spreadtrum).
    - If UE reports statically, UE needs to indicate compensation behaviour to NW
      * If the UE does not perform self-compensation, the UE should report a two-dimensional table which contains the fixed insertion loss mapping to NW according to the different SRS antenna switching capabilities.
      * If the UE does perform self-compensation but still cannot keep the power balanced, UE could configure a power threshold in case that beyond this value, UE could report Q (Q is equal to max power – power threshold) two-dimensional tables which contains the fixed insertion loss mapping according to the different SRS antenna switching capabilities.
    - If UE reports dynamically, UE report the difference value of each diversity branch output power to NW according to the SRS period (including periodic, semi-persistent and aperiodic) in real time
  + Proposal 3: Specify requirements for Case 1 scenarios with PSRS,PC ≤ PCMAX,L to ensure that UE performs SRS IL compensation (Intel).
  + Proposal 4: Both static and dynamic SRS IL report need to consider reporting granularity and assistance information (China Telecom).
  + Proposal 10: The following scenario can be considered as the target for SRS IL reporting: For all SRS resources within the set, all of PSRS equals to PCMAX. In this scenario, the estimated path loss could be high and all diversity branches becomes MOP limited due to ΔTRxSRS, or P-MPR dominated scenario (not in the scope), e.g. cell middle/edge (Huawei, HiSilicon)
  + Proposal 11: Given that specification defines the Tx power should be equally distributed across SRS ports for each SRS transmission, per SRS resource IL reporting would be sufficient (Huawei, HiSilicon).
  + Proposal 12: If dynamic reporting can be considered for SRS IL reporting, network configurable threshold related to e.g. historical change of PSRS can be considered in order to give the network authority for handling SRS IL reporting frequency (Huawei, HiSilicon).
  + Proposal 13: As another compromised solution, UE is allowed to indicate whether it enables self-compensation on the SRS IL once the network requests such information, which would benefit the network by adjusting expectation on the antenna switching SRS based PMI estimation (Huawei, HiSilicon).
  + Proposal 13: The UE should signal the set of values when there is a change in the mapping or numbering of the antenna ports (Lenovo).
  + Proposal 14: The UE should indicate whether it compensates the actual SRS insertion losses for each SRS port up to the configured maximum power for the port (Lenovo).
  + Proposal 15: For a UE that indicates that it compensates the actual SRS insertion loss for each SRS port, the gNB can determine the SRS transmit power for each SRS port by configuring the UE to transmit a power headroom report, including the maximum configured power, for the SRS port having the smallest insertion loss (Lenovo).
  + Proposal 16: IL imbalance reporting mechanism for SRS AS should include the configured maximum output power per SRS resource, the power headroom per SRS resource and ΔPPowerClass (Ericsson).
  + Proposal 17: 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 (Ericsson).
  + Proposal 18: Another way to resolve the SRS IL imbalance reporting issue would be to introduce two types of reporting for a UE: a “baseline” and an “advanced” reporting. The baseline reporting would not require any calibration at the UE and it could include e.g. the PHR and ΔPPowerClass information. The advanced reporting could in addition include the information on e.g. the configured maximum output power (Ericsson).

**Way forward**: RAN4 to further discuss compromise solutions with minimal impact on the specification.

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