**3GPP TSG-RAN WG4 Meeting # 99-e R4-2107919**

**Electronic Meeting, 19th – 27th May 2021**

**Agenda item:** 6.7.1

**Source:** Moderator (vivo)

**Title:** Email discussion summary for [99-e][109] NR\_TxD

**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.*

*List of candidate target of email discussion for 1st round and 2nd round*

The TxD and power class ambiguity problem had been on for some time. Based on latest RAN2 LS and evaluation, see if this issue could be closed.

* 1st round:
  + Discuss remaining issues for TxD, including reply LS to RAN2
  + Discuss power class ambiguity issue, converge on the treatment
* 2nd round:
  + Update the endorsed TxD CR
  + Agree/Endorse CR for power class if possible
  + Agree WF(s)
  + See if other output is needed or possible (LS/WF/CR, etc…)

# Topic #1: TxD

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

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2107616**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_99-e/Docs/R4-2107616.zip) | RAN2 | Reply LS to RAN4 on the capability of transparent TxD  RAN2 thanks RAN4 for the LS on signalling scheme of transparent TxD.  Regarding the new per-band capability signaling in Rel-16 for FR1 UEs supporting transparent TxD, RAN2 can add the corresponding capability in corresponding specification (TS 38.331 and TS 38.306).  RAN2 has discussed whether to enable release-independent support of this new capability from Rel-15, and the following agreements have been achieved:   * RAN2 can support release independent capability of transparent TxD for Rel-15, by allowing early implementation of the Rel-16 CRs. * It is possible to only apply the change for this new capability for PC2 UEs for Rel-15, but RAN2 would like to understand whether the Rel-16 capability signalling applies for all PCs, while Rel-15 capability signalling applies for just PC2 (as this difference in Rel-15 and Rel-16 capability might impact the signalling design)? * RAN2 would also like to confirm whether this new capability has any dependencies with other capabilities that should be captured by RAN2 (since the capability is intended as release independent, RAN2 may need to capture such pre-requisites explicitly).   **To RAN WG4**  RAN2 kindly request RAN4 to take the above information into account during the following work, and provide feedback, if any. |
| [**R4-2108793**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_99-e/Docs/R4-2108793.zip) | Qualcomm Incorporated | SRS switching and spectral flatness with TX diversity  **Proposal:** Specification changes to accommodate Tx Diversity are proposed as follows    **Proposal 2:** The draft CR [1] is changed according to following changes    **Observation:** The draft CR is not using agreed text format “requirement is defined as sum” |
| [**R4-2108794**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_99-e/Docs/R4-2108794.zip) | Qualcomm Incorporated | MPR for 2Tx devices  **Observation 1:** The proposed MPR relaxations in [2] seem to enable use of PC3 PA’s for PC2 with TxD.  **Observation 2**: If reference design is targeted for PC2 from the beginning, same MPR could be met as what is specified for PC2 now in the spec  **Observation 3**: -41 dBc RIMD level for the PA is the correct value  **Observation 4**: Edge RBs do not need additional MPR compared to the PC2 MPRs not in specification  **Observation 5:** Keeping the agreement of applying same MPR for UL MIMO and Tx Diversity and approving proposed [2] MPR’s would mean UL MIMO AMPR need to be revisited too  **Proposal:** 256 QAM DFT-s waveforms need 1 dB more MPR and CP-OFDM 2 dB more MPR for Tx diversity UEs |
| [**R4-2108909**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_99-e/Docs/R4-2108909.zip) | Nokia, Nokia Shanghai Bell | Relation between TxD and ul-FullPwrModes & TxD and SRS antenna switching  *Observations*  **Observation 1**: If PC2 TxD PA configuration is 26dBm + 23dBm, the below current requirement can cover the extra 3 dB relaxation due to non-full-rated-PA usage for 1TyR if we follow a principle of the past.  The value of ∆TRxSRS is 7.5dB for n79 and 6 dB for bands whose FUL\_high is lower than the FUL\_low of n79 when the device is capable of power class 2 in the band.  **Observation 2:** If PC2 TxD PA configuration is 26dBm + 26dBm, no extra 3 dB relaxation due to non-full-rated PA usage for 1TyR is needed.  **Observation 3:** If PC2 TxD PA configuration is 23dBm + 23dBm, the power transmitted via each antenna is lower than the PC2 for 1TyR by 3dB if Tx antenna virtualization is not used and this is not covered by the current specification.  **Observation 4:** If PC2 PA configuration is 23dBm + 23dBm and if Tx antenna virtualization is used, the situation becomes similar to Case 1(part of antennas is virtualized) or 2(all the antennas are virtualized).  **Observation 5:** If UE is assumed to virtualize Tx ports for the purpose of SRS antenna switching while NOT assumed to virtualize Rx ports for it in the same manner, the gain is not maximized.  **Observation 6:** If the above observations 1 - 4 are valid, the option 1a is at least not wrong if we follow the principle of the past for PC2 extra relaxation.  **Observation 7:** Without supporting UL MIMO in a given band, a UE supporting TxD cannot report any ul-FullPwrMode related capabilities.  **Observation 8:** How to achieve full power with two Tx chains is not specified. Hence it is up to UE implementation as far as the UEs meet all the requirements for TxD.  *Proposals*  **Proposal 1**: At least UE performance requirements related to SRS for DL CIS acquisition should be established based on the assumption that a UE uses the same antenna virtualization configuration between Tx and Rx.  **Proposal 2**: In case extra relaxation due to non-full-rated PA is introduced, specification must be clear that it applies to only 1TyR case.  **Proposal 3**: Regardless of PA configurations(two full-rated, two non-full-rated, partially full-rated ), the UE supporting TxD should meet all the requirements for TxD. |
| [**R4-2109420**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_99-e/Docs/R4-2109420.zip) | ZTE Wistron Telecom AB | On remaining issues on NR TxD  **Observation 1**: In transparent TxD, spatial copies of information are transmitted without intervention from BS.  **Observation 2**: In one-layer-two port configuration with full power transmission, spatial copies of information are transmitted in full power which is controlled by BS.  **Observation 3**: TxD and full power capability are two independent features with some overlappings.  **Proposal 2**: RAN4 take Option 2 regarding the relationship between TxD and full power capability.  **Proposal 1**: RAN4 reach a consensus on tentative understanding.  **Proposal 3:** No more discussion on transparent TxD antenna and channel models. |
| [**R4-2109678**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_99-e/Docs/R4-2109678.zip) | vivo | Remaining issues in Transparent Tx Diversity  **Observation 1:** RAN2 confirmed there will be a new capability in Rel-16 specification for transparent TxD.  **Observation 2:** Regarding the capability for Rel-15 UEs, RAN2 have agreed to support release independent capability of transparent TxD for Rel-15 UEs**.**  **Observation 3:** RAN2 is not clear the power class restriction for transparent TxD for different releases, and ask RAN4 to feedback this information.  **Proposal 1:** For Rel-16, confirm RAN2 there is no restriction for the power class of transparent TxD. For Rel-15, discuss whether PC2 restriction is necessary for release independency.  **Proposal 2:** Confirm RAN2 that there is no dependency with other capabilities for this transparent TxD capability.  **Proposal 3:** Introduce certain MPR relaxations for 2Tx compared to 1Tx. The detailed number can be based on evaluation.  **Proposal 4:** It is proposed to postpone the discussion, possibly leave to RAN5, after feature CR can be approved.  **Proposal 5:** A testing mode can only be the last resort and should be avoided wherever possible.  **Proposal 6:** Further clarify the SRS antenna switching requirements, possibly into *∆TRxSRS* based on the scheme in [6].  **Proposal 7:** No inter-dependency with transparent TxD capability with full power capability.  **Proposal 8:** Reply RAN5’s LS after RAN4 CR is stable and release independence applicability is confirmed. |
| [**R4-2109703**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_99-e/Docs/R4-2109703.zip) | LG Electronics Polska | MPR of transmit diversity for power class2  **Proposal 1**: Define MPR for power class 2 with Tx diversity with Table 2.1. |
| [**R4-2109974**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_99-e/Docs/R4-2109974.zip) | Ericsson | More on transparent TxD and a Draft Reply LS to RAN2  **Observation 1**:   * Transparent TxD can be substantially worse than single antenna operation under severe conditions   + When the channel is highly correlated, transparent TxD can be multiple dB worse when an inappropriate amount of CDD delay is used for PUSCH transmission * Transparent TxD is sensitive to proper choice of CDD delay even under conditions favorable to TxD   + Improper choice of CDD delay can result in roughly a dB loss for uncorrelated antennas * Transparent TxD can provide notable gain over single antenna operation in conditions favorable to diversity   + Gains of roughly 1 dB can be observed with appropriate CDD delay and when frequency hopping is used with uncorrelated antennas.   **Proposal 1:** further discuss the relevant antenna and channel models and their impact as part of, and prior to, concluding on conformance testing methodologies and reference receivers for TxD with conducted measurements.  **Observation 2**: Given the support for a wide variety of PA architectures, full configurability, and specified behavior of full-power UL MIMO, additional support for a transparent TxD capability is redundant and may lead to potential behavior ambiguity where UEs support full power operation.  the consequence of which is that  **Proposal 2**: UEs can support only one of full power capability and transparent TxD capability in a given band.  **Observation 3:** A UE that supports 1T2R antenna switching SRS should have at least one full power PA, which is inconsistent with the half power assumption driving the transparent TxD design.  **Observation 4:** Non-codebook based UEs required full power PAs per Tx chain for power efficient operation, which is incompatible with the half power assumption driving the transparent TxD design.  **Proposal 3**: Except for full power UL MIMO, a TxD capable UE can indicate support for a feature only if UE behavior and performance for the feature is unaffected by TxD capability; otherwise the combination is precluded by specification.  **Proposal 4**: RAN4 to confirm which multi-antenna features have UE behavior and performance that is unaffected by TxD capability.  **Observation 5:** according to the current Rel-16 version of the 38.101-1, a UE configured with full-power UL-MIMO must meet the power-class requirement per TX connector when DCI 0\_0 or 0\_1 with single-port is scheduled.  **Observation 6:** why not use the full-power Mode 1 with two half-power PAs instead of the TxD capability?  We propose that RAN2 informed on the dependencies between capabilities as per the LS below. |
| [**R4-2110815**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_99-e/Docs/R4-2110815.zip) | OPPO | R16 TxD testing issues and draft LS to RAN5  *Observation 1: Testing procedure and test mode signaling are falling into RAN5 scope should not be decided in RAN4. What RAN4 can discuss and decide is the UE behavior related to testing.*  *Observation 2: Only Option 1 (UE will keep the tx diversity status unchanged in conformance testing) is within RAN4 scope.*  *Proposal 1: It is proposed to agree that UE will keep the tx diversity status unchanged in conformance testing or leave it to RAN5.*  *Observation 3: Same logic can be applied for UL MIMO and TxD in power splitting between antenna connectors. The necessity of this discussion is unclear.*  *Observation 4: It is less likely the power split is always equal in implementation, and RAN5 tests should accommodate equal and unequal power splits, however, this testing specific issue shall be decided by RAN5 rather than RAN4.*  *Proposal 2: It is proposed to allow any power split between connectors, and it is up to RAN5 decide the test case design.*  *Proposal 3: It is proposed to inform RAN5 about the TxD requirement progress in RAN4 and also the testing related conclusions to facilitate test case design.* |
| [**R4-2111495**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_99-e/Docs/R4-2111495.zip) | Lenovo, Motorola Mobility | On Defining EVM for Transmit Diversity using the Pseudo-Inverse  Observation 1: If the pseudo-inverse is used to define and measure EVM, the resulting EVM definition  will depend on the channel between the transmitter and receiver.  Observation 2: With worst-case correlation of the transmitter noise, the EVM measured using the  pseudo-inverse may underestimate the EVM by a factor as large as 1.4.  Observation 3: The EVM definition agreed in RAN4#98-e-bis does not depend on the channel between  the transmitter and receiver.  Observation 4: The EVM definition agreed in RAN4 #98-e-bis assumes the maximum possible  correlation of the transmitter noise with worst-case phase. Thus, the definition will not  underestimate the EVM even though it is based on conductive measurements.  Because defining EVM using the pseudo-inverse will yield an EVM definition which is fundamentally depends on the propagation channel, and because the pseudo-inverse does not address the correlation of the transmitter noise that may not be present in conductive measurements *but will be present when the UE transmits through its antennas*, we have the following proposal.  **Proposal:** Keep the existing agreement in which the EVM for transparent transmit diversity is defined as  where EVM1 and EVM2 denote the EVM measured at the first and second antenna connectors and P1 and P2 denote the power measured at the first and second antenna connectors. |
| [**R4-2111011**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_99-e/Docs/R4-2111011.zip) | Skyworks Solutions Inc. | MPR evaluation for PC2 transparent Tx diversity  Observation summary:   * The effect of RIMD is noticeable but this may be more significant for ET PAs and cases with large MPR. * The RIMD effect will not be present in the conducted measurements as the antenna coupling will be removed, but needs to be accounted for in the MPR specification as the issue will exist in the field for regulated emissions * As expected the PC2+PC2 PA calibration case needs limited to no back-off due to the intrinsic 3dB headroom * For the PC3+PC3 PA calibration case, additional back off compared to PC2 single PA to account for RIMD and recovering from the 30dB ACLR linearity compared to 31dB.   Proposal on PC2 TxDiv MPR:   * MPR assessment must account for RIMD and its different behavior for different PA architectures like ET and APT * MPR is different for different PA architectures thus it is proposed that:   + PC3+PC2 PA calibration case is not pursued   + PC2+PC2 case is covered in the specification and could at least claim an MPR derived from the PC2 single Tx case or the PC1.5 2Tx case with a delta MPR.   + PC2 2Tx PC3+PC3 case has a slightly larger MPR than PC2 1Tx to account for the CDD and RIMD impacts and linearity recovery for the different ACLR capability. Whether this MPR can be the same as for UL MIMO is FFS but could be logical due to the similarities with single stream UL MIMO     Figure 5: ACLR, first MHz SEM, -13dBm/MHz SEM for P1 and PA2 wo RIMD, PA1+PA2 wo RIMD, PA1+PA2 w RIMD at 10dB antenna isolation |
| [**R4-2111440**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_99-e/Docs/R4-2111440.zip) | Huawei,HiSilicon, vivo, OPPO | CR for TS 38.101-1 Tx diversity requirements |
| R4-2111502 | Huawei,HiSilicon, vivo, OPPO | CR for TS 38.101-1 Tx diversity requirements |
| **[R4-2110816](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_99-e/Docs/R4-2110816.zip)** | OPPO | R16 SRS IL update  ***Observation 1: For 1T4R or t1r4-t2r4 SRS switch with TxD capability, 6dB/7.5dB additional IL as PC2 case is needed.***  ***Observation 2: For 2T4R SRS switch with TxD capability, 3dB/4.5dB additional IL is needed.***  ***Observation 3: For PC2 with TxD, if larger IL value is used then it will be covered by current PC2 wording in the spec.***  ***Observation 4: For PC3, current spec is enough and no need to mention TxD.***  ***Observation 5: For PC1.5, it needs to be added to spec like PC2 does and no need to mention TxD.***  ***Proposal 1: It is proposed to*** ***add PC1.5 to the ∆TRxSRS specification and no need to specify TxD.***  ***Proposal 2: It is proposed to change ∆TRxSRS specification as below from Rel-16.*** |
| [**R4-2110935**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_99-e/Docs/R4-2110935.zip) | OPPO | R16 CR on SRS IL |
| R4-2110936 | OPPO | R17 mirror CR on SRS IL |

## Open issues summary and discussion

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

### Sub-topic 1-1 RAN2 Reply LS related

*Sub-topic description:*

*Open issues and candidate options before e-meeting:*

#### Issue 1-1-1: Applicable power class for capability signaling in different releases

* Proposals
  + Option 1: Applies for all Power Classes for both Rel-15 and Rel-16
  + Option 2: Applies for only PC2 for Rel-15, and for all power classes in Rel-16;
  + Option 3: Others
* Recommended WF
  + [Option 1]

Discussion:

Agreement: Option 1 is agreeable.

~~Agreement: The target completion date of this TxD work is set to September 2021. After September, only maintenance work is allowed and the technique aspects should be discussed under a certain WID.~~

*Views’ collection for 1st round:*

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| **Company** | **Comments** |
| Qualcomm | Option 1. This simplifies ran2 as clarified offline by the LS proponent. |
| OPPO | Option 1. |
| Xiaomi | Option 1 |
| Huawei, HiSilicon | Option 1. |
| Skyworks | We support the idea that impact to RAN2 is minimized but we are not aware of any R15 cases other than PC3+PC3 TxDiv. |
| ZTE | Option 1. |
| Ericsson | Option 3. Is there any case other than the implementation of PC2 by two 23 dBm PAs? Is a PC1.5-capable UE going to indicate txDiversity-r16? Is there any implementation of PC1.5 other than with two 26 dBm PAs that would *not* indicate txDiversity-r16?  PC2 indication with two 23 dBm PAs we have discussed for three years. If only a matter of allowing a UE implemented with two 23 dBm PAs advertise PC2 NR capability and making sure it can pass the conformance tests for single-port transmissions, no matter the impact on the actual performance in the field, there is no need to introduce a txDiversity-r16 capability. The number of active TX connectors could be declared. However, then the actual UE power capability as seen in the field would be ambiguous.  Is actual power capability as seen at the gNB important?  If correlation is low, then diversity works. However, if higher or the CDD delay is unfortunate, it may look like below:    that could correspond to a PC3 single-TX or worse. The PHR reported is still based on the advertised PC2 and can thus be (even more) inaccurate.  At best the txDiveristy-16 capability would inform the gNB that the UE power capability may not be up to the advertised PC assuming that other multi-antenna features have behavior and performance unaffected by the txDiveristy-16 capability (see also comments to SRS switching). |
| LGE | Prefer option 1. In rely LS, RAN2 mentioned the release independent capability of transparent TxD for Rel-15 is possible. So all power classes for TxD applied for both rel-15 and Rel-16. |

*Status summary for 1st round:*

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| **Status summary**  A clear majority companies chose option 1 and it has been agreed in the GTW session that Option 1 is agreed. |
| *Recommendations for 2nd round:*  Agreement has reached, no need for 2nd round. |

#### Issue 1-1-2: Architecture assumption

Currently there are different understandings of Transparent TxD capable UE’s architecture:

* Proposals
  + Option 1: Full-power PA(s) implementation, compared to UE power class, is not precluded for UE with transparent TxD capability;
  + Option 2: UE with transparent TxD capability can only have half-power PAs compared to UE power class.
  + Option 3: Others
* Recommended WF
  + [Option 1]

*Views’ collection for 1st round:*

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| **Company** | **Comments** |
| OPPO | Option 3, the TxD is one feature and the PAs is implementation issue, so UE can use any PAs (full power or half power) to work with TxD. |
| Xiaomi | Option 1 |
| Huawei, HiSilicon | Option 3. There should be no limitation on specific UE implementation. |
| Skyworks | PA assumption is important to derive minimum requirements but once agree there should be choice in the implementation. For full power PA implementations, the 1Tx PC2 MPR would be easy to meet |
| ZTE | Option 3. Transparent TxD could be enabled for both full power and half power architecture. |
| Nokia | Option 3: as far as TxD does not affect UE’s behavior to use other features, it depends on UEs. But TxD should not impact on other features’ performance. It just kills precious features and this impact cannot be visible from NW perspective and that is quite critical. |
| Ericsson | Is an implementation with a full-power PA also indicating txDiveristy-r16? That would not reduce ambiguity. Why not use the FP UL-MIMO that was specified to support a wide variety of PA architectures with full configurability and specified behavior? Transparent TxD is already an integral part of of FP UL MIMO. |
| LGE | Option 3. This is up to RF architecture basis for transparent TxD. If RAN4 only consider 23+23 dBm for TxD RF requirements as worst RF architecture, then option 2 is feasible. Otherwise, full power PA implementation is not precluded. |

*Status summary for 1st round:*

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| **Status summary**  Though it seems that there are some misunderstandings of current options, especially option 1. A clear major companies select option 1 or option 3, most of them with similar explanation of prefer not to restrict full-power or half-power implementation for TxD. Option 2 was implicitly chosen by one company and question the justification and usefulness of other implementations.  In addition, Moderator would like to pointed out that “Increasing UE maximum power high limit” discussion in [126] may also related to this issue, since flexible scheme was raised on multiple TX cases and the overall power class may have quite flexible relationship with any RF chain, thus make the implementation even more flexible for one power class . |
| *Recommendations for 2nd round:*  Further check company’s view on this issue, see if an assumption that no restriction of full-power and/or half-power PAs should be mandated for TxD capable UEs. |

*Views’ collection for 2nt round:*

*Tentative agreement: No restriction of full-power and/or half-power PAs should be mandated for TxD capable UEs.*

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| **Company** | **Comments** |
| LGE | Support the tentative agreements from moderator |
| Ericsson | In our understanding the intention of txDiveristy-r16 is only to allow UEs implemented with two 23 dBm PAs in two TX to advertise PC2 and ensure that these UEs can pass the conformance tests. An implementation with a full-power PA also indicating txDiveristy-r16 would not reduce ambiguity. Why not use the FP UL-MIMO that was specified to support a wide variety of PA architectures with full configurability and specified behavior? |
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*Status summary for 2nt round:*

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| **Status summary**  There are still concerns on this issue, and no consensus can be reached in this meeting. This item in WF is FFS. |

#### Issue 1-1-3: Relation with full power capability

Clarify the relationship between transparent TxD capability signalling and full Tx power capability

* Proposals
  + Option 1: No dependency
  + Option 2: A UE can support only one of the two capabilities
* Recommended WF
  + TBA

*Views’ collection for 1st round:*

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| **Company** | **Comments** |
| Qualcomm | Option 1. No dependency |
| OPPO | Option 1. |
| Xiaomi | Option 1. It’s up to UE implementation |
| Huawei, HiSilicon | Option 1. No dependency. |
| Skyworks | No dependency |
| ZTE | Option 1. |
| Ericsson | Option 2. Transparent TxD is an integral part of FP UL-MIMO operation. No dependence? Which requirement applies? At the very minimum it should be made clear that the behavior of FP operation, if configured, is unaffected by the txDiversity-r16. |
| LGE | This is up to UE implementation. Both are possible. |

*Status summary for 1st round:*

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| **Status summary**  All but one company prefer option 1 and prefer this as an implementation. This is also related with previous issue . |
| *Recommendations for 2nd round:*  Further check if option 1 can be agreed or not. |

*Views’ collection for 2nt round:*

*Tentative agreement: No dependency between transparent TxD capability signaling and full Tx power capability. (Option 1)*

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| **Company** | **Comments** |
| LGE | Prefer option 1 |
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*Status summary for 2nt round:*

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| **Status summary**  There are still concerns on this issue, and no consensus can be reached in this meeting. This item in WF is FFS. |

#### Issue 1-1-4: Antenna virtualization for different purpose of SRS

In order to understand the relationship between transparent TxD and SRS antenna switching, and provide a basis for the requirements. Discuss whether the following proposals can be assumed.

* Proposals
  + Proposal 1: Antenna virtualization cannot be assumed for SRS antenna switching which is targeting DL CSI.
    - This is discussed in R4-2108793 and is the basis for the requirements proposal
  + Proposal 2: Antenna virtualization can be assumed for the SRS intended for UL PUSCH scheduling.
* Recommended WF
  + [Both Proposal 1 and Proposal 2]

*Views’ collection for 1st round:*

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| **Company** | **Comments** |
| Qualcomm | How UE virtualizes is up to implementation but since the virtualization or lack of it is transparent to the networks as long as UE is not changing it, only specification impact is the max power capability for the SRS in case UE does not virtualize RX ports. |
| OPPO | Proposal 1 is ok, but only for requirement definition instead of limiting implementation since this is up to UE whether the virtualization is used or not. |
| Xiaomi | Agree with the view from Qualcomm. |
| Huawei, HiSilicon | If the question is about SRS antenna switching, then proposal 2 on SRS usage for UL PUSCH is not relevant. As for proposal 1, it is up to UE implementation. What matters in RAN4 is how to consider the delta SRS in the requirement. Proposal 1 could be consider as an assumption for defining the requirement. |
| ZTE | Share similar view as Qualcomm. |
| Nokia | Though it is up to UE but if virtualization is used for Tx, the same should be used for Rx. That must be the precondition. Otherwise, that creates lose-lose relationship between UEs and NWs. |
| Ericsson | We share the view with Qualcomm. If a UE indicating txDiversity-16 is configured for e.g. 1T2R or 1T4R antenna switching, it should not virtualize the SRS but instead transmit on each RX chain. If the UE supports a full power one of its TX chains (e.g. Mode 2) it will not need to virtualize to reach full power. No dependency? |
| LGE | Currently, the antenna virtualization is related SRS antenna switching based on UL PUSCH scheduling. The DL CSI is could not assumed for antenna virtualization. So we support recommended WF. |

*Status summary for 1st round:*

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| **Status summary**  Proposal 1 was confirmed by first GTW session in the discussion of Issue 1-2-3.   * SRS antenna switching which was targeted for DL CSI would not use UL antenna virtualization~~, i.e. UL TxD~~   Proposal 2 was not quite related to SRS antenna switching pointed by one company and was not thoroughly discussed. |
| *Recommendations for 2nd round:*  Agreement was reached for proposal. Proposal 2 may not that needed in current stage. No need for 2nd round . |

#### Issue 1-1-5: Relation with SRS antenna switching

Clarify the relationship between transparent TxD capability signalling and SRS antenna switching

* Proposals
  + Option 1: No dependency
  + Option 2: A UE that supports 1T2R antenna switching SRS should have at least one full power PA
    - In another word, transparent TxD UE capable UE with an architecture of 23+23 for PC2, are not allowed to be 1T2R antenna switching capable
  + Option 3: Others
* Recommended WF
  + TBA

*Views’ collection for 1st round:*

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| **Company** | **Comments** |
| Qualcomm | Option 2 is interesting proposal. If accepted, then the relaxation to the max power would not be needed. However, then PC1.5 UE would not be able to support SRS antenna switching. |
| OPPO | Option 1, and not clear where the option 2 is coming from. |
| Xiaomi | Prefer Option 1. 1-1-4 and 1-1-5 are related and should be discussed together. |
| Huawei, sHiSilicon | Option 1. |
| ZTE | Option 1. |
| Nokia | At least we understand the motivation of the option 2. At least we need to make clear that even if TxD is used with some other features such as CA etc, the PC should stay or TxD feature should not degrade features concurrently used. |
| Ericsson | To OPPO: this is discussed in R4-2109974 for codebook- and non-codebook based precoding. The PC1.5 should not virtualize the SRS as discussed for 1-1-4.  Option 2: a UE supporting a full power one of its TX chains (e.g. Mode 2) does not need to virtualize to reach full power. |
| LGE | Option1. We think 1T2R is indicate with number antenna port. So 1 port is supported with 2 antenna connector as transparent TxD, it can be support 1T2R antenna switching. |

*Status summary for 1st round:*

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| --- |
| **Status summary**  Majority companies prefer option 1, and it has been pointed out that option 2 would means that SRS antenna switching functionality would be basically excluded for many TxD capable cases.  In addition, it has been agreed in 1st GTW for Issue 1-2-3:   * SRS antenna switching functionality cannot be excluded for UE supporting TxD.   This basically means that option 2 was not agreed. |
| *Recommendations for 2nd round:*  Further confirm whether option 1 can be agreed or not. |

*Views’ collection for 2nt round:*

*Tentative agreement: No dependency between transparent TxD capability signaling and SRS antenna swtiching capability. (Option 1)*

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| --- | --- |
| **Company** | **Comments** |
| LGE | Option 1 |
| Ericsson | Option 3: there is clearly a dependence between txDiversity-r16 and SRS antenna switching e.g. for the case in which the UE virtualizes the RX ports. A UE supporting a full power one of its TX chains (e.g. Mode 2) does not need to virtualize to reach full power. |
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*Status summary for 2nt round:*

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| --- |
| **Status summary**  There are still concerns on this issue, and no consensus can be reached in this meeting. This item in WF is FFS. |

#### Issue 1-1-6: Relation with Non-codebook based transmission

Clarify the relationship between transparent TxD capability signalling and non-codebook based transmission

* Proposals
  + Option 1: No dependency
  + Option 2: Non-codebook based UEs required full power PAs per Tx chain for power efficient operation.
  + Option 3: Others
* Recommended WF
  + TBA

*Views’ collection for 1st round:*

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| --- | --- |
| **Company** | **Comments** |
| Qualcomm | If option 2 is selected, the e.g. FPULTx mode 1 non-codebook behavior needs to be clarified since it can not meet full power according to 6.2.1 what the spec now demands. |
| OPPO | Option 1, and it is not clear where this question is coming from? |
| Huawei, HiSilicon | Option 1. |
| ZTE | Option 1. |
| Ericsson | See comment to 1-1-5. |
| LGE | Need further discuss to support codebook basis TxD. |

*Status summary for 1st round:*

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| --- |
| **Status summary**  Slight majority companies prefer option 1, while the question is still not clear enough by some company. |
| *Recommendations for 2nd round:*  Further discuss in the 2nd round, to see if more agreements can be reached or not. |

*Views’ collection for 2nt round:*

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| --- | --- |
| **Company** | **Comments** |
| LGE | We slightly prefer option 2. Because some UE do not support codebook based UE behavior in my view. So RAN4 can allow the non-codebook based UE for transparent TxD UE. |
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*Status summary for 2nt round:*

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| **Status summary**  There are still concerns on this issue, and no consensus can be reached in this meeting. This item in WF is FFS. |

#### Issue 1-1-7: Relation with other multi-antenna features

Clarify the relationship between transparent TxD capability signalling and other multi-antenna features

* Proposals
  + Option 1: No dependency
  + Option 2: A TxD capable UE can indicate support for a feature only if UE behavior and performance for the feature is unaffected by TxD capability.
  + Option 3: Others
* Recommended WF
  + TBA

*Views’ collection for 1st round:*

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| --- | --- |
| **Company** | **Comments** |
| Qualcomm | Agree w option 2 given that the outout power generation with two antenna connectors is allowed. |
| OPPO | Option 1, and it is not clear where this question is coming from? Besides, for option 2, not clear the meaning of “only if UE behavior and performance for the feature is unaffected by TxD capability”. |
| Huawei, HiSilicon | Option 1. What are the specific features mentioned here? Some issues discussed in topic #1 are not remaining issues in agreed WFs in previous RAN4 meetings. |
| ZTE | Option 1. TxD is treated as a separate feature. We don’t see the need to link TxD capability with other multi-antenna features. |
| Nokia | We agree with the Option 2. |
| Ericsson | Option 2. This is a minimum requirement. To Huawei: UL multi-antenna features, see R4-2109974. |
| LGE | Prefer option 2 |

*Status summary for 1st round:*

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| --- |
| **Status summary**  Views are divided. It seems that it is still not clear what specific features were mentioned and how this impact would be. |
| *Recommendations for 2nd round:*  Further explanations would be welcome from the proponents of this question. |

*Views’ collection for 2nt round:*

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| --- | --- |
| **Company** | **Comments** |
| LGE | If Transparent TxD is no dependency with UL-MIMO and other multi- antenna feature, then the UE also can support UL-MIMO feature. But, it is depend on the RF architecture. So, still prefer option 2. |
| Ericsson | Option 2. |
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*Status summary for 2nt round:*

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| --- |
| **Status summary**  There are still concerns on this issue, and no consensus can be reached in this meeting. This item in WF is FFS. |

### Sub-topic 1-2 Other Remaing issues

*Sub-topic description*

*Open issues and candidate options before e-meeting:*

#### Issue 1-2-1: MPR

The following evaluation and tentative suggestion had been provided:

1. R4-2111011 (Skyworks):
2. R4-2108794 (Qualcomm)
3. R4-2109703 (LG)
4. R4-2111440 (Huawei CR)

* Proposals
  + Companies can encourage to comment on the respective evaluation results
* Recommended WF
  + It is proposed to adopt the following offset based on 1TX

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Modulation | | MPR (dB) | | |
| Edge RB allocations | Outer RB allocations | Inner RB allocations |
| DFT-s-OFDM | Pi/2 BPSK | ≤ 3.5 | ≤ 0.5 | 0 |
| QPSK | ≤ 3.5+D1 | ≤ 1+D2 | 0+D6 |
| 16 QAM | ≤ 3.5+D1 | ≤ 2+D2 | ≤ 1+D6 |
| 64 QAM | ≤ 3.5+D3 | ≤ 2.5+D4 | |
| 256 QAM | ≤ 4.5 + [1] | | |
| CP-OFDM | QPSK | ≤ 3.5+D1 | ≤ 3+D2 | ≤ 1.5+D6 |
| 16 QAM | ≤ 3.5+D1 | ≤ 3+D2 | ≤ 2+D6 |
| 64 QAM | ≤ 3.5+D5 | | |
| 256 QAM | ≤ 6.5 + [2] | | |

* + Tentative offset values are as following:
    - Edge MPR for QPSK/16QAM (D1): [0.5~1.5]dB
    - Outer MPR for QPSK/16QAM (D2): [0.5~1.5]dB
    - Edge DFT-S MPR for 64QAM (D3): [0.5~1.5]dB
    - Outer/Inner DFT-S MPR for 64QAM (D4): [0.5~1.5]dB
    - CP-OFDM MPR for 64QAM (D5): [0.5~1.5]dB
    - Inner (other than High order) (D6): [0~0.5]dB
    - 256QAM proposals marked in the table;
    - Pi/w BPSK currently leave unchanged

Discussion:

T-Mobile: need clarification for LGE results. Do we need re-evaluate MPR for PC1.5?

LGE: in previous meeting, RAN4 agreed to re-evaluate by assuming 23+23. But for PC1.5 we use different architecture 26+26. We should consider IMD issue. Maybe we can consider average value.

Apple: MPR value, it seems to be based on simulation rather measurement. Only one company provides measurement result. Is IMD considered correctly in simulation? It could be underestimated. It is too early to decide and we should come back next meeting with more measurement results.

Ericsson: the relation to full power mode. Mode 1 is TxD. No additional MPR can apply when 1Tx allowed. TxD could have some degradation in some case. There would be a concern to allow additional MPR. We would like consider the consistency with full power mode. Clarification is needed.

Huawei: we disagree with comment of Ericsson. It depends on UE implementation. Regarding evaluation, last meeting we have evaluation assumptions. Based on the assumptions, Skyworks provide initial results. TxD is discussed for a long time. There is no new implementation. Based on existing UE, company can provide the measurement based on the existing UE. We can consider the delta from 1Tx by using TxD. Minor relaxation would be possible compared to two Tx requirement. Proposals from Qualcomm are OK for us, which provides relaxation for CP-OFDM. For this meeting, we need to make conclusion as soon as possible. Other work relies on the conclusion of TxD.

Qualcomm: PC1.5, I do not think we need change. We should keep consistency. We use measurement to calibrate the simulator.

Ericsson: for full power mode,

Huawei: for full power mode, we sent LS to RAN1 to clarity implementation. RAN1 is aware that the implementation could be different. Until now we only refer to PC3 table. There is no agreement that we should consider conclusion of TxD. It is clear that PC3 requirement cannot be reused for other PC.

Agreement:

In this meeting, RAN4 will try to agree on the ranges for MPR values if possible, and in the next meeting, RAN4 can down-select to concrete value within the agreed range.

*Views’ collection for 1st round:*

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| --- | --- |
| **Company** | **Comments** |
| OPPO | We see different results in different papers, are we going to choose one of them or average them? |
| Huawei, HiSilicon | both option b) and option d) are ok for us. |
| Skyworks | R4-2108794 choses a RIMD level based on 31dBC ACLR but the PC#=PC3 cases agreement was for a calibration point at 30dB ACLR. So we do not agree that the RIMD level should be reduced to 41dBc. From the analysis in fig1 it should rather be ~38dBc. We thus think that there will be a visible impact for edge allocations ~0.5dB. We concur with the conclusion that the most impacted case is for 256QAM EVM but the impact might be higher with ~38dB RIMD. Also 64QAM may already see some degradation. Also our measurements have shown that a small impact (at least 0.5dB) is there for edge and outer cases due to the combination of RIMD and lower PC3 PA linearity.  R4-2109703 proposes values that are more than 3dB higher than for single PC2 PA and in some cases larger than for PC1.5 which is hard to understand for edge and outer: edge benefit from a 3dB lower power level compared to PC1.5 and should only be affected by the slightly lower linearity (30 vs 31dB ACLR calibration) and some RIMD contribution. For outer the same applies for ACLR or SEM limited case. At this point we do not understand such a big difference including for inner especially as there seem to be no impact to 256QAM which is dominated by IBE/EVM like inner allocations  R4-2111440 only proposes a slight increase of edge allocation MPR comared to 1Tx PC2 this is ignoring any impact to outer and especially inner high order modulation EVM. We think this is too optimistic  Some compromise around b and d is probably a good start (if any agreement we would like to see brackets as we intend to verify multiple cases with measurements (not simulations)) |
| Ericsson | From an UL performance standpoint, the MPR should not be increased for a UE indicating tcDiversity-r16 given the actual performance as seen as the gNB receiver (see 1-1-1). Moreover, additional MPR is not allowed for FP Mode 1 for e.g. DCI 0\_0 fallback (can be transparent TxD). Otherwise there is dependence between the capability and the configured FP mode. |
| LGE | Based on 23+23 PA architecture, we derived the MPR requirements with RIMD issues and PA linearity. |

*Status summary for 1st round:*

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| --- |
| **Status summary**  As summarized in the GTW session. Views were provided and tentative ranges were also proposed. |
| *Recommendations for 2nd round:*  As agreed in the GTW:  In this meeting, RAN4 will try to agree on the ranges for MPR values if possible, |

*Views’ collection for 2nt round:*

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| --- | --- |
| **Company** | **Comments** |
| LGE | The MPR range shall be decided based on MPR results from interested companies. So we propose the MPR range as follow   * Edge MPR for QPSK/16QAM (D1): [0.5~3.0]dB * Outer MPR for QPSK/16QAM (D2): [0.5~2.5]dB * Edge DFT-S MPR for 64QAM (D3): [0.5~3.0]dB * Outer/Inner DFT-S MPR for 64QAM (D4): [0.5~2.0]dB * CP-OFDM MPR for 64QAM (D5): [0.5~2.0]dB * Inner (other than High order) (D6): [0~1.5]dB   The exact MPR value will be determined in next RAN4 meeting based on the MPR results from the interested companies. |
| Ericsson | Is the MPR for txDiversity-r16 the same as that for FP Mode 1 with half-power PAs?  From an UL performance standpoint, the MPR should not be increased for a UE indicating txDiversity-r16 and PC2 given the actual performance as seen as the gNB receiver. Now the |
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*Status summary for 2nt round:*

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| --- |
| **Status summary**  More options were raised but with no convergence. This item would be discussed in next meeting. |

#### Issue 1-2-2: A-MPR Related

* Proposals
  + Option 1: A-MPR as band specific requirements could be decoupled from the general TxD requirements
  + Option 2: Keeping the agreement of applying same MPR for UL MIMO and Tx Diversity would mean changed to the UL MIMO AMPR, too. (LGE,
* Recommended WF
  + Further discussion can be proceed after MPR was set
  + The baseline can be the current requirements

Discussion:

Huawei: A-MPR is band specific requirements. Usually we need complete the requirement for MPR first.

LGE: second to Huawei. We should decouple. Option 2 are fine for us.

Chair: in this meeting, we focus on MPR.

*Views’ collection for 1st round:*

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| --- | --- |
| **Company** | **Comments** |
| Qualcomm | Does option 1 mean there will be a list of bands where TxD is enabled? Or how is this decoupling stated in the specification? For option2, |
| OPPO | Option 2 and can be discussed after the MPR is finished. |
| Huawei, HiSilicon | Usually the band specific requirements are not discussed together with the general requirements for a feature. After completion of the MPR requirements, whether the existing A-MPR requirements need to be revisited can be considered case by case. |
| Skyworks | Since A-MPR is only related to emissions and A-MPR have good margins for outer and edge we do not think it is useful to revisit A-MPR. Anyhow MPR should be first. |
| LGE | Both option 1 & option 2 is fine. A-MPR issue will treated based on specific operator request to use TxD in specific operating band with additional regulatory requirements. |

*Status summary for 1st round:*

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| --- |
| **Status summary**  Views were provided. |
| *Recommendations for 2nd round:*  In this meeting, we focus on MPR. No need for 2nd round discussion. |

#### Issue 1-2-3: SRS switching requirements

* Proposals
  + Option 1: Based on R4-2108793
    - The ∆TRxSRS needs to be increased by 3 dB overall except for the PC2 case which accommodates the use of PA with 3 dB lower power for SRS antenna switching.



* + Option 2: Based on R4-2110816: Add PC1.5 to the ∆TRxSRS specification and no need to specify TxD



* + Option 3: Others
* Recommended WF
  + Accept the following assumptions:
    - SRS antenna switching which was targeted for DL CSI would not use UL antenna virtualization, i.e. UL TxD
    - The current wording in spec, which do not suppose support of TxD capability, had a pre-assumption that a full power PA is available.
      * Then it comes the 3dB additional loss in case a non-full power PA was selected.
    - TxD capable UE can have non full-power PAs only, while still can use SRS antenna switching
      * Then 3dB loss would be needed even for the first / first or second SRS port for SRS antenna switching
  + Based on previous assumptions, refine the requirements based on option 1
    - Add a specific condition for UE supports TxD as in option 1
    - Other part is FFS and may need further refinements

Discussion:

Moderator: we can first discuss the assumption and based on the assumption we can discuss how to define the requirements.

Qualcomm: We want to consider all the signals for TxD. Considering Nokia and Ericsson, should we allow UE to do SRS antenna switching with TxD? There would be complicated implantation.

Huawei: based on the paper from Qualcomm, we share the similar view that it depends on UE implementation. There is no need to mandate UE to do antenna virtualization for SRS for at least some cases. SRS antenna switching is option feature. If there is no requirement, we may not enable SRS antenna switching for TxD.

Oppo: We support Option 2. Option 1 means that TxD is separate configuration from SRS. This is not correct.

Vivo: We prefer to Option 1. There is very important issue. Firstly SRS antenna switching should not use any antenna virtualization, which is mentioned by Qualcomm. If we have restriction on SRS antenna switching use case, it is not desirable.

Ericsson: we agree with Qualcomm. We are not disputing that additional loss is not needed. In practice, we should include different antenna difference. We should not exclude SRS antenna switching.

Huawei: We can consider combining Option 1 and 2.

Agreement:

* SRS antenna switching which was targeted for DL CSI would not use UL antenna virtualization~~, i.e. UL TxD~~
* SRS antenna switching functionality cannot be excluded for UE supporting TxD.

Chair: Leave discussion on concrete value for loss and how to combine Option 1 and 2 to further email discussion.

*Views’ collection for 1st round:*

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| --- | --- |
| **Company** | **Comments** |
| Qualcomm | Option 2 does not allow 23+23 dBm implementation without virtualization of the Rx port. We can only agree to Option 1 unless issue 1-1-5 option 2 is agreed. |
| OPPO | Option 2.  The changes to Option 1 is not quite understandable, for example, if the intention is to define SRS IL for TxD specifically then the changes is not correct:   * in the 2nd change it says SRS IL is 4.5dB/3dB when device is capable of TxD in the band; * in the 3rd change it says SRS IL is 7.5dB/6dB when the device is capable of TxD in the band and condition in a) and b) are met.   For the 2nd change, it seems for UE with TxD no matter the SRS is configured or not the SRS IL will be 4.5dB/3dB with the 1st change, however, the SRS IL shall be applied only when SRS is configured. And if we look at the original spec wording there is no mention of SRS configuration because the whole section is under the condition that SRS is configured or transmit to a DL only carrier. Now with TxD as a standalone condition added the SRS IL will be applied with TxD no matter the SRS is configured or not. This is not correct.  For the 3rd change, it means 7.5dB and 6dB will be applied when SRS is configured. However, according to our discussion R4-2110816, this is not necessarily, even it considers UE with antenna virtualization.  And for the UE without antenna virtualization, when it was configured with 1T4R, the power level status is as below figure, so the antenna 1 comparing to antenna 0 is only the PCB IL here which is 4.5dB/3dB, meanwhile if we further consider the power class is PC2 actually so for the UE without antenna virtualization there will be 3dB loss. Then the total power in Ant1 will still be 7.5dB/6dB which is same conclusion as observation 1 in R4-2110816. So the conclusion still holds.    Therefore, from above analysis, the only needed change is introducing PC1.5 as Option 2. And the TxD is already been covered. |
| Xiaomi | We tend to support the view from Oppo. The original spec already can be applied for TxD case |
| Huawei, HiSilicon | Option 1 is acceptable for us. |
| ZTE | Option 1 with the only concern on the notation ∆TRxSRS, could be ∆TRxSRS, TxD, which not only covers SRS transmission, but also TxD if Option 1 agreed. |
| Nokia | The last text change in the Option 1 must be clear that PC3 should not have the same relaxation. We would like to understand why option a and b should be simultaneously met? In addition, we ‘d like to better understand why 2TxR needs such relaxation? The configured power calculation must use the sum of the output powers from two antenna ports. |
| Ericsson | Option 2. The explanation by OPPO is good. We share the view that the 3/4.5 dB relaxation is due to routing loss. The additional 3 dB is allowed no matter if the UE supports full power on one of its TX chains. In the field the effect if the antennas (not identical) will add further to the SRS power inaccuracy. Virtualizing the RX chains will not improve this.  Now, we recognize that margin for routing loss has to be granted for SRS antenna switching. |
| LGE | Prefer option 1 |

*Status summary for 1st round:*

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| --- |
| **Status summary**  General principles were discussed and confirmed in GTW session:   * SRS antenna switching which was targeted for DL CSI would not use UL antenna virtualization~~, i.e. UL TxD~~ * SRS antenna switching functionality cannot be excluded for UE supporting TxD. |
| *Recommendations for 2nd round:*  Further discuss if more general guidelines can be reached or not. If possible, more specific requirements can also be discussed. |

*Views’ collection for 2nt round:*

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| --- | --- |
| **Company** | **Comments** |
| LGE | Current guideline is enough to support transparent TxD. |
| Ericsson | The behavior of UEs supporting txDiversity-r16 and configured with SRS switching capability should be made clear. These UEs should not virtualize the RX ports not to further increase the SRS power uncertainty (the difference due to antenna performance is not even considered). |
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*Status summary for 2nt round:*

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| **Status summary**  A dedicated WF was agreed to further study in next meeting. |

#### Issue 1-2-4: TxD EVM spectrum flatness

* Proposals
  + Option 1: Based on R4-2108793:



* + Option 2: Others
* Recommended WF
  + TBA

Discussion:

Motorola mobility: we have comment similar to R&S. Do they cancel each other? We think we should consider flatness.

Qualcomm: We would like to learn more about the potential problem.

Motorola mobility: It could be one value. I can share one example.

*Views’ collection for 1st round:*

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| --- | --- |
| **Company** | **Comments** |
| Rohde & Schwarz | In principle we can agree to this approach. We think that there is a risk that the coefficients from both connectors may cancel each other out, but if the group is ok, then the approach is fine for us. |
| Huawei | Some clarification for option 1, whether the composite equalizer will be used for EVM measurement at each antenna connector? |
| Skyworks | Equalization will be needed especially because of the ripple observed from the coupling of the two paths with CDD. RAN5 may have to assess the measurement error related to this |
| ZTE | The composite EVM flatness should be consistent with the composite EVM agreed in RAN4#98bis-e, which means that the composite EVM flatness should be derived under the method of combining EVMs from two connectors corresponding to the composite EVM. Good to further check analytically if the flatness follows the same weights before we agree Option 1. |
| LGE | Prefer option 1 |
| Lenovo, Motorola Mobility | We share the concern expressed by Rohde & Schwartz on cancellation. We think that it is straightforward to create examples where the spectral flatness is satisfied on both antenna connectors, but then fails for transmit diversity. At least the amplitudes of EC1(f) and EC2(f) should be used in the equation. |
| Qualcomm | We appreciate the comments, and are open to working together to refine the formula.  We acknowledge the prospect of cancellation. Companies to check if this modification would work: |

*Status summary for 1st round:*

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| --- |
| **Status summary**  Qualcomm’s proposal was discussed and receive some support. Some problems were also reached. |
| *Recommendations for 2nd round:*  Discuss whether Qualcomm’s latest proposal could work or not: |

*Views’ collection for 2nt round:*

Question: whether Qualcomm’s latest proposal could work or not:

|  |  |
| --- | --- |
| **Company** | **Comments** |
| LGE | Support the revised EC (f) |
| Lenovo, Motorola Mobility | We are ok with the revised formula. The issue with the previous formula was that EC1(f1) could add in-phase with EC2(f1) while EC1(f2) could add out of phase with EC2(f2). The result would be very large EC(f1) with very small EC(f2) such that the ratio of these exceeds the peak-to-peak limit even if EC1(f) and EC2(f) pass on their own. |
| Ericsson | The problem of cancellation in the EC is the essentially same as that experienced in the UL receiver with correlated single-port transmissions. The measurement problem may be solved, however… |
|  |  |

*Status summary for 2nt round:*

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| **Status summary**  This is agreed and included in the WF and draft CR. |

#### Issue 1-2-5: Testing related issues

There are still two testing related issues following concept:

* UE behaviour under conformance testing
* Power splitting behaviour
* Proposals
  + Option 1: Leave these discussions to RAN5 and not pursue them before agreement of RAN4 CR.
  + Option 2: Continue discussion in RAN4.
* Recommended WF
  + [Option 1]

*Views’ collection for 1st round:*

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Qualcomm | Option 1 and 2 are both feasible in parallel. The actions towards specification and/or test procedure should be taken in ran5 but ran4 could instruct ran5 what is the expected UE behavior. |
| OPPO | Option 1. This is RAN5 scope issue. |
| Xiaomi | Option 1 |
| Huawei, HiSilicon | Option 1. The test related issues can be left to RAN5. If some addition inputs are needed from RAN4, it can be triggered by RAN5. |
| Skyworks | The work shall be left to RAN5 but RAN4 should provide some insights and especially the impact of CDD. |
| ZTE | Option 1. It is quite obvious to us. |
| Ericsson | The impact of CDD can also be seen in R4-2105082 and R4-2109974. |
| LGE | Prefer option 1 |
| Anritsu | Options 1 but also 2 as RAN4 needs ideally to agree on the repeatability of TxD status: can it be maintained in terms of timing to switch and the power splitting ratio between the two antenna ports? That would allow simpler TE architecture and reduce TE cost e.g. it would allow a flexibility of test sequence, both sequential measurements per antenna and simultaneous measurements based TE architectures could be considered. |

*Status summary for 1st round:*

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| --- |
| **Status summary**  Most companies can agree option 1, while among them some company still think option 2 is also meaningful. One company think TxD feature itself still have many problems. |
| *Recommendations for 2nd round:*  Try to confirm option 1. |

*Views’ collection for 2nt round:*

Recommended WF: Leave these discussions to RAN5 and not pursue them before agreement of RAN4 CR.

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| **Company** | **Comments** |
| LGE | Agreed recommend WF |
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*Status summary for 2nt round:*

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| --- |
| **Status summary**  Agreed in WF. |

#### Issue 1-2-6: TxD antenna and channel models

* Proposals
  + Option 1: No more discussion on these issues.
  + Option 2: Further discuss the relevant antenna and channel models and their impact as part of, and prior to, concluding on conformance testing methodologies and reference receivers for TxD with conducted measurements.
* Recommended WF
  + [Option 1]

*Views’ collection for 1st round:*

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| --- | --- |
| **Company** | **Comments** |
| OPPO | Option 1. |
| Huawei, HiSilicon | Option 1. |
| ZTE | Option 1. |

*Status summary for 1st round:*

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| --- |
| **Status summary**  No company prefer option 2. |
| *Recommendations for 2nd round:*  Agree option 1 and no need for 2nd round. |

### Sub-topic 1-3 CRs/TPs

*For close-to-finalize Wis and maintenance work, comments collections can be arranged for TPs and CRs. For ongoing Wis, suggest to focus on open issues discussion on 1st round.*

|  |  |
| --- | --- |
| **CR/TP number** | **Comments collection** |
| [**R4-2111440**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_99-e/Docs/R4-2111440.zip)  **(Huawei)** | qualcomm: 6.2G.1 says “is defined as the sum of the maximum output power from both” but 6.2G.2 and also 6.2G.3 says “power is measured as the sum of the maximum”.  Could we put Table 6.2.2-2a in to 6.2G.2? or is there is a reason to keep it in the 6.2.1?  We should include the SRS IL part here too and spectral flatness before agreeing. |
| Huawei: 6.2G.2 and 6.2G.3 can be revised. |
| Skyworks MPR values are too optimistic with only edge allocation being impacted. |
| Ericsson: why are the MPR requirements not consistent with those for FP modes (no relaxations allowed)? |
| LGE: MPR is can be updated by issue 1-2-1 decision. |
| [**R4-2110935**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_99-e/Docs/R4-2110935.zip)  **(OPPO)** | qualcomm: As in issue 1-2-3, this change is not sufficient. |
| OPPO: To QC, as we discussed in issue 1-2-3 the change is enough. And if it is not sufficient could QC please help to clarify and give some suggest wording? |
| Huawei: Changes on SRS Ilcan be included in the big CR after consensus is reached based on discussed for issue 1-2-3. |

*Status summary for 1st round:*

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| --- |
| **Status summary**  Both CRs have controversies and not likely to be finalized in this meeting. Some improvements were confirmed for R4-2111440 while R4-2110935 is a bit more unclear. |
| *Recommendations for 2nd round:*  Revise R4-2111440 to include new agreements for documentation, not pursued for agreement.  Returned to or postpone R4-2110935, further revision is possible depending on the progress. |

# Topic #2: Power Class related

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

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2108859**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_99-e/Docs/R4-2108859.zip) | Qualcomm Incorporated | Handling power class ambiguity  **Observation**: Rel-15 UE can rely on dedicated txd capability based on LS [1]  **Proposal 1**: Solve EN-DC power class ambiguity between SA and NSA by referring to TxD capability and allowing the relaxation to the power class for EN-DC mode only for UE that declare TxD capability for that band.  **Proposal 2**: Reply to RAN2 [1] that TxD capability is applicable to all power classes for all applicable releases. |
| [**R4-2109679**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_99-e/Docs/R4-2109679.zip) | vivo | Remaining issues in Power class & UL MIMO related requirments  **Observation 1:** With transparent TxD capability release independency from Rel-15 is confirmed by RAN2 at least for PC2, the meaning of current description of multiple possibilities of power class in NR part of NSA mode is also confirmed.  **Proposal 1:** For Rel-15 UE without the TxD capability, the current behaviour of multiple power class possibilities for NR part of NSA can be removed.  **Proposal 2:** For Rel-15 UE with the TxD capability, the current behaviour of multiple power class possibilities for NR part of NSA need to be kept, and further refinements targeting more precise PHR reporting can also be considered.  **Proposal 3:** Revise the power class part according to previous proposals and the general part can as the Annex.  **Proposal 4:** With the release independency of TxD capability to Rel-15, ue-PowerClass should always be supported for 1-port transmission fall back mode for SA.  **Proposal 5:** Reply GCF when all the related CRs are approved. |
| [**R4-2111441**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_99-e/Docs/R4-2111441.zip) | Huawei,HiSilicon | Discussion and draft reply LS on EN-DC power class  ***Observation 1****: Without a power class to indicate the difference between SA and NSA for the NR band, it’s ambiguous which power class would be used for PCMAX\_L,f,c,,NR**, consequently, UE may fail the Pcmax test for the NR part in an EN-DC band combination.*  ***Observation 2****: The main issue of Pcmax identified by RAN5 is to address the measurement problem.*  ***Proposal:*** *It is proposed to adopt the method to set a lower bound for PCMAX\_L,f,c,,NR if PPowerClass,NR is indicated as a higher power class rather than the default power class.* |
| [**R4-2111442**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_99-e/Docs/R4-2111442.zip) | Huawei,HiSilicon | CR for TS 38.101-3 correction of power class for EN-DC |

## Open issues summary and discussion

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

### Sub-topic 2-1 Power Class ambigulity

*Sub-topic description:*

*Open issues and candidate options before e-meeting:*

#### Issue 2-1-1: How to treat the ”famous sentence” for Rel-15

Regarding the description of multiple power class possibilities for NR part of NSA in Rel-15:

*Unless otherwise stated, if UE indicates IE maxNumberSRS-Ports-PerResource = n2 in NR standalone operation mode, the said UE shall meet the NR requirements for either power class 2 or power class 3 in EN-DC within FR1 if UE indicates IE maxNumberSRS-Ports-PerResource = n1 for EN-DC on this NR band.*

Further differentiation can be made based on whether TxD is supported or not, the following proposals are provided:

* Proposals
  + Proposal 1: For Rel-15 UE without the TxD capability, the current behaviour of multiple power class possibilities for NR part of NSA can be removed.
    - At least one full-power chain has to be equipped
  + Proposal 2: For Rel-15 UE with the TxD capability, the current behaviour of multiple power class possibilities for NR part of NSA need to be kept;
    - The two RF chains may all be half-power and reach total SA power class by TxD
* Recommended WF
  + [Both Proposal 1 and Proposal 2]

*Views’ collection for 1st round:*

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| --- | --- |
| **Company** | **Comments** |
| Qualcomm | Agree with both proposals |
| OPPO | For clarification, what is the meaning of “UE without TxD capability”, does that mean UE not support TxD feature or support this feature but no TxD capability signaling?  Clarification is needed before give answers. |
| Xiaomi | Agree with both proposals |
| Huawei, HiSilicon | Generally ok with the proposals. The clarification issue raised by OPPO can be considered. |
| Skyworks | Proposals are reasonable and it means that only PC2 is covered for R15 |
| ZTE | We are fine with the recommended WF. |
| LGE | Agree with recommended WF |

*Status summary for 1st round:*

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| --- |
| **Status summary**  Generally agreeable apart from a few questions for clarification . |
| *Recommendations for 2nd round:*  Confirm recommended WF and try to at least endorse a related CR. |

*Views’ collection for 2nt round:*

*Detailed discussion can be based on the draft CR.*

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| **Company** | **Comments** |
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*Status summary for 2nt round:*

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| **Status summary**  Draft CR submitted with no comments. Proposed to be endorsed. |

#### Issue 2-1-2: The Pcmax for NR for Rel-15 EN-DC

* Proposals
  + Option 1: The Pcmax for NR is modified to use the lower possible power class to decide the lower bound of the configured power. (Huawei)
  + Option 2: The Pcmax for NR is modified according to the declared NR power capability for NSA so that the PHR becomes correct. (Ericsson)
  + Option 3:Do not consider further refinements of Pcmax for NR.
  + Option 5: Others
* Recommended WF
  + TBA

*Views’ collection for 1st round:*

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| **Company** | **Comments** |
| Qualcomm | Option 2 sounds right (Where is Ericsson proposal in detail?) |
| Huawei, HiSilicon | Option 1. The change for Pcmax also needs to consider the PC1.5 UE which can be supported by release independent from Rel-15. |
| ZTE | Option 2. |
| Nokia | Option 2(it seems the only reasonable and practical way). |
| Ericsson | Option 2… described in R4-2105083 and a CR in R4-2105084. We gave up after last meeting and did not resubmit, but we can of course provide a CR is requested (see also comments to R4-2109679). |

*Status summary for 1st round:*

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| **Status summary**  Views are divided. Situation the same to previous meeting. |
| *Recommendations for 2nd round:*  No 2nd round discussion. Leave it to the next meeting. |

#### Issue 2-1-3: Fallback to 1-port Tx for SA in Rel-15

* Proposals
  + Option 1: Confirm ue-PowerClass should always be supported for 1-port transmission fall back mode for SA in Rel-15.
    - *UE do not support TxD capability would equip a full power chain*
    - *For UE support TxD capability, when falls back to 1-port transmission, it is also reasonable to suppose it would use TxD to achieve ue-PowerClass in standalone mode*
  + Option 2: Others
* Recommended WF
  + TBA

*Views’ collection for 1st round:*

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| --- | --- |
| **Company** | **Comments** |
| Qualcomm | Option 1. |
| OPPO | Option 1. |
| Xiaomi | Option 1 |
| Huawei, HiSilicon | Option 1. |
| Skyworks | Option 1 |
| ZTE | Option 1. |
| Ericsson | We assume that this is the main reason for the “release independence” – bypassing the TX-connector requirement of Rel-15. |
| LGE | Prefer option 1 |

*Status summary for 1st round:*

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| **Status summary**  Option 1 is confirmed. |
| *Recommendations for 2nd round:*  Further discuss whether a CR is needed or not for Rel-15 to reflect this understanding. |

*Views’ collection for 2nt round:*

Question: Whether a CR is needed or not for Rel-15 to reflect this understanding?

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| **Company** | **Comments** |
| Ericsson | At best the txDiversity-16 could indicate to the network that the actual power capability may not be quite as that advertised by the power class. This assuming that the behavior of other multi-antenna features is unaffected by the txDiversity-16 indication (this also includes SRS antenna switching).  Now, it is proposed that the txDiversity-r16 can also be used for implementations with a full-power PA as discussed above. This would effectively remove any possible virtue of the txDiversity-16 indication from a network standpoint. |
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*Status summary for 2nt round:*

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| **Status summary**  The comments here does not have a clear relation with this topic.  As in the WF, this issue is basically confirmed and draft CR would be discussed in next meeting. |

### Sub-topic 2-2 CRs/TPs

*Major close to finalize WIs and Rel-15 maintenance, comments collections can be arranged for TPs and CRs. For Rel-16 on-going WIs, suggest to focus on open issues discussion on 1st round.*

|  |  |
| --- | --- |
| **CR/TP number** | **Comments collection** |
| [**R4-2111442**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_99-e/Docs/R4-2111442.zip)  (Huawei) | Qualcomm; To us it seems this should have a reference to Txd capability and if it is indicated. This grants too broad relaxation. |
| Huawei: CR need to be revised to include the changes as in Issue 2-1-1, if the proposals in Issue 2-1-1 are agreeable. |
| Ericsson: not agreed. |
| [**R4-2109679**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_99-e/Docs/R4-2109679.zip)  (vivo, Draft CR in Annex) | Qualcomm: This looks ok since it uses the txd capability. |
| Ericsson: even better if the Pcmax,f,c would set in accordance with the txCapability-r16, adjusted by 3 dB if the UE supports PC2 with txCapability-r16 (similar to R4-2105084). Can perhaps be made if the RAN4 chair allows a CR? |
|  |
|  | Company A |
| Company B |
|  |

*Status summary for 1st round:*

|  |
| --- |
| **Status summary**  R4-2111442 is challenged, while R4-2109679 is generally supported. |
| *Recommendations for 2nd round:*  R4-2111442 would be postponed to next meeting .  Turn the draftCR in R4-2109679 to a formal CR. |

# Recommendations for Tdocs

## 1st round

**New tdocs**

|  |  |  |
| --- | --- | --- |
| **Title** | **Source** | **Comments** |
| Way Forward on NR TxD & Power Class | vivo |  |
| Way Forward on SRS antenna switching requirements for TxD | OPPO |  |
| Correction of general description of EN-DC related power class based on the TxD capability | vivo | TS 38.101-3, Rel-15, Cat F |

**Existing tdocs**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Tdoc number** | **Title** | | **Source** | **Recommendation** | | **Comments** |
|  |  | |  |  | |  |
| R4-2108793 | | SRS switching and spectral flatness with TX diversity | Qualcomm Incorporated | Noted |  | |
| R4-2108794 | | MPR for 2Tx devices | Qualcomm Incorporated | Noted |  | |
| R4-2108909 | | Relation between TxD and ul-FullPwrModes & TxD and SRS antenna switching | Nokia, Nokia Shanghai Bell | Noted |  | |
| R4-2109420 | | On remaining issues on NR TxD | ZTE Wistron Telecom AB | Noted |  | |
| R4-2109678 | | Remaining issues in Transparent Tx Diversity | vivo | Noted |  | |
| R4-2109703 | | MPR of transmit diversity for power class2 | LG Electronics Polska | Noted |  | |
| R4-2109974 | | More on transparent TxD and a Draft Reply LS to RAN2 | Ericsson | Noted |  | |
| R4-2110815 | | R16 TxD testing issues and draft LS to RAN5 | OPPO | Noted |  | |
| R4-2111440 | | CR for TS 38.101-1 Tx diversity requirements | Huawei,HiSilicon, vivo, OPPO | Revised |  | |
| R4-2111495 | | On Defining EVM for Transmit Diversity using the Pseudo-Inverse | Lenovo, Motorola Mobility | Noted |  | |
| R4-2111502 | | CR for TS 38.101-1 Tx diversity requirements | Huawei,HiSilicon, vivo, OPPO | Not Pursued |  | |
| [R4-2110816](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_99-e/Docs/R4-2110816.zip) | | R16 SRS IL update | OPPO | Noted | |  |
| [R4-2110935](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_99-e/Docs/R4-2110935.zip) | | R16 CR on SRS IL | OPPO | Postponed | |  |
| R4-2110936 | | R17 CR on SRS IL | OPPO | Postponed | |  |
| R4-2108859 | | Handling power class ambiguity | Qualcomm Incorporated | Noted | |  |
| R4-2109679 | | Remaining issues in Power class & UL MIMO related requirments | vivo | Noted | |  |
| R4-2111011 | | MPR evaluation for PC2 transparent Tx diversity | Skyworks Solutions Inc. | Noted | |  |
| R4-2111441 | | Discussion and draft reply LS on EN-DC power class | Huawei,HiSilicon | Noted | |  |
| R4-2111442 | | CR for TS 38.101-3 correction of power class for EN-DC | Huawei,HiSilicon | Noted | |  |

Notes:

1. Please include the summary of recommendations for all tdocs across all sub-topics incl. existing and new tdocs.
2. For the Recommendation column please include one of the following:
   1. CRs/TPs: Agreeable, Revised, Merged, Postponed, Not Pursued
   2. Other documents: Agreeable, Revised, Noted
3. For new LS documents, please include information on To/Cc WGs in the comments column
4. Do not include hyper-links in the documents

## 2nd round

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Tdoc number** | **Title** | **Source** | **Recommendation** | **Comments** |
| R4-2107740 | Way Forward on NR TxD & Power Class | vivo | Agreeable |  |
| R4-2107981 | Way Forward on SRS antenna switching requirements for TxD | OPPO | Agreeable |  |
| R4-2107781 | Correction of general description of EN-DC related power class based on the TxD capability | vivo | Endorsed | This is still a draft CR. |
| R4-2107782 | CR for TS 38.101-1 Tx diversity requirements | Huawei,HiSilicon, vivo, OPPO | [Endorsed] | *Email discussion continues. Decision is pending based on GTW session.* |
| [R4-2110935](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_99-e/Docs/R4-2110935.zip) | R16 CR on SRS IL | OPPO | Noted |  |
| R4-2110936 | R17 CR on SRS IL | OPPO | Not Pursued |  |

Notes:

1. Please include the summary of recommendations for all tdocs across all sub-topics.
2. For the Recommendation column please include one of the following:
   1. CRs/TPs: Agreeable, Revised, Merged, Postponed, Not Pursued
   2. Other documents: Agreeable, Revised, Noted
3. Do not include hyper-links in the documents