3GPP TSG-RAN WG4 Meeting # 98-e R4-210xxxx

**Electronic Meeting, 25 Jan - 5 Feb., 2021**

**Agenda item:** 7.19.2

**Source:** Moderator (vivo)

**Title:** Email discussion summary for [98e][112] Transmit diversity and power class related to UL MIMO

**Document for:** Information

# Introduction

*Briefly introduce background, the scope of this email discussion and provide some guidelines for email discussion if necessary.*

The release of transparent TxD was discussed for several meetings. In RAN4#97-e meeting, the transparent TxD was discussed under TEI16 as documented in [R4-2016959] and a WF [R4-2016830] was also agreed. The agreements are still limited:

* *Declaration for Default TX Connector*
* *MPR for Transparent and UL MIMO*

There are still divided views and some new options were also discussed. The main points including:

* New EVM definition for transparent TxD
* UE behavior on keeping the tx diversity under conformance testing
* UE behaviour for power splitting
* Signaling for Transparent TxD
* Applicability of TxD procedure & requirements
* Necessity of CDD related requirement

In addition, there is a long standing RAN5 LS in [R4-1916132] that have not been replied. One draft reply was prepared in [R4-2015321] but was not discussed.

In RAN4#95-e, the Power class & UL-MIMO related topic were discussed and documented in [R4-2008935], a WF [R4-2008408] was noted since no conclusion could be reached. In RAN#88-e, the power class issue was discussed and an conclusion have been made [RP-201392] for Rel-16 power class clarification. In RAN4#96-e meeting, the TxD and Power class issues were separated, and power class related topic was officially suspended for one meeting to prioritize Rel-16 WIs. However, still a few papers were submitted as in [R4-2011860] and an LS [R4-2011903] and draft CR [R4-2011770] to reflect what have been achieved in RAN#88-e.

In RAN4#97-e, this discussion was also documented in [R4-2016959] and [R4-2016830].However, still there are some remaining issues apart from TxD, the main topic is:

* RAN4 clarification of NSA NR power class (Rel-15)

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

* 1st round: TBA
  + Further discuss and solve the remaining issues;
* 2nd round: TBA
  + Based on results from 1st round, proceed as much as possible.

# Topic #1: Transparent TxD

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

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| *R4-20xxxxx* | *Company A* | *Proposal 1:*  *Observation 1:* |
| [**R4-2100095**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_98_e/Docs/R4-2100095.zip) | Anritsu corporation | *Observation 1: There is a possibility that the UE switches its TxD status while ramping up/down its output power level for relative power control tolerance test.*  *Observation 2: For FR1 RF test system, to achieve the measurement with TxD feature regardless with the TxD status, there is a need to carry out measurements twice in series by switching measurement paths of two antenna connectors.*  *Proposal 1: Allow a flexibility in the FR1 RF test system to carry out measurement twice in series to achieve the measurements with TxD feature.*  *Observation 3: Option 2 is acceptable on condition that a repeatability of TxD activation/deactivation timing in a UE is maintained.*  *Proposal 2: Agree with option 1b or 2 depending on the repeatability of TxD activation/deactivation timing in a UE.*  *Observation 4: A necessity of a signalling for transparent TxD depends on how we define requirements and measurement procedures for the UE with TxD feature.*  *Proposal 3: In a case the signalling is necessary, our preference is Option 2.*  *Proposal 4: It is suggested for the signalling to report not only the capability but also the TxD on/off status. Also another test command to control TxD on/off status is required.* |
| [**R4-2100523**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_98_e/Docs/R4-2100523.zip) | Apple Inc. | Observation 1: Currently three options are available to solve the challenges with TxD (modifiedMPRbehavior bits, new capability signalling, new power class). Due to the drawbacks of the first two solutions only a new power class seems to be a promising candidate which also could lead to a release independent solution.  Proposal 1: Further discuss the introduction of a new power class.  Proposal 2: Relaxations for TxD should be defined by measurements. Corresponding test requirements should be adjusted so that TxD is properly handled with all the given impairments. Those additional relaxations should not change already agreed PC2 MPR but should be gated behind a certain signalling.  **Proposal 3:** Postpone introduction of dual Tx 23dBm power class in NR-U until TxD framework is completed. |
| [**R4-2100592**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_98_e/Docs/R4-2100592.zip) | Qualcomm Incorporated | **Observation 1:** UE with Tx Diversity from RAN4 specification viewpoint is new kind of UE  **Observation 2:** A set up that uses high isolation channels suppresses the reverse IMD mechanism for UEs that use Tx diversity.  **Observation 3:** Retain the power weighted EVM construct of [4] for UEs with Tx diversity:    **Observation 4:** LDD or CDD has no impact on the result of UE’s tested performance in RAN4 context for Tx diversity  **Proposal 1:**  Define a new per band capability to declare if UE implements Tx diversity |
| R4-2100593 | Qualcomm Incorporated | withdrawn |
| [**R4-2100914**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_98_e/Docs/R4-2100914.zip) | Samsung | **Observation 1: The time-domain CDD-based operation for transparent TxD can represented by the frequency domain filtering . By adopting CDD parameters as**  **and** , **and assuming equal power splitting , which varies over subcarriers.**  **Observation 2: The frequency-domain filtering modeling () used to derive per-port EVM () is general enough to cover CDD-based transparent TxD.**  **Observation 3: The antenna port EVM () is general for all kinds of receivers used for CDD-based transparent TxD.**  **Observation 4: The port effectively observed in receiver side is smaller than per-connector observed and .**  **Observation 5: No MMSE receiver is needed to be implemented in TE for TX antenna port EVM.**  **Observation 6: The two EVM definitions for transparent TxD are compared as below:**    **Proposal-1: RAN4 adopt TX antenna port EVM definition**  **Proposal 2: Per instructed by the signaling to enable test mode, UE should keep its Tx diversity status unchanged during the conformance tests, in terms of**   * **(1) TX diversity mode, such as 1TX or 2TX;** * **(2) If 2TX diversity mode is applicable, equal power splitting can be locked.**   **Observation 7: The performance of CDD scheme at least depends on factors including: the choice of cyclic delay difference ∆m (correspondingly obtainable TX diversity), the impact of practical channel estimation at gNB, the channel correlation and the delay profile over two TX antennas.**  **Observation 8: Even the following requirements are specified, CDD-based scheme can still not guarantee better performance than 1TX scheme baseline:**  **- Minimum allocation bandwidth of contiguous PRB for transparent TxD;**  **- Upper and lower bound of the sum of TAE+CDD for transparent TxD;**  **- Minimum number of Rx antenna.**  **Proposal 3: CDD-related requirement shall not be introduced** |
| [**R4-2101108**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_98_e/Docs/R4-2101108.zip) | Xiaomi | **Proposal 1: Option 1b is preferable for UE behavior under conformance testing.**  **Proposal 2: it is proposed to choose option 1a as UE behavior for power splitting.**  **Proposal 3: it is proposed to choose option 1a for the issue on Signaling for Transparent TxD** |
| [**R4-2101289**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_98_e/Docs/R4-2101289.zip) | Intel Corporation | **Proposal 1: Take as specified EVM for transparent TxD.**  **Proposal 2: UE under test should keep tx diversity status unchanged in conformance test (option 1a), if signalling is needed for some UEs to perform transparent TxD (option 1b), such signalling should be optional. Regardless option 1a and 1b, TE should detect and sum for every power step and change in condition from all connectors (Option 2).**  **Proposal 3: Define equal power split between Tx connectors.**  **Proposal 4: Both Option 1a and 1b can be used.**  **Proposal 5: For better clarity, the transparent TxD specific requirements and test procedure should be differentiated with general case.**  **Proposal 6: The requirements of TAE+CDD on transparent TxD should be specified in order to have performance guaranteed.**  **Proposal 7: Simulation assumption should be specified for simulation campaign as Table 1:** |
| [**R4-2101721**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_98_e/Docs/R4-2101721.zip) | Ericsson | **Proposal 1: in the absence of a TE reference receiver, the max(EVM1,EVM2) < EVMreq should be used for the two antenna connectors with EVMreq the EVM minimum requirement.**  **Proposal 2: RAN4 should not set any requirements on the (transparent) S-CDD, consult with RAN1 on the issue of S-CDD and signal cancellation.** |
| [**R4-2101751**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_98_e/Docs/R4-2101751.zip) | OPPO | **2.1 Declaration for Default TX Connector and UE Behaviour under Conformance Testing**  ***Observation 1: UE is not expected to change transmit antennas during conduct tests, and declaration based antenna selection method is applicable.***  ***Proposal 1: It is proposed to assume UE connector under test is unchanged and either UE declaration based method or test mode based method can be used.***  ***Proposal 2: Inform RAN5 about the information above and it is up to RAN5 decide whether UE declaration based method or test mode based method can be used in conformance testing.***  **2.2 Power splitting**  ***Observation 2: No such issue has been brought up in UL MIMO and same principle can be used for TxD.***  ***Observation 3: This issue shall be distinguished as two aspects, one is for requirement definition, and the other is for UE implementation.***  ***Observation 4: Even power is equally split between logical antenna ports, the ILs are most likely different considering the different antenna locations which leads to the conduct power different.***  ***Proposal 3: It is proposed to keep flexibility of UE implementation and allow any power split between connectors but requirements are defined under the assumption that power is equally split.***  **2.3 Signaling for Transparent TxD**  ***Observation 5: It is not clear the intention of introducing TxD signaling and the only possible reason is to make the TxD be aware to TE during testing.***  ***Observation 6: UE declaration method can be used to apply corresponding TxD requirements and no signaling is needed.***  ***Proposal 4: It is proposed to not introducing signaling for TxD and UE declaration can be used for conformance testing.***  ***Proposal 5: It is proposed to focus on TxD requirements definition and further discuss the test specific issues afterwards in maintenance manner.*** |
| [**R4-2101850**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_98_e/Docs/R4-2101850.zip) | ZTE Wistron Telecom AB | **Observation 1: If introducing transparent TxD testing for EVM, combining multiple signal copies should be clearly defined in the specs.**  **Observation 2: A more general Option 2a can be revised as**  **Observation 3: Option 1/Option 2a/Option 2b correspond to an EGC, equal gain LMMSE and selective combination respectively.**  **Observation 4: Of all three options, Option 1 has the lowest SNR, which means that EVM requirement is effectively relaxed if taking Option 2a or 2b compared with Option 1.**  **Proposal: Keep as it is agreed on EVM for transparent TxD, i.e., Option 1.** |
| [**R4-2102089**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_98_e/Docs/R4-2102089.zip) | Rohde & Schwarz | **Observation 1:** Annex F of TS 38.101-1 and Annex E of TS 38.521-1 must be updated to accommodate the UL MIMO EVM measurements.  **Proposal 1:** The EVM requirements in chapter 6.4 of TS 38.101-1 shall be changed to a per layer requirement together with the necessary updates to the Annexes.  **Proposal 2:** RAN4 agrees to define a zero-forcing receiver for the purpose of measuring UL MIMO EVM.  **Proposal 3:** The same receiver architecture shall be used for FR1 and FR2.  **Proposal 4:** Once the definition of the zero-forcing MIMO receiver is complete, the Tx diversity EVM definition shall be updated to also use the MIMO receiver. In the meantime either Option 1 or 2b is used. |
| [**R4-2102383**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_98_e/Docs/R4-2102383.zip) | Huawei, HiSilicon | ***Observation 1: Requirements for ULFPTx can be used as a reference to define the TxD related requirements.***  ***Observation 2: Main TxD requirements are power/emissions related ones as well as MPR and EVM.***  ***Observation 3: According to ULFPTx, there is no difference of PC3 MPR requirement for 1Tx or 2Tx***  ***Observation 4: The so called transparent TxD requirements should be defined for UE supporting 2Tx rather than for UE operateing in TxD mode.***  ***Proposal 1: It is proposed to focus on the affected requirements and corresponding spec changes list in the table below and close the TEI topic ASAP:***  ***Proposal 2: It is proposed to make decision on the test related issues list in the table below:***   |  |  | | --- | --- | | **Items** | **Proposed measurement procedure or UE behavior** | | UE behavior under conformance testing | No need to keep TxD status unchanged all the time during the test and test mode is not necessary. | | Power splitting behavior | Split the power equally between connectors during the test but no need to limit the UE behavior like that in real application. | |
| [**R4-2102704**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_98_e/Docs/R4-2102704.zip) | vivo | **Proposal 1**: Keep the already agreed EVM definition since it can also work and testable and no new consensus can be foreseen.  **Observation 1**: Even with possible signalling, UE transparent TxD behaviour cannot be controlled by the network. It is only possible to indicate to the network/TE if signalling is introduced.  **Observation 2:** It iswidely recognised that the testability and requirements applicability is questionable for option 2, though option 1a/b also have drawbacks.  **Proposal 2**: Confirm “*UE will keep the tx diversity status unchanged in conformance testing.*” Based on basic testability consideration. Whether test mode is used or not can be FFS.  **Proposal 3**: Allow any power split between connectors.(option 2)  **Observation 3**: The main intention for new signalling/power class is for network to consider this TxD structure information.  **Observation 4**: Signalling reporting seems to be more dynamic and reflecting current statue, while power class is more a static structure.  **Proposal 4:** If UE TxD status is proved needed by the network, signalling may be more preferable compared to new power class.  **Proposal 5**: Not to define CDD related requirement, at least for Rel-16.  **Proposal 6**: Reply RAN5’s LS. |
| [**R4-2102917**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_98_e/Docs/R4-2102917.zip) | Lenovo, Motorola Mobility | **Proposal 1a:** The EVM requirement is applied to the **antenna port**. The antenna port EVM **is defined** as the output of an unbiased linear MMSE receiver for which the EVM is given by  where  and is defined in Figure 1**.**  **Proposal 1b:** If the test equipment cannot measure the covariance of transmitter noise , then is defined as  *If there is a desire to follow the precedence of using a zero-forcing receiver to define EVM* as is the case for single antenna transmission, then the port EVM for transmit diversity should be measured in accordance with Proposal 2a or 2b.  **Proposal 2a:** The EVM requirement is applied to the **antenna port**. The antenna port EVM **is defined** as the output of a zero-forcing receiver and which the EVM can be upper bounded by  Where and denote the measured power on the first and second transmit antennas, and denotes the correlation coefficient defined as .  **Proposal 2a:** If the test equipment cannot measure the correlation coefficient , then is defined as |

## Open issues summary

*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: Transparent TxD Testing issues

*Sub-topic description:*

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

**Issue 1-1-1: EVM for Transparent TxD**

* Proposals
  + Option 1: As in agreed WF R4-2008465
  + Option 2: As has been provided in R4-2016288:

The EVM requirement is applied to the **antenna port**. The antenna port EVM **is defined** as the output of an unbiased linear MMSE receiver for which the EVM is given by

where is given by

and

Alternatively, the EVM can be calculated as

where

If the test equipment cannot measure the covariance of transmitter noise at the two antenna connectors, then is measured as

* + Option 3:

The EVM requirement is applied to the **antenna port**. The antenna port EVM **is defined** as the output of a zero-forcing receiver and which the EVM can be upper bounded by

Where and denote the measured power on the first and second transmit antennas, and denotes the correlation coefficient defined as .

Alternatively, if the test equipment cannot measure the correlation coefficient , then is defined as

* Recommended WF
  + Option 1
    - Keep previous agreement since no new agreement can be reached.

**Issue 1-1-2: UE behaviour under conformance testing**

* Background: Motivation is to guide how to test requirements that require power changes such as relative power control
* Proposals:
  + Option 1a: UE will keep the tx diversity status unchanged in conformance testing.
  + Option 1b: Test mode signalling is implemented to instruct UE to keep TX div status unchanged
  + Option 2a: TE will detect and sum for every power step and change in condition from **declared** connector, with no precondition
  + Option 2b: TE will detect and sum for every power step and change in condition from **declared** connector, based on pre-condition that a repeatability of TxD activation/deactivation timing in a UE is maintained can be fulfilled.
* Recommended WF
  + TBA

**Issue 1-1-3: Power splitting behaviour**

* Background: Motivation is to guide how to test requirements that require power changes such as relative power control
  + **Question 1:** What would be the impact for the requirements and testability with tentative equal power split restriction?
* Proposals:
  + Option 1: Only allow equal power split between connectors
  + Excludes 17+17+20 dBm implementations
  + Excludes power control optimizations
  + Option 1a: Per instructed as test mode, UE should keep equal power split between connectors in all cases.
  + Option 2: Allow any power split between connectors
    - Question: Is power split ratio allowed to be changed during test?
* Recommended WF
  + TBA

### Sub-topic 1-2: Signaling and others

*Sub-topic description*

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

**Issue 1-2-1: Applicability of Transparent TxD Requirement**

**The applicability of the newly introduced test procedure (if any) and specific requirement (if any) for transparent TxD UE :**

**• whether or not applicable to UE implementation without transparent TxD**

* Proposals
  + Option 1: Not applicable
  + Option 2: Applicable
* Recommended WF
  + Option 1

**Issue 1-2-2: Whether and how a UE implementation use transparent TxD should be signalled.**

* Proposals
  + Option 1: Introduce some sort of signaling by UE
    - Option 1a. Use ModifiedMPRbehavior bits to signal additional relaxations;
    - Option 1b: Introducing a new (capability) signalling for TxD
      * Capability reporting for supporting TxD
      * [Capability reporting for TxD Enable/Disable status]
    - Option 1c: Introducing a new power class (e.g. PC2.5) for TxD
  + Option 2: Based on UE vendor declaration.
  + Option 3: Using existing signalling to indicate the 2Tx implementation capability.
* Recommended WF
  + TBA

**Issue 1-2-3: Whether (and how) CDD related requirements, e.g. TAE+CDD, is need to be specified for transparent TxD UE.**

* Proposals
  + Option 1: Yes
  + Option 2: No.
  + Option 2b. No at least for Rel-16
* Recommended WF
  + TBA.

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| XXX | Sub topic 1-1:  Sub topic 1-2:  ….  Others: |
| Anritsu | Issue 1-1-2: We appreciate moderator for capturing new option (opt 2b) as an additional proposal.  Before deciding the policy with the UE behaviour, it is appreciated if we can hear a view from OEMs on whether the repeatability of TxD activation / deactivation timing can be maintained.  Issue 1-1-3: As for the question at Option 2, from test procedure point of view, we think it is similar to the issue 1-1-2. It is acceptable that power split ratio changes during test as far as the repeatability is maintained. (timing or threshold power level to change the ratio need to be same during the test.) |
| Xiaomi | **Issue 1-1-1: EVM for Transparent TxD**  Slightly prefer option 1. For the progress of the issue, is also acceptable for us.  **Issue 1-1-2: UE behaviour under conformance testing**  Option 1a or 1b  **Issue 1-1-3: Power splitting behaviour**  No strong view on this proposal. But if equal splitting can simplify the test during testing, we prefer option 1 or 1a  **Issue 1-2-1: Applicability of Transparent TxD Requirement**  Option 1  **Issue 1-2-2: Whether and how a UE implementation use transparent TxD should be signalled.**  Option 1a. From regulatory requirements point of view, there are no need to define different requirements, except MPR(A-MPR) requirements which may need additional relaxations due to additional IMD emissions for Tx diversity. Thus, the simplest solution is option 1a that Using ModifiedMPRbehavior bits to signal additional relaxations. |
| ZTE | **Issue 1-1-1 EVM for Transparent TxD**  We prefer to Option 1. As we analyzed in our contribution, of all the three options on the table, Option 1 has the lowest SNR. If we take Option 2 or 3, the final EVM requirement is relaxed equivalently.  **Issue 1-1-2: UE behaviour under conformance testing**  Option 1a. Exact meaning of "Tx diversity status" may need to be clarified, e.g., active antenna connectors where UL transmission is performed, and power ratio among these antenna connectors?  **Issue 1-1-3: Power splitting behaviour**  Option 1 and Option 1a. If we allow any power split between connectors, the performance gain from transparent TxD may not be stable/guaranteed, besides the corresponding requirement on power change in one branch even if keeping the same total power.  **Issue 1-2-1: Applicability of Transparent TxD Requirement**  Option 1.  **Issue 1-2-2: Whether and how a UE implementation use transparent TxD should be signaled**  Option 1a or Option 3. Any UE with 2Tx implementation capability may operate in transparent TxD mode by default.  **Issue 1-2-3: Whehter (and how) CDD related requirements, e.g., TAE+CDD, is need to be specified for transparent TxD UE**  Option 1. |
| Ericsson | **Issue 1-1-1 EVM for Transparent TxD**  We can accept Option 3 as a compromise, even if it implies a less stringent requirements than the corresponding DL EVM requirements for a BS with antenna connectors. The background of Option 3 is well known, and the existing single connector requirement is indeed based on ZF equalization. If a ZF receiver is implemented for UL-MIMO, it is recognised that this could also be used for TxD (and the resulting noise covariance estimate).  **Issue 1-1-2: UE behaviour under conformance testing**  The tests should represent performance in the field. Option 2a appears attractive at a first glance, it appears less sensitive to the TxD state/status.  What is the impact on relative power control performance with correlated inputs on the two connectors, possibly with transparent CDD applied the performance of which also depends on the allocation size and frequency location within the carrier?  **Issue 1-1-3: Power splitting behaviour**  Is there any possibility other than Option 2 for ‘transparent’ TxD?  We note that there is a similarity to verification of e.g. FP Mode 1 that achieves full power by antenna virtualization.  **Issue 1-2-1: Applicability of Transparent TxD Requirement**  May depends on the test method chosen, e.g. if per-connector measurements are used. The test procedure a RAN5 expert area.  **Issue 1-2-2: Whether and how a UE implementation use transparent TxD should be signalled**  Option 1b or 1c. The power class could be used for PHR and PC, a similar concept already introduced with the specification of PC1.5.  **Issue 1-2-3: Whehter (and how) CDD related requirements, e.g., TAE+CDD, is need to be specified for transparent TxD UE**  Probably Option 2. If requirements are specified, then RAN1 should be involved.  TxD is already part of FP operation. The main concerns with TxD is signal cancellation and variability of actual power capability in the field with e.g. RB allocation and size. S-CDD less effective for smaller allocation sizes. There is also a potential impact on uplink CSI estimation. |
| LGE | **Issue 1-1-1 EVM for Transparent TxD**  We prefer to Option 1 as previous agreements  **Issue 1-1-2: UE behaviour under conformance testing**  Prefer option 1b for test mode  **Issue 1-1-3: Power splitting behaviour**  The equal power splitting is baseline for Tx diversity operation. So prefer option 1 or 1a  **Issue 1-2-1: Applicability of Transparent TxD Requirement**  Agree with Ericsson, the applicability issue can be discussed to in RAN5.  **Issue 1-2-2: Whether and how a UE implementation use transparent TxD should be signalled.**  Prefer option 1a (ModifiedMPRbehavior bits) and option 3 (existing signalling)  **Issue 1-2-3: Whether (and how) CDD related requirements, e.g. TAE+CDD, is need to be specified for transparent TxD UE.**  Prefer Option 2b. No at least for Rel-16 |
| Rohde & Schwarz | **Issue 1-1-1 EVM for Transparent TxD**  We are ok with the moderators proposal. This could be revisited once the receiver architecture for UL MIMO has been finalized. As we discuss in the thread [102] we need more time to check the details described there.  **Issue 1-1-2 & Issue 1-1-3:** We have a similar view here as Anritsu. |
| Huawei, HiSilicon | **Issue 1-1-1 EVM for Transparent TxD**  Preference is option 1. ZF receiver is not necessary to be used for TxD and this no clear definition of applicability of the requirement to antenna port.  **Issue 1-1-2: UE behaviour under conformance testing**  Option 2a. The measurement should reflect the real use scenario. Testing mode cannot fulfil this purpose and the additional development burden is unnecessary.  **Issue 1-1-3: Power splitting behaviour**  Option 2. The power splitting depends on the UE implementation.  **Issue 1-2-1: Applicability of Transparent TxD Requirement**  It seems we may not exclude option 2. For the UE supporting TxD, we can define a set of TxD requirements. But it doesn't mean that the UE always work on the TxD mode. Applicability of TxD requirement should also cover this scenario, and it also depends on the measurement procedure.  **Issue 1-2-2: Whether and how a UE implementation use transparent TxD should be signalled**  Based on GTW discussion, option 1b is selected.  **Issue 1-2-3: Whehter (and how) CDD related requirements, e.g., TAE+CDD, is need to be specified for transparent TxD UE**  Option 2. CDD delay is determined by UE implementation. If the value is specifically specified, we don't think this can still be considered as transparent TxD. |
| Qualcomm | Issue 1-1-1: **EVM for Transparent TxD**  Option 1 (due to other options not being perfect either)  Option 2 type solutions that rely on output combining are not bad, but they bring in their own set of unresolved issues:   1. UEs that use multiple Tx chains for diversity have a major disadvantage, reverse IMDs, compared to single PA UEs. The combining method ignores this problem, and so is optimistic for TxD UEs, but not optimistic for single PA UEs. This inconsistency can be very misleading about the actual OTA EVM of the two device types. A method that combines multiple outputs (for example MRC ZF) must also use a channel that has realistic coupling between the PAs, not high isolation wired channels like in current RAN4 test methodology. (see R4-2100592). 2. There may be further technical problems to resolve with LMMSE combining techniques. Workarounds for invertibility problems in LMMSE based equalizers are based on numerical precision, therefore not practical (example: what is the threshold of condition number when the TE transitions to workaround method from main method?)   In conclusion, the EVM calculated by a combining method is no more relevant than power weighted EVM because each method ignores some aspect or another.  Min() and max() formulas are not suitable because UEs can have any power split, and there are IMD related impairments at the top of the range (min() is not fair) and noise limited impairments at the bottom of the range (max() is not fair).  Option 3 is FFS, we would need more time to evaluate.  **Issue 1-1-2: UE behaviour under conformance testing**  Option 2b  **Issue 1-1-3: Power splitting behaviour**  Option 2. There should be no restriction on UE behavior regarding repeatability of power split.  **Issue 1-2-1:** Test procedure should be separate. Option 1  Issue 1-2-2: Dedicated signalling, option 1b  Issue 1-2-3: No need to specify CDD etc if testing is done per connector. Option 2. |
| OPPO | **Issue 1-1-2: UE behaviour under conformance testing**  For static test cases, Opton 1a/1b is enough, but for cases like relative power control the Option 2a or 2b are ok and all these should be decided by RAN5 not RAN4.  **Issue 1-1-3: Power splitting behaviour**  Option 2, same as UL MIMO. This is implementation issue.  **Issue 1-2-1: Applicability of Transparent TxD Requirement**  Option 1.  **Issue 1-2-3: Whether (and how) CDD related requirements, e.g. TAE+CDD, is need to be specified for transparent TxD UE.**  Option 2. |
| Samsung | Issue 1-1-1: EVM for Transparent TxD  Still prefer Opiton-2 (by restricting equal power allocation between two TX during test).  Actually we agree with QC’s observation that if EVM test method with isolated 2 cables between the UE and TE to enable testing, the testing will ignore the coupling between two TX antennas, which somehow give favor to TxD (but nothing to traditional 1TX scheme). However the method used for option-1 also can’t capture the coupling btw two TX, and I don’t believe by just applying isolated wire in EVM, any method can consider this coupling during EVM testing.  For Option-3: although to have inverted H is an easier method to derived the equivalent noise after combiner’s filtering, but it seems not valid because the ZF combiner used R4-2102917 require “per antenna reference symbols are transmitted so that H can be estimated”, and it is questionable because in real practice, gNB can’t estimate only H because the CDD-based Tx diversity will introduce phase-shifting (as analyzed in our paper R4-2100914) which can’t be restored by gNB (i.e., TxD operation is after inserting RS). If that is the case, the following equation has problem:  In the above equation, is a 2x1 vector, and my understanding is pseudo-inversion of is needed, so the RX filtering should be . So, we need more time to think under this condition, can equivalent noise level is independent of the channel matrix H or not.  Issue 1-1-2: UE behaviour under conformance testing  Prefer Option 1b for test mode. For Option 2b newly added by Moderator, we are okay with the principle, but the problem is how UE vendor can guarantee “pre-condition that a repeatability of TxD activation/deactivation timing in a UE is maintained can be fulfilled”, if there is no test mode signaling. Seems the intention is to ask OEM to have debug command (?), which is not preferred by us.  Issue 1-1-3: Power splitting behavior  Option 1 or 1a.  Issue 1-2-1: Applicability of Transparent TxD Requirement  Agree with Moderator suggested WF for Option 1  Issue 1-2-3: Whether (and how) CDD related requirements, e.g. TAE+CDD, is need to be specified for transparent TxD UE  Option 2 or 2b. |
| Lenovo, Motorola Mobility | Issue 1-1-1: EVM for Transparent TxD  Our current preference is to use the zero-forcing equalizer in Option 3 to have consistency with single antenna transmission and uplink MIMO.  If there is a desire to avoid combining gain to compensate for the reverse IMD’s not addressed by conductive testing, then the transmitter noise can be assumed to be completely correlated as this eliminates the combining gain. In this case, the EVM for the zero-forcing receiver is given by  and this can be computed by the test equipment without implementation of the zero-forcing receiver. As mentioned in our paper (and by Samsung above), the channel H cannot be estimated without the transmission of per antenna reference symbols, which is not expected. However, the signal-to-noise ratio for the receiver and the corresponding EVM can be computed by the test equipment. Furthermore, it is straightforward that the receiver can achieve an EVM at least as good as the zero-forcing receiver by using the unbiased linear MMSE for which the EVM with fully correlated noise is given by and for which per antenna reference symbols are not required (the min is always less than the average above) |
| Nokia | **Issue 1-1-3: Power splitting behaviour**  Before discussing this, it would be better to how to test relevant requirements like relative power tolerance. The test decision is made per antenna port and both ports shall pass the criteria or the sum of the power of each antenna ports should pass the criteria? Do we happen to have a clear agreement on this? |
| Skyworks | Issue 1-1-1: **EVM for Transparent TxD**  Given that test with two connectors eliminates the antenna coupling and thus eliminates the non-linear part of the EVM from the measurement that can’t be eliminated at the base-station, we believe it is safe to use an EVM definition that is conservative.  **Issue 1-1-2: UE behaviour under conformance testing**  We prefer option 1a but also we would like to understand how some of the other options can be implemented given:  Non equal power split, tolerances on power steps. We believe that the safest way is to keep the status unchanged for at least the dynamic range used for MPR.  **Issue 1-1-3: Power splitting behaviour**  MPR has been derived based on equal power splitting (some tolerance is acceptable as long at the sum is within the power class tolerance). Moreover for the MPR to be valid the backoff should be applied to both side equaly  Issue 1-2-2: Dedicated signalling, prefer option 1c as it can apply more widely and is consistent with PC1.5. please note that PC2 Ul CA is now also discussed using 2xPC3 PAs. Separate power class or power class is cleaner and can have a dedicated MPR/AMPR |
| Apple | **Issue 1-2-1 Applicability of Transparent TxD Requirements**  Option 1: UEs without TxD should not be required to be tested with newly introduced procedure for TxD  **Issue 1-2-2 Whether and how a UE implementation use transparent TxD should be signalled**  With option 1b being agreed during GTW, next some open question should be discussed.  The way of implementing TxD (e.g. switching TxD or always on TxD) has different impact on the network. Switching TxD (where TxD is off in lower power region and active in high power region) has a certain transient behavior, causing power disruption when one of the Tx chains is switched on or off. Even if the UE can estimate power changes well enough (meaning the sum of UE output power) it has no knowledge about the phase relation of the two Tx streams at BS antenna, potentially causing large power differences due to inphase or canceling effects. This effect of power disruption at BS antenna on power control loop needs to be considered and analyzed for TxD on/off switching.  Further situations to ponder are PHR reporting in scenarios where both Tx streams are in strong cancelation to each other (especially found in LOS scenario, CDD can help with decorrelation but has its limits). The UE might report sufficient PHR and receives commands from the network to raise the output power. Due to potential signal cancelation at the BS antennas, the power increase can be far lower than expected by the BS. How does this affect the network and power control loop?  **Issue 1-2-3 Whether (and how) CDD related requirements, e.g. TAE+CDD, is needed to be specified for transparent TxD UE**  Option 1 (please see concerns in Issue 1-2-2) |

### CRs/TPs comments collection

*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** |
| R4-2100594  R4-2100595  Introduction of Tx diversity in tor 38101-1 | Company A |
| Company B |
|  |
| [**R4-2102384**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_98_e/Docs/R4-2102384.zip)  R4-2102683  CR for TS 38.101-1 Tx diversity requirements | Anritsu: Not sure if we can assume the TxD feature as “transparent” if we apply different requirements depending on the TxD status. |
| Ericsson: not agreed. CRs should be treated once RAN4 has made decisions on requirements and test cases for TxD. |
| Qualcomm: This change does not accommodate UE with 2 port but no TxD. Also, the capability indication is not here. We would prefer to wait until we have agreements before drafint CRs |
|  | Company A |
| Company B |
|  |

## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

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| --- | --- |
|  | **Status summary** |
| **Sub-topic#1** | *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:* |

*Recommendations on WF/LS assignment*

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|  | **WF/LS t-doc Title** | **Assigned Company,**  **WF or LS lead** |
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### CRs/TPs

*Moderator tries to summarize discussion status for 1st round and provides recommendation on CRs/TPs Status update*

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| **CR/TP number** | **CRs/TPs Status update recommendation** |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

## Discussion on 2nd round (if applicable)

## Summary on 2nd round (if applicable)

*Moderator tries to summarize discussion status for 2nd round and provided recommendation on CRs/TPs/WFs/LSs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP/LS/WF number** | **T-doc Status update recommendation** |
| XXX | *Based on 2nd round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

# Topic #2: Power Class related req.

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

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| *R4-20xxxxx* | *Company A* | *Proposal 1:*  *Observation 1:* |
| [**R4-2102385**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_98_e/Docs/R4-2102385.zip) | Huawei, HiSilicon | ***Observation 3: 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****, either the value is determined by UE declaration during the measurement or to use the lower possible power class to decide the lower bound of the configured power.***  **Draft reply LS is provided as below for approval.** |
| [**R4-2102705**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_98_e/Docs/R4-2102705.zip) | vivo | **Observation 1**: For SA power class fall back to single antenna port, current wording for Rel-15 basically kept the same and no further clarification is provided.  **Proposal 1**: Discuss an explanation on the current wording “the requirements in clause 6.2.1 apply” for power class fall back for SA UL-MIMO in Rel-15.  **Proposal 2**: For NSA NR power class, chose option 5 or option 1 as previous suggested.  **Proposal 3**: If consensus cannot be reached, it may not necessary to combine TxD applicable release with this NSA power class fallback . |
|  |  |  |

## Open issues summary

*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

*Sub-topic description:*

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

**Issue 2-1-1: Whether and how Rel-15 NSA power class should be revised.**

* Proposals
  + Option 1: The Pcmax for NR is modified according to the declared NR power capability for NSA so that the PHR becomes correct. (Based on R4-2015976 & R4-2015977)
  + Option 2: Introduce the Rel-16 defined power class UE capability for Rel-15, and Indication of UE implementation by declaration. (Based on R4-2016479 observation 1)
  + Option 3: The Pcmax for NR is modified to use the lower possible power class to decide the lower bound of the configured power. (Based on R4-2016479 observation 3 & R4-2016482, & R4-2102385)
  + Option 4: Any other combined/refined revision.
  + Option 5: Further revision not needed.
* Recommended WF
  + TBA

**Issue 2-1-2: Whether applicability of TxD for Rel-15 would impact the previous Issue for NSA.**

* Proposals
  + Option 1:Yes;
  + Option 2: No.
* Recommended WF
  + TBA

**Issue 2-1-3: Confirm an explanation on the current wording for power class fall back for SA UL-MIMO in Rel-15.**

Background & motivation:

Rel-15: *“If UE is scheduled for single antenna-port PUSCH transmission by DCI format 0\_0 or by DCI format 0\_1 for single antenna port codebook based transmission, the requirements in clause 6.2.1 apply.”*

Rel-16: *“If UE is scheduled for single antenna-port PUSCH transmission by DCI format 0\_0 or by DCI format 0\_1 for single antenna port codebook based transmission, the requirements in clause 6.2.1 apply for the power class as indicated by the ue-PowerClass field in capability signalling.”*

* Proposals
  + Option 1: Rel-15 is the same to Rel-16;
  + Option 2: Rel-15 can still have different explanation compared to Rel-16.
* Recommended WF
  + TBA

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| XXX | Sub topic 2-1:  Sub topic 2-2:  ….  Others: |
| ZTE | **Issue 2-1-1 Whether and how Rel-15 NSA power class should be revised**  Option 1 preferred.  **Issue 2-1-2: Whether applicability of TxD for Rel-15 would impact the previous Issue for NSA**  No  **Issue 2-1-3: Confirm an explanation on the current wording for power class fall back for SA UL-MIMO in Rel-15**  Option 2 as there may be legacy Rel-15 UEs with different interpretations. |
| Ericsson | **Issue 2-1-1: Whether and how Rel-15 NSA power class should be revised**  Option 1, then the PHR would be correct. It can also be verified that Pcmax,c and PHR are reported correctly according to a declared NR power capability for NSA.  **Issue 2-1-2: Whether applicability of TxD for Rel-15 would impact the previous Issue for NSA**  Option 1: yes, the discussion on the NSA power ambiguity pertained to UEs advertising a higher power class by means of two-layer transmissions. For transparent TxD the same indication would be applicable with a single layer, the actual power capability to be determined by the Rel-16 work on TxD.  **Issue 2-1-3: Confirm an explanation on the current wording for power class fall back for SA UL-MIMO in Rel-15**  Option 1 according to the current version of the 38.101-1. The UE output power is specified at the antenna, the UE NR power class shall be as indicated by the *ue-PowerClass,* the same for Rel-15. |
| Huawei, HiSilicon | **Issue 2-1-1: Whether and how Rel-15 NSA power class should be revised**  Option 3 is preferred. UE declaration is not visible for the network, the purpose is to correct the Pcmax to facilitate the measurement of the output power. And even without the changes for Pcmax, in our view the measurement issue can also be addressed by RAN5 with UE declaration.  **Issue 2-1-2: Whether applicability of TxD for Rel-15 would impact the previous Issue for NSA**  Option 1: No. Supporting TxD is not directly relevant to the issue identified originally. As the assumption of UE implementation is 2Tx. In that sense, still the power class for the NR part could be lower than the reported SA power class.  **Issue 2-1-3: Confirm an explanation on the current wording for power class fall back for SA UL-MIMO in Rel-15**  Option 1. For SA, the power class should be the same was already an agreement in RAN4 for Rel-15. |
| Qualcomm | Issue 2-1-1: We should explore this together with the TX diversity declaration and capability. So something needs to be done but not clear what  Issue 2-1-2: Option 1, txd has big impact on this issue.  Issue 2-1-3: Option 2, with the recent agreements in gtw, we should have different wording in rel15 |
| OPPO | **Issue 2-1-1: Whether and how Rel-15 NSA power class should be revised.**  Option 3 since TxD is allowed in Rel-15 based on UE declaration.  **Issue 2-1-2: Whether applicability of TxD for Rel-15 would impact the previous Issue for NSA.**  Option 1. Yes. If TxD is supported, then the power class of UE will be consistent in single and two antenna port and issue solved.  **Issue 2-1-3: Confirm an explanation on the current wording for power class fall back for SA UL-MIMO in Rel-15.**  Option 2. |

### CRs/TPs comments collection

*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.*

|  |  |
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| **CR/TP number** | **Comments collection** |
| [**R4-2015977**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2015977.zip)  (Ericsson) Correction of Pcmax for an NR PC2 UE supporting NR PC3 for EN-DC | Qualcomm: Would like to wait until the txd declaration and capability and requirements are clear before this CR |
| Company B |
|  |
| [**R4-2016482**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2016482.zip)  (Huawei) CR for TS 38.101-3: correction of power class for EN-DC | Qualcomm: Would like to wait until the txd declaration and capability and requirements are clear before this CR |
| Company B |
|  |

## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

|  |  |
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|  | **Status summary** |
| **Sub-topic#1** | *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:* |

*Suggestion on WF/LS assignment*

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|  | **WF/LS t-doc Title** | **Assigned Company,**  **WF or LS lead** |
| #1 |  |  |

### CRs/TPs

*Moderator tries to summarize discussion status for 1st round and provided recommendation on CRs/TPs Status update suggestion*

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| **CR/TP number** | **CRs/TPs Status update recommendation** |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

## Discussion on 2nd round (if applicable)

## Summary on 2nd round (if applicable)

*Moderator tries to summarize discussion status for 2nd round and provided recommendation on CRs/TPs/WFs/LSs Status update suggestion*

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| **CR/TP/LS/WF number** | **T-doc Status update recommendation** |
| XXX | *Based on 2nd round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |