**3GPP TSG-RAN WG4 Meeting # 104-e R4-2214193**

**Electronic Meeting, 15 – 26 Aug. 2022**

**Agenda item:** 9.2.2.3, 9.2.2.4

**Source:** Moderator (OPPO)

**Title:** Email Discussion Summary for [104-e][333] FR1\_TRP\_TRS\_Part2

**Document for:** Information

# Introduction

*Contributions submitted to AI 9.2.2.3 UE with multiple antennas test methodology and AI 9.2.2.4 Test time reduction of FR1 TRP TRS WI are captured in this email discussion. Test strategy and methodology on multiple antennas and test time reduction will be discussed.*

# Topic #1: Test methodology for UE with multi-antenna

*The following multi-antenna techniques will be discussed in this section.*

* *UL Transmit Diversity (considering one layer UL MIMO)*
* *Transmit Antenna Switch*

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2211559 | Huawei Tech.(UK) Co.. Ltd | **Proposal 1**: under test configuration of (a) and (b), if the peak SAR positions change by 2cm or higher, TAS could be deemed to be active.  **Proposal 2**: Either method one or method two could be used to detect TAA on or off status using fast SAR measurement. However, method two is easier to implement. |
| R4-2212375 | Apple | **Proposal 1**: While studies are conducted to guarantee the optimal UE radiated performance at the test environment are done. Evaluate multiple antenna system measuring TRP per antenna under test mode separately and TAS Off.  **Proposal 2**: RAN4 to avoid elaborating a test where dedicated TxD/TAS features algorithms and triggers needs to be declared to labs in order to proper evaluate UE radiated performance.  **Proposal 3**: In case of still pursuing the test with multiple Tx antennas, RAN4 shall propose a comprehensive test campaign to stress different TxD/TAS system implementation correlating results with manufacturers real environment radiated performance expectations and test vendors limitations, such as link antenna placement variations and an optimal TPMI search for each device orientation within the test environment. |
| R4-2213423 | OPPO | **Proposal 1**: The approach of combining the measurement antenna and the link antenna to be one unified antenna in the OTA chamber provides stable measurement results to verify the UE OTA performance with transmit antenna switching function ON. |
| R4-2213424 | OPPO | **Proposal 1**: The topic of test methodology for UE with multi-antenna could include three sub-topics, i.e.   * Test methodology for UE with TxD * Test methodology for UE with TAS ON * Test methodology for UE with one-layer UL MIMO   **Proposal 2**: The test methodology for UE with one-layer UL MIMO can be studied and discussed under another sub-topic/sub-thread separated with TxD.  **Proposal 3**: The test methodology for UE with TxD can be defined firstly for the UEs that support TxD feature and 23+23 PA architecture. |

## Open issues summary

### Sub-topic 1-1: Solution for TAS and TAA detection

* Proposal 1: under test configuration of (a) and (b), if the peak SAR positions change by 2cm or higher, TAS could be deemed to be active.
* Proposal 2: Either method one or method two could be used to detect TAA on or off status using fast SAR measurement. However, method two is easier to implement.
* Recommended WF
  + TBA

### Sub-topic 1-2: Proposals to multi antenna test methodology

**Issue 1-2-1: How to evaluate multiple antenna system on UE?**

* Proposal: While studies are conducted to guarantee the optimal UE radiated performance at the test environment are done. Evaluate multiple antenna system measuring TRP per antenna under test mode separately and TAS Off.
* Recommended WF
  + TBA

**Issue 1-2-2: View on dedicated TxD/TAS features algorithms and triggers**

* Proposal: RAN4 to avoid elaborating a test where dedicated TxD/TAS features algorithms and triggers needs to be declared to labs in order to proper evaluate UE radiated performance.
* Recommended WF
  + TBA

**Issue 1-2-3: Is a test campaign needed to correlate between test methodology and real environment expectations?**

* Proposal: In case of still pursuing the test with multiple Tx antennas, RAN4 shall propose a comprehensive test campaign to stress different TxD/TAS system implementation correlating results with manufacturers real environment radiated performance expectations and test vendors limitations, such as link antenna placement variations and an optimal TPMI search for each device orientation within the test environment.
* Recommended WF
  + TBA

**Issue 1-2-4: Consideration on TxD and one layer UL MIMO**

* Proposal 1: The topic of test methodology for UE with multi-antenna could include three sub-topics, i.e.
  + Test methodology for UE with TxD
  + Test methodology for UE with TAS ON
  + Test methodology for UE with one-layer UL MIMO
* Proposal 2: The test methodology for UE with one-layer UL MIMO can be studied and discussed under another sub-topic/sub-thread separated with TxD.
* Recommended WF
  + TBA

**Issue 1-2-5: Proposal to test methodology for TxD**

* Proposal: The test methodology for UE with TxD can be defined firstly for the UEs that support TxD feature and 23+23 PA architecture.
* Recommended WF
  + TBA

**Issue 1-2-6: Proposal to test methodology for TAS ON**

* Proposal: The approach of combining the measurement antenna and the link antenna to be one unified antenna in the OTA chamber provides stable measurement results to verify the UE OTA performance with transmit antenna switching function ON.
* Recommended WF
  + TBA

## Companies views’ collection for 1st round

### Open issues

**Sub-topic 1-1: Solution for TAS and TAA detection**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Huawei | Support both proposals. However proposal 1 needs to be tested in a lab. |
| R&S | Both proposed methods using Fast SAR measurements look like a reasonable approach for quick confirmation whether TAS or TAA are active in a DUT.  These methods could be included in TR 38.834, but only as informative guidance and thus cannot be part of the TS. |
| Apple | Both methods are based on Near Field Scanning, such equipment or even SAR lab will be required to perform this investigation. Most likely such test equipment might not be available in all test labs. It’s desirable to develop a method to determine TAS off based on the minimum test equipment setup required for all test labs, e.g.: such as radiation pattern benchmark over different device orientations. |
| vivo | As we commented last meeting, SAR and OTA may be different labs in each company, it would increase additional efforts by using SAR system for OTA related verification. Besides, given Fast SAR was not adopted in other OTA SDOs for antenna verification, I would prefer to collect more measurement results to confirm the feasibility of this approach and final “TAS/TAA ON or OFF” criteria. |
| Qualcomm | Share the similar view as Apple and vivo. The test equipment for Fast SAR approach might not be able to apply for all the OTA test labs. In addition, SAR testing is out of 3GPP scope. We would like to leave the details of how to use Fast SAR measurements to lab rather specifying in the 3GPP TR. |
| OPPO | The proposed methods seem workable for verifying TAS and TAA ON/OFF. However, the methods would not be widely used considering not all OTA labs equipped with Fast SAR test box. We support to capture the methods as informative guidance. |
| Samsung | Similar as other already confirmed TAS off verification methods, the proposals here can also be regarded as informative methods without necessary to be captured into TS. |

**Sub-topic 1-2: Proposals to multi antenna test methodology**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Huawei | **Issue 1-2-1: How to evaluate multiple antenna system on UE?**  **Issue 1-2-2: View on dedicated TxD/TAS features algorithms and triggers**  **Issue 1-2-3: Is a test campaign needed to correlate between test methodology and real environment expectations?**  Support the proposal.  **Issue 1-2-4: Consideration on TxD and one layer UL MIMO**  Support the proposal 1 and 2.  **Issue 1-2-5: Proposal to test methodology for TxD**  Support the proposal.  **Issue 1-2-6: Proposal to test methodology for TAS ON**  Support the proposal. |
| R&S | **Issue 1-2-1: How to evaluate multiple antenna system on UE?**  We have mentioned several times that the TAS ON methodology proposed in Issue 1-2-6 by combining link and measurement in the same test antenna, which was originally described in R4-2113986, is feasible and ensures repeatable results among systems. If this test methodology is agreeable, TRP can be tested for the combination of antennas.  **Issue 1-2-2: View on dedicated TxD/TAS features algorithms and triggers**  The proposal seems reasonable, but it somehow conflicts with the proposal in Issue 1-2-1 to test TRP per antenna under test mode, since some declaration and support to the lab would be required.  **Issue 1-2-3: Is a test campaign needed to correlate between test methodology and real environment expectations?**  We don’t think a test campaign is required since the methodology proposed for TAS ON (i.e. combining link and power measurement in the same test antenna) will ensure a consistent environment is used among chambers.  With respect to TPMI, if the usage of TPMI is deemed feasible to ensure stable conditions for TxD, the exact procedure (e.g. testing with several TPMI indexes per test point in the sphere) can be defined based on companies’ contributions. In our understanding, this could be introduced with an allowance to test with single TPMI index (or even no configuration) based on manufacturer declaration in order to speed up testing in cases where TxD is not implemented.  **Issue 1-2-4: Consideration on TxD and one layer UL MIMO**  -  **Issue 1-2-5: Proposal to test methodology for TxD**  -  **Issue 1-2-6: Proposal to test methodology for TAS ON**  We agree to the proposal, and we appreciate the feedback provided in R4-2213423 based on measurements. |
| Apple | **Issue 1-2-1: How to evaluate multiple antenna system on UE?**  As a proponent we support the proposal  **Issue 1-2-2: View on dedicated TxD/TAS features algorithms and triggers**  As a proponent we support the proposal  **Issue 1-2-3: Is a test campaign needed to correlate between test methodology and real environment expectations?**  As a proponent we support the proposal  **Issue 1-2-4: Consideration on TxD and one layer UL MIMO**  We do not support including TAS ON within Proposal 1. As discussed in R4-2212375, UEs can have sophisticated RF front-end and switching algorithms simply enabling TAS without considering case-by-case can have unknown consequences on OTA measurements within different labs.  We can support Proposal 2, this topic needs further study to consider eventual test conditions variations, and determine if different labs with different Tes can correlate results.  In general, developing test methodology for TxD and UL MIMO can be handled in two separate tracks.  **Issue 1-2-5: Proposal to test methodology for TxD**  We are fine with this proposal, however potential issues related to destructive interference needs to be considered  **Issue 1-2-6: Proposal to test methodology for TAS ON**  We do not support the Proposal, as discussed on R4-2212375 there’s no specification to determine the link antenna placement in the OTA chamber, every OTA chamber manufacturer has its own link antenna placement. Considering that TAS can be controlled dynamically with such open-loop feedback, measurement results on same UE will vary from chamber to chamber. |
| vivo | **Issue 1-2-1: How to evaluate multiple antenna system on UE?**  For 2Tx test cases, we still prefer a measurement methodology with multi-antenna actived and not locked. Otherwise, the basic motivation to develop test method for TxD/TAS is unclear for us. We suggest more study on this topic.  **Issue 1-2-2: View on dedicated TxD/TAS features algorithms and triggers**  In general, we support the idea that UE specific algorithms shall not be declared.  **Issue 1-2-3: Is a test campaign needed to correlate between test methodology and real environment expectations?**  For TAS on, we think correlations between test lab and real UE radiated performance would be valuable. But for TxD, we believe this is a fixed configuration in test lab or in real environment, so maybe test campaign only in test lab is sufficient.  For both of these two, we suggest further study is required.  **Issue 1-2-4: Consideration on TxD and one layer UL MIMO**  We are not clear about proposal 1, is the intention to develop one general test methodology to cover all the three UE features verification?  Not clear about the proposal in P2, but the test methodology for TxD and one-layer UL MIMO could be different, the UE capability or test case applicability should be considered together to avoid duplicated testing of a UE.  **Issue 1-2-5: Proposal to test methodology for TxD**  It is expected that the TxD methodology should apply to different UE PA architecture and different power class.  **Issue 1-2-6: Proposal to test methodology for TAS ON**  Given there are different TAS ON algorithms for different UE implementation, a test campaign for verification of different devices is suggested before concluding the test methodology. |
| Qualcomm | Issue 1-2-1: How to evaluate multiple antenna system on UE?  We should avoid using test mode in the testing. Test mode is not preferred.  Issue 1-2-2: View on dedicated TxD/TAS features algorithms and triggers  Agree with the proposal.  Issue 1-2-4: Consideration on TxD and one layer UL MIMO  OK with P2 if it means RAN4 to consider to define a general test method to test both TxD and one layer UL MIMO.  Issue 1-2-5: Proposal to test methodology for TxD  OK with proposal. |
| OPPO | **Issue 1-2-1: How to evaluate multiple antenna system on UE?**  We echo with vivo that multi-antenna activated and not locked are the favorable test configurations for UE with multi Tx antennas.  **Issue 1-2-2: View on dedicated TxD/TAS features algorithms and triggers**  We support that the dedicated algorithms and/or implementations are not required to be declared. Test method should be defined based on common understanding and typical implementation on TxD/TAS features.  **Issue 1-2-3: Is a test campaign needed to correlate between test methodology and real environment expectations?**  The correlation may be helpful to verify the test methodology. However, how to quantify “the real environment expectations”? To some extent, it will be related to UE’s dedicated algorithms and/or implementations. Therefore, we have concern on the processes and outcomes of such a test campaign. More inputs about test campaign are welcome.  **Issue 1-2-4: Consideration on TxD and one layer UL MIMO**  As the proponent, the intention of the proposal is that, multi-antenna techniques i.e. TxD and TAS are already considered in Annex E of TR 38.834, UL MIMO should also be included in parallel with TxD and TAS.  Response to vivo: it is not target to develop one general test methodology for all three multi-antenna techniques because the three topics are discussed in parallel.  **Issue 1-2-5: Proposal to test methodology for TxD**  Support the proposal as the proponent.  **Issue 1-2-6: Proposal to test methodology for TAS ON**  Support the proposal as the proponent.  Thanks Apple’s explicit description on TAS consideration in R4-2212375. We agree that different link antenna placement in chamber will lead to different TRP results when TAS ON. That is why we propose to combine the link antenna and the measurement antenna, where give the link antenna a unique position without ambiguity. |
| Samsung | **Issue 1-2-1: How to evaluate multiple antenna system on UE?**  Non-locked mode is preferred, however, test mode should not be precluded as there is no perfect methods identified till now.  **Issue 1-2-2: View on dedicated TxD/TAS features algorithms and triggers**  Detailed algorithms should not be declared.  **Issue 1-2-3: Is a test campaign needed to correlate between test methodology and real environment expectations?**  The intention is reasonable, however we echo with OPPO that it seems difficult to establish criteria for “the real environment expectations”  **Issue 1-2-4: Consideration on TxD and one layer UL MIMO**  Our understanding is that UL MIMO is not in current WI scope yet.  **Issue 1-2-5: Proposal to test methodology for TxD**  Support the proposal  **Issue 1-2-6: Proposal to test methodology for TAS ON**  It seems premature to conclude the feasibility. This method only apply to UE which rely on DL signal level for transmit antenna switching, and how to set the DL power for each direction may not easily to be standardized so far. |
| AT&T | **Issue 1-2-5: Proposal to test methodology for TxD**  This seems to be out of scope for Rel-17 based on the WF for concluding the WI in topic [332].  ***Proposal 5: TRP TRS test methods study for 2Tx chain (TxD/UL-MIMO), reverb-chamber system, RedCap UE, and other deprioritized aspects can be further discussed and well organized in a new Rel-18 TRP TRS WI***  **Issue 1-2-6: Proposal to test methodology for TAS ON**  This is definitely out of scope in Rel-17. |

### CRs/TPs comments collection

*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** |
|  | 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.*

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

### CRs/TPs

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

*Note: The tdoc decisions shall be provided in Section 3 and this table is optional in case moderators would like to provide additional information.*

|  |  |
| --- | --- |
| **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)

# Topic #2: Test time reduction

*The following aspects for test time reduction will be discussed in this section.*

* *Reduce EN-DC combinations*
* *Reduce SA test time*
* *Other techniques to reduce the FR1 OTA test time*

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2213419 | OPPO | **Proposal 1**: Test time reduction is not essential demand for EN-DC bands combination consideration based on the conclusion that only one EN-DC band combination for each NR band is tested.  **Proposal 2**: The single point offset approach can not be used without UE’s declaration of antenna pattern consistency. |

## Open issues summary

### Sub-topic 2-1 Conclusion on test time reduction for EN-DC combinations

* Proposal: Test time reduction is not essential demand for EN-DC bands combination consideration based on the conclusion that only one EN-DC band combination for each NR band is tested.
* Recommended WF
  + TBA

### Sub-topic 2-2 Applicability of single point offset approach

* Proposal: The single point offset approach can not be used without UE’s declaration of antenna pattern consistency.
* Recommended WF
  + TBA

## Companies views’ collection for 1st round

### Open issues

**Sub topic 2-1 Conclusion on test time reduction for EN-DC combinations**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Huawei | Support the proposal. |
| R&S | We support the proposal. |
| Apple | Support the proposal |
| Qualcomm | OK with proposal. |
| OPPO | Support the proposal. |
| Samsung | Support the proposal. The existing rules for ENDC can be seen as kind of test time reduction. |
| AT&T | Support the proposal. |

**Sub topic 2-2 Applicability of single point offset approach**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Huawei | Agree with the conclusion. The reason is likely due to differences in antenna efficiency between SA and ENDC antennas. The TRP would be roughly same with different antenna patterns provide that the antenna efficiencies are the same. Because TRP can approximated as “maximum conducted power” minus “antenna efficiency”. |
| R&S | We agree to the proposal.  In regards to Huawei’s comment, it is true that efficiency could be roughly the same for different antenna tuning states, but how the pattern changes actually matters in case of phantom testing. E.g. slight antenna pattern changes between tuning states may couple differently to Right Hand Phantom and Left Hand Phantom. Thus, the TRP value may change. |
| Apple | Agree with the proposal, without UE pattern declaration single point offset approach is unreliable. |
| Vivo | Agree with the proposal. |
| Qualcomm | Agree with the proposal. |
| OPPO | Support the proposal. |
| Samsung | Support the proposal. |
| AT&T | Support the proposal in general but we don’t see the need for the single-offset test based on the proposal in Sub-topic 2-1. |

### 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** |
| XXX | Company A |
| Company B |
|  |
| YYY | 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.*

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

### CRs/TPs

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

|  |  |
| --- | --- |
| **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)

*Moderator can provide summary of 2nd round here. Note that recommended decisions on tdocs should be provided in the section titled ”Recommendations for Tdocs”.*

# Recommendations for Tdocs

## 1st round

**New tdocs**

|  |  |  |  |
| --- | --- | --- | --- |
| **New Tdoc number** | **Title** | **Source** | **Comments** |
|  | WF on … | YYY |  |
|  | LS on … | ZZZ | To: RAN\_X; Cc: RAN\_Y |
|  |  |  |  |

**Existing tdocs**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Tdoc number** | **Revised to** | **Title** | **Source** | **Recommendation** | **Comments** |
| R4-22xxxxx |  | CR on … | XXX | Agreeable, Revised, Merged, Postponed, Not Pursued |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

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** | **Revised to** | **Title** | **Source** | **Recommendation** | **Comments** |
| R4-22xxxxx |  | CR on … | XXX | Agreeable, Revised, Merged, Postponed, Not Pursued |  |
| R4-22xxxxx |  | WF on … | YYY | Agreeable, Revised, Noted |  |
| R4-22xxxxx |  | LS on … | ZZZ | Agreeable, Revised, Noted |  |
|  |  |  |  |  |  |

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

# Annex

Contact information

|  |  |  |
| --- | --- | --- |
| **Company** | **Name** | **Email address** |
| Huawei | Hai Zhou | [hai.zhou1@huawei.com](mailto:hai.zhou1@huawei.com) |
| Rohde & Schwarz | Jose M. Fortes | [Jose.Fortes@rohde-schwarz.com](mailto:Jose.Fortes@rohde-schwarz.com) |
| Apple | Istvan Szini | [Istvan@apple.com](mailto:Istvan@apple.com) |
| Qualcomm | Bin Han | [binhan@qti.qualcomm.com](mailto:binhan@qti.qualcomm.com) |
| OPPO | Qifei Liu | [liuqifei@oppo.com](mailto:liuqifei@oppo.com) |
| AT&T | Ron Borsato | ronald.borsato@att.com |

Note:

1. Please add your contact information in above table once you make comments on this email thread.
2. If multiple delegates from the same company make comments on single email thread, please add you name as suffix after company name when make comments i.e. Company A (XX, XX)