**3GPP TSG-RAN WG4 Meeting # 102-e R4-2207179**

**Electronic Meeting, February 21 – March 3, 2022**

**Agenda item:** 11.1

**Source:** Moderator (Intel Corporation)

**Title:** Email discussion summary for [102-e][337] FR2\_enhTestMethods

**Document for:** Information

# Introduction

*This document covers discussions of the Enhanced Test Methods in FR2 study item.*

# Topic #1: General status of SI (AI 11.1)

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2203706**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2203706.zip)  Proposals to conclude the enhanced test methods study item | Apple | Proposal 1: RAN4 should conclude the preliminary MU assessments for UE RF, RRM, and demodulation based on the agreed assumption on the number of UE antenna elements.  Proposal 2: RAN4 should conclude the max achievable SNR for demodulation and for RRM in the beam peak direction.  Proposal 3: RAN4 should conclude the applicability of Objectives 1-5 to FR2-2 based on the above agreements and capture the related agreements in TR38.884. |

## Open issues summary

### Sub-topic 1-1: Remaining work of SI

**Issue 1-1: Proposals to conclude SI**

*Remaining open issues of the SI are related to Objective 7 (testability aspects for the extension to FR2-2).*

*- Extend the applicability of the RF, RRM, and demodulation permitted methods in TR38.810 to FR2-2*

*- Extend the applicability of Objectives 1 through 5 of this SI to FR2-2*

*The following proposals are listed in R4-2203706 for the conclusion of the SI within Rel-17 scope.*

* **Proposal 1:** RAN4 should conclude the preliminary MU assessments for UE RF, RRM, and demodulation based on the agreed assumption on the number of UE antenna elements.
* **Proposal 2:** RAN4 should conclude the max achievable SNR for demodulation and for RRM in the beam peak direction.
* **Proposal 3:** RAN4 should conclude the applicability of Objectives 1-5 to FR2-2 based on the agreements below and capture the related agreements in TR38.884.
  + As a starting point, the same High DL power and low UL power test cases for which NF based solutions (i.e. CFFNF, CFFDNF, and CFFdeltaNF) are applicable in FR2-1, can be considered for NF based solutions applicability in FR2-2. In case relaxations are needed for IFF/DFF methods for a given test case, it is up to RAN5 to confirm applicability of NF based solutions
  + At least, RSRPB based Rx beam peak search, Single link polarization measurement and Fast Spherical Coverage Method can be applied to 52.6-71GHz directly
* Recommended WF
  + Moderator suggests companies share their views on the three proposals to conclude the SI.

## Companies views’ collection for 1st round

### Open issues

Sub-topic 1-1: Proposals to conclude SI

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| **Company** | **Comments** |
| R&S | Sub-topic 1-1: Proposals to conclude SI  Regarding proposal 1, we don’t think the impact on MU is limited to the number of the UE antenna elements, which is related to grid studies for RF or DL SNR calculations for RRM/Demod, but also other test system components are affected. During past few meetings it was discussed how extending existing systems will impact the MU for FR2-1 and it was agreed that “MU assessment will be revised to reflect proper **frequency-dependent** parameters”.  Proposal 2 is reasonable, although there are still many parameters which are TBD to conclude on the achievable SNR.  We are ok with proposal 3. |
| Apple | How can we make progress on grid studies for RF and DL SNR calculations? |
| vivo | We also think the antenna assumption and corresponding measurement grids should be defined in RAN4. |
| Intel | Proposal 1 – agree overall, but perhaps we can further specify, as agreed in RAN4 #101e (R4-2120767), that MU assessment will focus on PC3 in Rel-17  **Agreement:** MU assessment for FR2-2 will focus on PC3 in Rel-17 timeline. This, however, does not deprioritize the general work on other UE types in the WI (i.e., FWA and vehicular).  Proposal 2 – agreeable  Proposal 3 – ok overall, but we can further capture last meeting’s agreement (R4-2203079):  Candidate options:   * **Proposal:** Applicability of methodology enhancements of three methods in Objective 5 can be extended to FR2-2. Objective 3 discussions should be postponed until core requirements are discussed. Lastly, we should further discuss the remaining objectives   **Agreement:** Approve the proposal and extend applicability of Objective 2 and Objective 5 solutions to FR2-2 |

### CRs/TPs comments collection

*Moderator suggests companies to comment directly for the CR below. in 1.3.2 CRs/TPs comment collection*

|  |  |
| --- | --- |
| **CR/TP number** | **Comments collection** |
|  | Company A |
| Company B |
|  |
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## 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 #1-1: Remaining work of SI** | **Issue 1-1: Proposals to conclude SI**  *Candidate options:*   * **Proposal 1:** RAN4 should conclude the preliminary MU assessments for UE RF, RRM, and demodulation based on the agreed assumption on the number of UE antenna elements. * **Proposal 2:** RAN4 should conclude the max achievable SNR for demodulation and for RRM in the beam peak direction. * **Proposal 3:** RAN4 should conclude the applicability of Objectives 1-5 to FR2-2 based on the agreements below and capture the related agreements in TR38.884.   + As a starting point, the same High DL power and low UL power test cases for which NF based solutions (i.e. CFFNF, CFFDNF, and CFFdeltaNF) are applicable in FR2-1, can be considered for NF based solutions applicability in FR2-2. In case relaxations are needed for IFF/DFF methods for a given test case, it is up to RAN5 to confirm applicability of NF based solutions   + At least, RSRPB based Rx beam peak search, Single link polarization measurement and Fast Spherical Coverage Method can be applied to 52.6-71GHz directly   *Overall, content in the proposals is agreeable. It was commented that measurement grids should be defined in RAN4. Additionally, the following agreements were suggested to be added:*   * *For Proposal 1*   **Agreement:** MU assessment for FR2-2 will focus on PC3 in Rel-17 timeline. This, however, does not deprioritize the general work on other UE types in the WI (i.e., FWA and vehicular).   * *For Proposal 3* * **Proposal:** Applicability of methodology enhancements of three methods in Objective 5 can be extended to FR2-2. Objective 3 discussions should be postponed until core requirements are discussed. Lastly, we should further discuss the remaining objectives   **Agreement:** Approve the proposal and extend applicability of Objective 2 and Objective 5 solutions to FR2-2  *Recommendations for 2nd round:*  *For Proposal 1 and Proposal 3, include the content of previous agreements (captured above). Work on the wording of the proposals and any additional content (i.e., measurement grid) to be captured.* |

### 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

**TBA**

# Topic #2: OTA test methods for UE RF, RRM and demodulation for 52.6~71GHz (AI 11.1.2)

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2203636**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2203636.zip)  On FR2-2 Antenna Assumptions | Keysight Technologies UK Ltd | Proposal 1: Feedback is requested from chipset vendors/device manufacturers which single-element antenna assumptions should be considered for PC1, PC2, and PC3 in FR2-2.  Proposal 2: Feedback is requested to clarify the worst-case antenna array configuration (MxN) for PC1 and PC2 UEs in FR2-2.  Proposal 3: Feedback is requested to clarify the beam steering assumptions for PC1, PC2, and PC3 UEs in FR2-2. |
| [**R4-2203704**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2203704.zip)  TP to TR38.884 on minimum SNR for RRM test cases for band n263 | Apple | TP on minimum SNR for RRM test cases for band n263, considering this tentative agreement from RAN4 #101Bis-e:  Agreement: Min SENS for n263 400 MHz, based on averaging the proposals in the table is [-73.0 dBm] |
| [**R4-2203705**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2203705.zip)  TP to TR38.884 on minimum SNR for demodulation test cases for band n263 | Apple | TP on minimum SNR for demodulation test cases for band n263, considering this tentative agreement from RAN4 #101Bis-e:  Agreement: Min SENS for n263 400 MHz, based on averaging the proposals in the table is [-73.0 dBm] |
| [**R4-2204386**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2204386.zip)  FR2-2 OTA test methods for UE demodulation | Intel Corporation | Proposal 1: Ask inputs from TE vendors on possible adjustment of TE parameters to increase max achievable DL SNR during the demod test.  Proposal 2: Discuss the following ways how to increase max achievable SNR for demod testing:   1. Decrease ∆thermal value 2. Adjust TE parameters (e.g., power amplifier 1dB compression point, probe antenna gain) 3. Restrict allocation size within CBWs   Proposal 3: Consider 400MHz as a baseline assumption on max applicable CBW and sampling frequency for definition of multi-path fading channel model. |
| [**R4-2204964**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2204964.zip)  TP to TR38.884 on applicability extension of test methods for band FR2-2 | vivo | Provides text proposal to TR 38.884 to capture the applicability of some test methods agreed to be extended to FR2-2 |
| [**R4-2204965**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2204965.zip)  Discussion on test methods for FR2-2 | vivo | Proposal 1: For single UE antenna element pattern parameters of FR2-2, reusing the assumptions of FR2-1 except for frequency range.  Proposal 2: Unless otherwise stated, test capability extension of permitted test methods confirmed for FR2-2 can apply to n262.  Proposal 3: Extend applicability of Objective 2 and Objective 5 solutions to n262. |
| [**R4-2205007**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2205007.zip)  Discussion on FR2-2 OTA test methods | Huawei, HiSilicon | Proposal 1: Single UE antenna element pattern parameters can be reused as Table G.1.1-1 in TR38.810, and half-power beamwidth and gain need to be further confirmed. |
| [**R4-2205915**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2205915.zip)  FR2-2 OTA test methods for UE RRM | Intel Corporation | Proposal 1: Informative assessment of testable RRM DL SNR range for FR2-2 should be performed for the first and second scenario of RRM requirements and for both types of RRM requirements.  Proposal 2: Study the gain difference between fine and rough beams for FR2-2. |
| [**R4-2206091**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2206091.zip)  On general aspects and UE testing methodology for FR2-2 | Intel Corporation | Observation 1: Current test methods in TR 38.810 have been extended to FR2-2, but the general testing and calibration aspects have not.  Proposal 1: RAN4 should confirm if the testing and calibration aspects detailed in Clause 5.2.1.3 of TR 38.810 can be extended to FR2-2.  Observation 2: RAN4 should discuss if a radiating aperture of 5cm can be reused for FR2-2 PC3 derivations. Given the increase in path loss, we may also consider lowering the value of D.  Proposal 2: If D = 5cm is reused for FR2-2, a column for 71 GHz will be added to the minimum range length of DFF table in TR 38.810 (Table 5.2.1.2-1).  Table 5.2.1.2-1: Minimum Range Length of DFF System for D = 5cm   |  |  |  |  | | --- | --- | --- | --- | | f [GHz]  QZ [cm] | 24.25 | … | 71 | | **15** | 0.45 | … | 1.23 | | **30** | 0.53 | … | 1.31 | |
| [**R4-2206092**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2206092.zip)  TP for TR 38.884 on NR test methods extension to FR2-2 | Intel Corporation | Text proposal to TR 38.884 on the extension of test methods to FR2-2 covers the following:   1. RF enhanced test methods extensions approved in R4-2203079 2. General testing and calibration aspects 3. Propagation conditions |
| [**R4-2206116**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2206116.zip)  MIMO EVM Measurement for FR2 | Lenovo | In Section 5.2.3.1.1.2 of TR 38.884-120 on “Method 1 MIMO Equalization,” there is the following text:  “The ZF equalizer coefficients are calculated as pseudo inverse of effective channel matrix, in general:  **Observation 1**: *The expression is not the pseudo-inverse of a square matrix*.  Observation 2: Since the MIMO layers cannot be separated if the matrix does not have full rank, *there is no need for the pseudo-inverse*.  Observation 3: The zero-forcing receiver should be defined using the simple rather than using the expression which is not the pseudo-inverse and requires two additional matrix multiplications.  **Proposal 1:** For two-layer uplink MIMO in FR2, define the zero-forcing receiver as the inverse of the effective channel matrix so that  **Proposal 2:** Agree to the text proposal for Section 5.2.3.1.1.2 of TR38.884-130 in the Appendix. |

## Open issues summary

### Sub-topic 2-1: General aspects

**Issue 2-1a: General testing and calibration**

*Permitted test methods have been agreed to be extended to FR2-2, but while somewhat implied, the general testing and calibration aspects have not been confirmed to be extended as well.*

* Proposal 1: RAN4 should confirm if the testing and calibration aspects detailed in Clause 5.2.1.3 of TR 38.810 can be extended to FR2-2.
* Recommended WF
  + Moderator suggests companies share their views on whether we can confirm the testing and calibration aspects found in Clause 5.2.1.3 of TR 38.810 can be extended to FR2-2.

**Issue 2-1b: Radiating aperture**

*Given the latest core discussion agreement on the antenna array assumption (R4-2202366), RAN4 should address if a radiating aperture of 5cm can be reused for FR2-2 PC3 derivation, or if a different value is needed.*

* Option 1: Yes, 5cm can be reused for D
  + Proposal: If D = 5cm is reused for FR2-2, a column for 71 GHz will be added to the minimum range length of DFF table in TR 38.810 (Table 5.2.1.2-1).
* Option 2: No, a different value is needed
* Recommended WF
  + Moderator recommends companies provide their input on whether 5cm can be reused, or if another value is needed.
  + If 5cm is reused, a column for 71GHz can be added to Table 5.2.1.2-1. If a different value is agreed, then the min. range length of DFF will be calculated based on that value and can be captured in TR 38.884.

### Sub-topic 2-2: UE types

**Issue 2-2a: Single-element antenna assumptions for PC1, PC2 and PC3**

*Table G.1.1-1 in TR 38.810 details the parameters to use in simulations for the radiation pattern of a single-element antenna.*

Table G.1.1-1: Single Antenna Element Radiation Pattern

|  |  |
| --- | --- |
| Antenna element horizontal radiation pattern | , Am =30 d |
| Horizontal half-power beamwidth of single element | 260° |
| Antenna element vertical radiation pattern | , SLAv =30 dB |
| Vertical half-power beamwidth of single array element | [130º] |
| Array element radiation pattern |  |
| Element gain without antenna losses | [ GE,max = 1.5 dBi ] |

* Proposal 1: Feedback is requested from chipset vendors/device manufacturers which single-element antenna assumptions should be considered for PC1, PC2, and PC3 in FR2-2. (Keysight)
* Proposal 2: Single UE antenna element pattern parameters can be reused as Table G.1.1-1 in TR38.810, and half-power beamwidth and gain need to be further confirmed. (Huawei)
* Recommended WF
  + Companies are encouraged to provide their feedback on which single-element antenna assumptions should be considered for PC3, PC1 and PC2.
  + Moderator suggests companies consider Table G.1.1-1 as baseline and share their views on modifications needed. Content of Table G1.1-2 may also be discussed.

Table G.1.1-2: Composite Antenna Array Radiation Pattern

|  |  |
| --- | --- |
| Composite array radiation pattern in dB | the super position vector is given by:    the weighting is given by: |
| Antenna array configuration (Row×Column) | 8 × 2 |
| Horizontal radiating element spacing dh/λ | 0.5 |
| Vertical radiating element spacing dv/λ | 0.5 |

**Issue 2-2b: Worst-case antenna array configuration (MxN) for PC1 and PC2**

*In RAN4 #101Bis-e, the following agreement was captured for PC3 (R4-2203079)*

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| --- |
| **Agreement:** The worst-case antenna assumption for testability and MU assessment of handheld UEs in FR2-2 is [8 x2]. Single UE antenna element pattern parameters, similar to Table 5.2.3.3-1, need to be finalized in RAN4#102-e. |

* Proposal: Feedback is requested to clarify the worst-case antenna array configuration (MxN) for PC1 and PC2 UEs in FR2-2. (Keysight)
* Recommended WF
  + Moderator suggests companies consider the core requirement discussions and share their views on the worst-case antenna array configuration of PC1 and PC2

**Issue 2-2c: Beam steering assumptions**

*For PC3 in FR2-1, TR 38.810 includes the following beam steering assumptions:*

* *Two 8x2 antenna arrays are integrated in the UE for the spherical coverage analyses*
* *The implementation loss for the antenna near the front is 5dB less than that for the antenna near the back*
* *For Beam Steering Assumptions*
  + *In the xz plane, 45° beam steering granularity (from 45° to 135°) has been used*
  + *In the xy plane, 22.5° beam steering granularity (from -90° to 90°) has been used*

*While the assumption for PC1 in FR2-1 are (R5-198203):*

* *Number of Antenna Arrays – PC1 is notionally a single array device.*
* *Beam Steering assumptions are:*
* *In the xz plane, 4° beam steering granularity (from 30° to 150°)*
* *In the xy plane, 4° beam steering granularity (from -60° to 60°)*
* Proposal: Feedback is requested to clarify the beam steering assumptions for PC1, PC2, and PC3 UEs in FR2-2. (Keysight)
* Recommended WF
  + Moderator recommends companies provide feedback on the beam steering characteristics of PC3, PC2, and PC1 in FR2-2

### Sub-topic 2-3: Test methodology for UE RF

**Issue 2-3: MIMO EVM Measurement**

*In R4-2206116, an issue of EVM measurement for two-layer Tx is identified. Basically, using pseudo-inverse matrix in zero-forcing equalization does not allow to separate MIMO layers and hence correctly measure EVM. The following observations and proposals were made:*

* Observation 1: The expression is not the pseudo-inverse of a square matrix.
* Observation 2: Since the MIMO layers cannot be separated if the matrix does not have full rank, there is no need for the pseudo-inverse.
* Observation 3: The zero-forcing receiver should be defined using the simple rather than using the expression which is not the pseudo-inverse and requires two additional matrix multiplications.
* Proposal 1: For two-layer uplink MIMO in FR2, define the zero-forcing receiver as the inverse of the effective channel matrix so that
* Proposal 2: Agree to the text proposal for Section 5.2.3.1.1.2 of TR38.884-130 in the Appendix.
* Recommended WF
  + Companies are encouraged to provide their view on the necessity of EVM measurement methodology update and suggested text proposal for TR38.884.

### Sub-topic 2-4: Test methodology for RRM

**Issue 2-4: Informative assessment of testable RRM DL SNR range**

*Captured in R4-2203079*

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| **Agreement:** Perform an informative assessment of testable RRM DL SNR range for FR2-2 for maximum frequency (~71GHz) using TR38.810 methodology as starting point. |

* Proposal 1: Informative assessment of testable RRM DL SNR range for FR2-2 should be performed for the first and second scenario of RRM requirements and for both types of RRM requirements
* Proposal 2: Study the gain difference between fine and rough beams for FR2-2
* Recommended WF
  + Companies are encouraged to discuss proposed scenarios and types for SNR assessment. Discussion on necessity of revision of gain difference between fine and rough for FR2-2 is needed.

### Sub-topic 2-5: Test methodology for UE demodulation and CSI

**Issue 2-5a: Informative assessment of testable Demodulation DL SNR range**

*Initial parameters to assess max testable DL SNR were agreed previous meeting. Same time, TE parameters require further confirmation. Analysis provided previous and this meeting show that max DL SNR is quite limited under FR2-1 assumptions on TE parameters.*

* Proposal 1: Ask inputs from TE vendors on possible adjustment of TE parameters to increase max achievable DL SNR during the demodulation test.
* Recommended WF
  + Moderator recommends TE vendors provide their feedback

**Issue 2-5b: FR2-2 max achievable DL SNR adjustment**

*Several ways were proposed on how to increase max achievable SNR for demodulation testing*

* Option 1: Decrease ∆thermal value
* Option 2: Adjust TE parameters (e.g., power amplifier 1dB compression point, probe antenna gain)
* Option 3: Restrict allocation size within CBWs
* Recommended WF
  + Companies are encouraged to provide their view on the proposed options

**Issue 2-5c: Path delay grid**

*Captured in R4-2203079*

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| **Agreement:** Path delay grid   * Max applicable channel bandwidth:   + Option 1: 2GHz   + Option 2: Smaller than 2GHz * Sampling frequency:   + Option 1: 2GHz   + Option 2: 800/400MHz |

* Proposal 1: Consider 400MHz as a baseline assumption on max applicable CBW and sampling frequency for definition of multi-path fading channel model.
* Recommended WF
  + Companies are encouraged to provide their view on the proposed option to limit sampling frequency and max applicable channel bandwidth by 400 MHz

### Sub-topic 2-6: Text proposals for TR 38.884

**Issue 2-6a: TP on minimum SNR for RRM test cases for band n263**

* Recommended WF
  + Moderator suggests companies provide any feedback on TP R4-2203704 directly into Section **2.3.2 CRs/TPs** **comments collection**.

**Issue 2-6b: TP on minimum SNR for demodulation test cases for band n263**

* Recommended WF
  + Moderator suggests companies provide any feedback on TP R4-2203705 directly into Section **2.3.2 CRs/TPs** **comments collection**.

**Issue 2-6c: TP on applicability extension of test methods**

*TP R4-2204964 captures the applicability extension of some enhanced test methods to FR2-2.*

* Recommended WF
  + Moderator suggests companies provide any feedback on TP R4-2204964 directly into Section **2.3.2 CRs/TPs** **comments collection**.

**Issue 2-6d: TP on NR test methods extension to FR2-2**

*TP R4-2206092 includes the RF enhanced test methods extensions approved in R4-2203079, general testing and calibration aspects, and propagation conditions content.*

* Recommended WF
  + Moderator suggests companies provide their feedback on TP R4-2206092 directly into Section **2.3.2 CRs/TPs** **comments collection**. Please include any edits on the wording used.
  + Content of TP R4-2204964 (Issue 2-6c) can be merged into R4-2203079

## Companies views’ collection for 1st round

### Open issues

Sub-topic 2-1: General aspects

Issue 2-1a: General testing and calibration

Issue 2-1b: Radiating aperture

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| **Company** | **Comments** |
| R&S | Issue 2-1a: General testing and calibration  Proposal 1 is ok.  Issue 2-1b: Radiating aperture  We support Option 1. |
| Keysight | Issue 2-1b: Radiating aperture  We are hesitant to agree on option 1 without specific feedback from OEMs and/or chipset vendors. It seems counter-intuitive that the antenna aperture for the higher frequency range remains the same and thus the range length increases with increasing frequency. In the antenna array assumptions, we define in Table G.1.1-2 that the horizontal & vertical radiating element spacings, dh/λ and dv/λ, are 0.5. This would theoretically imply a 2.3cm antenna aperture at 52.6GHz. |
| Apple | Issue 2-1a: General testing and calibration  We support Proposal 1  Issue 2-1b: Radiating aperture  We support Option 1 (at least for PC3) |
| vivo | Issue 2-1a: General testing and calibration  We support Proposal 1  Issue 2-1b: Radiating aperture  Option 1 is OK for us currently. Further update should not be precluded. |
| Keysight | If we select Option 1 for PC3, i.e., radiating aperture of D=5cm, we should adjust the antenna array assumptions to technically justify this choice as the current assumptions yield a D of 2.3cm. This can be achieved by increasing the number of elements and/or increasing the d/ spacing. |
| Qualcomm | Issue 2-1b Radiating aperture, D=5 cm is ok for PC3  We think that from a test method perspective, the most conservative assumption is that the FR2-2 elements share space on the antenna module originally sized for FR2-1. Even if the elements itself are not spread over the entire module, the ground plane remains active in defining the element beam patterns up to a point. Note that d/lambda can still be assumed to be 0.5 |
| Huawei,  Hisilicon | Issue 2-1a:ok  Issue 2-1b: In our view, the 5cm can be reused for PC3. Considering a typical element spacing of 0.5 λ, an array with 8 elements on a single axis would be in 5cm at 71 GHz. |
| Intel | Issue 2-1a: General testing and calibration  Proposal 1 is agreeable  Issue 2-1b: Radiating aperture  Should be ok to use D = 5cm, but should further discuss to confirm |

Sub-topic 2-2: UE types

Issue 2-2a: Single-element antenna assumptions for PC3, PC1 and PC2

Issue 2-2b: Worst-case antenna array configuration (MxN) for PC1 and PC2

Issue 2-2c: Beam steering assumptions of PC3, PC1 and PC2

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| **Company** | **Comments** |
| R&S | Issue 2-2a: Single-element antenna assumptions for PC1, PC2 and PC3  In our view, the 90º/90º assumption is more realistic and it was the main reason to use it for PC3 optional grid and PC1 grid studies. Thus, we support Proposal 1.  Issue 2-2b: Worst-case antenna array configuration (MxN) for PC1 and PC2  For PC1, current common assumption in the RF session is 64 elements, what could be translated into 8x8. Thus, and comparing to the worst case used for PC1 in FR2-1, we think a 12x12 should be considered as worst case for PC1 in FR2-2. |
| LGE | Issue 2-2a, 2-2b, 2-2c  Currently EIRP and EIRS requirements for PC2 based on 16 antenna elements (8x2) have been proposed in RF session, but values are still under discussion. When it comes to other issues above the PC2 assumptions should be aligned with PC3. When decisions for the PC2 requirements have been done in the RF session, these issues 2-2a > 2-2c shall be further discussed. |
| Keysight | Issue 2-2a/b/c  We tend to agree that the 130/260 assumption should no longer be considered going forward given the feedback received/decisions made in RAN5. We should hold off deciding on array assumptions without specific feedback from OEMs and/or chipset vendors as the HPBWs might even be smaller for FR2-2?!. |
| Apple | Issue 2-2a: Single-element antenna assumptions for PC3, PC1 and PC2  In R4-2200438 and R4-2203707 we discussed the impact of the integration of an 8-element antenna array into the handheld form factor. This is manifest in lensing of antenna element patterns. Translating this effect to the idealized definition of the antenna patterns per TR38.803, we should consider reducing the half-power beamwidth per element, and we are open to discussion the magnitude of the reduction, considering that these measurement grid simulations aim to capture the worst-case MU rather than the minimum device performance.  Issue 2-2c: Beam steering assumptions of PC3, PC1 and PC2  We are fine to reuse the TR38.810 beam steering assumptions |
| vivo | Issue 2-2a: we are OK to use 90º/90º assumption for PC3.  Issue 2-2b: we suggest RAN4 to focus group efforts on the finalization of PC3 related part, given quite tight timeline of SI. |
| Qualcomm | Issue 2-2a:  90/90 is indeed more realistic for FR2-1, Perhaps further narrowing is necessary for FR2-2, we would like more time to suggest numbers based on further study.  Issue 2-2b: MxN  For PC1: We are ok to reuse FR2-1 assumption of 12x12 but prefer to scale up to 16x16 given foreseen reduction in EIRP capability.  Issue 2-2c: Beam Steering  For PC1, FR2-1 assumption can be reused if 12x12 is also reused. For 16x16 a theoretical scaling can be used, where steering granularity reduces with beam width. |
| Huawei, Hisilicon | Issue 2-2a:  Similar view with Qualcomm. |
| Intel | Issue 2-2a: Single-element antenna assumptions for PC3, PC1 and PC2  For PC3, agree that integration impact should be considered, and half-power beamwidth further discussed.  Issue 2-2a, 2-2b and 2-2c:  For PC1 and PC2, since these are currently under discussion in the RF session, we can address/confirm these aspects once core discussions are concluded |

Sub-topic 2-3: Test methodology for UE RF

Issue 2-3: MIMO EVM Measurement

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| **Company** | **Comments** |
| R&S | Issue 2-3: MIMO EVM Measurement  We have discussed this proposal from Lenovo already a couple of times during the past meetings and there is the same proposal from Lenovo for FR1 as well in this meeting.  As said before, we do not disagree with the technical arguments but we think it is better to have a unified implementation for FR1, FR2, two and one layer cases.  However, to conclude this discussion and avoid further back and forth, we can compromise to Lenovo’s proposal in R4-2206116 for the 2x2 UL MIMO case. |
| Lenovo | Thanks to R&S for this compromise. |
| Qualcomm | We agree that inv(H) is all that is required for rank2. The triple product variant is identical to inv(H) for rank 2, if needlessly complex for rank 2. The advantage of the triple product formulation is seamless use across both, rank and rank 2 1 UL. For rank1, the triple product formulation implements MRC which is the desired result. We are ok with the compromise also. |

Sub-topic 2-4: Test methodology for UE RRM

Issue 2-4: Informative assessment of testable RRM DL SNR range

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| **Company** | **Comments** |
| Apple | We would like to check the progress of RRM discussions until the second round. |
| Qualcomm | We are OK with proposal 1. For proposal 2, we can use the agreed difference, i.e., 7dB, between fine and rough beam from FR2-1 as the start point since a larger difference would lead to bad performance for FR2-2. |
| Intel | Gain difference between fine and rough beams agreed for FR2-1 might not be applicable to FR2-2 due to different antenna characteristics. Therefore, we proposed to study gain difference for FR2-2. |

Sub-topic 2-5: Test methodology for UE demodulation and CSI

Issue 2-5a: Informative assessment of testable Demodulation DL SNR range

Issue 2-5b: FR2-2 max achievable DL SNR adjustment

Issue 2-5c: Path delay grid

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| **Company** | **Comments** |
| Keysight | **Issue 2-5c: Path delay grid**  What is the justification to limit the max CBW to 400MHz since there was no contribution this meeting to limit max CBW to 400 MHz.  Regarding limiting the sampling frequency, Keysight does not recommend to fix Fsample at this stage as the schedule of practical implementations for FR2-2 is still open. Our recommendation is to define the channel models with accurate delay grid and implementation should be left vendor specific. A validation procedure and acceptance criteria for channel model implementation tolerances should be specified later. The proposed Fsample values are potential options, but for example the signal sample rate is likely to be a multiple of 122.88 MHz in practical implementations. So fixing to a specific Fsample at this stage doesn’t seem feasible |
| R&S | Issue 2-5a: Informative assessment of testable Demodulation DL SNR range  On proposal 1, there is very limited room for TE vendors to “adjust” parameters. For example:  - Antenna gain is mainly given by the geometry of the system and thus, assuming existing FR2-1 system are reused, antenna gain cannot be adjusted. I.e. same chamber, same focal length, same reflector, same HPBW, same gain.  - For the PA we need further check, but looking at state-of-the-art components they typically provide less output power in FR2-2 range compared to FR2-1 range.  Issue 2-5b: FR2-2 max achievable DL SNR adjustment  Regarding Option 2, please check our comments for issue 2-5a.  In our understanding, Option 3 is the best and easiest option to improve the achievable SNR.  Issue 2-5c: Path delay grid  We agree with the general approach proposed by Intel, since it follows the agreed and well working approach for Rel-15 Demod/RRM channel models.  We are still checking on the feasible bandwidth for the sampling rate, so this value needs to be kept open. Having an example based on 400 MHz is fine, with the understanding that the value is only used to illustrate the principle. |
| Qualcomm | Issue 2-5b: FR2-2 max achievable DL SNR adjustment  Option 1 would lead to larger MU which is not preferred. Option 2 would depend on TEV’s input. Option 3 is the feasible way. |
| Intel | Issue 2-5a: Informative assessment of testable Demodulation DL SNR range  Thanks R&S for the initial inputs. We encourage to further check what parameters can be adjusted otherwise we do not have ability to configure sufficient SNR for RRM/Demod tests.  Issue 2-5b: FR2-2 max achievable DL SNR adjustment  Based on our evaluations all three options should be assumed as a single set of methodology change. None of these options as a single solution allow to increase SNR sufficiently. For example, even if we limit allocation size by 32 PRBs, it allows to configure only 12.2 dB SNR that is not enough for demodulation test cases.  We need to provide our conclusion to demod room on max testable SNR this meeting. Performance part for FR2-2 is already started and lack of this input has direct impact on performance part progress.  We encourage companies to check the following aspects:   * Acceptable ∆thermal decrease   + *At least 2 dB can be considered for FR2-2 in our understanding.* * Possible adjustment of TE parameters (e.g., power amplifier 1dB compression point, probe antenna gain) * Acceptable restriction of allocation size within CBW   + *Not less than 66 PRBs is our preference, but if it will be insufficient, we are fine to further reduce this value.*   Issue 2-5c: Path delay grid  To KS:we have submitted R4-2204386 this meeting in which we propose to limit CBW by 400 MHz mainly due to small max achievable SNR in FR2-2 with broad CBWs.  FR2-1 channel models are specified for up to 200 MHz CBWs with 200 MHz sampling frequency. We prefer to consider the same methodology to have a certain limitation because channel impulse response is quite different for different sampling frequencies. Same time, to define performance requirements RAN4 needs to have a common assumption on the assumed CIR. |

### CRs/TPs comments collection

*Moderator suggests companies comment directly to the CRs/TPs comment collection for the CRs below.*

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| --- | --- |
| **CR/TP number** | **Comments collection** |
| R4-2203704 | R&S: The values for DL SNR should be aligned with the ones from Demod after concluding the discussions for R4-2203705. |
| Qualcomm: Seems the max SNR for Scenario 1 for Type 2 with 400MHz should be 1.2dB? |
| Intel: Similar comment as for R4-2203705. Also, confirmation on fine-rough beam gain difference in needed for FR2-2. |
| R4-2203705 | R&S: The values for the different parameters to derive the max DL SNR (Table 7.2.3-1) should be aligned to the ones proposed in R4-2204386 which we think are more accurate, also taking into account things like DL power setting uncertainty. This will require to revise the values for tables 7.2.3-1 and 7.2.3-2.  Parameters “TE DL absolute power setting uncertainty”, “Probe antenna gain” and “Beam peak search procedure error”, can be taken from R4-2204386, but need to be kept in brackets for further study. Especially, amplifier P1dB and DL power uncertainty will have a big impact on the achievable DL SNR and the values will very likely be worse than the values for FR2-1. |
| Apple: we are fine to revise the TP to merge the analysis in R4-2204386 as well as companies' comments |
| Intel: Our evaluations show other values for the maximum DL testable SNR. From 1600 MHz there is even no room for BB SNR due to high Noc level. Same time there is SNR improvement for 2000 MHz compared to 1600 MHz in R4-2203705. We suggest keeping these values still TBD and align firstly on methodology and parameters. |
| R4-2204964 | Apple: we agree with the changes introduced in this TP |
| vivo: we are ok to mark this TP as merged. And the content can be added in Intel rev of R4-2206092 |
| R4-2206092 | R&S: The test proposal seems fine in general. The value for the bandwidth used for the sampling frequency requires further discussion in future meetings. |
| Keysight: We prefer to finalize the CBW and fsample first |
| Apple: we agree with the changes introduced in this TP |

## 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# 2-1: General aspects** | **Issue 2-1a: General testing and calibration**  *Candidate options:*   * Proposal 1: RAN4 should confirm if the testing and calibration aspects detailed in Clause 5.2.1.3 of TR 38.810 can be extended to FR2-2.   *Tentative agreements: Approve Proposal 1; testing and calibration aspects can be extended to FR2-2. Relevant text is already included in TP R4-2206092.*  *Recommendations for 2nd round: No further discussion needed*  **Issue 2-1b: Radiating aperture**  *Candidate options:*   * Option 1: Yes, 5cm can be reused for D   + Proposal: If D = 5cm is reused for FR2-2, a column for 71 GHz will be added to the minimum range length of DFF table in TR 38.810 (Table 5.2.1.2-1). * Option 2: No, a different value is needed   *For PC3, majority view is that we can reuse D = 5cm. However, considering we are moving up in frequency and wavelength/design size is reduced, it was brought up that the array assumptions should be modified to technically justify keeping the same radiating aperture size.*  *Recommendations for 2nd round:*  *Need to confirm 5cm can be reused. Further discuss which assumptions, if any, should be modified to justify reusing D = 5cm for FR2-2. For this discussion, keep in mind the design and test system frequency range.* |
| **Sub-topic# 2-2: UE types** | **Issue 2-2a: Single-element antenna assumptions for PC3, PC1 and PC2**  *Candidate options:*   * Proposal 1: Feedback is requested from chipset vendors/device manufacturers which single-element antenna assumptions should be considered for PC1, PC2, and PC3 in FR2-2. * Proposal 2: Single UE antenna element pattern parameters can be reused as Table G.1.1-1 in TR38.810, and half-power beamwidth and gain need to be further confirmed.   *For PC3, companies are aligned in revising the 130º /260º assumption, and it was suggested that 90º/90º assumption is more realistic. Also, there were comments on considering integration impact and further discussing the half-power beamwidth.*  *Recommendations for 2nd round:*  *Discuss the reduction in half-power beamwidth considering the impact of integrating a design into a hand-held form factor. Additionally, discuss if a 90º/90º assumption is agreeable.*  **Issue 2-2b: Worst-case antenna array configuration (MxN) for PC1 and PC2**  *Candidate option:*   * Proposal: Feedback is requested to clarify the worst-case antenna array configuration (MxN) for PC1 and PC2 UEs in FR2-2. (Keysight)   *For PC1, 12x12 and scaling up to 16x16 were suggested. It was noted that RF session is still discussing array size for PC1 and PC2 (for PC1, 32 to 64 elements are being considered, while PC2 has mainly focused on 16 elements). Because of this, it is advised to wait for core discussion conclusion. Focus on PC3 was also recommended.*  *Recommendations for 2nd round:*  *Postpone PC1 and PC2 worst-case array configuration decision until core discussions are concluded. Views on configuration options may still be shared in the second round.*  **Issue 2-2c: Beam steering assumptions of PC3, PC1 and PC2**  *Candidate option:*   * Proposal: Feedback is requested to clarify the beam steering assumptions for PC1, PC2, and PC3 UEs in FR2-2. (Keysight)   *Potentially reusing the TR38.810 beam steering assumptions was suggested. For PC1 and PC2, as with Issue 2-2b, discussion can be postponed until discussion is concluded in RF session.*  *Recommendations for 2nd round:*  *Discuss whether we can reuse the beam steering assumptions in TR38.810* |
| **Sub-topic# 2-3: Test methods for UE RF** | **Issue 2-3: MIMO EVM Measurement**  *Candidate options:*   * Proposal 1: For two-layer uplink MIMO in FR2, define the zero-forcing receiver as the inverse of the effective channel matrix so that * Proposal 2: Agree to the text proposal for Section 5.2.3.1.1.2 of TR38.884-130 in the Appendix.   *Tentative agreements: Approve Proposal 1 and Proposal 2*  *Recommendations for 2nd round: NA* |
| **Sub-topic# 2-4: Test methods for RRM** | **Issue 2-4: Informative assessment of testable RRM DL SNR range**  *Tentative agreements:*   * *Perform informative assessment of testable RRM DL SNR range for FR2-2 for the first and second scenario of RRM requirements and for both types of RRM requirements* * *Assume [7] dB gain between fine and rough beams for FR2-2*   + *Further confirmation of this value is needed.*   *Recommendations for 2nd round:*  *Further discuss applicable gain difference for FR2-2.* |
| **Sub-topic# 2-5: Test methods for UE demod and CSI** | **Issue 2-5a: Informative assessment of testable Demodulation DL SNR range**  *No need to discuss this issue further since it is captured in Issue 2-5b discussion*  *Candidate options: NA*  *Recommendations for 2nd round: NA*  **Issue 2-5b: FR2-2 max achievable DL SNR adjustment**  *Limited number of comments. More discussion is needed.*  *Tentative agreements:*  *Further discuss the following ways on test methodology change*   * *Acceptable ∆thermal decrease*   + *Option 1:1 dB similar to FR2-1*   + *Option 2: 2dB*   + *Other options are not precluded* * *Adjustment of TE* * *Acceptable restriction of allocation size within CBW*   *Recommendations for 2nd round:*  *Continue discussion based on the tentative agreement*  **Issue 2-5c: Path delay grid**  *Two options were proposed during the first-round discussions*  *Tentative agreements: NA*  *Candidate options:*   * *Option 1: Limit max applicable CBW and sampling frequency by 400MHz* * *Option 2: Define accurate delay grid*   + *Specify validation procedure and acceptance criteria for channel model implementation tolerances.*   *Recommendations for 2nd round:*  *Continue discussion and try to converge on some option this meeting considering impact on other WIs.* |

### 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** |
| R4-2203704 | *To be revised based on round 1 comments* |
| R4-2203705 | *To be revised based on round 1 comments* |
| R4-2204964 | *To be merged into the revision of R4-2206092* |
| R4-2206092 | *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**

|  |  |  |
| --- | --- | --- |
| **Title** | **Source** | **Comments** |
| WF on FR2-2 OTA test methods | Intel Corporation |  |
| TP for TR 38.884 on NR test methods extension to FR2-2 | Intel Corporation | Revision of tdoc R4-2206092 |
| TP to TR38.884 on minimum SNR for RRM test cases for band n263 | Apple | Revision of tdoc R4-2203704 |
| TP to TR38.884 on minimum SNR for demodulation test cases for band n263 | Apple | Revision of tdoc R4-2203705 |

**Existing tdocs**

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| **T-doc number** | **Title** | **Source** | **Recommendation** | **Comments** |
| R4-2203636 | On FR2-2 Antenna Assumptions | Keysight Technologies UK Ltd | Noted |  |
| R4-2203704 | TP to TR38.884 on minimum SNR for RRM test cases for band n263 | Apple | Revised |  |
| R4-2203705 | TP to TR38.884 on minimum SNR for demodulation test cases for band n263 | Apple | Revised |  |
| R4-2203706 | Proposals to conclude the enhanced test methods study item | Apple | Noted |  |
| R4-2204386 | FR2-2 OTA test methods for UE demodulation | Intel Corporation | Noted |  |
| R4-2204964 | TP to TR38.884 on applicability extension of test methods for band FR2-2 | vivo | Merged | Content will be merged into the revision of R4-2206092 |
| R4-2204965 | Discussion on test methods for FR2-2 | vivo | Noted |  |
| R4-2205007 | Discussion on FR2-2 OTA test methods | Huawei, HiSilicon | Noted |  |
| R4-2205915 | FR2-2 OTA test methods for UE RRM | Intel Corporation | Noted |  |
| R4-2206091 | On general aspects and UE testing methodology for FR2-2 | Intel Corporation | Noted |  |
| R4-2206092 | TP for TR 38.884 on NR test methods extension to FR2-2 | Intel Corporation | Revised |  |
| R4-2206116 | MIMO EVM Measurement for FR2 | Lenovo | Noted | Text proposal content can be merged into the revision of R4-2206092 |

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

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| **T-doc number** | **Title** | **Source** | **Recommendation** | **Comments** |
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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** |
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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)