**3GPP TSG-RAN WG4 Meeting #110bis R4-2405843**

**Changsha, China, 15th – 19th April, 2024**

**Agenda item:** 6.11.4

**Source:** Moderator (China Telecom)

**Title:** Topic summary for [110bis] [324] NR\_demod\_enh3\_Part1

**Document for:** Information

# Introduction

This contribution summarizes the open issues, candidate options as well as the recommended WF for the advanced receiver for MU-MIMO part of the Rel-18 NR demodulation requirement evolution WI under agenda 6.11.

# Topic #1: Test parameters and simulation results

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2404211 | Qualcomm Incorporated | Proposal 1: The R-ML requirement is applicable only when all the conditions in the previous observation are satisfied and signaled to the DUT UE. We suggest to signal 256QAM MCS table for maximum MCS table of co-scheduled UEs in the test, which is a more practical case.Proposal 2: When defining the requirement, the precoding matrices across co-scheduled UEs should be orthogonal given that it is a simple enhancement from the network to achieve a better performance in MU-MIMO scenarios.Proposal 3: Introduce demod requirements for R-ML receiver when DCI 6 is signaled unless significant concerns are raised.Proposal 4: We propose to consider the following categories of tests and list the corresponding receiver architecture:Type of DUT/DCI signaling MOD detection supported MOD detection not supportedDCI 1-5 R-ML R-MLDCI 6 R-ML• Applicability of this test depends on UE capability/declaration E-LMMSE or test not applicable• May have the same configuration as the corresponding R-ML test, but the SNR requirement can be different• Pending on the following FFS: whether test cases need to be introduced for cases which R-ML receiver not applicableWe also propose to have the same test configurations for the two rows except different DCI signaling (using a slightly different DCI signaling applicability scope of each code point without violating the definition) to simplify the test configurations. Note that DCI 6 can be tested by the identical tests with two sets of requirements. Therefore, we have a common test set for all the entries above except DCI signaling and SNR requirements.Proposal 5: When UE satisfies the requirement of the tests with DCI 6 is signaled, it can skip the corresponding tests with identical test configurations except MU-MIMO DCI signaling being 1 to 5.Proposal 6: For the common test set proposed above, we propose the following configurations besides the common ones proposed above.• Full allocation, 1 co-scheduled UE, and the co-scheduled UE modulation order is smaller than the target UE modulation order to achieve better R-ML receiver gain. Partial allocation can be considered if RAN4 agrees that it is a practical scenario that requires verification.Test Rank/DMRS Serving MCS Intf MCS Channel1 1+1 13 (16QAM) QPSK TDL-C 300ns 100Hz, Med. Corr. 2 2+2 17 (64QAM) 16QAM TDL-A 30ns 10Hz, Low corr. |
| R4-2404237 | MediaTek Inc. | Observation #1: On Rank 1+1 tests with 2T2R MCS17 for target UE leads to too high SNR requirements in our view.Observation #2: On Rank 1+1 tests with 2T2R and MCS13 for target UE our simulations show the following channels as feasible tests: TDLC300-100 ULA medium with both precoder options, and TDLC300-100 ULA low.Proposal #1: For 1+1 2T2R, we support orthogonal precoding, TDLC300-100, ULA medium, MCS 13 (Table 1) for Target UE, QPSK for co-UE.Observation #3: On Rank 1+1 tests with 2T4R TDLA30-10 ULA low does not give enough gain over MMSE-IRC.Observation #4: On Rank 1+1 tests with 2T4R MCS17 for target UE leads to too high SNR requirements in our view.Observation #5: On Rank 1+1 tests with 2T4R and MCS13 for target UE our simulations show the following channels as feasible tests: TDLC300-100 ULA medium with both precoder options.Proposal #2: For 1+1 2T4R, we support orthogonal precoding, TDLC300-100, ULA medium, MCS 13 (Table 1) for Target UE, QPSK for co-UE.Observation #6: On Rank 2+2 tests with 4T4R and MCS17 for target UE does not give enough gain over MMSE-IRC.Observation #7: On Rank 2+2 tests with 4T4R and MCS13 for target UE gives limited gain over MMSE-IRC.Proposal #3: For 2+2 4T4R, we support orthogonal precoding, TDLA30-10, XP medium, MCS 13 (Table 1), or MCS17, for Target UE, QPSK for co-UE.Proposal #4: Use the same test configurations to MOBD tests as selected for genie MO, if possibleProposal #5: We support Option 2 not to introduce such test for UE not supporting BD-MO with R-ML.Proposal #6: We support Option 2 to signal MCS table in tests without modulation order blind detection.Proposal #7: We support Option 1 with RRC-based assistant signalling indicating 256-QAM MCS table for co-scheduled UEs.Proposal #8: We propose to remove Notes in Proposal 1 to test MODB capable UEs also with known MO. |
| R4-2404238 | MediaTek Inc. | Simulation results of Advanced receiver to cancel inter-user interference for MU-MIMOObservations of Rank 1+1 2T2R testsObservation #1: Rank 1+1 tests with 2T2R MCS17 for target UE lead to too high SNR requirements in our view.Observation #2: On Rank 1+1 tests with 2T2R and MCS13 for target UE our simulations show the following channels as feasible tests: TDLC300-100 ULA medium with both precoder options, and TDLC300-100 ULA low with random precoder.Observations of Rank 1+1 2T4R testsObservation #3: On Rank 1+1 tests with 2T4R TDLA30-10 ULA low R-ML does not give enough gain over MMSE-IRC.Observation #4: On Rank 1+1 tests with 2T4R MCS17 for target UE leads to too high SNR requirements in our view.Observation #5: On Rank 1+1 tests with 2T4R and MCS13 for target UE our simulations show the following channels as feasible tests: TDLC300-100 ULA medium with both precoder options.Observations of Rank 2+2 4T4R testsObservation #6: On Rank 2+2 tests with 4T4R and MCS17 for target UE R-ML does not give enough gain over MMSE-IRC.Observation #7: On Rank 2+2 tests with 4T4R and MCS13 for target UE R-ML gives limited gain over MMSE-IRC. |
| R4-2404293 | Apple | Observation #1: For all cases evaluated R-ML performance is better than baseline MMSE-IRC when modulation order is signaled.Observation #2: For 4x4 cases the performance gain of R-ML for ULA -Low and XP medium antenna correlation are comparable when modulation order is signaledObservation #3: The performance is improved by ~ 1dB with orthogonal precoder compared to random precoder for 1+1 with medium ant correlation when modulation order is signaled.Observation #4: For 1+1 with TDLA channel, Low antenna correlation, the performance with R-ML is very close to MMSE-IRC with modulation order detection.Observation #5: For 1+1 with either TDLC channel or Medium antenna correlation the performance of R-ML is better than MMSE-IRC across both MCS13+QPSK and MCS17+16QAM with modulation order detectionObservation #6: Performance with orthogonal precoder is significantly better than random precoder with modulation order detectionObservation #7: For 2+2 performance with R-ML with modulation order detection is not significantly better than MMSE-IRCProposal #1: Requirements with modulation order detection are only applicable to UE supporting modulation order detection. Proposal #2: No new requirements are introduced for UEs that don’t support this feature of modulation order detection in Rel-18. Observation #8: The RRC NWA for MCS table indication is not conditioned on UE capability for R-ML receiver in MU-MIMO without modulation order signaled. Proposal #3: For RRC assistance information on MCS table of potential co-scheduled UEs indicate 64QAM MCS table.Observation #9: The target UE is not configured with 256QAM in the test, and there is no need to configure 256QAM MCS table in the test. Proposal #4: In test configuration use MCS table 1 – 64QAM for target UE. Observation #10: There is significant performance delta with orthogonal precoders compared to random precoder. Observation #11: The UE is not being tested with in any different way by using random precoder for co-scheduled UEs.Observation #12: Using random precoders for RAN4 requirements sets a bad precedent. Proposal #5: Define requirements for MU-MIMO with advanced receiver using orthogonal precoders for all cases.Proposal #6: If requirements with 2T4R are defined use MediumA instead of Medium antenna correlation.Proposal #7: Define requirements with the following test parameters when modulation order is signaled: For rank 1+1 tests with 2T2R: Target MCS: 13 (Table 1) Co-scheduled UE: QPSK MIMO configuration: 2x2 ULA Med  Channel: TDLC300-100 Orthogonal precodersFor rank 2+2 tests with 4T4R: Target MCS: 17 (Table 1) Co-scheduled UE: 16QAM MIMO configuration: 4x4 ULA Low Channel: TDLA30-10Proposal #8: Define requirements with the following test parameters when modulation order is not signaled: For rank 1+1 tests with 2T2R and 2T4R: Target MCS: 17 (Table 1) Co-scheduled UE: 16QAM MIMO configuration: 2x2 , 2x4 ULA Low Channel: TDLC300-100 Orthogonal precoders |
| R4-2404294 | Apple | Simulation resultsObservation #1: For all cases evaluated R-ML performance is better than baseline MMSE-IRCObservation #2: For 4x4 cases the performance gain of R-ML for ULA -Low and XP medium antenna correlation are comparableObservation #3: The performance is improved by ~ 1dB with orthogonal precoder compared to random precoder for 1+1 with medium ant correlation. Observation #4: For 1+1 with TDLA channel, Low antenna correlation, the performance with R-ML is very close to MMSE-IRCObservation #5: For 1+1 with either TDLC channel or Medium antenna correlation the performance of R-ML is better than MMSE-IRC across both MCS13+QPSK and MCS17+16QAMObservation #6: Performance with orthogonal precoder is significantly better than random precoder Observation #7: For 2+2 performance with R-ML with BD-MO is not significantly better than MMSE-IRC |
| R4-2404296 | Apple | Simulation result summary for MU-MIMO with advanced receiver |
| R4-2404391 | China Telecom | Proposal 1: Consider the following case for Rank 1+1 with 2T2R test requirement without modulation order blind detection:– Random precoding, TDLC300-100, ULA medium, MCS 13 (Table 1) for Target UE, QPSK for co-UE, full FDRA for the co-UEProposal 2: Consider the following case for Rank 2+2 with 4T4R test requirement without modulation order blind detection:– Orthogonal precoding, TDLA30-10, ULA Low, MCS 17 (Table 1) for Target UE, 16QAM for co-UE. full FDRA for the co-UEProposal 3: Consider the following case for Rank 1+1 with 2T2R test requirement with modulation order blind detection:– Case#27: Random precoding, TDLC300-100, ULA low, MCS 17 (Table 1) for Target UE, 16QAM for co-UE, full FDRA for the co-UEProposal 4: 2T4R with rank 1+1, follow the same test scope for requirements without modulation order blind detection.Proposal 5: Consider the following case for Rank 2+2 with 4T4R test requirement with modulation order blind detection:– Case#32: Orthogonal precoding, TDLA30-10, XP medium, MCS 13 (Table 1) for Target UE, QPSK for co-UE, full FDRA for the co-UEProposal 6: Do not introduce such test for UE not support BD-MO with R-ML.Observation 1: RAN4 has already agreed that UE modulation order blind detection capability is optional without capability signaling thus the NW is highly likely to message this RRC signaling for all UEs supporting R-ML receiver in practical.Proposal 7: For the RRC assistant information configuration on the MCS table, the RRC configuration on MCS Table should be ‘256QAM MCS Table’ for both tests with and without modulation order blind detection.Proposal 8: Introduce applicability rule to skip tests with modulation order indicated for UEs capable of BD MO.Proposal 9: The following detailed test applicability rule is proposed: |
| R4-2404392 | China Telecom | Discussion on test parameters for the advanced receiver for MU-MIMO: Simulation results |
| R4-2404525 | Nokia | Test requirements without modulation order blind detection (DCI index 1-5 is indicated)Observation 1: Using orthogonal precoder or co-UE gives < 1dB gain as compared to using random precoder with R ML receiver for rank 1+1 cases 2T2R and 2T4R antenna configurations.Proposal 1: Define Rank 1+1 with 2T2R using following parameters (case 1): Random precoding, TDLC300-100, ULA medium, MCS 13 (Table 1) for Target UE, QPSK for co-UE, full FDRA for the co-UE.Observation 2: Last meeting (RAN4#110) it was agreed to not define test with rank1+1 with 2T4R antenna configuration if test with rank2+2 with 4T4R is defined.Proposal 2: If requirements are introduced for rank 1+1 with 2T4R then define using following parameters (case 3): Random precoding, TDLC300-100, ULA medium, MCS 13 (Table 1) for Target UE, QPSK for co-UE, full FDRA for the co-UE.Observation 3: 16QAM is a typical MO in deployment and it exercise the reduced complexity part of R-ML in rank 2+2 cases.Observation 4: R-ML receiver shows 1.5 to 2dB gain over E-IRC/MMSE-IRC and feasible SNR (<20dB) for rank 2+2 cases with 16QAM scheduled for co-UE.Proposal 3: Define Rank 2+2 tests with 16 QAM scheduled for co-UE using either ULA low or XP medium antenna configurations (cases 7, 8 in latest simulation results template)Test requirements with modulation order blind detection (DCI index 6 is indicated)Observation 5: Requirement definition for rank 1+1 test cases with 2T2R and 2T4R being considered for UEs without MO BD are feasible also with MO BDProposal 4: Define rank 1+1 testcases with MO BD to be the same as without MO BD but with signalling of DCI index 6.Proposal 5: Define rank 2+2 test case with MO BD using MCS13 for target UE and QPSK for co-UE and using XP medium antenna correlation (Case 32)Whether to tests UE not supporting BD-MO with R-ML with DCI index 6 is indicatedObservation 6: E-IRC receiver has no or marginal gain over Rel 17 MMSE-IRC receiver when antenna correlation is low.Observation 7: E-IRC receiver requires over 20 dB SNR in medium antenna correlation to achieve 70% throughput.Proposal 6: Not to define E-IRC receiver based testcases for UEs not supporting BD-MO when DCI index 6 is signalled.MCS TableObservation 8: UEs not supporting MO BD are not expected to use R-ML receiver when DCI value 6 is signalled to them.Proposal 7: Do not introduce RRC assistant information regarding MCS table of co-UEs to UEs not supporting MO BD (option 1).Proposal 8: Introduce RRC assistant information signalling of ‘256 QAM MCS table’ for co-UEs to UEs supporting MO BD (option 1).For UE supporting MO BD, whether to introduce applicability ruleObservation 9: UEs capable of BD MO should be capable of passing all tests meant for UEs without BD MO support.Proposal 9: Introduce applicability rule to skip tests with modulation order indicated for UEs capable of BD MO in cases where there is insignificant difference (< 0.5 dB) between DCI 1 to 5 requirements and DCI 6 requirements with same configuration of target and co-UEs. |
| R4-2404526 | Nokia | On Advanced Receivers - Test parameters - Simulations |
| R4-2404750 | Samsung | Proposal 1: For Rank 1+1 with 2T2R, select Case#5: Orthogonal precoding, TDLC300-100, ULA medium, MCS 13 (Table 1) for Target UE, QPSK for co-UE, full FDRA for the co-UE as the test assumptions.Proposal 2: For Rank 1+1 with 2T4R, if test requirements are introduced, prefer to select Case#6: Orthogonal precoding, TDLC300-100, ULA medium, MCS 13 (Table 1) for Target UE, QPSK for co-UE, full FDRA for the co-UE as the test assumptions.Proposal 3: For Rank 2+2 with 4T4R, prefer to select Case#9 or Case#10 as the simulation assumptions.– Case#9: Orthogonal precoding, TDLA30-10, ULA Low, MCS 17 (Table 1) for Target UE, 16QAM for co-UE, full FDRA for the co-UE– Case#10: Orthogonal precoding, TDLA30-10, XP medium, MCS 17 (Table 1) for Target UE, 16QAM for co-UE, full FDRA for the co-UEProposal 4: For test requirements with modulation order blind detection (DCI index 6 is indicated), prefer to select Case#31 and Case#32 for Rank 1+1 with 2T2R and 2T4R separately. And for Rank 2+2 with 4T4R scenario, prefer to select Case#34.Proposal 5: Do not introduce test cases for UE not supporting BD-MO with R-ML with DCI index 6 is indicated.Proposal 6: For UEs not supporting modulation order blind detection, no need for the network to inform MCS table information to the UE.Proposal 7: For UEs supporting modulation order blind detection, RRC-based assistant signalling on MCS table should be align with the MCS table configuration in the test.Proposal 8: For UE supporting MO BD, do not prefer to introduce applicability rule to skip test(s) with modulation order indicated.Proposal 9: Introduce applicability rule in Clause 5.1.1.3 for UEs supporting MU-MIMO Interference Mitigation advanced receiver (R-ML) as below: |
| R4-2405156 | Huawei, HiSilicon | Proposal 4: RAN4 to consider following test setup for cases without modulation order detection. For Rank 1+1: TDLC300-100, Orthogonal PMI selection, 2T2R ULA medium, MCS13(Target UE) +QPSK(Co-UE) For Rank 2+2: TDLA30-10, Orthogonal PMI selection, 4T4R, XPL medium, MCS13(Target UE) +QPSK(Co-UE) DCI index 1 is configured and RRC assistant signaling on MCS table is disabled.Proposal 5: RAN4 to consider following test setup for cases with modulation order detection. For Rank 1+1: TDLC300-100, Orthogonal PMI selection, 2T2R/2T4R ULA medium, MCS17(Target UE) +16QAM(Co-UE) DCI assistant signaling is disabled and RRC assistant signaling on MCS table indicates “256QAM Table”.Proposal 6: Introduce the test applicability rules that if UE passes the Rank 1+1 cases with MO detection, UE can skip the Rank 1+1 cases without MO detection. |
| R4-2405157 | Huawei, HiSilicon | Simulation results for advanced receiver for MU-MIMO |
| R4-2405203 | ZTE Corporation | Proposal 1. Do not introduce test cases for UE not support BD-MO with R-ML.Proposal 2. No need for the network to inform such information to the UE when UEs not support modulation order blind detection.Proposal 3. Align with the MCS table configuration in the test when UEs supporting modulation order blind detection.Proposal 4. Introduce applicability rule to skip tests with modulation order indicated for UEs capable of BD MO.Proposal 5. Considering the following applicable rule for R-ML receiver. |
| R4-2405204 | ZTE Corporation | Simulation results for MU-MIMO with R-ML receiver |
| R4-2405476 | Ericsson | Proposal 1: Select case#1 for rank 1+1 with 2T2RProposal 2: Select case#4 for rank 1+1 with 2T4R (if introduced)Proposal 3: Select case#10 or case#11 for rank 2+2 with 4T4RObservation 1: for rank 1+1 with 2T2R, case #21, 22, 29 and 31 showed enough gainObservation 2: For rank 1+1 with 2T4R, only case#24 and 30 showed enough gainObservation 3: For rank 2+2 with 4T4R, both case#33 and 34 showed enough gainProposal 4: No need for the network to inform such information to those UEs not supporting modulation order blind detectionProposal 5: RRC-based assistant signaling on MCS table should be ‘256QAM MCS Table’ for those UEs supporting modulation order blind detectionProposal 6: Consider proposal 1 from the WF [1] as the basis of the test applicability rule. |
| R4-2405477 | Ericsson | Updated simulation results for phase II |

## Open issues summary

### Sub-topic 1-1 Test parameters

**Issue 1-1-1: Test setting for when UE is indicated Modulation order (DCI index 1-5 is indicated)**

* *Status in the last meeting WF in R4-2402864*

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| *For Rank 1+1 with 2T2R, down select among the following cases:** + *Case#1:**Random precoding, TDLC300-100, ULA medium, MCS 13 (Table 1) for Target UE, QPSK for co-UE, full FDRA for the co-UE*
	+ *Case#5: Orthogonal precoding, TDLC300-100, ULA medium, MCS 13 (Table 1) for Target UE, QPSK for co-UE. full FDRA for the co-UE*

*For Rank 1+1 with 2T4R:** + *Not cover Rank 1+1 with 2T4R for test if test case is defined for rank 2+2*
	+ *IF test requirements are introduced for rank 1+1 with 2T4R, down select among the following cases:*
		- *Random precoding, TDLC300-100, ULA medium, MCS 13 (Table 1) for Target UE, QPSK for co-UE, full FDRA for the co-UE*
		- *Orthogonal precoding, TDLC300-100, ULA medium, MCS 13 (Table 1) for Target UE, QPSK for co-UE. full FDRA for the co-UE*

*For Rank 2+2 with 4T4R, down select among the following cases:** + *Case#7: Orthogonal precoding, TDLA30-10, ULA Low, MCS 13 (Table 1) for Target UE, QPSK for co-UE, full FDRA for the co-UE*
	+ *Case#8: Orthogonal precoding, TDLA30-10, XP medium, MCS 13 (Table 1) for Target UE, QPSK for co-UE. full FDRA for the co-UE*
	+ *Case#9: Orthogonal precoding, TDLA30-10, ULA Low, MCS 17 (Table 1) for Target UE, 16QAM for co-UE. full FDRA for the co-UE*
	+ *Case#10: Orthogonal precoding, TDLA30-10, XP medium, MCS 17 (Table 1) for Target UE, 16QAM for co-UE. full FDRA for the co-UE*
	+ *Orthogonal precoding, TDLA30-10, XP medium, MCS 17 (Table 1) for Target UE, QPSK for co-UE. full FDRA for the co-UE*
 |

* Proposals for Rank 1+1 with 2T2R:
	+ Option 1: **Random precoding**, TDLC300-100, ULA medium, MCS 13 (Table 1) for Target UE, QPSK for co-UE, full FDRA for the co-UE (China Telecom, Nokia, Ericsson)
		- CTC: For 2Tx tests with rank 1, there are totally only 4 candidate precoders to use, which is a strict restriction to require NW in reality to only schedule orthogonal precoding.
	+ Option 2: **Orthogonal precoding**, TDLC300-100, ULA medium, MCS 13 (Table 1) for Target UE, QPSK for co-UE. full FDRA for the co-UE (Qualcomm, MTK, Apple, Samsung, Huawei)
* Proposals for Rank 1+1 with 2T4R (if introduced)
	+ Option 1: Random precoding, TDLC300-100, ULA medium, MCS 13 (Table 1) for Target UE, QPSK for co-UE, full FDRA for the co-UE (Nokia, Ericsson)
	+ Option 2: Orthogonal precoding, TDLC300-100, ULA medium, MCS 13 (Table 1) for Target UE, QPSK for co-UE. full FDRA for the co-UE (MTK, Samsung)
* Proposals for Rank 2+2 with 4T4R:
	+ Option 1: Orthogonal precoding, TDLA30-10, XP medium, MCS 13 (Table 1) for Target UE, QPSK for co-UE. full FDRA for the co-UE (MTK, Huawei)
	+ Option 2: Orthogonal precoding, TDLA30-10, ULA Low, MCS 17 (Table 1) for Target UE, 16QAM for co-UE. full FDRA for the co-UE (China Telecom, Qualcomm, Apple, Nokia, Samsung)
	+ Option 3: Orthogonal precoding, TDLA30-10, XP medium, MCS 17 (Table 1) for Target UE, 16QAM for co-UE. full FDRA for the co-UE (Samsung, Ericsson, Nokia)
	+ Option 4: Orthogonal precoding, TDLA30-10, XP medium, MCS 17 (Table 1) for Target UE, QPSK for co-UE. full FDRA for the co-UE (MTK, Ericsson)
* Recommended WF
	+ Need discussion based on the simulation result summary

**Issue 1-1-2: Test setting for when UE is not indicated Modulation order (DCI index 6 is indicated)**

* *Status in the last meeting WF in R4-2402864*

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| * + *Down select among the Case#21 to Case#34 in R4-2400805*
	+ *Remove Case 35 and 36 in the study given most companies show limited performance gain over the baseline*
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* Proposals for Rank 1+1 with 2T2R:
	+ Option 1: Random precoding, TDLC300-100, ULA low, MCS 17 (Table 1) for Target UE, 16QAM for co-UE, full FDRA for the co-UE (China Telecom)
	+ Option 2: Orthogonal precoding, TDLC300-100, ULA low, MCS 13 (Table 1) for Target UE, QPSK for co-UE, full FDRA for the co-UE (Apple)
	+ Option 3: Orthogonal precoding, TDLC300-100, ULA medium, MCS 17 (Table 1) for Target UE, 16QAM for co-UE, full FDRA for the co-UE (Samsung, Huawei)
	+ Option 4: Same configuration as tests without modulation order blind detection (Qualcomm, MTK, Nokia)
* Proposals for Rank 1+1 with 2T4R:
	+ Option 1: Follow the same test scope for requirements without modulation order blind detection (China Telecom, MTK, Nokia)
	+ Option 2: Orthogonal precoding, TDLC300-100, ULA medium, MCS 17 (Table 1) for Target UE, 16QAM for co-UE, full FDRA for the co-UE (Samsung, Huawei)
	+ Option 3: Orthogonal precoding, TDLC300-100, ULA low, MCS 13 (Table 1) for Target UE, QPSK for co-UE, full FDRA for the co-UE (Apple)
* Proposals for Rank 2+2 with 4T4R:
	+ Option 1: Introduce rank 2+2 4T4R requirements with modulation order blind detection (China Telecom, Qualcomm, MTK, Nokia, Samsung)
		- Option 1A: Orthogonal precoding, TDLA30-10, XP medium, MCS 13 (Table 1) for Target UE, QPSK for co-UE, full FDRA for the co-UE (China Telecom, Nokia, Samsung)
		- Option 1B: Same configuration as tests without modulation order blind detection (Qualcomm, MTK)
	+ Option 2: Do not introduce rank 2+2 4T4R requirements with modulation order blind detection (Apple, [Huawei])
* Recommended WF
	+ Need discussion based on the simulation result summary

**Issue 1-1-3: Whether to tests UE not support BD-MO with R-ML with DCI index 6 is indicated**

* *Status in the last meeting WF in R4-2402864*

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| * + *Option 1: Introduce test cases only applicable to the UE which can perform E-IRC receiver in that case*
	+ *Option 2: Do not introduce such test for UE not support BD-MO with R-ML*
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* Proposals:
	+ Option 1: Introduce test cases only applicable to the UE which can perform E-IRC receiver in that case (Qualcomm)
		- QC: Same test configuration as UE supporting modulation order blind detection.
	+ Option 2: Do not introduce such test for UE not support BD-MO with R-ML (China Telecom, MTK, Apple, Nokia, Samsung, ZTE)
* Recommended WF
	+ Option 2?

**Issue 1-1-4: RRC assistant information configuration on the MCS table**

* *Status in the last meeting WF in R4-2402864*

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| *Candidate options on the RRC assistant information configuration on the MCS table:** + *For UEs not supporting modulation order blind detection:*
		- *Option 1: No need for the network to inform such information to the UE*
		- *Option 2: Should be presented regardless of whether the UE supports MO BD*
		- *Option 2A: ‘64QAM MCS Table’*
	+ *For UEs supporting modulation order blind detection:*
		- *Option 1: RRC-based assistant signalling on MCS Table should be ‘256QAM MCS Table’*
		- *Option 2: Align with the MCS Table configuration in the test*
 |

* Proposals:
	+ For UEs not supporting modulation order blind detection:
		- Option 1: No need for the network to inform such information to the UE (Nokia, Samsung, Huawei, ZTE, Ericsson)
		- Option 2: Signalled regardless of whether the UE supports MO BD (China Telecom, Qualcomm, MTK, Apple)
		- Option 2A: 256QAM MCS Table (China Telecom, Qualcomm, MTK)
		- Option 2B: 64QAM MCS table (Apple)
	+ For UEs supporting modulation order blind detection:
		- Option 1: 256QAM MCS Table (China Telecom, MTK, Nokia, Huawei, Ericsson)
		- Option 2: Align with the MCS Table configuration in the test, i.e., 64QAM MCS table (Apple, Samsung, ZTE)
* Recommended WF
	+ TBA

### Sub-topic 1-2 Test applicability

**Issue 1-2-1: For UE supporting MO BD, whether to introduce applicability rule to skip test(s) with modulation order indicated**

* *Status in the last meeting WF in R4-2402864*

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| * + *Option 1: Introduce applicability rule to skip tests with modulation order indicated for UEs capable of BD MO*
	+ *Option 2: Do not introduce applicable rule skip tests with modulation order indicated*
 |

* Proposals:
	+ Option 1: Introduce applicability rule to skip tests with modulation order indicated for UEs capable of BD MO (China Telecom, Qualcomm, Huawei, ZTE, Nokia in case there is there is insignificant difference between with and without MO BD)
	+ Option 2: Do not introduce applicable rule skip tests with modulation order indicated (MTK, Samsung)
* Recommended WF
	+ Discussion needed.

**Issue 1-2-2: Test applicability rule for different test cases**

* *Agreements in the previous WF in R4-2321114*

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| *Test scope** + *Reuse the same test scope for Rel-17 MMSE-IRC for MU-MIMO (across both with MO signalled and not signaled):*
* *Both FDD 15kHz SCS with 10MHz CHBW and TDD 30kHz SCS with 40MHz CHBW*
* *2Tx-2Rx with rank 1+1 for target and co-scheduled UE*
* *2Tx-4Rx with rank 1+1 for target and co-scheduled UE*
* *4Tx-4Rx, with rank 2+2 for target and co-scheduled UE(s)*
	+ *FFS on the test applicability rule based on different UE types.*

*The UE Types to be covered in terms of #layers it can process with R-ML:*1. *Capability when modulation order is signaled (index 1-5)*
	1. *Up to maxNumberMIMO-LayersPDSCH layers across target and co-scheduled UEs in 2 RX and 4RX condition*
2. *Capability when modulation order is not signalled (index 6)*
	1. *UE cannot support R-ML*
	2. *UE can support 2 layers across target and co-scheduled UEs with 2RX and 4RX*
	3. *UE can support 2 layers across target and co-scheduled UEs with 2RX and can support maxNumberMIMO-LayersPDSCH layers across target and co-scheduled UEs with 4RX*
3. *Capability when modulation order is not signalled (index 7)*
	1. *UE is not expected to support R-ML*
 |

* Proposals:
	+ Proposal 1: (China Telecom, [Qualcomm, Ericsson])

|  |  |  |
| --- | --- | --- |
| UE type | Test applicability | Note |
| R-ML for up to *maxNumberMIMO-LayersPDSCH* layers across target and co-scheduled UEs with 2 RX when co-scheduled UE(s)’ modulation order is signaled | Test 1-1 |  |
| R-ML for up to *maxNumberMIMO-LayersPDSCH* layers across target and co-scheduled UEs with 4 RX when co-scheduled UE(s)’ modulation order is signaled | [Test 2-1]Test 3-1 |  |
| R-ML [for 2 layers across target and co-scheduled UEs with 2RX] with MO Not signaledR-ML [for maxNumberMIMO-LayersPDSCH layers across target and co-scheduled UEs with 2RX] with MO Not signaled | Test 1-1Test 1-2 | Test 1-1 can be skipped if Test 1-2 is passed. |
| R-ML [for 2 layers across target and co-scheduled UEs with 4RX] with MO Not signaled | [Test 2-1Test 2-2] | Test 2-1 can be skipped if Test 2-2 is passed. |
| R-ML [for maxNumberMIMO-LayersPDSCH layers across target and co-scheduled UEs with 4RX] with MO Not signaled | [Test 2-1Test 2-2]Test 3-1Test 3-2 | Test 2-1 can be skipped if Test 2-2 is passed.Test 3-1 can be skipped if Test 3-2 is passed. |
| Test 1-1: 2Tx-2Rx with rank 1+1 with modulation order signaledTest 1-2: 2Tx-2Rx with rank 1+1 with modulation order Not signaled[Test 2-1: 2Tx-4Rx with rank 1+1 with modulation order signaled][Test 2-2: 2Tx-4Rx with rank 1+1 with modulation order Not signaled]Test 3-1: 4Tx-4Rx with rank 2+2 with modulation order signaledTest 3-2: 4Tx-4Rx with rank 2+2 with modulation order Not signaled |

* + Proposal 2: (Samsung)

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| --- | --- | --- | --- |
| **UE feature/capability [14]** | **Test type** | **Test list** | **Applicability notes** |
| MU-MIMO Interference Mitigation advanced receiver (R-ML), when co-scheduled UE(s)’ modulation order is signaled | FR1 FDD | PDSCH | Clause 5.2.2.1.XClause 5.2.3.1.X | If UE only support R-ML receivers for MU-MIMO for 2 layers across target and co-scheduled UE with 2Rx, Test 1-1 in Clause 5.2.2.1.X should be passed.If UE support R-ML receivers for MU-MIMO for maxNumberMIMO-LayersPDSCH layers across target and co-scheduled UEs with 4RX, Test 1-1 in Clause 5.2.3.1.X should be passed. |
| FR1 TDD | PDSCH | Clause 5.2.2.2.XClause 5.2.3.2.X | If UE only support R-ML receivers for MU-MIMO for 2 layers across target and co-scheduled UE with 2Rx, Test 1-1 in Clause 5.2.2.2.X should be passed.If UE support R-ML receivers for MU-MIMO for maxNumberMIMO-LayersPDSCH layers across target and co-scheduled UEs with 4RX, Test 1-1 in Clause 5.2.3.2.X should be passed. |
| MU-MIMO Interference Mitigation advanced receiver (R-ML) with modulation order detection, when co-scheduled UE(s)’ modulation order is not signaled | FR1 FDD | PDSCH | Clause 5.2.2.1.XClause 5.2.3.1.X | If UE only support R-ML receivers for MU-MIMO for 2 layers across target and co-scheduled UE with 2Rx, Test 1-2 in Clause 5.2.2.1.X should be passed.If UE support R-ML receivers for MU-MIMO for maxNumberMIMO-LayersPDSCH layers across target and co-scheduled UEs with 4RX, Test 1-2 in Clause 5.2.3.1.X should be passed. |
| FR1 TDD | PDSCH | Clause 5.2.2.2.XClause 5.2.3.2.X | If UE only support R-ML receivers for MU-MIMO for 2 layers across target and co-scheduled UE with 2Rx, Test 1-2 in Clause 5.2.2.2.X should be passed.If UE support R-ML receivers for MU-MIMO for maxNumberMIMO-LayersPDSCH layers across target and co-scheduled UEs with 4RX, Test 1-2 in Clause 5.2.3.2.X should be passed. |

* + Proposal 3: (ZTE)

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| **UE feature/capability** | **Test type** | **Test list** | **Applicability notes** |
| MU-MIMO Interference Mitigation advanced receiver with modulation order not signalled | FR1 FDD | PDSCH | Clause 5.2.2.1.X (Test X1)Clause 5.2.3.1.X(Test X1) | The UE can perform R-ML receiver when assistance of network signalling is no configured. |
|  | FR1 TDD | PDSCH | Clause 5.2.2.2.X(Test X1)Clasue 5.2.3.2.X(Test X1) |  |
| MU-MIMO Interference Mitigation advanced receiver with modulation order signalled | FR1 FDD | PDSCH | Clause 5.2.2.1.X(Test Y1)Clause 5.2.3.1.X(Test Y1) | If the Test X1 in Clause 5.2.2.1.X is passed, the test coverage can be consider fulfilled without executing Test Y1 in clause 5.2.2.1.X.If the Test X1 in Clause 5.2.3.1.X is passed, the test coverage can be consider fulfilled without executing Test Y1 in clause 5.2.3.1.X. |
|  | FR1 TDD | PDSCH | Clause 5.2.2.2.X(Test Y1)Clause 5.2.3.2.X(Test Y1) | If the Test X1 in Clause 5.2.2.2.X is passed, the test coverage can be consider fulfilled without executing Test Y in clause 5.2.2.2.X.If the Test X1 in Clause 5.2.3.2.X is passed, the test coverage can be consider fulfilled without executing Test Y in clause 5.2.3.2.X. |

* Recommended WF
	+ Discuss within draft CR R4-2404751.

# Topic #2: Receiver assumption and NWA signaling

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2404211 | Qualcomm Incorporated | Proposal 7: If RAN4 agrees to not define 2+2 test under DCI 6, we propose to unify the two sub-UE features into one by removing number of layer descriptions to align the definition in the following:R-ML (reduced complexity ML) receivers with enhanced inter-user interference suppression for MU-MIMO when co-scheduled UE(s)’ modulation order is not signaled. |
| R4-2404292 | Apple | Observation #1: Based on performance evaluation we don’t see it feasible to define requirements with 4 layers with modulation order detection. Proposal #1: Remove FG 36-2b from UE feature list. |
| R4-2405156 | Huawei, HiSilicon | R4-2405156 Huawei,HiSilicon Proposal 1: Modify the note “ UE supports R-ML on MU-MIMO on single carrier operation. UE optionally supports R-ML on MU-MIMO on one or more carriers in CA operation” to “ UE supports R-ML on MU-MIMO on single carrier operation. UE optionally supports R-ML on MU-MIMO on one or more carriers in CA, NE-DC, EN-DC and NR-DC operation”.Observation 1: BS should be clearly informed that whether UE support decoding PDCCH with additional 3 bits DCI assistant signaling.Proposal 2: For the consequence if the feature group 36-1 is not supported by the UE, add following: UE is not capable of decoding PDCCH with DCI bits on presence of the co-scheduled UE information field in DCI format 1\_1.Proposal 3: Update the feature 36-1 as following:36. NR\_demod\_enh3 36-1 MU-MIMO Interference Mitigation advanced receiver  R-ML (reduced complexity ML) receivers with enhanced inter-user interference suppression, for MU-MIMO up to maxNumberMIMO-LayersPDSCH layers across target and co-scheduled UEs with 2 RX and 4RX antennas, when co-scheduled UE(s)’ modulation order is signaled UE not capable of advanced receiver to suppress inter-user inference in MU-MIMO; UE not capable of decoding PDCCH with DCI bits of the co-scheduled UE information field in DCI format 1\_1. Per UENote: UE supports R-ML on MU-MIMO on single carrier operation. UE optionally supports R-ML on MU-MIMO on one or more carriers in CA,NE-DC, EN-DC and NR-DC operation No FR1 only N/A Optional with capability signaling |
| R4-2405251 | Nokia | Observation 1: The phrase “the UE may assume” means that the UE should and will base its implementation on this assumption, hence it is not expected the UE will have special capabilities to handle situations where the assumption does not apply, hence we see no need to specifically indicate if different power boosting is configured in the NWProposal 1: Do not introduce RRC signalling to indicate different power boosting. |

## Open issues summary

### Sub-topic 2-1 UE capability aspects

**Issue 2-1-1: Details for UE capability definition**

* *Status in the last meeting WF in R4-2321114*

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| *The following feature has been captured in the R18 UE feature list LS to RAN2:*

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| --- | --- | --- | --- | --- | --- |
| ***Index*** | ***Feature group*** | ***Components*** | ***Prerequisite feature groups*** |  | ***Mandatory/Optional*** |
| *36-1* | *MU-MIMO Interference Mitigation advanced receiver*  | *R-ML (reduced complexity ML) receivers with enhanced inter-user interference suppression, for MU-MIMO up to maxNumberMIMO-LayersPDSCH layers across target and co-scheduled UEs with 2 RX and 4RX antennas, when co-scheduled UE(s)’ modulation order is signaled* | *3-4* | *…* | *Optional with capability signaling* |
| *36-2a* | *MU-MIMO Interference Mitigation advanced receiver with modulation order detection*  | *R-ML (reduced complexity ML) receivers with enhanced inter-user interference suppression for MU-MIMO* ***[for 2 layers across target and co-scheduled UEs with 2RX and 4RX]*** *when co-scheduled UE(s)’ modulation order is not signaled* | *36-1* | *…* | *Optional without capability signaling* |
| *36-2b* | *MU-MIMO Interference Mitigation advanced receiver with modulation order detection* | *R-ML (reduced complexity ML) receivers with enhanced inter-user interference suppression for MU-MIMO* ***[for 2 layers across target and co-scheduled UEs with 2RX and maxNumberMIMO-LayersPDSCH layers across target and co-scheduled UEs with 4RX]*** *when co-scheduled UE(s)’ modulation order is not signaled* | *36-1* | *…* | *Optional without capability signaling* |

 |

* Proposals on 36-2a and 36-2b:
	+ Proposal 1: Combine 36-2a and 36-2b and remove number of layer descriptions if RAN4 agrees to not define 2+2 test under DCI 6 (Qualcomm)
	+ Proposal 2: Remove FG 36-2b and keep 36-2a from UE feature list (Apple)
* Proposals on 36-1:
	+ Proposal 1: Update the feature 36-1 as following (Huawei)

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 36. NR\_demod\_enh3 | 36-1 | MU-MIMO Interference Mitigation advanced receiver  | R-ML (reduced complexity ML) receivers with enhanced inter-user interference suppression, for MU-MIMO up to *maxNumberMIMO-LayersPDSCH* layers across target and co-scheduled UEs with 2 RX and 4RX antennas, when co-scheduled UE(s)’ modulation order is signaled | UE not capable of advanced receiver to suppress inter-user inference in MU-MIMO; UE not capable of decoding PDCCH with DCI bits of the co-scheduled UE information field in DCI format 1\_1. | Per UENote: UE supports R-ML on MU-MIMO on single carrier operation. UE optionally supports R-ML on MU-MIMO on one or more carriers in CA,NE-DC, EN-DC and NR-DC operation  | No | FR1 only | N/A |  | Optional with capability signaling |

* Recommended WF
	+ For 36-2a and 36-2b, discuss after test scope for modulation order blind detection is clear.
	+ Quick check if update proposal on 36-1 can be accepted or not.

### Sub-topic 2-2 Others

**Issue 2-2-1: Assistant signalling on DMRS Power Boosting configuration**

* Proposals:
	+ Proposal 1: Do not introduce RRC signalling to indicate different power boosting (Nokia)
* Recommended WF
	+ RAN4 has provided our views in the LS R4-2403086 to RAN1 and RAN2. It is now RAN2’s decision based on their expertise as well as feedback from RAN4 and RAN1 (if any).
	+ No discussion on this issue.

# Topic #3: Draft CRs

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2404751 | Samsung | Draft CR on applicability rule of advanced receiver for MU-MIMO |
| R4-2405475 | Ericsson | Draft CR to 38.101-4 Introduction of FDD 2Rx PDSCH requirements for advanced receiver for MU-MIMO |
| R4-2405216 | ZTE Corporation | Draft CR on introduction of TDD 2Rx requirements for advanced receiver for MU-MIMO |
| R4-2404295 | Apple | DraftCR on FDD 4Rx requirements for advanced receiver for MU-MIMO |
| R4-2404239 | MediaTek inc. | Draft CR to 38.101-4 TDD 4Rx PDSCH requirements of MU-MIMO |
| R4-2404527 | Nokia | DraftCR for 38.101-4 on RMC for Advanced Receivers |
| R4-2404393 | China Telecom | Draft big CR for UE advanced receiver performance requirements for MU-MIMO |

## Open issues

**Issue 3-1: Draft CR review**

* Companies to provide comments and response under e-mail thread [110bis] [324] NR\_demod\_enh3\_Part1 – draft CR review.

**Issue 3-2: Whether new R-ML requirements should be captured in new clauses or in the existing clauses for MMSE-IRC under intra-cell inter-user scenario**

* Proposals:
	+ In draft CR R4-2405475/5216/4239, new clauses are created in TS38.101-4 for advanced receivers for MU-MIMO.
	+ In draft CR R4-2404295, R-ML new requirements are introduced in the existing clauses for MMSE-IRC under intra-cell inter-user scenario.
		- CTC: We will need to update 38.307 and may also need to update the existing test applicability rule.
		- QC: It might be cleaner if we have the test in the same clause but with letter suffix like A/B/C/D etc since it’s a different release from original clause.
* Release independent rule for R17 MMSE-IRC requirements in 38.307:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| * Table 5.4-1: Additional requirements of other release independent features

|  |  |  |  |
| --- | --- | --- | --- |
| Feature | Releaseindependent from | Requirements to be fulfilled(see 38.307 of the REL when the feature was introduced) | Further information |
| … | … | … | … |
| UE demodulation and CSI requirements for MMSE-IRC receiver for scenarios with inter cell and intra cell inter user interference | Rel-15 | Table B.3.3-1 | Rel-17 WI NR\_demod\_enh2-Perf: see Table B.3.3-1. These requirements are optional for Rel-15 and Rel-16 UEs and can be executed based on UE declaration. |

Table B.3.3-1: UE PDSCH demodulation and CSI requirements with MMSE-IRC receiver for scenarios with inter cell interference and intra cell inter user interference

|  |  |
| --- | --- |
| Section / Clause | Description |
| 5.2.2.1.15 | PDSCH demodulation requirements with inter cell interference for 2RX FDD |
| 5.2.3.1.15 | PDSCH demodulation requirements with inter cell interference for 4RX FDD |
| 5.2.2.2.16 | PDSCH demodulation requirements with inter cell interference for 2RX TDD |
| 5.2.3.2.16 | PDSCH demodulation requirements with inter cell interference for 4RX TDD |
| 5.2.2.1.16 | PDSCH demodulation requirements with intra cell inter user interference for 2RX FDD |
| 5.2.3.1.16 | PDSCH demodulation requirements with intra cell inter user interference for 4RX FDD |
| 5.2.2.2.17 | PDSCH demodulation requirements with intra cell inter user interference for 2RX TDD |
| 5.2.3.2.17 | PDSCH demodulation requirements with intra cell inter user interference for 4RX TDD |
| 6.2.2.1.2.3 | CQI requirements with inter cell interference for 2RX FDD |
| 6.2.3.1.2.3 | CQI requirements with inter cell interference for 4RX FDD |
| 6.2.2.2.2.2 | CQI requirements with inter cell interference for 2RX TDD |
| 6.2.3.2.2.2 | CQI requirements with inter cell interference for 4RX TDD |

 |

* Recommended WF
	+ Encourage feedback from other companies.