**3GPP TSG-RAN WG4 Meeting #110bis R4-2405849**

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

**Agenda item:** 6.21.4

**Source:** Moderator (Ericsson)

**Title:** Topic summary for [110bis][330] NR\_redcap\_enh\_demod

**Document for:** Information

# Introduction

This topic summary lists open issues on Demodulation performance part for Rel-18 WI Enhanced support of reduced capability NR devices.

* 6.21.3.1: UE demodulation performance and CSI requirements [NR\_redcap\_enh-Perf]

# Topic #1: UE demodulation and CSI reporting requirements

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2404329 | Apple | **Observation 1:** Rel-17 RedCap defines both Rank 1 and Rank 2 PDSCH requirements for 1Rx/2Rx UEs**Proposal 1:** Define Rank 1 and Rank 2 requirements for PDSCH for 64QAM modulation **Observation 2:** Use of 256 QAM modulation is an optional feature, as recognized in Rel-17 RedCap**Observation 3:** Use of 256 QAM modulation would exceed the maximum TBS for Rel-18 RedCap at meaningful PRB allocations**Proposal 2:** Do not define new requirements for PDSCH involving 256 QAM**Proposal 3:** RAN4 to discuss whether CQI and RI requirements can be reused by analysing what configurations might need to be adapted. |
| R4-2404330 | Apple | Not available |
| R4-2405097 | Ericsson | **Proposal 1:** Define PDSCH demodulation requirements with 64QAM with rank 1 for both 1Rx/2Rx.**Proposal 2:** Not to define PDSCH demodulation requirements with 256QAM for eRedCap UE.**Proposal 3:** Revise the simulation parameters for PDSCH test cases for UE supporting eRedCapNotReducedBB-BW-r18 (TDD SCS=30kHz) as follows:* QPSK: PRB size from 12 to 52, and TBS from 928 to 3840
* 16QAM: PRB size from 25 to 20.

**Proposal 4:** For SDR requirements, add the following sentence in TS 38.101-4 5.5.1: * For eRedCap with reduced peak date rate and reduced baseband bandwidth in FR1 (not supporting supporting *eRedCapNotReducedBB-BW-r18*), only 25 PRBs for 15kHz SCS and 12RBs for 30kHz SCS are allocated for PDSCH transmission.

**Proposal 5:** Add the definition of eRedCap in TS 38.101-4 3.1:* **eRedCap:** A UE with enhanced reduced capabilities as specified in clause 4.2 in TS 38.306 [14].

**Observation 1:** The smallest configurable PRB size for CSI-RS for CSI acquisition is 24 for eRedCap.**Proposal 6:** Configure the following CSI-RS frequency occupation parameters for CSI reporting requirements for eRedCap.* Frequency occupation for NZP CSI-RS for CSI acquisition: Start PRB 0 and number of PRB = 24
* Frequency occupation for ZP CSI-RS for CSI acquisition: Start PRB 0 and number of PRB = 24

**Proposal 7:** Configure the following PDSCH PRB allocation parameters for CSI reporting requirements for eRedCap to align with PRBs used for CSI-RS transmission. * For CQI reporting test, add the following note in the CQI-TBS table.

|  |  |  |
| --- | --- | --- |
| Number of allocated PDSCH resource blocks (Note 1) | 15 | 7 |
| Note 1: PDSCH are allocated from PRB 0 |

* For PMI reporting test, add the following note in the FRC table.

|  |  |  |
| --- | --- | --- |
| Reference channel |  | R.PDSCH.x-x.x |
| Channel bandwidth | MHz | 10 |
| Subcarrier spacing | kHz | 15 |
| Number of allocated resource blocks (Note 1) | PRBs | 25 |
| Note 1: PDSCH is allocated from PRB 0.  |

**Proposal 8:** Set SNR=5/6dB and SNR=11/12dB for CQI reporting test in static condition for FDD/HD-FDD/TDD with 1Rx, same as Rel-17 RedCap CQI reporting test in static condition. **Proposal 9:** Set SNR=8/9dB and SNR=14/15dB for CQI reporting test in static condition for FDD/HD-FDD/TDD with 2Rx, same as Rel-17 RedCap CQI reporting test in static condition.**Proposal 10:** Set SNR=9/10dB and SNR=15/16dB for CQI reporting test in fading condition for FDD/HD-FDD/TDD with 1Rx, same as Rel-17 RedCap CQI reporting test in fading condition. **Proposal 11:** Set SNR=6/7dB for CQI reporting test in fading condition for FDD/HD-FDD/TDD with 2Rx, same as Rel-17 RedCap CQI reporting test in fading condition. **Proposal 12:** Apply the same requirements as Rel-17 RedCap UE CQI reporting test in fading condition:* A CQI index not in the set {median CQI - 1, median CQI, median CQI + 1} shall be reported at least α% of the time where α = 20%.
* Throughput ratio of follow CQI and fixed median CQI shall be ≥ γ, where γ = 1.05
* Average BLER with follow CQI shall be greater than or equal to 0.02.

**Proposal 13:** Apply the same requirements as Rel-17 RedCap UE PMI reporting test for FDD/HD-FDD/TDD with 1Rx/2Rx:* Define the test metric as $γ=\frac{t\_{ue}}{t\_{rnd}}$ , where $t\_{ue}$ is 90 % of the maximum throughput obtained at $SNR\_{ue}$ using the precoders configured according to the UE reports, and $t\_{rnd}$ is the throughput measured at $SNR\_{ue}$ with random precoding based on type I Single Panel codebook.
* Set γ=1.3

**Proposal 14:** RAN4 should discuss the specification structure for eRedCap PDSCH demodulation and CQI/PMI reporting requirements.**Proposal 15:** Introduce applicability of demodulation requirements for eRedCap UE as follows in TS 38.101-4 5.1.1.**Proposal 16:** Introduce applicability of CSI reporting requirements for eRedCap UE as follows in TS 38.101-4 6.1.1. |
| R4-2405098 | Ericsson | Simulation results |
| R4-2405099 | Ericsson | Simulation results summary |
| R4-2405160 | Huawei, HiSilicon | **Proposal 1:** RAN4 to introduce 64QAM and 256QAM requirements for UE supporting or not supporting eRedCapNotReducedBB-BW-r18**Proposal 2:** Use tests listed in Table 2-1 for UE supporting or not supporting eRedCapNotReducedBB-BW-r18**Proposal 3:** Use CSI-RS configuration in Table 2-2 for CSI test |
| R4-2405161 | Huawei, HiSilicon | Simulation results |
| R4-2405941 | Qualcomm Incorporated | **Proposal 1:** RAN4 to consider the initial simulation results in the above tables for defining PDSCH demod performance.**Proposal 2:** Consider deprioritizing 256QAM modulation scheme for PDSCH demod tests.**Proposal 3:** Specify 64QAM test with rank1 configuration.**Proposal 4:** RAN4 to discuss CSI-RS BW allocation in CQI tests for eRedCap UEs. |

## Open issues summary

### Sub-topic 1-1 PDSCH demodulation requirements

Background: RAN4#110 agreed to define PDSCH demodulation requirements with QPSK/16QAM for FDD/HD-FDD/TDD with 1Rx/2Rx, however it was FFS whether to define 64QAM/256QAM requirements.

* Additional test case options for **FDD/HD-FDD 1Rx/2Rx**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Received antennas | Modulation | Code rate | Rank | PRB size | TBS | Propagation |
| 64QAM 1Rx | 1Rx | MCS19 in Table 1 | 0.50 | Rank 1 | 25 | 9992 | TDLA30-10 |
| 64QAM 2Rx Option 1 | 2Rx | MCS19 in Table 1 | 0.50 | Rank 1 | 25 | 9992 | TDLA30-10 |
| 64QAM 2Rx Option 2 | 2Rx | MCS19 in Table 1 | 0.50 | Rank 2 | 12 | 9480 | TDLA30-10 |
| 256QAM | 1Rx | MCS20 in Table 2 | 0.67 | Rank 1 | 14 | 9736 | TDLA30-10 |
| 256QAM | 2Rx | MCS24 in Table 2 | 0.82 | Rank 1 | 11 | 9480 | TDLA30-10 |

* Additional test case options for **TDD 1Rx/2Rx**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Received antennas | Modulation | Code rate | Rank | PRB size | TBS | Propagation |
| 64QAM 1Rx | 1Rx | MCS19 in Table 1 | 0.50 | Rank 1 | 12 | 4736 | TDLA30-10 |
| 64QAM 2Rx Option 1 | 2Rx | MCS19 in Table 1 | 0.50 | Rank 1 | 12 | 4736 | TDLA30-10 |
| 64QAM 2Rx Option 2 | 2Rx | MCS19 in Table 1 | 0.50 | Rank 2 | 6 | 4736 | TDLA30-10 |
| 256QAM | 1Rx | MCS20 in Table 2 | 0.67 | Rank 1 | 7 | 4864 | TDLA30-10 |
| 256QAM | 2Rx | MCS24 in Table 2 | 0.82 | Rank 1 | 5 | 4352 | TDLA30-10 |

**Issue 1-1-1: PDSCH test cases for 64QAM**

* Proposals
	+ Option 1 (Apple, Huawei): 64QAM Rank 1 for 1Rx, and 64QAM Rank 2 for 2Rx (Same as Rel-17).
	+ Option 2 (Ericsson, Qualcomm): 64QAM Rank 1 for both 1Rx and 2Rx.
* Recommended WF
	+ Define 64QAM UE demodulation requirements.
		- For 1Rx UE, define 64QAM rank 1.
		- For 2Rx UE, discuss 64QAM rank 1 or rank 2.

**Issue 1-1-2: PDSCH test cases for 256QAM**

* Proposals
	+ Option 1 (Apple, Ericsson, Qualcomm): Not define 256QAM demodulation requirements.
	+ Option 2 (Huawei): Define 256QAM demodulation requirements.
* Recommended WF
	+ Discuss the options.

**Issue 1-1-3: Correction of test setup**

Background: RAN4#110 agreed to set the following parameters for PDSCH demodulation requirements for UE supporting *eRedCapNotReducedBB-BW-r18* (TDD SCS=30kHz).

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Received antennas | Modulation | Code rate | Rank | PRB size | TBS | Propagation |
| QPSK | 1Rx/2Rx | MCS4 in Table 1 | 1/3  | Rank 1 | 12 | 928 | TDLB100-400 |
| 16QAM | 1Rx/2Rx | MCS13 in Table 1 | 0.47 | Rank 1 | 25 | 4992 | TDLC300-100 |

* Proposal (Ericsson)
	+ Correct the parameters as follows.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Received antennas | Modulation | Code rate | Rank | PRB size | TBS | Propagation |
| QPSK | 1Rx/2Rx | MCS4 in Table 1 | 1/3  | Rank 1 | 51 | 3840 | TDLB100-400 |
| 16QAM | 1Rx/2Rx | MCS13 in Table 1 | 0.47 | Rank 1 | 20 | 4992 | TDLC300-100 |

* Recommended WF
	+ **Moderator expects this is agreeable without discussion.**
	+ Capture the correction in the simulation assumption.

### Sub-topic 1-2 SDR requirements

**Issue 1-2-1: How to capture the applicability**

* Proposals (Ericsson)
	+ Add the following sentence in TS 38.101-4 5.5.1

|  |
| --- |
| For eRedCap with reduced peak date rate and reduced baseband bandwidth in FR1 (not supporting eRedCapNotReducedBB-BW-r18), only 25 PRBs for 15kHz SCS and 12RBs for 30kHz SCS are allocated for PDSCH transmission. |

* Recommended WF
	+ Discuss the detailed wording during the review of the draft CR.

### Sub-topic 1-3 CSI reporting requirements

**Issue 1-3-1: CSI-RS configuration for CSI reporting requirements**

Background: RAN4#110 agreed to adjust the PDSCH PRB size so that it does not exceed eRedCap capability, 10Mbps, however RAN4 has not decided the PRB size for CSI-RS configuration for CSI acquisition.

* Proposals
	+ Option 1 (Huawei): Configure BWP size, CSI-RS PRBs and PDSCH PRBs as follows:

|  |  |  |
| --- | --- | --- |
|  | CQI tests (static/fading) | PMI test |
| FDD SCS=15kHz | BWP:52 RBs CSI-RS: 24RBsPDSCH:15 RBs | BWP:52 RBs CSI-RS: 28RBsPDSCH: 25RBs |
| TDD SCS=30kHZ | BWP:52 RBs CSI-RS: 24RBsPDSCH:7RBs | BWP:52 RBs CSI-RS: 24RBsPDSCH: 15RBs |

* + Option 2 (Ericsson): Start PRB 0 and number of PRB = 24 for NZP-CSI-RS and ZP CSI-RS
		- Specify PDSCH are allocated from PRB 0
	+ Option 3 (Qualcomm): Discuss CSI-RS BW allocation in CQI tests for eRedCap UEs.
* Recommended WF
	+ Moderator: All the companies agree to align CSI-RS PRB size and PDSCH PRB size as much as possible.
	+ Configure the following parameters for CSI reporting tests:

|  |  |  |
| --- | --- | --- |
|  | CQI tests (static/fading) | PMI test |
| FDDCBW/SCS=10MHz/15kHz | BWP:52 RBs CSI-RS: 24RBs (PRB 0 to 23)PDSCH:15 RBs (PRB 0 to 14)) | BWP:52 RBs CSI-RS: 28RBs (PRB 0 to 27)PDSCH: 25RBs (PRB 0 to 24) |
| TDDCBW/SCS=20MHz/30kHz | BWP:51 RBs CSI-RS: 24RBs (PRB 0 to 23)PDSCH:7RBs (PRB 0 to 6) | BWP:51 RBs CSI-RS: 24RBs (PRB 0 to 23)PDSCH: 15RBs (PRB 0 to 14) |
| Note: BWP size is same as the transmission bandwidth in TS38.101-1 5.3.2.  |

**Issue 1-3-2: CQI reporting test in static condition**

* Proposal (Ericsson):
	+ Set SNR=5/6dB and SNR=11/12dB for CQI reporting test in static condition for FDD/HD-FDD/TDD with 1Rx, same as Rel-17 RedCap CQI reporting test in static condition.
	+ Set SNR=8/9dB and SNR=14/15dB for CQI reporting test in static condition for FDD/HD-FDD/TDD with 2Rx, same as Rel-17 RedCap CQI reporting test in static condition.
* Recommended WF
	+ Discuss whether to apply the same test points as Rel-17 RedCap CQI reporting requirements in static condition.

**Issue 1-3-3: CQI reporting test in fading condition**

* Proposals (Ericsson):
	+ Set SNR=9/10dB and SNR=15/16dB for CQI reporting test in fading condition for FDD/HD-FDD/TDD with 1Rx, same as Rel-17 RedCap CQI reporting test in fading condition
	+ Set SNR=6/7dB for CQI reporting test in fading condition for FDD/HD-FDD/TDD with 2Rx, same as Rel-17 RedCap CQI reporting test in fading condition.
	+ Apply the same requirements as Rel-17 RedCap UE CQI reporting test in fading condition:
		- A CQI index not in the set {median CQI - 1, median CQI, median CQI + 1} shall be reported at least α% of the time where α = 20%.
		- Throughput ratio of follow CQI and fixed median CQI shall be ≥ γ, where γ = 1.05
		- Average BLER with follow CQI shall be greater than or equal to 0.02.
* Recommended WF
	+ Discuss whether to apply the same test points and requirements as Rel-17 RedCap CQI reporting requirements in fading condition.

**Issue 1-3-4: PMI reporting tests**

* Proposals (Ericsson)
	+ Apply the same requirements as Rel-17 RedCap UE PMI reporting test for FDD/HD-FDD/TDD with 1Rx/2Rx:
		- Define the test metric as $γ=\frac{t\_{ue}}{t\_{rnd}}$ , where $t\_{ue}$ is 90 % of the maximum throughput obtained at $SNR\_{ue}$ using the precoders configured according to the UE reports, and $t\_{rnd}$ is the throughput measured at $SNR\_{ue}$ with random precoding based on type I Single Panel codebook.
		- Set γ=1.3.
* Recommended WF
	+ Discuss whether to apply the same test points and requirements as Rel-17 RedCap PMI reporting requirements.

### Sub-topic 1-4 Applicability of requirements

**Issue 1-4-1: Test applicability of UE demodulation requirements**

* Proposals (Ericsson)
	+ Add the definition of eRedCap in TS 38.101-4 3.1:
	+ Introduce applicability of demodulation requirements for eRedCap UE as follows in TS 38.101-4 5.1.1.
* Recommended WF
	+ Discuss whether to add the definition of eRedCap in TS 38.101-4 3.1 and whether to add the following table in TS 38.101-4 5.1.1.

|  |
| --- |
| * **eRedCap:** A UE with enhanced reduced capabilities as specified in clause 4.2 in TS 38.306 [14].
 |

|  |  |  |  |
| --- | --- | --- | --- |
| **UE capability** | **Test type** | **Test list** | **Applicability notes** |
| eRedCap with 1RX | FR1 FDD and HD-FDD (Note 1) | PDSCH | Clause 5.2.1.1.x |  |
|  |  | PDCCH | All tests in Clause 5.3.1.1.1 |  |
|  |  | PBCH | All tests in Clause 5.4.1.1 |  |
|  |  | SDR | Clause 5.5.1 |  |
|  | FR1 TDD | PDSCH | Clause 5.2.1.2.x |  |
|  |  | PDCCH | All tests in Clause 5.3.1.2.1 |  |
|  |  | PBCH | All tests in Clause 5.4.1.2 |  |
|  |  | SDR | Clause 5.5.1 |  |
| eRedCap with 2RX | FR1 FDD and HD-FDD (Note 1) | PDSCH | Clause 5.2.2.1.x |  |
|  |  | PDCCH | All tests in Clause 5.3.2.1.4 |  |
|  |  | PBCH | Clause 5.4.2.1 (Table 5.4.2.1-2 Test 1)Clause 5.4.2.1 (Table 5.4.2.1-3 Test 1) |  |
|  |  | SDR | Clause 5.5.1 |  |
|  | FR1 TDD | PDSCH | Clause 5.2.2.2.x |  |
|  |  | PDCCH | All tests in Clause 5.3.2.2.4 |  |
|  |  | PBCH | Clause 5.4.2.2 (Table 5.4.2.2-4 Test 1)Clause 5.4.2.2 (Table 5.4.2.2-5 Test 1) |  |
|  |  | SDR | Clause 5.5.1 |  |
| Note 1: If UE support only HD-FDD in a FDD band, this UE is tested with HD-FDD mode otherwise UE is tested with full-duplex FDD mode |

**Issue 1-4-2: Test applicability of CSI reporting requirements**

* Proposals (Ericsson)
	+ Introduce applicability of demodulation requirements for eRedCap UE as follows in TS 38.101-4 6.1.1
* Recommended WF
	+ Discuss whether to add the following table in TS 38.101-4 6.1.1.
	+ Note it depends on the conclusion on the issues 1-4-1, 1-4-2, and 1-5-1 whether to apply the same test points and criteria as Rel-17 RedCap CQI/PMI reporting requirements. If new requirements are specified, may need to add new sections.

|  |  |  |  |
| --- | --- | --- | --- |
| UE capability | Test type | Test list | Applicability notes |
| eRedCap with 1RX | FR1 FDD and HD-FDD (Note 1) | CQI | All tests in Clause 6.2.1.1.1.1All tests in Clause 6.2.1.1.2.1 |  |
|  |  | PMI | All tests in Clause 6.3.1.1.1 |  |
|  | FR1 TDD | CQI | All tests in Clause 6.2.1.2.1.1All tests in Clause 6.2.1.2.2.1 |  |
|  |  | PMI | All tests in Clause 6.3.1.2.1 |  |
| eRedCap with 2RX | FR1 FDD and HD-FDD (Note 1) | CQI | All tests in Clause 6.2.2.1.1.4All tests in Clause 6.2.2.1.2.4 |  |
|  |  | PMI | Clause 6.3.2.1.1 (Test 1) |  |
|  | FR1 TDD | CQI | All tests in Clause 6.2.2.2.1.5All tests in Clause 6.2.2.2.2.4 |  |
|  |  | PMI | Clause 6.3.2.2.7 (Test 1) |  |
| Note 1: If UE support only HD-FDD in a FDD band, this UE is tested with HD-FDD mode otherwise UE is tested with full-duplex FDD mode |

### Sub-topic 1-5 CR work split

**Issue 1-5-1: CR work split**

Moderator proposes to discuss the CR work split for Rel-18 eRedCap UE demodulation and CSI reporting requirements according to the workplan agreed in RAN4#110.

# Recommendation for Tdocs

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Suggested status** | **Comments** |
| R4-2404329 | Noted |  |
| R4-2404330 | Noted or Withdrawn | Not available yet. |
| R4-2405097 | Noted |  |
| R4-2405098 | Noted |  |
| R4-2405160 | Noted |  |
| R4-2405161 | Noted |  |
| R4-2405941 | Noted |  |
| R4-2405099 | Noted | Simulation results summary |