**3GPP TSG-RAN WG4 Meeting # 109 R4-2318223**

**Chicago, US, November 13 – November 17, 2023**

**Agenda item:** 8.36.3

**Source:** Moderator (Ericsson)

**Title:** Topic summary for [109][331] NR\_DSS\_enh

**Document for:** Information

# Introduction

This topic summary lists the open issues on the UE demodulation performance part in Rel-18 WI Enhancement of NR Dynamic spectrum sharing (DSS).

# Topic #1: NR PDCCH reception in symbols with LTE CRS REs

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2318588**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_109/Docs/R4-2318588.zip) | Apple | 1. **Evaluate performance with different configurations before finalizing the parameters for defining PDCCH demod requirements with eDSS.** 2. **Common parameters for PDCCH performance evaluation in eDSS: DCI format: 1\_0**   **CCE to REG mapping: Non-interleaved**  **REG bundle size: 6 PRB**  **CORESET duration: 2 symbols (symbol 1, 2)**  **Precoder: Random precoder with precoder cycling per REG bundle**  **LTE CRS: 4 ports TX assumption for overlapping REs: Puncture PDCCH and DMRS REs overlapping with LTE CRS LTE PDCCH, PDSCH: No transmission**  **Slots with LTE PBCH/PSS/SSS: No PDCCH transmission**  **Channel estimation: PDCCH CE only on clean symbols**   1. **Test parameters for PDCCH performance evaluation in eDSS:**  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | SCS(KHz)/CBW (MHz) | CORESET RB | Payload | AL | Propagation condition | Antenna configuration | | 15/10 | 48 | 39 | 4 | TDLA30-10 | 4x2 Low | | 15/10 | 48 | 39 | 8 | TDLC300-100 | 4x2 Low | | 15/10 | 48 | 39 | 4 | TDLA30-10 | 4x4 Low | | 15/10 | 48 | 39 | 8 | TDLC300-100 | 4x4 Low | |
| [**R4-2318664**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_109/Docs/R4-2318664.zip) | MediaTek inc. | ***Proposal 1***: Consider single non-overlapping CRS rate matching patterns for PDCCH demodulation requirements.  ***Proposal 2***: Consider Table 1 for simulation assumptions and Table 2 for PDCCH requirements  Table 1. Simulation assumptions   |  |  | | --- | --- | | Parameters | Values | | SCS | 15 kHz | | Bandwidth | 10 MHz | | Channel model | TDLC300-100 | | Antenna configuration | 2x2 and 2x4 | | CRS | 4 port CRS | | DCI payload (excluding CRC) | 60 bits | | Interleaving | Non-interleaved | | Precoding | Precoder cycling per REG bundle | | REG bundle size | 6 | | Shift index | 0 | | CORSET duration | 2  (2nd symbol and 3rd symbol) | | CORSET RB | 48 | | AL | 4 and 8 | | Note 1: The bandwidth of NR CORESET is within the bandwidth of LTE.  Note 2: gNB punctures the PDCCH data and DMRS REs overlapped with LTE CRS.  **Note 3:** PDCCH channel estimation is assumed to use only the clean PDCCH symbol. | |   Table 2. Minimum requirements for PDCCH reception in symbols with LTE CRS REs   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | **Bandwidth (MHz)** | **CORESET RB** | **CORESET duration** | **Aggregation level** | **Propagation Condition** | **Antenna configuration and correlation Matrix** | **Reference value** | | | **Pm-dsg (%)** | **SNR (dB)** | | 10 | 48 | 2 | 4 | TDLA30-10 | 2x2 Low | 1 | TBD | | 10 | 48 | 2 | 8 | TDLC300-100 | 2x4 Low | 1 | TBD | |
| [**R4-2318729**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_109/Docs/R4-2318729.zip) | Qualcomm India Pvt Ltd | **Observation 1: Typical BS having 4-port LTE CRS may use all 4 ports for NR PDCCH transmission.**  **Proposal 1: Define NR PDCCH performance requirement with 4x2 and 4x4 antenna configurations.**  **Proposal 2: Consider TDLA30-10 as the channel model for NR PDCCH performance requirement.**  **Observation 2: DCI format 1\_0 has a lower code rate and could be more robust to NR PDCCH puncturing.**  **Proposal 3: Define NR PDCCH requirement with only DCI format 1\_0.** |
| [**R4-2319222**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_109/Docs/R4-2319222.zip) | Ericsson | ***Observation 1: From demodulation perspective, configuring two or more CRS rate matching patterns doesn't alter the processing compared to a single, non-overlapping CRS rate matching pattern. However, it may result in worse performance due to the reduced resources available for channel estimation.***  ***Proposal 1: Propose to consider single non-overlapping CRS rate matching pattern for PDCCH demodulation definition.***  ***Proposal 2: Propose following parameter assumptions for PDCCH requirement:***   |  |  | | --- | --- | | **Parameters** | **Values** | | Carrier frequency | 2 GHz | | SCS | 15 kHz | | Bandwidth | 10 MHz | | Channel model | TDLC300-100 | | Antenna configuration | 1x2, 1x4; 2x2, 2x4 | | CRS | 4 port CRS without power boosted | | Interleaving | Non-interleaved | | Precoding | Precoder cycling per REG bundle | | REG bundle size | 6 | | UE receiver assumption | Use only the clean PDCCH symbol | | gNB assumption | PDCCH data and DMRS REs overlapped with LTE CRS are punctured. | |  |  |   ***Proposal 3: Propose following test cases for evaluation purpose:***   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | **Test number** | **Bandwidth (MHz)** | **Symbols with PDCCH** | **Aggregation level** | **Propagation Condition** | **Antenna configuration and correlation Matrix** | **Reference value** | | | **Pm-dsg (%)** | **SNR (dB)** | | 1Tx | | | | | | | | | 1 | 10 | 2 | 2 | TDLA30-10 | 1x2, 1x4 Low | 1 |  | | 2 | 10 | 2 | 4 | TDLA30-10 | 1x2, 1x4 Low | 1 |  | | 3 | 10 | 2 | 16 | TDLA30-10 | 1x2, 1x4 Low | 1 |  | | 2Tx | | | | | | | | | 4 | 10 | 2 | 4 | TDLC300-100 | 2x2, 2x4 Low | 1 |  | | 5 | 10 | 2 | 8 | TDLC300-100 | 2x2, 2x4 Low | 1 |  | |
| [**R4-2319545**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_109/Docs/R4-2319545.zip) | ZTE Corporation | ***Proposal 1. Considering the following detailed assumptions for DSS scenario.***   * ***2-symbol CORESET*** * ***Basic assumptions***   + ***Rate matching pattern***     - ***Single non-overlapping CRS rate matching patterns for PDCCH demodulation.***   + ***4 CRS ports for LTE***   + ***Symbol #0: LTE PDCCH/PCFICH***   + ***Symbol #1: NR PDCCH overlapping with LTE CRS***   + ***Symbol #2: NR PDCCH***   ***Proposal 2. Considering aggregation level 2, 4, 8 for DSS requirements.***  ***Proposal 3. Considering above table 1 and table 2 as simulation assumptions and minimum performance requirements for DSS scenario.***  Table 1. Simulation assumptions for DSS scenario   |  |  | | --- | --- | | * **Parameters** | **Values** | | Carrier frequency | 2 GHz | | SCS | 15 kHz | | Bandwidth | 10 MHz | | Channel model | TDLC300-100 | | Antenna configuration | 1x2, 1x4; 2x2, 2x4 | | CRS | 4 port CRS without power boosted | | DCI payload (excluding CRC) | 52 bits | | Interleaving | Non-interleaved | | Precoding | Precoder cycling per REG bundle | | REG bundle size | 6 REGs |   Table 2. minimum performance for DSS scenario   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | **Test number** | **Bandwidth (MHz)** | **Symbols with PDCCH** | **Aggregation level** | **Propagation Condition** | **Antenna configuration and correlation Matrix** | **Reference value** | | | **Pm-dsg (%)** | **SNR (dB)** | | 1 | 10 | 2 | 2 | TDLA30-10 | 1x2, 1x4 Low | 1 |  | | 2 | 10 | 2 | 4 | TDLA30-10 | 1x2, 1x4 Low | 1 |  | | 3 | 10 | 2 | 8 | TDLC300-100 | 2x2, 2x4 Low | 1 |  | |
| [**R4-2320200**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_109/Docs/R4-2320200.zip) | Huawei,HiSilicon | Observation 1: CRS patterns with different vShift leads to same number of punctured REs per RB which leads to same performance.  Proposal 1: Only consider single non-overlapping CRS rate matching pattern  Proposal 2: Don't model LTE PDCCH/PCFICH transmission on symbol #0  Proposal 3: For performance requirements definition, consider receiver assumption: UE set LLR of PDCCH data to 0 for CRS REs.  Proposal 4: Consider 10MHz/15kHz for FDD, regarding TDD, FFS 10MHz/15kHz or 20MHz/15kHz  Proposal 5: Only consider AL4 for requirements definition |
| [**R4-2320585**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_109/Docs/R4-2320585.zip) | Nokia, Nokia Shanghai Bell | **Observation 1: The PDCCH performance of enhanced DSS depends on the power difference between the power ratio of LTE-CRS RE and NR PDCCH DMRS RE as well as the Aggregation level.**  **Proposal 1: RAN4 to consider all aggregation level for PDCCH requirements, namely, 1, 2, 4, 8 and 16.**  **Proposal 2: As it is already agreed to use only clean symbol and the PDCCH data and DMRS REs overlapped with LTE CRS are punctured, RAN4 shall consider the case of without power boosting, in which the power ratio can be set to 0 dB.**  **Proposal 3: RAN4 to consider possible antenna configurations of 1x2, 1x4, 2x2, 2x4.** |
|  |  |  |

## Open issues summary

### Sub-topic 1-1 PDCCH demodulation requirements

**Issue 1-1-1: CRS rate matching pattern assumption**

* Proposals
  + Option 1 (MediaTek, ZTE, Ericsson, Huawei): Single non-overlapping rate matching pattern
    - Huawei: CRS patterns with different vShift leads to same number of punctured REs per RB which leads to same performance.
  + Option 2: Others
* Recommended WF
  + Discuss whether option 1 can be assumed.

**Issue 1-1-2: UE receiver assumption**

* Proposals
  + Option 1 (Huawei): For performance requirements definition, consider receiver assumption: UE set LLR of PDCCH data to 0 for CRS REs.
* Recommended WF
  + Previous agreements: PDCCH channel estimation is assumed to use only the clean PDCCH symbol.
  + Discuss whether option 1 can be further assumed.

**Issue 1-1-3: Common parameters**

* Proposals
  + Option 1 (Apple):
    - DCI format: 1\_0 (Qualcomm)
    - CCE to REG mapping: Non-interleaved
    - REG bundle size: 6 PRB
    - Precoder: Random precoder with precoder cycling per REG bundle
    - LTE CRS: 4 Ports
    - TX assumption for overlapping REs: Puncture PDCCH and DMRS REs overlapping with LTE CRS
    - LTE PDCCH, PDSCH: No transmission
    - Slots with LTE PBCH/PSS/SSS: No PDCCH transmission
    - Channel estimation: PDCCH CE only on clean symbols
  + Option 2: Others
* Recommended WF
  + Discuss whether option 1 is agreeable.

**Issue 1-1-4: Payload bits**

* Proposals
  + Option 1 (Apple): 39 bits
  + Option 2 (MTK, Huawei): 60 bits(Without CRC)
  + Option 3 (ZTE): 52 bits
* Recommended WF
  + Discuss options.

**Issue 1-1-5: Antenna configuration**

* Proposals
  + Option 1 (MTK): 2x2, 2x4 low
  + Option 2 (Apple, Qualcomm, Huawei): 4x2, 4x4 low
  + Option 3 (Ericsson, Nokia): 1x2, 1x4, 2x2, 2x4 low
* Recommended WF
  + Discuss options.

**Issue 1-1-6: Channel bandwidth**

* Proposals
  + For FDD,
    - Option 1 (Apple, MTK, Ericsson, Huawei): For FDD, consider 10MHz/15kHz.
  + For TDD
    - Option 1: 10MHz/15kHz
    - Option 2: 20MHz/15kHz
      * Huawei: 10MHz/15kHz is used for R15 NR-LTE co-existence case, 20MHz/15kHz is used for CRS-IM test
* Recommended WF
  + For FDD, check whether option 1 is agreeable.
  + For TDD, further discuss two options:
    - Option 1: 10MHz/15kHz
    - Option 2: 20MHz/15kHz

**Issue 1-1-7: Aggregation level**

* Proposals
  + Option 1 (Nokia): 1, 2, 4, 8 and 16
  + Option 2 (Ericsson): 2, 4, 8, 16 for evaluation purpose
  + Option 3 (Apple, MTK): 4, 8
  + Option 4 (Huawei): 4 only (For requirements definition purpose)
* Recommended WF
  + Moderator recommends to first discuss a set of aggregation levels for evaluations purpose, and to make further down selection (if needed) for defining requirements in the next meeting.

**Issue 1-1-8: Channel model**

* Proposals
  + Option 1 (Qualcomm): TDLA30-10 only
  + Option 2 (Apple, MTK, ZTE): TDLA30-10 for AL=4, TDLC300-100 for AL=8
  + Option 3 (Ericsson): For 1Tx, TDLA30-10; For 2Tx, TDLC300-100
  + Option 4 (Huawei): TDLC300-100 only
* Recommended WF
  + Discuss options.

**Issue 1-1-9: Power ratio of LTE-CRS RE/NR PDCCH-DMRS RE**

* Proposals
  + Option 1 (Nokia): 0dB
    - Nokia: As it is already agreed to use only clean symbol and the PDCCH data and DMRS REs overlapped with LTE CRS are punctured, RAN4 shall consider the case of without power boosting.
  + Option 2 (Huawei): 3dB
* Recommended WF
  + Discuss options.

**Issue 1-1-10: Test cases**

* Proposals
  + Option 1 (Ericsson) for evaluation purpose:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Test number** | **Bandwidth (MHz)** | **Symbols with PDCCH** | **Aggregation level** | **Propagation Condition** | **Antenna configuration and correlation Matrix** | **Reference value** | |
| **Pm-dsg (%)** | **SNR (dB)** |
| 1Tx | | | | | | | |
| 1 | 10 | 2 | 2 | TDLA30-10 | 1x2, 1x4 Low | 1 |  |
| 2 | 10 | 2 | 4 | TDLA30-10 | 1x2, 1x4 Low | 1 |  |
| 3 | 10 | 2 | 16 | TDLA30-10 | 1x2, 1x4 Low | 1 |  |
| 2Tx | | | | | | | |
| 4 | 10 | 2 | 4 | TDLC300-100 | 2x2, 2x4 Low | 1 |  |
| 5 | 10 | 2 | 8 | TDLC300-100 | 2x2, 2x4 Low | 1 |  |

* + Option 2 (Apple) for evaluation purpose:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| SCS(KHz)/CBW (MHz) | CORESET RB | Payload | AL | Propagation condition | Antenna configuration |
| 15/10 | 48 | 39 | 4 | TDLA30-10 | 4x2 Low |
| 15/10 | 48 | 39 | 8 | TDLC300-100 | 4x2 Low |
| 15/10 | 48 | 39 | 4 | TDLA30-10 | 4x4 Low |
| 15/10 | 48 | 39 | 8 | TDLC300-100 | 4x4 Low |

* + Option 3 (MTK) for minimum requirements:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Bandwidth (MHz)** | **CORESET RB** | **CORESET duration** | **Aggregation level** | **Propagation Condition** | **Antenna configuration and correlation Matrix** | **Reference value** | |
| **Pm-dsg (%)** | **SNR (dB)** |
| 10 | 48 | 2 | 4 | TDLA30-10 | 2x2 Low | 1 | TBD |
| 10 | 48 | 2 | 8 | TDLC300-100 | 2x4 Low | 1 | TBD |

* + Option 4 (ZTE) for minimum requirements:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Test number** | **Bandwidth (MHz)** | **Symbols with PDCCH** | **Aggregation level** | **Propagation Condition** | **Antenna configuration and correlation Matrix** | **Reference value** | |
| **Pm-dsg (%)** | **SNR (dB)** |
| 1 | 10 | 2 | 2 | TDLA30-10 | 1x2, 1x4 Low | 1 |  |
| 2 | 10 | 2 | 4 | TDLA30-10 | 1x2, 1x4 Low | 1 |  |
| 3 | 10 | 2 | 8 | TDLC300-100 | 2x2, 2x4 Low | 1 |  |

* + Option 5 (Huawei) for evaluation purpose:

|  |  |
| --- | --- |
| Parameters | Values |
| Carrier frequency | 2 GHz |
| SCS | 15 kHz |
| Bandwidth | 20MHz |
| LTE Bandwidth | 20MHz |
| Channel model | TDL-C 300-100 |
| Correlation | Low |
| Number of BS antennas | 4Tx |
| Number of UE antennas | 2 Rx |
| DCI payload (excluding CRC) | 60 bits without CRC |
| Interleaving | Non-Interleaved |
| Precoding | Precoder cycling per REG bundle |
| REG bundle size | 6 PRBs |
| CRS | single 4 port CRS pattern |
| Aggregation level | 1,2,4,8,16 |
| CORESET | Symbol 1 and 2 |
| Channel estimation | Use clean symbol |
| Transmitter | DMRS REs and data REs overlapped with CRS are punctured |
| Receiver | Puncture the CRS REs |
| Power ratio of LTE-CRS RE/NR PDCCH-DMRS RE | 3dB |

* Recommended WF
  + Postpone and depend on the outcome of discussions for above parameters.
  + Moderator recommends to first agree on several cases for evaluation purpose and discuss the exact cases (make further down-selection if needed) for requirement in the next meeting.
  + Discuss cases for evaluation purpose. Companies are encouraged to bring corresponding simulation results in the next meeting.