**3GPP TSG-RAN WG4 Meeting #110R4-2401140**

**Athens, GR, Feb 26 – Mar 01, 2024**

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| *CR-Form-v12.2* | | | | | | | | |
| **CHANGE REQUEST** | | | | | | | | |
|  | | | | | | | | |
|  | **38.101-4** | **CR** | **0485** | **rev** | **-** | **Current version:** | **18.2.0** |  |
|  | | | | | | | | |
| *For* [***HE******LP***](http://www.3gpp.org/3G_Specs/CRs.htm#_blank)*on using this form: comprehensive instructions can be found at* [*http://www.3gpp.org/Change-Requests*](http://www.3gpp.org/Change-Requests)*.* | | | | | | | | |
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| ***Proposed change affects:*** | UICC apps |  | ME | **X** | Radio Access Network |  | Core Network |  |

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|  | | | | | | | | | | |
| ***Title:*** | [NR\_FR2\_multiRX\_DL-Perf] Big CR to TS38.101-4 UE demodulation and CSI performance requirements for FR2 multi-Rx | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Source to WG:*** | Qualcomm Inc | | | | | | | | | |
| ***Source to TSG:*** | R4 | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Work item code:*** | NR\_FR2\_multiRX\_DL-Perf | | | | |  | ***Date:*** | | | 03/04/2024 |
|  |  | | | |  | |  | | |  |
| ***Category:*** | **B** |  | | | | | ***Release:*** | | | *Rel-18* |
|  | *Use one of the following categories:* ***F*** *(correction)* ***A*** *(mirror corresponding to a change in an earlier release)* ***B*** *(addition of feature),* ***C*** *(functional modification of feature)* ***D*** *(editorial modification)*  Detailed explanations of the above categories can be found in 3GPP [TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm). | | | | | | | | *Use one of the following releases: Rel-8 (Release 8) Rel-9 (Release 9) Rel-10 (Release 10) Rel-11 (Release 11) … Rel-16 (Release 16) Rel-17 (Release 17) Rel-18 (Release 18) Rel-19 (Release 19)* | |
|  |  | | | | | | | | | |
| ***Reason for change:*** | | The Big CR includes all draft CRs to be captured in TS 38.101-4 pertaining to NR\_FR2\_multiRX\_DL-Perf WI endorsed during RAN4#110. The reason for changes for each CR is provided below:   1. R4-2403063, Draft CR on applicability of requirements for FR2 multi-Rx; Samsung   - RAN4 has agreed to introduce PDSCH demod and PMI reporting requirements for FR2 multi-Rx, related applicability of requirements need to be updated accordingly   1. R4-2403084, Draft CR on Minimum requirements and FRC definition for sDCI SDM; Huawei, HiSilicon   - Introduce minimum requirements and FRC definition for sDCI SDM.   1. R4-2402990, Draft CR for 38.101-4: Minimum requirements and Measurement Channel for mDCI non-overlapping; Nokia, Nokia Shaghai Bell   - Introduction of minimum requirements for mDCI in non-overlapping case  4. R4-2402988, DraftCR on PDSCH demod requirements for mDCI fully-overlapping with multi-RX in FR2; Apple  - RAN4 has agreed to introduce PDSCH demod requirements with multi- DCI fully overlapping case with multi-RX in FR2  5. R4-2402993, Draft CR to 38.101-4: PMI reporting requirements for FR2 multipanel reception; MediaTek  - The PMI reporting requirements for FR2 multipanel reception agreed to be defined  6. R4-2402991, [NR\_FR2\_multiRX\_DL-Perf] Draft CR to 38.101-4 Include the FR2 multi-rx correlation model in the specification; Qualcomm  - RAN4 has defined a new spatial correlation model for FR2 multi-Rx | | | | | | | | |
|  | |  | | | | | | | | |
| ***Summary of change:*** | | The summary of changes for each draft CR is provided below:  R4-2403063  Update requirements in following clauses:  - 7.1.1.3  - 7.1.1.4  - 7.1.1.9 (new sub-clause)  R4-2403084  - For introducing minimum requirements and FRC definition for sDCI SDM, add clause 7.2.2.2.X3, update clause A.3.2.2.5.  R4-2402990  -Introduction of one additional section for definition of new requirements and addition of new reference measurement channels to existing table  R4-2402988  - Introduced the section for requirements with multi-DCI fully overlapping case with multi-RX in FR2.  R4-2402993  - New Chapter 8.3.3.2.2  - Two new reference channels added in A.3.2.2.5  R4-2402991  -Include agreed correlation model for FR2 multi-Rx in 38.101-4 | | | | | | | | |
|  | |  | | | | | | | | |
| ***Consequences if not approved:*** | | Performance requirements for FR2 multi-Rx will remian undefined | | | | | | | | |
|  | |  | | | | | | | | |
| ***Clauses affected:*** | | R4-2403063  - 7.1.1.3  - 7.1.1.4  - 7.1.1.9 (new)  R4-2403084  - 7.2.2.2.X3 (new)  - A.3.2.2.5  R4-2402990  - 7.2.2.2.X1 (new)  - A3.2.2.5  R4-2402988  - 7.2.2.2.X2 (new)  R4-2402993  -8.3.3.2.2 (new)  -A.3.2.2.5  R4-2402991  B.2.3.3 (new sub-clause) | | | | | | | | |
|  | |  | | | | | | | | |
|  | | **Y** | **N** |  | | | |  | | |
| ***Other specs*** | |  |  | Other core specifications | | | | TS/TR ... CR ... | | |
| ***affected:*** | | **X** |  | Test specifications | | | | 38.521-4 | | |
| ***(show related CRs)*** | |  |  | O&M Specifications | | | | TS/TR ... CR ... | | |
|  | |  | | | | | | | | |
| ***Other comments:*** | | New clauses: 7.1.1.9, 7.2.2.2.5, 7.2.2.2.X1, 7.2.2.2.X2, 8.3.3.2.2, B.2.3.3 | | | | | | | | |
|  | |  | | | | | | | | |
| ***This CR's revision history:*** | |  | | | | | | | | |

# 7 Demodulation performance requirements (Radiated requirements)

7.1 General

7.1.1 Applicability of requirements

**<< Unchanged sections omitted >>**

**--- Start of change R4-2403063 ---**

#### 7.1.1.3 Applicability of requirements for optional UE features

The performance requirements in Table 7.1.1.3-1 shall apply for UEs which support optional UE features only.

Table 7.1.1.3-1: Requirements applicability for optional UE features

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| UE feature/capability [14] | Test type | | Test list | Applicability notes | |
| SU-MIMO Interference Mitigation advanced receiver | FR2-1 TDD | PDSCH | Clause 7.2.2.2.1 (Test 3-1) |  | |
| Basic DL NR-NR CA operation (*supportedBandCombinationList*) | NR CA | SDR | Clause 7.5A.1 | 1) Up to 16 DL carriers  2) Same numerology across carrier for data/control channel at a given time | |
| PDSCH repetitions over multiple slots *(pdsch-RepetitionMultiSlots)* | FR2-1 TDD | PDSCH | Clause 7.2.2.2.2 |  | |
| Alternative 64QAM MCS table for PDSCHNew 64QAM MCS table for PDSCH (*dl-64QAM-MCS-TableAlt*) | FR2 TDD | PDSCH | Clause 7.2.2.2.2 | |  |
| DRX Adaptation (*drx-Adaptation-r16*) | FR2-1 TDD | PDCCH | Clause 7.3.2.2.3 | If the Test 3-1 in Clause 7.3.2.2.3 is passed, the test coverage can be considered fulfilled without executing Test 1-2 in clause 7.3.2.2.1. | |
| 256QAM for PDSCH  (*pdsch-256QAM-FR2*) | FR2-1 TDD | PDSCH | Clause 7.2.2.2.1 (Test 1-4) |  | |
| 256QAM for PDSCH (*pdsch-256QAM-FR2*) | FR2-1 TDD | SDR | Clause 7.5A.1 | For UE capable of *pdsch-256QAM-FR2* for certain band(s), *mcs-Table* is configured to ‘64QAM’ for SDR test. | |
| Support of FR2 HST operation [(FR2 UE power class PC6 signalling is used to indicate support of feature group)] | FR2-1 TDD | PDSCH | [Clause 7.2.2.2.4] |  | |
| Support of Single Carrier operations with 120kHz SCS for FR2-2  (*initialAccessSSB-120kHz-r17)* | FR2-2 TDD | PDSCH | Clause 7.2.2.2.1  (Table 7.2.2.2.1-6: Test 4-1, 4-2, 4-3, 4-4) |  | |
|  |  | PDCCH | Clause 7.3.2.2  (Table 7.3.2.2.1-2: Test 1a-1, 1a-2, 1a-3)  (Table 7.3.2.2.2-2, Test 3-1, 3-2) |  | |
|  |  | PBCH | Clause 7.4.2.2  (Table 7.4.2.2-2: Test 3) |  | |
| Support of 480kHz SCS for FR2-2  (*ul-FR2-2-SCS-480kHz-r17* and *initialAccessSSB-480kHz-r17)* | FR2-2 TDD | PDSCH | Clause 7.2.2.2.1  (Table 7.2.2.2.1-6: Test 4-5, 4-6) |  | |
|  |  | PDCCH | Clause 7.3.2.2  (Table 7.3.2.2.1-2: Test 1a-4) (Table 7.3.2.2.2-2, Test 3-3) |  | |
|  |  | PBCH | Clause 7.4.2.2  (Table 7.4.2.2-2: Test 4) |  | |
| Support simultaneous reception with different QCL Type-D RSs (*simultaneousReceptionDiffTypeD-r16*) | FR2  TDD | PDSCH | Clause 7.2.2.2.5  Clause 7.2.2.2.X1  Clause 7.2.2.2.X2 |  | |
| Single DCI based SDM transmission for simultaneous reception support (*singleDCI-SDM-scheme-r16*) | FR2  TDD | PDSCH | Clause 7.2.2.2.5 |  | |
| Multi DCI based simultaneous reception non-overlapping support (*multiDCI-MultiTRP-r16*) | FR2  TDD | PDSCH | Clause 7.2.2.2.X1 |  | |
| Multi DCI based simultaneous reception fully-overlapping support (*overlapPDSCHsFullyFreqTime-r16*) | FR2  TDD | PDSCH | Clause 7.2.2.2.X2 |  | |
| Support of 2-port DL PTRS *(supportTwoPortDL-PTRS-r16)* | FR2  TDD | PDSCH | Clause 7.2.2.2.5 Test 1-2 |  | |

7.1.1.4 Applicability of requirements for mandatory UE features with capability signalling

The performance requirements in Table 7.1.1.4-1 shall apply for UEs which support mandatory UE features with capability signalling only.

Table 7.1.1.4-1: Requirements applicability for mandatory features with UE capability signalling

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| UE feature/capability [14] | Test type | | Test list | Applicability notes |
| Supported maximum number of PDSCH MIMO layers (*maxNumberMIMO-LayersPDSCH)* | FR2 TDD | PDSCH | Clause 7.2.2.2.1 (Tests from 2-1 to 2-6) | The requirements apply only in case the PDSCH MIMO rank in the test case does not exceed UE PDSCH MIMO layers capability |
| Support of PT-RS with one antenna port for DL reception (*onePortsPTRS*) | FR2 TDD | PDSCH | Clause 7.2 |  |
| SDR | Clause 7.5.1  Clause 7.5A.1 |
| PCell operation on FR2 (*pCell-FR2*) | FR2 TDD | SDR | Clause 7.5A.1 |  |
| PDSCH mapping type B (*pdsch-MappingTypeB*) | FR2 TDD | PDSCH | Clause 7.2.2.2.3 |  |
| Support number of active TCI states per BWP per CC, including control and data (maxNumberActiveTCI-PerBWP) | FR2 TDD | PDSCH | Clause 7.2.2.2.4 (Test 1-2) | The requirements apply only when maxNumberActiveTCI-PerBWP is other than n1. |
| Support for maximum number of TRS resource sets per CC which the UE can track simultaneously (*maxSimultaneousResourceSetsPerCC*) | FR2 TDD | PDSCH | Clause 7.2.2.2.5  Clause 7.2.2.2.X1  Clause 7.2.2.2.X2 | The requirements apply only when *maxSimultaneousResourceSetsPerCC* ≥ 2 |

**<< Unchanged sections omitted >>**

7.1.1.9 Applicability of different requirements with simulataneous reception

The applicability rules for different requirements with simulataneous reception transmission schemes in section 7 are specified in Table 7.1.1.9-1.

Table 7.1.1.9-1: Applicability of different requirements with simultaneous reception

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| If UE has passed | | | UE can skip | | | Applicability notes |
| Test type | | Test list | Test type | | Test list |
| FR2 TDD | PDSCH | Clause 7.2.2.2.5 (Test 1-1) | FR2 TDD | PDSCH | Clause 7.2.2.2.5 (Test 1-2) | If UE supports one PTRS port per TRxP configuration, UE is not tested for one PTRS port across TRxPs; |

**--- End of change R4-2403063---**

## 7.2 PDSCH demodulation requirements

**<< Unchanged sections omitted >>**

### 7.2.2 2RX requirements

**<< Unchanged sections omitted >>**

#### 7.2.2.2 TDD

**<< Unchanged sections omitted >>**

**--- Start of change R4-2402990 ---**

##### 7.2.2.2.X1 Minimum requirements for Multi-DCI non-overlapping based transmission scheme

The performance requirements are specified in Table 7.2.2.2.X1-3 with the addition of the parameters in Table 7.2.2.2.X1-2 and the downlink physical channel setup according to Annex C.5.1.

The test purposes are specified in Table 7.2.2.2.X1-1.

Table 7.2.2.2.X1-1: Tests purpose

|  |  |
| --- | --- |
| Purpose | Test index |
| Verify the PDSCH performance when UE is configured two different values of CORESETPoolIndex in ControlResourceSet and when UE receives multiple PDCCHs scheduling non-overlapping PDSCHs | 1-1 |

Table 7.2.2.2.X1-2: Test Parameters

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Parameter | | | | Unit | Value | |
| TRxP #1(Note 1) | TRxP #2(Note 1) |
| SSB | | | |  | SSB#0 | SSB#1 |
| PDCCH configuration | | TCI state | |  | TCI State #0 | TCI State #1 |
| CORESETPoolIndex | |  | 0,1 | |
| CSI-RS for tracking | | First subcarrier index in the PRB used for CSI-RS | |  | k0=0 for CSI-RS resources 1,2,3,4 | k0=1 for CSI-RS resources 5,6,7,8 |
| First OFDM symbol in the PRB used for CSI-RS | |  | l0 = 6 for CSI-RS resources 1 and 3  l0 = 10 for CSI-RS resources 2 and 4 | l0 = 6 for CSI-RS resources 5 and 7  l0 = 10 for CSI-RS resources 6 and 8 |
| Number of CSI-RS ports (X) | |  | 1 for CSI-RS resource 1,2,3,4 | 1 for CSI-RS resource 5,6,7,8 |
| CDM Type | |  | ‘No CDM’ for CSI-RS resource 1,2,3,4,5,6,7,8 | |
| Density | |  | 3 | |
| CSI-RS periodicity | | Slots | 160 | |
| CSI-RS offset | | Slots | 80 for CSI-RS resources 1 and 2  81 for CSI-RS resources 3 and 4 | 80 for CSI-RS resources 5 and 6  81 for CSI-RS resources 7 and 8 |
| QCL info | |  | TCI state #0 | TCI state #1 |
| CSI-RS for beam refinement | | First subcarrier index in the PRB used for CSI-RS | |  | k0=0 for CSI-RS resources 1,2 | k0=1 for CSI-RS resources 3,4 |
| First OFDM symbol in the PRB used for CSI-RS | |  | l0 = 8 for CSI-RS resource 1  l0 = 9 for CSI-RS resource 2 | l0 = 8 for CSI-RS resource 3  l0 = 9 for CSI-RS resource 4 |
| Number of CSI-RS ports (X) | |  | 1 for CSI-RS resource 1,2 | 1 for CSI-RS resource 3,4 |
| CDM Type | |  | ‘No CDM’ for CSI-RS resource 1,2,3,4 | |
| Density | |  | 3 | |
| CSI-RS periodicity | | Slots | 160 | |
| CSI-RS offset | | Slots | 0 for CSI-RS resources 1,2 | 0 for CSI-RS resources 3, 4 |
| QCL info | |  | TCI state #2 | TCI state #3 |
| PTRS | | Frequency density (*KPT-RS*) | |  | 2 | 2 |
| Time density (*LPT-RS*) | |  | 1 | 1 |
| Resource Element Offset | |  | 2 | 2 |
| Duplex mode | | | |  | TDD | |
| Active DL BWP index | | | |  | 1 | |
| PDSCH configuration | Mapping type | | |  | Type A | |
| k0 | | |  | 0 | |
| Starting symbol (S) | | |  | 2 | |
| Length (L) | | |  | 12 | |
| PRB bundling type | | |  | Static | |
| PRB bundling size | | |  | 2 | |
| Resource allocation type | | |  | Type 1 | |
| RBG size | | |  | Config2 | |
| VRB-to-PRB mapping type | | |  | Non-interleaved | |
| VRB-to-PRB mapping interleaver bundle size | | |  | N/A | |
| Num CDM groups without data | | |  | 2 | 2 |
| PDSCH DMRS configuration | Antenna port indexes | | |  | {1000, 1001} | {1002, 1003} |
| TCI state | | |  | TCI State #0 | TCI State #1 |
| DMRS Type | | |  | Type 1 | |
| Number of additional DMRS | | |  | 1 | |
| Maximum number of OFDM symbols for DL front loaded DMRS | | |  | 1 | |
| TCI State #0 | Type 1 QCL information | | SSB resource |  | SSB #0 | N/A |
| QCL Type |  | Type C | N/A |
| Type 2 QCL information | | SSB resource |  | SSB #0 | N/A |
| QCL Type |  | Type D | N/A |
| TCI State #1 | Type 1 QCL information | | SSB resource |  | N/A | SSB #1 |
| QCL Type |  | N/A | Type C |
| Type 2 QCL information | | SSB resource |  | N/A | SSB #1 |
| QCL Type |  | N/A | Type D |
| TCI State #1 | Type 1 QCL information | | CSI-RS resource |  | CSI-RS resource 1 from 'CSI-RS for tracking’ configuration | N/A |
| QCL Type |  | Type A | N/A |
| Type 2 QCL information | | CSI-RS resource |  | CSI-RS resource 1 from 'CSI-RS for tracking’ configuration | N/A |
| QCL Type |  | Type D | N/A |
| TCI State #2 | Type 1 QCL information | | CSI-RS resource |  | N/A | CSI-RS resource 5 from 'CSI-RS for tracking’ configuration |
| QCL Type |  | N/A | Type A |
| Type 2 QCL information | | CSI-RS resource |  | N/A | CSI-RS resource 5 from 'CSI-RS for tracking’ configuration |
| QCL Type |  | N/A | Type D |
| Resource allocation | | | |  | Non-overlapping | |
| Timing offset of the second TRxP from the first TRxP | | | | us | 0.25 | |
| Frequency offset of the second TRxP from the first TRxP | | | | Hz | 0 | |
| Number of HARQ Processes | | | |  | 8 | |
| The number of slots between PDSCH and corresponding HARQ-ACK information | | | |  | Specific to each TDD UL-DL pattern and as defined in Annex A.1.2 | |
| Precoding configuration | | | |  | SP Type I, independent precoding generation is applied for both TRxPs, random per slot with PRB bundling granularity | |
| Note 1: PDSCH transmission is done from both TRxPs. Transmission from TRxP #1 uses CORESETPoolIndex 0 and transmission from TRxP #2 uses CORESETPoolIndex 1 | | | | | | |

Table 7.2.2.2.X1-3: Minimum performance

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Test num. | Reference channel | | Bandwidth (MHz) / Subcarrier spacing (kHz) | Modulation format and code rate | TDD UL-DL pattern | Propagation condition(Note 1) | Correlation matrix and antenna configuration(Note 2) | Reference value | |
| Fraction of maximum throughput (%) | SNR (dB)(Note 3) |
|  | TRxP #1 | TRxP #2 |  |  |  |  |  |  |  |
| 1-1 | R.PDSCH.5-2.4 TDD | R.PDSCH.5-2.5 TDD | 100 / 120 | 16QAM, 0.48 | FR2.120-1 | TDLA30-75 | 4x4 FR2- mTRxP-mRX  ρ = -12dB | 70 | [14.8] |
| Note 1: The propagation conditions apply to each of TRxP #1 and TRxP #2 and are statistically independent  Note 2: Correlation matrix according to the [FR2-mTxRP-mRX] in B.x.x.x. TRxP#1 uses TX antenna indices (1,2) and TRxP#2 uses TX antenna indices (3,4) corresponding to the respective antenna configuration matrix rows.  Note 3: SNR corresponds to SNR of TRxP #1 and TRxP #2 as defined in 4.4.2 | | | | | | | | | |

**--- End of change R4-2402990 ---**

**--- Start of change R4-2402988 ---**

##### 7.2.2.2.X2 Minimum requirements for PDSCH Multi-DCI based transmission scheme

The performance requirements are specified in Table 7.2.2.2.X2-3, with the addition of test parameters in Table 7.2.2.2.X2-2 and the downlink physical channel setup according to Annex C.3.1.

The test purposes are specified in Table 7.2.2.2.X2-1.

Table 7.2.2.2.X2-1: Tests purpose

|  |  |
| --- | --- |
| Purpose | Test index |
| Verify the PDSCH performance when UE is configured two different values of CORESETPoolIndex in ControlResourceSet and when UE receives multiple PDCCHs scheduling fully-overlapping PDSCHs with simultaneous reception | 1-1 |

Table 7.2.2.2.X2-2: Test parameters

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Parameter | | | | Unit | Value | |
| TRxP #1(Note 1) | TRxP #2(Note 1) |
| SSB | | | |  | SSB#0 | SSB#1 |
| PDCCH configuration | | TCI state | |  | TCI State #0 | TCI State #1 |
| CORESETPoolIndex | |  | 0,1 | |
| CSI-RS for tracking | | First subcarrier index in the PRB used for CSI-RS | |  | k0=0 for CSI-RS resources 1,2,3,4 | k0=1 for CSI-RS resources 5,6,7,8 |
| First OFDM symbol in the PRB used for CSI-RS | |  | l0 = 6 for CSI-RS resources 1 and 3  l0 = 10 for CSI-RS resources 2 and 4 | l0 = 6 for CSI-RS resources 5 and 7  l0 = 10 for CSI-RS resources 6 and 8 |
| Number of CSI-RS ports (X) | |  | 1 for CSI-RS resource 1,2,3,4 | 1 for CSI-RS resource 5,6,7,8 |
| CDM Type | |  | ‘No CDM’ for CSI-RS resource 1,2,3,4,5,6,7,8 | |
| Density | |  | 3 | |
| CSI-RS periodicity | | Slots | 160 | |
| CSI-RS offset | | Slots | 80 for CSI-RS resources 1 and 2  81 for CSI-RS resources 3 and 4 | 80 for CSI-RS resources 5 and 6  81 for CSI-RS resources 7 and 8 |
| QCL info | |  | TCI state #0 | TCI state #1 |
| CSI-RS for beam refinement | | First subcarrier index in the PRB used for CSI-RS | |  | k0=0 for CSI-RS resources 1,2 | k0=1 for CSI-RS resources 3,4 |
| First OFDM symbol in the PRB used for CSI-RS | |  | l0 = 8 for CSI-RS resource 1  l0 = 9 for CSI-RS resource 2 | l0 = 8 for CSI-RS resource 3  l0 = 9 for CSI-RS resource 4 |
| Number of CSI-RS ports (X) | |  | 1 for CSI-RS resource 1,2 | 1 for CSI-RS resource 3,4 |
| CDM Type | |  | ‘No CDM’ for CSI-RS resource 1,2,3,4 | |
| Density | |  | 3 | |
| CSI-RS periodicity | | Slots | 160 | |
| CSI-RS offset | | Slots | 0 for CSI-RS resources 1,2 | 0 for CSI-RS resources 3, 4 |
| QCL info | |  | TCI state #2 | TCI state #3 |
| PTRS | | Frequency density (*KPT-RS*) | |  | 2 | 2 |
| Time density (*LPT-RS*) | |  | 1 | 1 |
| Resource Element Offset | |  | 2 | 0 |
| Duplex mode | | | |  | TDD | |
| Active DL BWP index | | | |  | 1 | |
| PDSCH configuration | Mapping type | | |  | Type A | |
| k0 | | |  | 0 | |
| Starting symbol (S) | | |  | 2 | |
| Length (L) | | |  | 12 | |
| PRB bundling type | | |  | Static | |
| PRB bundling size | | |  | 2 | |
| Resource allocation type | | |  | Type 1 | |
| RBG size | | |  | Config2 | |
| VRB-to-PRB mapping type | | |  | Non-interleaved | |
| VRB-to-PRB mapping interleaver bundle size | | |  | N/A | |
| Num CDM groups without data | | |  | 2 | 2 |
| PDSCH DMRS configuration | Antenna port indexes | | |  | {1000} | {1002} |
| TCI state | | |  | TCI State #0 | TCI State #1 |
| DMRS Type | | |  | Type 1 | |
| Number of additional DMRS | | |  | 1 | |
| Maximum number of OFDM symbols for DL front loaded DMRS | | |  | 1 | |
| TCI State #0 | Type 1 QCL information | | SSB resource |  | SSB #0 | N/A |
| QCL Type |  | Type C | N/A |
| Type 2 QCL information | | SSB resource |  | SSB #0 | N/A |
| QCL Type |  | Type D | N/A |
| TCI State #1 | Type 1 QCL information | | SSB resource |  | N/A | SSB #1 |
| QCL Type |  | N/A | Type C |
| Type 2 QCL information | | SSB resource |  | N/A | SSB #1 |
| QCL Type |  | N/A | Type D |
| TCI State #2 | Type 1 QCL information | | CSI-RS resource |  | CSI-RS resource 1 from 'CSI-RS for tracking’ configuration | N/A |
| QCL Type |  | Type A | N/A |
| Type 2 QCL information | | CSI-RS resource |  | CSI-RS resource 1 from 'CSI-RS for tracking’ configuration | N/A |
| QCL Type |  | Type D | N/A |
| TCI State #3 | Type 1 QCL information | | CSI-RS resource |  | N/A | CSI-RS resource 5 from 'CSI-RS for tracking’ configuration |
| QCL Type |  | N/A | Type A |
| Type 2 QCL information | | CSI-RS resource |  | N/A | CSI-RS resource 5 from 'CSI-RS for tracking’ configuration |
| QCL Type |  | N/A | Type D |
| Resource allocation | | | |  | Fully-overlapping | |
| Timing offset of the second TRxP from the first TRxP | | | | us | -0.0625 | |
| Frequency offset of the second TRxP from the first TRxP | | | | Hz | 600 | |
| Number of HARQ Processes | | | |  | 8 | |
| The number of slots between PDSCH and corresponding HARQ-ACK information | | | |  | Specific to each TDD UL-DL pattern and as defined in Annex A.1.2 | |
| Precoding configuration | | | |  | SP Type I, independent precoding generation is applied for both TRxPs, random per slot with PRB bundling granularity | |
| Note 1: PDSCH transmission is done from both TRxPs. Transmission from TRxP #1 uses CORESETPoolIndex 0 and transmission from TRxP #2 uses CORESETPoolIndex 1 | | | | | | |

Table 7.2.2.2.X2-3: Minimum performance

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Test num. | Reference channel | | Bandwidth (MHz) / Subcarrier spacing (kHz) | Modulation format and code rate | TDD UL-DL pattern | Propagation condition(Note 1) | Correlation matrix and antenna configuration(Note 2) | Reference value | |
| Fraction of maximum throughput (%) | SNR (dB)(Note 3) |
| 1-1 | TRxP #1 | TRxP #2 | 100 / 120 | 64QAM, 0.43 | FR2.120-1 | TDLA30-75 | 4x4 FR2- mTRxP-mRX r=-12dB | 70 | [14.3] |
| R.PDSCH.5-3.3 TDD | R.PDSCH.5-3.3 TDD |
| Note 1: The propagation conditions apply to each of TRxP #1 and TRxP #2 and are statistically independent  Note 2: Correlation matrix according to the FR2-mTxRP-mRX in B.2.3.3. TRxP#1 uses TX antenna indices (1,2) and TRxP#2 uses TX antenna indices (3,4) corresponding to the respective antenna configuration matrix rows.  Note 3: SNR corresponds to SNR of TRxP #1 and TRxP #2 as defined in 4.4.2 | | | | | | | | | |

**--- End of change R4-2402988 ---**

**--- Start of change R4-2403084 ---**

7.2.2.2.X3 Minimum requirements for PDSCH Single-DCI based SDM scheme

The performance requirements are specified in Table 7.2.2.2.5-3, with the addition of test parameters in Table 7.2.2.2.5-2 and the downlink physical channel setup according to Annex C.5.1.

The test purposes are specified in Table 7.2.2.2.5-1.

**Table 7.2.2.2.X3-1: Tests purpose**

|  |  |
| --- | --- |
| **Purpose** | **Test index** |
| Verify the PDSCH performance with Single-DCI based SDM scheme for multi-Rx simultaneous DL reception. | 1-1, 1-2 |

**Table 7.2.2.2.X3-2: Test Parameters**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Parameter** | | | | **Unit** | **Value** | |
| **TRxP #1(Note 1)** | **TRxP #2(Note 1)** |
| SSB | | | |  | SSB #0 | SSB #1 |
| PDCCH configuration | | TCI state | |  | TCI State #2 | N/A |
| CORESETPoolIndex | |  | 0 | N/A |
| CSI-RS for tracking | | First subcarrier index in the PRB used for CSI-RS | |  | k0=0 for CSI-RS resources 1,2,3,4 | k0=1 for CSI-RS resources 5,6,7,8 |
| First OFDM symbol in the PRB used for CSI-RS | |  | l0 = 6 for CSI-RS resources 1 and 3  l0 = 10 for CSI-RS resources 2 and 4 | l0 = 6 for CSI-RS resources 5 and 7  l0 = 10 for CSI-RS resources 6 and 8 |
| Number of CSI-RS ports (X) | |  | 1 for CSI-RS resource 1,2,3,4 | 1 for CSI-RS resource 5,6,7,8 |
| CDM Type | |  | ‘No CDM’ for CSI-RS resource 1,2,3,4,5,6,7,8 | |
| Density | |  | 3 | |
| CSI-RS periodicity | | Slots | 160 | |
| CSI-RS offset | | Slots | 80 for CSI-RS resources 1 and 2  81 for CSI-RS resources 3 and 4 | 80 for CSI-RS resources 5 and 6  81 for CSI-RS resources 7 and 8 |
| QCL info | |  | TCI state #0 | TCI state #1 |
| CSI-RS for beam refinement | | First subcarrier index in the PRB used for CSI-RS (k0) | |  | k0=0 for CSI-RS resource 1,2 | k0=1 for CSI-RS resource 3,4 |
| First OFDM symbol in the PRB used for CSI-RS (l0) | |  | l0 = 8 for CSI-RS resource 1  l0 = 9 for CSI-RS resource 2 | l0 = 8 for CSI-RS resource 3  l0 = 9 for CSI-RS resource 4 |
| Number of CSI-RS ports (X) | |  | 1 for CSI-RS resource 1,2 | 1 for CSI-RS resource 3,4 |
| CDM Type | |  | 'No CDM' for CSI-RS resource 1,2 | 'No CDM' for CSI-RS resource 3,4 |
| Density (ρ) | |  | 3 for CSI-RS resource 1,2 | 3 for CSI-RS resource 3,4 |
| CSI-RS periodicity | |  | 160 for CSI-RS resource 1,2 | 160 for CSI-RS resource 3,4 |
| CSI-RS offset | |  | 0 for CSI-RS resource 1,2 | 0 for CSI-RS resource 3,4 |
| Repetition | |  | ON | ON |
| QCL info | |  | TCI state #2 | TCI state #3 |
| Duplex mode | | | |  | TDD | |
| Active DL BWP index | | | |  | 1 | |
| PDSCH configuration | Mapping type | | |  | Type A | |
| k0 | | |  | 0 | |
| Starting symbol (S) | | |  | 1 | |
| Length (L) | | |  | Specific to each Reference channel as defined in A.3.2.2 | |
| PRB bundling type | | |  | Static | |
| PRB bundling size | | |  | 2 | |
| Resource allocation type | | |  | Type 1 | |
| RBG size | | |  | Config2 | |
| VRB-to-PRB mapping type | | |  | Non-interleaved | |
| VRB-to-PRB mapping interleaver bundle size | | |  | N/A | |
| PDSCH DMRS configuration | Antenna port indexes | | |  | 1000 | 1002 |
| TCI state | | |  | TCI State #2 | TCI State #3 |
| DMRS Type | | |  | Type 1 | |
| Number of additional DMRS | | |  | 1 | |
| Maximum number of OFDM symbols for DL front loaded DMRS | | |  | 1 | |
| TCI State #0 | Type 1 QCL information | | SSB index |  | SSB #0 | N/A |
| QCL Type |  | Type C | N/A |
| Type 2 QCL information | | SSB index |  | SSB #0 | N/A |
| QCL Type |  | Type D | N/A |
| TCI State #1 | Type 1 QCL information | | SSB index |  | N/A | SSB #1 |
| QCL Type |  | N/A | Type C |
| Type 2 QCL information | | SSB index |  | N/A | SSB #1 |
| QCL Type |  | N/A | Type D |
| TCI State #2 | Type 1 QCL information | | CSI-RS resource |  | CSI-RS resource 1 from 'CSI-RS for tracking’ configuration | N/A |
| QCL Type |  | Type A | N/A |
| Type 2 QCL information | | CSI-RS resource |  | CSI-RS resource 1 from 'CSI-RS for tracking’ configuration | N/A |
| QCL Type |  | Type D | N/A |
| TCI State #3 | Type 1 QCL information | | CSI-RS resource |  | N/A | CSI-RS resource 5 from 'CSI-RS for tracking’ configuration |
| QCL Type |  | N/A | Type A |
| Type 2 QCL information | | CSI-RS resource |  | N/A | CSI-RS resource 5 from 'CSI-RS for tracking’ configuration |
| QCL Type |  | N/A | Type D |
| PTRS configuration | Frequency density (*KPT-RS*) | | |  | 2 | 2 for Test 1-2, Disabled for Test 1-1 |
| Time density (*LPT-RS*) | | |  | 1 | 1 for Test 1-2, Disabled for Test 1-1 |
| Resource Element Offset | | |  | 2 | 3 for Test 1-2, N/A for Test 1-1 |
| Resource allocation | | | |  | Full-overlapping | |
| Timing offset of the second TRxP from the first TRxP | | | | us | -0.0625 | |
| Frequency offset of the second TRxP from the first TRxP | | | | Hz | 600 | |
| Number of HARQ Processes | | | |  | 8 | |
| The number of slots between PDSCH and corresponding HARQ-ACK information | | | |  | Specific to each TDD UL-DL pattern and as defined in Annex A.1.2 | |
| Precoding configuration | | | |  | SP Type I, independent precoding generation is applied for both TRxPs, random per slot with PRB bundling granularity. | |
| Note 1: PDSCH transmission is done from both TRxPs (PDSCH Layer 0 is transmitted from TRxP #1 and PDSCH layer 1 is transmitted from TRxP #2) | | | | | | |

**Table 7.2.2.2.X3-3: Minimum performance**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Reference channel** | **Bandwidth (MHz) / Subcarrier spacing (kHz)** | **Modulation and code rate** | **TDD UL-DL pattern** | **Propagation condition** | **Correlation matrix and antenna configuration** | **Reference value** | |
| **Fraction of maximum throughput (%)** | **SNRBB (dB)** |
| 1-1 | R.PDSCH.5-16.1 TDD | 100 / 120 | 16QAM, 0.48 | FR2.120-1 | TDLA30-35 | 4x4 XPL Low | 70 | [12.4] |
| 1-2 | R.PDSCH.5-16.2 TDD | 100 / 120 | 16QAM, 0.48 | FR2.120-1 | TDLA30-35 | 4x4 XPL Low | 70 | [12.4] |
| Note 1: The propagation conditions apply to each of TRxP #1 and TRxP #2 and are statistically independent  Note 2: Correlation matrix according to the [FR2-mTxRP-mRX] in B.x.x.x. TRxP#1 uses TX antenna indices (1,2) and TRxP#2 uses TX antenna indices (3,4) corresponding to the respective antenna configuration matrix rows.  Note 3: SNR corresponds to SNR of TRxP #1 and TRxP #2 as defined in 4.4.2 | | | | | | | | |

**---End of change R4-2403084 ---**

# 8 CSI reporting requirements (Radiated requirements)

**<< Unchanged sections omitted >>**

## 8.3 Reporting of Precoding Matrix Indicator (PMI)

**<< Unchanged sections omitted >>**

**--- Start of change R4-2402993 ---**

##### 8.3.3.2.2 Single PMI with 2 ports TypeI-SinglePanel Codebook for Single-DCI based transmission scheme with simultaneous reception

For the parameters specified in Table 8.3.3.2.2-1, and using the downlink physical channels specified in Annex C.3.1, the minimum requirements are specified in Table 8.3.3.2.2-2.

Table 8.3.3.2.2-1: Test parameters (dual-layer)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter | | | | | Unit | Value | | |
| TRxP #1(Note 1) | | TRxP #2(Note 1) |
| SSB | | | | |  | SSB#0 | | SSB#1 |
| PDCCH configuration | | | TCI state | |  | TCI State #2 | | N/A |
| CORESETPoolIndex | |  | 0 | | N/A |
| CSI-RS for tracking | | | First subcarrier index in the PRB used for CSI-RS | |  | k0=0 for CSI-RS resources 1,2,3,4 | | k0=1 for CSI-RS resources 5,6,7,8 |
| First OFDM symbol in the PRB used for CSI-RS | |  | l0 = 4 for CSI-RS resources 1 and 3  l0 = 8 for CSI-RS resources 2 and 4 | | l0 = 4 for CSI-RS resources 5 and 7  l0 = 8 for CSI-RS resources 6 and 8 |
| Number of CSI-RS ports (X) | |  | 1 for CSI-RS resource 1,2,3,4 | | 1 for CSI-RS resource 5,6,7,8 |
| CDM Type | |  | ‘No CDM’ for CSI-RS resource 1,2,3,4,5,6,7,8 | | |
| Density | |  | 3 | | |
| CSI-RS periodicity | | Slots | 160 | | |
| CSI-RS offset | | Slots | 80 for CSI-RS resources 1 and 2  81 for CSI-RS resources 3 and 4 | | 80 for CSI-RS resources 5 and 6  81 for CSI-RS resources 7 and 8 |
| QCL info | |  | TCI state #0 | | TCI state #1 |
| CSI-RS for beam refinement | | | First subcarrier index in the PRB used for CSI-RS | |  | k0=0 for CSI-RS resources 1 and 2 | | k0=1 for CSI-RS resources 3 and 4 |
| First OFDM symbol in the PRB used for CSI-RS | |  | l0 = 8 for CSI-RS resource 1  l0 = 9 for CSI-RS resource 2 | | l0 = 8 for CSI-RS resource 3  l0 = 9 for CSI-RS resource 4 |
| Number of CSI-RS ports (X) | |  | 1 for CSI-RS resources 1,2,3,4 | | |
| CDM Type | |  | ‘No CDM’ for CSI-RS resources 1,2,3,4 | | |
| Density | |  | 3 | | |
| CSI-RS periodicity | | Slots | 160 | | |
| CSI-RS offset | | Slots | 0 for CSI-RS resources 1,2,3,4 | | |
| QCL info | |  | TCI state #2 | | TCI state #3 |
| Duplex mode | | | | |  | TDD | | |
| Bandwidth | | | | | MHz | 100 | | |
| Subcarrier spacing | | | | | kHz | 120 | | |
| TDD DL-UL configurations | | | | |  | FR1.120-1 as specified in Annex A.1.3 | | |
| Active DL BWP index | | | | |  | 1 | | |
| Propagation channel | | | | |  | TDLA30-35 | | |
| Correlation matrix and antenna configuration (Note 6) | | | | |  | 4x4 FR2- mTRxP-mRX  ρ = -12dB | | |
| Beamforming Model | | | | |  | As specified in Annex B.4.1 (Note 4) | | |
| PDSCH configuration | Mapping type | | | |  | Type A | | |
| k0 | | | |  | 0 | | |
| Starting symbol (S) | | | |  | 2 | | |
| Length (L) | | | |  | 12 | | |
| PRB bundling type | | | |  | Static | | |
| PRB bundling size | | | |  | 2 | | |
| Resource allocation type | | | |  | Type 1 | | |
| RBG size | | | |  | Config2 | | |
| VRB-to-PRB mapping type | | | |  | Non-interleaved | | |
| VRB-to-PRB mapping interleaver bundle size | | | |  | N/A | | |
| PDSCH DMRS configuration | Antenna port indexes | | | |  | 1000 | | 1002 |
| TCI state | | | |  | TCI State #0 | | TCI State #1 |
| DMRS Type | | | |  | Type 1 | | |
| Number of additional DMRS | | | |  | 1 | | |
| Maximum number of OFDM symbols for DL front loaded DMRS | | | |  | 1 | | |
| PTRS configuration (Note 5) | Frequency density (*KPT-RS*) | | | |  | 2 | | Test 1: N/A  Test 2: 2 |
| Time density (*LPT-RS*) | | | |  | 1 | | Test 1: N/A  Test 2: 1 |
| Resource Element Offset | | | |  | 2 | | Test 1: N/A  Test 2: 3 |
| TCI State #0 | Type 1 QCL information | | | SSB index |  | SSB #0 | | N/A |
| QCL Type |  | Type C | | N/A |
| Type 2 QCL information | | | SSB index |  | SSB #0 | | N/A |
| QCL Type |  | Type D | | N/A |
| TCI State #1 | Type 1 QCL information | | | SSB index |  | N/A | | SSB #1 |
| QCL Type |  | N/A | | Type C |
| Type 2 QCL information | | | SSB index |  | N/A | | SSB #1 |
| QCL Type |  | N/A | | Type D |
| TCI State #2 | Type 1 QCL information | | | CSI-RS resource |  | CSI-RS resource 1 from 'CSI-RS for tracking’ configuration | | N/A |
| QCL Type |  | Type A | | N/A |
| Type 2 QCL information | | | CSI-RS resource |  | CSI-RS resource 1 from 'CSI-RS for tracking’ configuration | | N/A |
| QCL Type |  | Type D | | N/A |
| TCI State #3 | Type 1 QCL information | | | CSI-RS resource |  | N/A | | CSI-RS resource 5 from 'CSI-RS for tracking’ configuration |
| QCL Type |  | N/A | | Type A |
| Type 2 QCL information | | | CSI-RS resource |  | N/A | | CSI-RS resource 5 from 'CSI-RS for tracking’ configuration |
| QCL Type |  | N/A | | Type D |
| Resource allocation | | | | |  | Full-overlapping | | |
| Timing offset of the second TRxP from the first TRxP | | | | | us | 0 | | |
| Frequency offset of the second TRxP from the first TRxP | | | | | Hz | 0 | | |
| Number of HARQ Processes | | | | |  | 8 | | |
| The number of slots between PDSCH and corresponding HARQ-ACK information | | | | |  | Specific to each TDD UL-DL pattern and as defined in Annex A.1.3 | | |
| ZP CSI-RS configuration | | CSI-RS resource Type | | |  | Periodic | | |
| Number of CSI-RS ports (*X*) | | |  | 4 | | |
| CDM Type | | |  | FD-CDM2 | | |
| Density (ρ) | | |  | 1 | | |
| First subcarrier index in the PRB used for CSI-RS (k0) | | |  | Row 4, (8,-) | | |
| First OFDM symbol in the PRB used for CSI-RS (l0) | | |  | (13) | | |
| CSI-RS  periodicity and offset | | | slot | 5/1 | | |
| NZP CSI-RS for CSI acquisition | | CSI-RS resource ID | | |  | Resource #9 | Resource #10 | |
| CSI-RS resource Type | | |  | Aperiodic | Aperiodic | |
| Number of CSI-RS ports (*X*) | | |  | 2 | 2 | |
| CDM Type | | |  | FD-CDM2 | FD-CDM2 | |
| Density (ρ) | | |  | 1 | 1 | |
| First subcarrier index in the PRB used for CSI-RS (k0, k1 ) | | |  | Row 3, (8,-) | Row 3, (10,-) | |
| First OFDM symbol in the PRB used for CSI-RS (l0) | | |  | (12) | (12) | |
| CSI-RS  periodicity and offset | | | slot | Not configured | Not configured | |
| aperiodicTriggeringOffset | | |  | 0 | 0 | |
| CSI-IM configuration | | CSI-IM resource Type | | |  | Aperiodic | | |
| CSI-IM RE pattern | | |  | Pattern 1 | | |
| CSI-IM Resource Mapping  (kCSI-IM,lCSI-IM) | | |  | (8,13) | | |
| CSI-IM timeConfig  periodicity and offset | | | slot | Not configured | | |
| ReportConfigType | | | | |  | Aperiodic | | |
| CQI-table | | | | |  | Table 1 | | |
| reportQuantity | | | | |  | cri-RI-PMI-CQI | | |
| csi-ReportMode | | | | |  | Mode1 | | |
| numberOfSingleTRP-CSI-Mode1 | | | | |  |  | | |
| CMR pairing and grouping | | | | |  | CMR group #1: {NZP CSI-RS resource #9}, with  CMR group #2: {NZP CSI-RS resource #10}, with  CMR paring: {NZP CSI-RS resource #9, NZP CSI-RS resource #10} | | |
| timeRestrictionForChannelMeasurements | | | | |  | Not configured | | |
| timeRestrictionForInterferenceMeasurements | | | | |  | Not configured | | |
| cqi-FormatIndicator | | | | |  | Wideband | | |
| pmi-FormatIndicator | | | | |  | Wideband | | |
| Sub-band Size | | | | | RB | 8 | | |
| csi-ReportingBand | | | | |  | 1111111 | | |
| CSI-Report periodicity and offset | | | | | slot | Not configured | | |
| Aperiodic Report Slot Offset | | | | |  | 8 | | |
| CSI request | | | | |  | 1 in slots i, where mod(i, 5) = 1, otherwise it is equal to 0 | | |
| reportTriggerSize | | | | |  | 1 | | |
| CSI-AperiodicTriggerStateList | | | | |  | One State with one Associated Report Configuration  Associated Report Configuration contains pointers to NZP CSI-RS and CSI-IM | | |
| Codebook configuration | | CodebookType | | |  | typeI-SinglePanel | | |
| CodebookMode | | |  | 1 | | |
| (CodebookConfig-N1,CodebookConfig-N2) | | |  | (1,1) | | |
| (CodebookConfig-O1,CodebookConfig-O2) | | |  | (1,1) | | |
| CodebookSubsetRestriction | | |  | 001111 | | |
| RI Restriction | | |  | N/A | | |
| Physical channel for CSI report | | | | |  | PUSCH | | |
| CQI/RI/PMI delay | | | | | ms | 1.75 | | |
| Maximum number of HARQ transmission | | | | |  | 4 | | |
| Measurement channel | | | | |  | Test 1: R.PDSCH.5-7.2 TDD Test 2:  R.PDSCH.5-7.3 TDD | | |
| PDSCH & PDSCH DMRS Precoding configuration for random Precoding | | | | |  | Single Panel Type I, Random precoder selection updated per slot, with equal probability of each applicable i1, i2 combination, and with Wideband granularity | | |
| Note 1: PDSCH transmission is done from both TRxPs (PDSCH Layer 0 is transmitted from TRxP #1 and PDSCH layer 1 is transmitted from TRxP #2)  Note 2: When Throughput is measured using random precoder selection, the precoder shall be updated in each slot (0.125 ms granularity) with equal probability of each applicable i1, i2 combination.  Note 3: If the UE reports in an available uplink reporting instance at slot#n based on PMI estimation at a downlink slot not later than slot#(n-4), this reported PMI cannot be applied at the gNB downlink before slot#(n+4).  Note 4: Randomization of the principle beam direction per TRxP shall be used as specified in Annex B.2.3.2.3.  Note 5: PT-RS configuration in Test 1 uses single port (one TRxP) and Test 2 used dual port (both TRxPs)  Note 6: Correlation matrix according to the [FR2-mTxRP-mRX] in B.x.x.x. TRxP#1 uses TX antenna indices (1,2) and TRxP#2 uses TX antenna indices (3,4) corresponding to the respective antenna configuration matrix rows | | | | | | | | |

Table 8.3.3.2.2-2: Minimum requirement

|  |  |  |
| --- | --- | --- |
| Parameter | Test 1 | Test 2 |
| ** | [1.15] | [1.15] |

**--- End of change R4-2402993 ---**

# A.3 DL reference measurement channels

**<< Unchanged sections omitted >>**

## A.3.2 Reference measurement channels for PDSCH performance requirements

**<< Unchanged sections omitted >>**

### A.3.2.2 TDD

**<< Unchanged sections omitted >>**

#### A.3.2.2.5 Reference measurement channels for SCS 120 kHz FR2

**<< Unchanged sections omitted >>**

**--- Start of change R4-2402990 ---**

A.3.2.2.5 Reference measurement channels for SCS 120 kHz FR2

Table A.3.2.2.5-1: PDSCH Reference Channel for TDD UL-DL pattern FR2.120-1 and FR2.120-1A (QPSK)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Parameter** | **Unit** | **Value** | | | | |
| Reference channel |  | R.PDSCH.5-1.1 TDD | R.PDSCH.5-1.2 TDD |  |  |  |
| Channel bandwidth | MHz | 100 | 100 |  |  |  |
| Subcarrier spacing | kHz | 120 | 120 |  |  |  |
| Allocated resource blocks | PRBs | 66 | 66 |  |  |  |
| Number of consecutive PDSCH symbols |  |  |  |  |  |  |
| For Slots 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,159} |  | N/A | N/A |  |  |  |
| For Slot i, if mod(i, 5) = 3 for i from {0,…, 159} |  | 9 | 2 |  |  |  |
| For Slot i, if mod(i, 5) = {0,1,2} for i from {1,…,159} |  | 13 | 2 |  |  |  |
| Allocated slots per 2 frames |  | 127 | 127 |  |  |  |
| MCS table |  | 64QAM | 64QAM |  |  |  |
| MCS index |  | 4 | 4 |  |  |  |
| Modulation |  | QPSK | QPSK |  |  |  |
| Target Coding Rate |  | 0.30 | 0.30 |  |  |  |
| Number of MIMO layers |  | 1 | 1 |  |  |  |
| Number of DMRS REs |  |  |  |  |  |  |
| For Slots 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,159} |  | N/A | N/A |  |  |  |
| For Slot i, if mod(i, 5) = 3 for i from {0,…, 159} |  | 12 | 6 |  |  |  |
| For Slot i, if mod(i, 5) = {0,1,2} for i from {1,…,159} |  | 12 | 6 |  |  |  |
| Overhead for TBS determination |  | 6 | 0 |  |  |  |
| Information Bit Payload per Slot |  |  |  |  |  |  |
| For Slots 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,159} | Bits | N/A | N/A |  |  |  |
| For Slot i, if mod(i, 5) = 3 for i from {0,…, 159} | Bits | 3624 | 736 |  |  |  |
| For Slot i, if mod(i, 5) = {0,1,2} for i from {1,…,159} | Bits | 5504 | 736 |  |  |  |
| Transport block CRC per Slot |  |  |  |  |  |  |
| For Slots 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,159} | Bits | N/A | N/A |  |  |  |
| For Slot i, if mod(i, 5) = 3 for i from {0,…, 159} | Bits | 16 | 16 |  |  |  |
| For Slot i, if mod(i, 5) = {0,1,2} for i from {1,…,159} | Bits | 24 | 16 |  |  |  |
| Number of Code Blocks per Slot |  |  |  |  |  |  |
| For Slots 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,159} | CBs | N/A | N/A |  |  |  |
| For Slot i, if mod(i, 5) = 3 for i from {0,…, 159} | CBs | 1 | 1 |  |  |  |
| For Slot i, if mod(i, 5) = {0,1,2} for i from {1,…,159} | CBs | 1 | 1 |  |  |  |
| Binary Channel Bits Per Slot |  |  |  |  |  |  |
| For Slots 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,159} | Bits | N/A | N/A |  |  |  |
| For Slots i = 80, 81 | Bits | 17514 | 2310 |  |  |  |
| For Slot i, if mod(i, 5) = 3 for i from {0,…, 159} | Bits | 12210 | 2310 |  |  |  |
| For Slot i, if mod(i, 5) = {0,1,2} for i from {1,…,79,82,…,159} | Bits | 18282 | 2310 |  |  |  |
| Max. Throughput averaged over 2 frames | Mbps | 31.942 | 4.673 |  |  |  |
| Note 1: SS/PBCH block is transmitted in slot #0 with periodicity 20 ms  Note 2: Slot i is slot index per 2 frames | | | | | | |

Table A.3.2.2.5-2: PDSCH Reference Channel for TDD UL-DL pattern FR2.120-1 (16QAM)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Parameter** | **Unit** | **Value** | | | | |
| Reference channel |  | R.PDSCH.5-2.1 TDD | R.PDSCH.5-2.2 TDD | R.PDSCH.5-2.3 TDD | R.PDSCH.5-2.4 TDD | R.PDSCH.5-2.5 TDD |
| Channel bandwidth | MHz | 100 | 100 | 200 | 100 | 100 |
| Subcarrier spacing | kHz | 120 | 120 | 120 | 120 | 120 |
| Allocated resource blocks | PRBs | 66 | 66 | 132 | 33 (Note 3) | 33 (Note 4) |
| Number of consecutive PDSCH symbols |  |  |  |  |  |  |
| For Slots 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,159} |  | N/A | N/A | N/A | N/A | N/A |
| For Slot i, if mod(i, 5) = 3 for i from {0,…, 159} |  | 9 | 9 | 9 | 8 | 8 |
| For Slot i, if mod(i, 5) = {0,1,2} for i from {1,…,159} |  | 13 | 13 | 13 | 12 | 12 |
| Allocated slots per 2 frames |  | 127 | 127 | 127 | 127 | 127 |
| MCS table |  | 64QAM | 64QAM | 64QAM | 64QAM | 64QAM |
| MCS index |  | 13 | 13 | 13 | 13 | 13 |
| Modulation |  | 16QAM | 16QAM | 16QAM | 16QAM | 16QAM |
| Target Coding Rate |  | 0.48 | 0.48 | 0.48 | 0.48 | 0.48 |
| Number of MIMO layers |  | 1 | 2 | 2 | 2 | 2 |
| Number of DMRS REs |  |  |  |  |  |  |
| For Slots 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,159} |  | N/A | N/A | N/A | N/A | N/A |
| For Slot i, if mod(i, 5) = 3 for i from {0,…, 159} |  | 12 | 12 | 12 | 12 | 12 |
| For Slot i, if mod(i, 5) = {0,1,2} for i from {1,…,159} |  | 12 | 12 | 12 | 12 | 12 |
| Overhead for TBS determination |  | 6 | 6 | 6 | 6 | 6 |
| Information Bit Payload per Slot |  |  |  |  |  |  |
| For Slots 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,159} | Bits | N/A | N/A | N/A | N/A | N/A |
| For Slot i, if mod(i, 5) = 3 for i from {0,…, 159} | Bits | 11272 | 22536 | 45096 | 9992 | 9992 |
| For Slot i, if mod(i, 5) = {0,1,2} for i from {1,…,159} | Bits | 17424 | 34816 | 69672 | 15880 | 15880 |
| Transport block CRC per Slot |  |  |  |  |  |  |
| For Slots 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,159} | Bits | N/A | N/A | N/A | N/A | N/A |
| For Slot i, if mod(i, 5) = 3 for i from {0,…, 159} | Bits | 24 | 24 | 24 | 24 | 24 |
| For Slot i, if mod(i, 5) = {0,1,2} for i from {1,…,159} | Bits | 24 | 24 | 24 | 24 | 24 |
| Number of Code Blocks per Slot |  |  |  |  |  |  |
| For Slots 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,159} | CBs | N/A | N/A | N/A | N/A | N/A |
| For Slot i, if mod(i, 5) = 3 for i from {0,…, 159} | CBs | 2 | 3 | 6 | 2 | 2 |
| For Slot i, if mod(i, 5) = {0,1,2} for i from {1,…,159} | CBs | 3 | 5 | 9 | 3 | 3 |
| Binary Channel Bits Per Slot |  |  |  |  |  |  |
| For Slots 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,159} | Bits | N/A | N/A | N/A | N/A | N/A |
| For Slots i = 80, 81 | Bits | 36564 | 70056 | 139920 | 31984 | 31984 |
| For Slots i = 82 | Bits | 35028 | 73128 | 146256 | 33568 | 33568 |
| For Slots i = 83 | Bits | 22884 | 48840 | 97680 | 21408 | 21408 |
| For Slot i, if mod(i, 5) = 3 for i from {0,…, 159} | Bits | 24420 | 48840 | 97680 | 21408 | 21408 |
| For Slot i, if mod(i, 5) = {0,1,2} for i from {1,…,79,84,…,159} | Bits | 36564 | 73128 | 146256 | 33568 | 33568 |
| Max. Throughput averaged over 2 frames | Mbps | 100.799 | 201.434 | 403.096 | 91.417 | 91.417 |
| Note 1: SS/PBCH block is transmitted in slot #0 with periodicity 20 ms  Note 2: Slot i is slot index per 2 frames  Note 3: PDSCH is scheduled in PRB numbers from 0 to 32.  Note 4: PDSCH is scheduled in PRB numbers from 33 to 65. | | | | | | |

**--- End of change R4-2402990 ---**

**--- Start of change R4-2402988 ---**

**Table A.3.2.2.5-3: PDSCH Reference Channel for TDD UL-DL pattern FR2.120-1 (64QAM)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Parameter** | **Unit** | **Value** | | | | |
| Reference channel |  | R.PDSCH.5-3.1 TDD | R.PDSCH.5-3.2 TDD | R.PDSCH.5-3.3 TDD |  |  |
| Channel bandwidth | MHz | 100 | 100 | 100 |  |  |
| Subcarrier spacing | kHz | 120 | 120 | 120 |  |  |
| Allocated resource blocks | PRBs | 66 | 66 | 66 |  |  |
| Number of consecutive PDSCH symbols |  |  |  |  |  |  |
| For Slots 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,159} |  | N/A | N/A | N/A |  |  |
| For Slots i = 80, 81 |  | 9 | N/A | 12 |  |  |
| For Slot i, if mod(i, 5) = 3 for i from {0,…, 159} |  | 9 | 9 | 8 |  |  |
| For Slot i, if mod(i, 5) = {0,1,2} for i from {1,…,159} |  | 13 | 13 | 12 |  |  |
| Allocated slots per 2 frames |  | 127 | 125 | 127 |  |  |
| MCS table |  | 64QAM | 64QAM | 64QAM |  |  |
| MCS index |  | 18 | 17 | 17 |  |  |
| Modulation |  | 64QAM | 64QAM | 64QAM |  |  |
| Target Coding Rate |  | 0.46 | 0.43 | 0.43 |  |  |
| Number of MIMO layers |  | 1 | 1 | 1 |  |  |
| Number of DMRS REs |  |  |  |  |  |  |
| For Slots 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,159} |  | N/A | N/A | N/A |  |  |
| For Slots i = 80, 81 |  | 12 | N/A | 24 |  |  |
| For Slot i, if mod(i, 5) = 3 for i from {0,…, 159} |  | 12 | 12 | 24 |  |  |
| For Slot i, if mod(i, 5) = {0,1,2} for i from {1,…,159} |  | 12 | 12 | 24 |  |  |
| Overhead for TBS determination |  | 6 | 6 | 6 |  |  |
| Information Bit Payload per Slot |  |  |  |  |  |  |
| For Slots 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,159} | Bits | N/A | N/A | N/A |  |  |
| For Slots i = 80, 81 | Bits | 25104 | N/A | 19465 |  |  |
| For Slot i, if mod(i, 5) = 3 for i from {0,…, 159} | Bits | 16136 | 15112 | 11272 |  |  |
| For Slot i, if mod(i, 5) = {0,1,2} for i from {1,…,159} | Bits | 25104 | 23568 | 19465 |  |  |
| Transport block CRC per Slot |  |  |  |  |  |  |
| For Slots 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,159} | Bits | N/A | N/A | N/A |  |  |
| For Slots i = 80, 81 | Bits | 24 | N/A | 24 |  |  |
| For Slot i, if mod(i, 5) = 3 for i from {0,…, 159} | Bits | 24 | 24 | 24 |  |  |
| For Slot i, if mod(i, 5) = {0,1,2} for i from {1,…,159} | Bits | 24 | 24 | 24 |  |  |
| Number of Code Blocks per Slot |  |  |  |  |  |  |
| For Slots 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,159} | CBs | N/A | N/A | N/A |  |  |
| For Slots i = 80, 81 | CBs | 3 | N/A | 3 |  |  |
| For Slot i, if mod(i, 5) = 3 for i from {0,…, 159} | CBs | 2 | TBA | 2 |  |  |
| For Slot i, if mod(i, 5) = {0,1,2} for i from {1,…,159} | CBs | 3 | TBA | 3 |  |  |
| Binary Channel Bits Per Slot |  |  |  |  |  |  |
| For Slots 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,159} | Bits | N/A | N/A | N/A |  |  |
| For Slots i = 80, 81 | Bits | 52470 | N/A | 43164 |  |  |
| For Slot i, if mod(i, 5) = 3 for i from {0,…, 159} | Bits | 36630 | 35640 | 27324 |  |  |
| For Slot i, if mod(i, 5) = {0,1,2} for i from {1,…,79,82,…,159} | Bits | 54846 | 54648 | 45540 |  |  |
| Max. Throughput averaged over 2 frames | Mbps | 145.062 | 136.1272 | 116.638 |  |  |
| Note 1: SS/PBCH block is transmitted in slot #0 with periodicity 20 ms  Note 2: Slot i is slot index per 2 frames | | | | | | |

**--- End of change R4-2402988 ---**

**--- Start of change R4-2402993 ---**

Table A.3.2.2.5-7: PDSCH Reference Channel for TDD PMI reporting requirements with UL-DL pattern FR2.120-1 (16QAM)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Parameter | Unit | Value | | | | |
| Reference channel |  | R.PDSCH.5-7.1 TDD | R.PDSCH.5-7.2 TDD | R.PDSCH.5-7.3 TDD |  |  |
| Channel bandwidth | MHz | 100 | 100 | 100 |  |  |
| Subcarrier spacing | kHz | 120 | 120 | 120 |  |  |
| Allocated resource blocks | PRBs | 66 | 66 | 66 |  |  |
| Number of consecutive PDSCH symbols |  | 12 | 12 | 12 |  |  |
| Allocated slots per 2 frames |  | 63 | 63 | 63 |  |  |
| MCS table |  | 64QAM | 64QAM | 64QAM |  |  |
| MCS index |  | 13 | 13 | 13 |  |  |
| Modulation |  | 16QAM | 16QAM | 16QAM |  |  |
| Target Coding Rate |  | 0.48 | 0.48 | 0.48 |  |  |
| Number of MIMO layers |  | 1 | 2 | 2 |  |  |
| Number of DMRS REs (Note 3) |  | 24 | 24 | 24 |  |  |
| Overhead for TBS determination |  | 6 | 6 | 12 |  |  |
| Information Bit Payload per Slot |  |  |  |  |  |  |
| For Slots 0 and Slot i, if mod(i, 5) = {3,4} for i from {0,…,159} | Bits | N/A | N/A | N/A |  |  |
| For CSI-RS Slot i, if mod(i,5) =1 for i from {0,…,159} | Bits | N/A | N/A | N/A |  |  |
| For Slot i = 80 | Bits | 14344 | 28680 | 27144 |  |  |
| For Slot i, if mod(i, 5) = {0,2} for i from {1,…,79,82,…,159} | Bits | 14344 | 28680 | 27144 |  |  |
| Transport block CRC per Slot |  |  |  |  |  |  |
| For Slots 0 and Slot i, if mod(i, 5) = {3,4} for i from {0,…,159} | Bits | N/A | N/A | N/A |  |  |
| For CSI-RS Slot i, if mod(i,5) =1 for i from {0,…,159} | Bits | N/A | N/A | N/A |  |  |
| For Slot i = 80 | Bits | 24 | 24 | 24 |  |  |
| For Slot i, if mod(i, 5) = {0,2} for i from {1,…,79,82,…,159} | Bits | 24 | 24 | 24 |  |  |
| Number of Code Blocks per Slot |  |  |  |  |  |  |
| For Slots 0 and Slot i, if mod(i, 5) = {3,4} for i from {0,…,159} | CBs | N/A | N/A | N/A |  |  |
| For CSI-RS Slot i, if mod(i,5) =1 for i from {0,…,159} | CBs | N/A | N/A | N/A |  |  |
| For Slot i = 80 | CBs | 2 | 4 | 4 |  |  |
| For Slot i, if mod(i, 5) = {0,2} for i from {1,…,79,82,…,159} | CBs | 2 | 4 | 4 |  |  |
| Binary Channel Bits Per Slot |  |  |  |  |  |  |
| For Slots 0 and Slot i, if mod(i, 5) = {3,4} for i from {0,…,159} | Bits | N/A | N/A | N/A |  |  |
| For CSI-RS Slot i, if mod(i,5) =1 for i from {0,…,159} | Bits | N/A | N/A | N/A |  |  |
| For Slot i = 80 | Bits | 28824 | 57552 | 54912 |  |  |
| For Slot i, if mod(i, 5) = {0,2} for i from {1,…,79,82,…,159} | Bits | 30360 | 60720 | 58080 |  |  |
| Max. Throughput averaged over 2 frames | Mbps | 45.1836 | 90.342 | 85.504 |  |  |
| Note 1: SS/PBCH block is transmitted in slot #0 with periodicity 20 ms  Note 2: Slot i is slot index per 2 frames  Note 3: Number of DMRS REs includes the overhead of the DM-RS CDM groups without data | | | | | | |

**--- End of change R4-2402993 ---**

**--- Start of change R4-2403084 ---**

**Table A.3.2.2.5-16 Reference measurement channels for PDSCH Single-DCI based SDM scheme for FR2.120-1 (64QAM)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Parameter** | **Unit** | **Value** | | | | |
| Reference channel |  | R.PDSCH.5-16.1 TDD | R.PDSCH.5-16.2 TDD |  |  |  |
| Channel bandwidth | MHz | 100 | 100 |  |  |  |
| Subcarrier spacing | kHz | 120 | 120 |  |  |  |
| Allocated resource blocks | PRBs | 66 | 66 |  |  |  |
| Number of consecutive PDSCH symbols |  |  |  |  |  |  |
| For Slots 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,159} |  | N/A | N/A |  |  |  |
| For Slot i, if mod(i, 5) = 3 for i from {0,…, 159} |  | 9 | 9 |  |  |  |
| For Slot i, if mod(i, 5) = {0,1,2} for i from {1,…,159} |  | 13 | 13 |  |  |  |
| Allocated slots per 2 frames |  | 127 | 127 |  |  |  |
| MCS table |  | 64QAM | 64QAM |  |  |  |
| MCS index |  | 17 | 17 |  |  |  |
| Modulation |  | 64QAM | 64QAM |  |  |  |
| Target Coding Rate |  | 0.43 | 0.43 |  |  |  |
| Number of MIMO layers |  | 2 | 2 |  |  |  |
| Number of DMRS REs |  |  |  |  |  |  |
| For Slots 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,159} |  | N/A | N/A |  |  |  |
| For Slot i, if mod(i, 5) = 3 for i from {0,…, 159} |  | 24 | 24 |  |  |  |
| For Slot i, if mod(i, 5) = {0,1,2} for i from {1,…,159} |  | 24 | 24 |  |  |  |
| Overhead for TBS determination |  | 6 | 12 |  |  |  |
| Information Bit Payload per Slot |  |  |  |  |  |  |
| For Slots 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,159} | Bits | N/A | N/A |  |  |  |
| For Slot i, if mod(i, 5) = 3 for i from {0,…, 159} | Bits | 26632 | 24576 |  |  |  |
| For Slot i, if mod(i, 5) = {0,1,2} for i from {1,…,159} | Bits | 43032 | 40976 |  |  |  |
| Transport block CRC per Slot |  |  |  |  |  |  |
| For Slots 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,159} | Bits | N/A | N/A |  |  |  |
| For Slot i, if mod(i, 5) = 3 for i from {0,…, 159} | Bits | 24 | 24 |  |  |  |
| For Slot i, if mod(i, 5) = {0,1,2} for i from {1,…,159} | Bits | 24 | 24 |  |  |  |
| Number of Code Blocks per Slot |  |  |  |  |  |  |
| For Slots 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,159} | CBs | N/A | N/A |  |  |  |
| For Slot i, if mod(i, 5) = 3 for i from {0,…, 159} | CBs | 4 | 3 |  |  |  |
| For Slot i, if mod(i, 5) = {0,1,2} for i from {1,…,159} | CBs | 6 | 5 |  |  |  |
| Binary Channel Bits Per Slot |  |  |  |  |  |  |
| For Slots 0 and Slot i, if mod(i, 5) = 4 for i from {0,…,159} | Bits | N/A | N/A |  |  |  |
| For Slots i = 80, 81 | Bits | 95436 | 91080 |  |  |  |
| For Slot i, if mod(i, 5) = 3 for i from {0,…, 159} | Bits | 63756 | 60984 |  |  |  |
| For Slot i, if mod(i, 5) = {0,1,2} for i from {1,…,79,82,…,159} | Bits | 100188 | 95832 |  |  |  |
| Max. Throughput averaged over 2 frames | Mbps | 247.0132 | 233.9576 |  |  |  |
| Note 1: SS/PBCH block is transmitted in slot #0 with periodicity 20 ms  Note 2: Slot i is slot index per 2 frames | | | | | | |

**--- End of change R4-2403084 ---**

# B.2 Multi-path fading propagation conditions

**<< Unchanged sections omitted >>**

## B.2.3 MIMO Channel Correlation Matrices

**<< Unchanged sections omitted >>**

**--- Start of change R4-2402991---**

B.2.3.3 MIMO Correlation Matrices for FR2 simultaneous reception

The correlation model for FR2 simultaneous reception in a two TRxP scenario with 1 antenna elecment with the same polarization in one direction at the gNB and UE side is defined as follows,

,

Where:

* is a correlation matrix for each link between TRPs to receiver modules at the UE side generated with
* is the correlation matrix for each link between TRP to UE RX.   
  . With 2 RX per TRP and UE-RX, is the polarization coefficient matrix as defined in Annex B2.3.2 using parameter γ=0.0625;
* denotes the Kronecker product,
* denotes the diagonal matrix,
* is a vector of re-arranged channel values for 2 antenna elements at each TRP and receiver module, defined as follows:
* *vec*( ) denotes vectorizing matrix column-by-column.

**--- End of change R4-2402991---**