TCOE India Evaluation Report of the TSDSI RIT

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# Introduction

This report contains the evaluation results received from TCOE proponents, which are reviewed and harmonized in TCOE meetings and used to summarize the evaluation results for quantitative assessment on TSDSI RIT proposal. All evaluation results were generated by following the IMT‑2020 evaluation methodology as provided in ITU-R M.2412. Table 1 shows the different sources of the evaluation results.

Table 1 Sources for the evaluation results

|  |  |
| --- | --- |
| Source 1 | Center for Excellence in Wireless Technology (CEWiT) |
| Source 2 | Indian Institute of Technology Madras (IITM) |
| Source 3 | Indian Institute of Technology Hyderabad (IITH) |
| Source 4 | Indian Institute of Technology Kharagpur (IIT KGP) |
| Source 5 | Indian Institute of Sciences (IISc) |

# Evaluation summary

In this final report, the following KPIs have been evaluated for the TSDSI RIT based on RIT Submission from TSDSI ([IMT-2020/19](https://www.itu.int/md/meetingdoc.asp?lang=en&parent=R15-IMT.2020-C-0019)) along with the update ([5D/1301](https://www.itu.int/md/R15-WP5D-C-1301/en)).

|  |  |
| --- | --- |
| Test environment | Does the Evaluation Report indicate that the minimum technical performance requirements are met in the test environment? |
| Indoor Hotspot-eMBB | Fully Evaluated. Meets the requirement for the required KPIs. |
| Dense Urban-eMBB | Fully Evaluated. Meets the requirement for the required KPIs. |
| Rural-eMBB | Fully Evaluated. Meets the requirement for the required KPIs. |
| Urban Macro–mMTC | Fully Evaluated. Meets the requirement for the required KPIs. |
| Urban Macro–URLLC | Fully evaluated. Meets the requirement for the required KPIs. |

The following KPIs have been evaluated in this report.

|  |  |  |
| --- | --- | --- |
| Simulation | Analytical | Inspection |
| 1. Average spectral efficiency 2. 5th percentile user spectral efficiency 3. Mobility 4. Reliability 5. Connection Density | 1. Peak data rate 2. Peak spectral efficiency 3. User experienced data rate 4. Area traffic capacity 5. User Plane Latency 6. Control Plane Latency 7. Mobility Interruption Time | 1. Bandwidth 2. Energy Efficiency 3. Spectrum |

In the next Table, the summary of the evaluated KPIs is provided for quick reference. From the table we observe that the TSDSI RIT meets the requirements for all the required KPIs.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Minimum technical performance requirements item (5.2.4.3.x), units, and Report ITU-R M.2410-0 section reference(1) | Category | | | Required value | Value obtained by the evaluation group | Requirement met? | Comments (3) |
|  | Usage scenario | Test environment | Downlink or uplink |  |  |  |  |
| 5.2.4.3.1 Peak data rate (Gbit/s) (4.1) | eMBB | Not applicable | Downlink | 20 | 39.2 | Yes | 16 Component carriers |
| Uplink | 10 | 20 | Yes |
| 5.2.4.3.2 Peak spectral efficiency (bit/s/Hz) (4.2) | eMBB | Not applicable | Downlink | 30 | 48.9 | Yes |  |
| Uplink | 15 | 25 | Yes |
| 5.2.4.3.3 User experienced data rate (Mbit/s) (4.3) | eMBB | Dense Urban – eMBB | Downlink | 100 | 132.16 – 136.28 | Yes |  |
| Uplink | 50 | 60.9 - 72 | Yes |  |
| 5.2.4.3.4 5th percentile user spectral efficiency (bit/s/Hz) (4.4) | eMBB | Indoor Hotspot – eMBB | Downlink | 0.3 | 0.34 | Yes | FDD Configuration A |
| 0.34 | Yes | TDD Configuration A |
| Uplink | 0.21 | 0.34 | Yes | FDD Configuration A |
| 0.35 | Yes | TDD Configuration A |
| eMBB | Dense Urban – eMBB | Downlink | 0.225 | 0.28 | Yes | FDD Configuration A |
| 0.25 | Yes | TDD Configuration A |
| Uplink | 0.15 | 0.18 | Yes | FDD Configuration A |
| 0.17 | Yes | TDD Configuration A |
| eMBB | Rural – eMBB | Downlink | 0.12 | 0.14 | Yes | FDD Configuration A |
| 0.22 | Yes | FDD Configuration B |
| 0.22 | Yes | FDD Configuration C |
| 0.13 | Yes | TDD Configuration A |
| 0.25 | Yes | TDD Configuration B |
| 0.26 | Yes | TDD Configuration C |
| Uplink | 0.045 | 0.09 | Yes | FDD configuration A |
| 0.062 | Yes | FDD Configuration B |
| 0.055 | Yes | FDD Configuration C |
| 0.074 | Yes | TDD Configuration A |
| 0.061 | Yes | TDD Configuration B |
| 0.06 | Yes | TDD Configuration C |
| 5.2.4.3.5 Average spectral efficiency (bit/s/Hz/ TRxP) (4.5) | eMBB | Indoor Hotspot – eMBB | Downlink | 9 | 9.8 | Yes | FDD Configuration A |
| 9.5 | Yes | TDD Configuration A |
| Uplink | 6.75 | 8.8 | Yes | FDD Configuration A |
| 7.01 | Yes | TDD Configuration A |
| eMBB | Dense Urban – eMBB | Downlink | 7.8 | 11.5 | Yes | FDD Configuration A |
| 11.1 | Yes | TDD Configuration A |
| Uplink | 5.4 | 7.88 | Yes | FDD Configuration A |
| 7.05 | Yes | TDD Configuration A |
| eMBB | Rural – eMBB | Downlink | 3.3 | 6.3 | Yes | FDD configuration A |
| 8.24 | Yes | FDD Configuration B |
| 6.3 | Yes | FDD Configuration C |
| 5.8 | Yes | TDD Configuration A |
| 8.01 | Yes | TDD Configuration B |
| 7.47 | Yes | TDD Configuration C |
| Uplink | 1.6 | 4.7 | Yes | FDD configuration A |
| 3.72 | Yes | FDD Configuration B |
| 4.13 | Yes | FDD Configuration C |
| 4.05 | Yes | TDD Configuration A |
| 3.51 | Yes | TDD Configuration B |
| 3.17 | Yes | TDD Configuration C |
| 5.2.4.3.6 Area traffic capacity (Mbit/s/m2) (4.6) | eMBB | Indoor-Hotspot – eMBB | Downlink | 10 | 10.04 – 11.43 | Yes |  |
| 5.2.4.3.7 User plane latency (ms) (4.7.1) | eMBB | Not applicable | Downlink | 4 | 0.415 – 2.656 | Yes |  |
| Uplink | 0.415 – 2.656 | Yes |
| URLLC | Not applicable | Downlink | 1 | 0.415 – 0.919 | Yes |  |
| Uplink | 0.415 – 0.919 | Yes |
| 5.2.4.3.8 Control plane latency (ms) (4.7.2) | eMBB | Not applicable | Not applicable | 20 | 11.654 – 18.041 | Yes |  |
| URLLC | Not applicable | Not applicable | 20 | 11.654 – 18.041 | Yes |  |
| 5.2.4.3.9 Connection density (devices/km2) (4.8) | mMTC | Urban Macro – mMTC | Uplink | 1 000 000 | 2167241 | Yes | ISD 1732m |
| 38841650 | Yes | ISD 500m |
| 5.2.4.3.10 Energy efficiency (4.9) | eMBB | Not applicable | Device | Capability to support a high sleep ratio and long sleep duration | 84.2% – 99.5% | Yes |  |
| Network | 82.9% - 99.9% |
| 5.2.4.3.11 Reliability (4.10) | URLLC | Urban Macro –URLLC | Downlink | 1-10−5 success probability of transmitting a layer 2 PDU (protocol data unit) of size 32 bytes within 1 ms in channel quality of coverage edge  99.999% | 99.9994% - 99.9995% | Yes |  |
| Uplink | 99.99998%  - 99.99999% | Yes |  |
| 5.2.4.3.12 Mobility classes (4.11) | eMBB | Indoor Hotspot – eMBB | Uplink | Stationary, Pedestrian | Stationary, Pedestrian | Yes |  |
| eMBB | Dense Urban – eMBB | Uplink | Stationary, Pedestrian, Vehicular (up to 30 km/h) | Stationary, Pedestrian,  Vehicular (up to 30 km/h) | Yes |  |
| eMBB | Rural – eMBB | Uplink | Pedestrian, Vehicular, High speed vehicular | Pedestrian, Vehicular, High speed vehicular | Yes |  |
| 5.2.4.3.13  Mobility Traffic channel link data rates (bit/s/Hz) (4.11) | eMBB | Indoor Hotspot – eMBB | Uplink | 1.5 (10 km/h) | 2.59 | Yes |  |
| eMBB | Dense Urban – eMBB | Uplink | 1.12 (30 km/h) | 2.44 | Yes |  |
| eMBB | Rural – eMBB | Uplink | 0.8 (120 km/h) | 2.53 | Yes | Configuration A |
| 0.45 (500 km/h) | 2.12 | Yes |
| 0.8 (120 km/h) | 2.80 | Yes | Configuration B |
| 0.45 (500 km/h) | 2.51 | Yes |
| 5.2.4.3.14 Mobility interruption time (ms)  (4.12) | eMBB and URLLC | Not applicable | Not applicable | 0 | 0 | Yes |  |
| 5.2.4.3.15 Bandwidth and Scalability (4.13) | Not applicable | Not applicable | Not applicable | At least 100 MHz | 800 MHz - 6.4 GHz | Yes |  |
| Up to 1 GHz | Yes |
| Support of multiple different bandwidth values | 3 - 13 different component carrier bandwidth values | Yes |
|  | (1) As defined in Report ITU-R M.2410-0.  (2) According to the evaluation methodology specified in Report ITU-R M.2412-0.  (3) Proponents should report their selected evaluation methodology of the Connection density, the channel model variant used, and evaluation configuration(s) with their exact values (e.g. antenna element number, bandwidth, etc.) per test environment, and could provide other relevant information as well. For details, refer to Report ITU-R M.2412-0, in particular, § 7.1.3 for the evaluation methodologies, § 8.4 for the evaluation configurations per each test environment, and Annex 1 on the channel model variants.  (4) Refer to § 7.3.1 of Report ITU-R M.2412-0. | | | | | | |

# Simulation KPIs

## Average Spectral Efficiency and 5-percentile Spectral Efficiency

In this Section, we evaluate the ASE and fifth percentile SE for all the required test environments. As required by Report ITU-R M.2412, the average spectral efficiency and the 5th percentile user spectral efficiency are assessed jointly using the same simulation.

### Indoor Hotspot (InH) Test Environment

The RIT was evaluated for Configuration A, *i.e.,* a carrier frequency of 4 GHz for both FDD and TDD.

#### Downlink Simulation Parameters

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **InH - eMBB** |  | |  |  |
| **Technical configuration Parameters** | Reference value | |  | |
|  |  |  | **FDD** | **TDD** |
| Multiple access | OFDMA | | Aligned with reference | Aligned with reference |
| Duplexing |  | | FDD | TDD |
| Network synchronization | Synchronized | | Aligned with reference | Aligned with reference |
| Modulation | Up to 256 QAM | | Aligned with reference | Aligned with reference |
| Coding on PDSCH | LDPC Max code-block size=8448bit  [with BP decoding] | | Aligned with reference | Aligned with reference |
| Numerology | 15 kHz / 30 kHz, 14 OFDM symbol slot | | 15 kHz SCS, 14 OFDM symbol slot | 15 kHz SCS, 14 OFDM symbol slot |
| Guard band ratio on simulation bandwidth | FDD: 6.4% (for 10 MHz bandwidth) TDD: 8.2% (51 RB for 30kHz SCS and 20 MHz bandwidth) TDD: 4.6% (106 RB for 15kHz SCS and 20 MHz bandwidth) | | Aligned with reference | Aligned with reference |
| Simulation bandwidth | FDD: 10 MHz TDD: 20 MHz | | 10 MHz | 20 MHz |
| Frame structure |  | | FDD: Full downlink | DSUUD |
| Transmission scheme | closed SU/MU-MIMO adaptation | | closed SU/MU-MIMO adaptation | closed SU/MU-MIMO adaptation |
| DL CSI measurement |  | | Non-precoded CSI-RS based | Non-precoded CSI-RS based |
| DL codebook |  | | Type I codebook; | Type I codebook; |
| PRB bundling |  | | 4 PRBs | 4 PRBs |
| MU dimension |  | | Up to 12 layers | Up to 12 layers |
| SU dimension |  | | For 4Rx: Up to 4 layers | For 4Rx: Up to 4 layers |
| Codeword (CW)-to-layer mapping | For 1~4 layers, CW1; For 5 layers or more, two CWs | | Aligned with reference | Aligned with reference |
| SRS transmission | Companies to Report: • Precoded or non-precoded SRS transmission; • SRS switch or not for 1T4R/2T4R/1T2R • SRS bandwidth • Number of OFDM symbols within 1 slot for SRS transmission per UE | | N/A | NA |
| CSI feedback |  | | PMI, CQI: every 5 slot; RI: every 5 slot; Subband based | CQI: every 5 slot; RI: every 5 slot, CRI: every 5 slot Subband based |
| Interference measurement |  | | SU-CQI; | SU-CQI; |
| CBG | 1 | | Aligned with reference | Aligned with reference |
| ACK/NACK delay |  | | 4 slots | The next available UL slot |
| Re-transmission delay |  | | The next available DL slot after receiving NACK | The next available DL slot after receiving NACK |
| Antenna configuration at TRxP | (M, N, P, Mg, Ng; Mp, Np) | | 12TRxP: For 32T, (M,N,P,Mg,Ng; Mp,Np) = (4,4,2,1,1;4,4)  (dH,dV) = (0.5, 0.5)λ | 12TRxP:For 32T, (M,N,P,Mg,Ng; Mp,Np) = (4,4,2,1,1;4,4)  (dH,dV) = (0.5, 0.5)λ |
| Antenna configuration at UE | (M, N, P, Mg, Ng; Mp, Np) | | For 12TRxP:   - For 4R, (M,N,P,Mg,Ng; Mp,Np) = (1,2,2,1,1; 1,2) (dH,dV) = (0.5, NA )λ | For 12TRxP:   - For 4R, (M,N,P,Mg,Ng; Mp,Np) = (1,2,2,1,1; 1,2) (dH,dV) = (0.5, NA)λ |
| Scheduling | PF | | Aligned with reference | Aligned with reference |
| Receiver | MMSE-IRC | | Aligned with reference | Aligned with reference |
| Channel estimation | Non-ideal | | Non-ideal | Non-ideal |
|  |  | |  |  |
| **System configuration parameters** | Reference Value | |  |  |
| TRxP number per site | 1 | 3 | Aligned with reference | Aligned with reference |
| Mechanic tilt | 180° in GCS (pointing to the ground) | [110°] in GCS | Aligned with reference | Aligned with reference |
| Electronic tilt | 90° in LCS | 90° in LCS | Aligned with reference | Aligned with reference |
| Handover margin (dB) |  | | 0 | 0 |
| UT attachment | Based on RSRP (formula as shown in Appendix 3 of RP-180524) from port 0  The UE panel with the best receive SNR is chosen. i.e. no combining is done between panels. | | Aligned with reference | Aligned with reference |
| Wrapping around method | No wrapping around | | Aligned with reference | Aligned with reference |
| Beam set at TRxP (Constraints for the range of selective analog beams per TRxP) | - | | - | - |
| Beam set at UE (Constraints for the range of selective analog beams for UE) | - | | - | - |
| Criteria for selection for serving TRxP | Maximizing RSRP where the digital beamforming is not considered | | Aligned with reference | Aligned with reference |
| Criteria for analog beam selection for serving TRxP | - | | - | - |
| Analog beam selection for interfering TRxP | - | | - | - |

#### Uplink Simulation Parameters

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **InH - eMBB** |  |  |  |  |
| **Technical configuration Parameters** | Reference value | |  | |
|  |  |  | **NR FDD** | **NR TDD** |
| Multiple access | OFDMA | | Aligned with reference | Aligned with reference |
| Duplexing |  | | FDD | TDD |
| Network synchronization | Synchronized | | Aligned with reference | Aligned with reference |
| Modulation | Up to 256QAM | | Aligned with reference | Aligned with reference |
| Coding on PUSCH | LDPC Max code-block size=8448bit  [with BP decoding] | | Aligned with reference | Aligned with reference |
| Numerology | 15 kHz / 30 kHz, 14 OFDM symbol slot | | 15 kHz SCS, 14 OFDM symbol slot | 15 kHz SCS, 14 OFDM symbol slot |
| Guard band ratio on simulation bandwidth | FDD: 6.4% (for 10 MHz bandwidth) TDD: 8.2% (51 RB for 30kHz SCS and 20 MHz bandwidth) TDD: 4.6% (106 RB for 15kHz SCS and 20 MHz bandwidth) | | Aligned with reference | Aligned with reference |
| Simulation bandwidth | FDD: 10 MHz TDD: 20 MHz | | 10 MHz | 20 MHz |
| Frame structure |  | | Full uplink | DSUUD |
| Transmission scheme | UL codebook based SU-MIMO / MU-MIMO | | UL SU-MIMO with rank adaptation | UL SU-MIMO with rank adaptation |
| UL codebook |  | | 4Tx codebook | 4Tx codebook |
| MU dimension |  | | N/A | N/A |
| SU dimension |  | | For 4Tx: Up to 4 layers | For 4Tx: Up to 4 layers |
| Codeword (CW)-to-layer mapping | For 1~4 layers, CW1; For 5 layers or more, two CWs | | Aligned with reference | Aligned with reference |
| SRS transmission | Companies to Report: • Precoded or non-precoded SRS transmission; • SRS switch or not for 1T4R/2T4R/1T2R • SRS bandwidth • Number of OFDM symbols within 1 slot for SRS transmission per UE | | Non-precoded SRS, 4 SRS ports (with 4 SRS resources); 2 symbols for SRS in every 5 slots, | Non-precoded SRS, 4 SRS ports (with 4 SRS resources); 2 symbols for SRS in every 5 slots, |
| Antenna configuration at TRxP | (M, N, P, Mg, Ng; Mp, Np) | | 12TRxP: For 32R, (M,N,P,Mg,Ng; Mp,Np) = (4,4,2,1,1;4,4)  (dH,dV) = (0.5, 0.5)λ | 12TRxP:For 32R, (M,N,P,Mg,Ng; Mp,Np) = (4,4,2,1,1;4,4)  (dH,dV) = (0.5, 0.5)λ |
| Antenna configuration at UE | (M, N, P, Mg, Ng; Mp, Np) | | 12TRxP:   (M,N,P,Mg,Ng; Mp,Np) = (1,2,2,1,1; 1,2); (dH, dV)=( 0.5, N/A)λ | 12TRxP:   (M,N,P,Mg,Ng; Mp,Np) = (1,2,2,1,1; 1,2); (dH, dV)=( 0.5, N/A)λ |
| Max CBG number | 1 | | Aligned with reference | Aligned with reference |
| UL re-transmission delay |  | | Next available UL slot after receiving retransmission indication | Next available UL slot after receiving retransmission indication |
| Scheduling | PF | | Aligned with reference | Aligned with reference |
| Receiver | MMSE-IRC | | Aligned with reference | Aligned with reference |
| Channel estimation |  | | Non-ideal | Non-ideal |
| Power control parameter |  | | P0=-76, alpha = 0.8 | P0=-76, alpha = 0.8 |
| Power backoff model |  | | Continuous RB allocation: follow T3.9038.101 for FR1; Non-continuous RB allocation: additional 2 dB reduction | Continuous RB allocation: follow T3.9038.101 for FR1; Non-continuous RB allocation: additional 2 dB reduction |
|  |  | |  |  |
| **System configuration parameters** | Reference Value | |  |  |
| TRxP number per site | 1 | 3 | Aligned with reference | Aligned with reference |
| Mechanic tilt | 180° in GCS (pointing to the ground) | [110°] in GCS | Aligned with reference | Aligned with reference |
| Electronic tilt | 90° in LCS | 90° in LCS | Aligned with reference | Aligned with reference |
| Handover margin (dB) |  | | 0 | 0 |
| UT attachment | Based on RSRP from port 0  The UE panel with the best receive SNR is chosen. i.e. no combining is done between panels. | | Aligned with reference | Aligned with reference |
| Wrapping around method | No wrapping around | | Aligned with reference | Aligned with reference |
| Beam set at TRxP (Constraints for the range of selective analog beams per TRxP) | - | | - | - |
| Beam set at UE (Constraints for the range of selective analog beams for UE) | - | | - | - |
| Criteria for selection for serving TRxP | Maximizing RSRP where the digital beamforming is not considered | | Aligned with reference | Aligned with reference |
| Criteria for analog beam selection for serving TRxP | - | | - | - |
| Analog beam selection for interfering TRxP | - | | - | - |
| Other system configuration parameters align with Report ITU-R M.2412 | | |  |  |

#### Simulation Results

Average spectral efficiency for TDD configuration for the Indoor hotspot test environment

|  |  |  |
| --- | --- | --- |
|  | ITU Requirement | TCOE INDIA |
| Downlink | 9 [bit/s/Hz/TRxP] | 9.5 |
| Uplink | 6.75 [bit/s/Hz/TRxP] | 7.01 |

Average spectral efficiency for FDD configuration for the Indoor hotspot test environment

|  |  |  |
| --- | --- | --- |
|  | ITU Requirement | TCOE INDIA |
| Downlink | 9 [bit/s/Hz/TRxP] | 9.8 |
| Uplink | 6.75 [bit/s/Hz/TRxP] | 8.8 |
|  |  |  |

5th-percentile spectral efficiency for TDD configuration for the Indoor hotspot test environment

|  |  |  |
| --- | --- | --- |
|  | ITU Requirement | TCOE INDIA |
| Downlink | 0.3 | 0.34 |
| Uplink | 0.21 | 0.35 |

5th-percentile spectral efficiency for FDD configuration for the Indoor hotspot test environment

|  |  |  |
| --- | --- | --- |
|  | ITU Requirement | TCOE INDIA |
| Downlink | 0.3 | 0.34 |
| Uplink | 0.21 | 0.34 |

### Dense Urban Test Environment

The RIT was evaluated for Configuration A, *i.e.,* a carrier frequency of 4 GHz for both FDD and TDD.

#### Downlink Simulation Parameters

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Dense Urban - eMBB** |  |  | |  | |
| **Technical configuration Parameters** | Reference value for NR |  | |  | |
| **FDD** | | **TDD** | |
| Multiple access | OFDMA | Aligned with reference | | Aligned with reference | |
| Duplexing |  | FDD | | TDD | |
| Network synchronization | Synchronized | Aligned with reference | | Aligned with reference | |
| Modulation | Up to 256 QAM | Aligned with reference | | Aligned with reference | |
| Coding on PDSCH | LDPC Max code-block size=8448bit  [with BP decoding] | Aligned with reference | | Aligned with reference | |
| Numerology | 15KHz / 30kHz, 14 OFDM symbol slot | 15kHz SCS, 14 OFDM symbol slot | | 15kHz SCS, 14 OFDM symbol slot | |
| Guard band ratio on simulation bandwidth | FDD: 6.4% (for 10 MHz) TDD: 8.2% (51 RB for 30kHz SCS and 20 MHz bandwidth) TDD: 4.6% (106 RB for 15kHz SCS and 20 MHz bandwidth) | Aligned with reference | | Aligned with reference | |
| Simulation bandwidth | FDD: 10 MHz TDD: 20 MHz | Aligned with reference | | Aligned with reference | |
| Frame structure |  | Full downlink | | DSUUD | |
| Transmission scheme | Closed SU/MU-MIMO adaptation | Aligned with reference | | Aligned with reference | |
| DL CSI measurement |  | Non-precoded CSI-RS based | | Non-precoded CSI-RS based | |
| DL codebook |  | Type I codebook | | Type I codebook | |
| PRB bundling |  | 4 PRBs | | 4 PRBs | |
| MU dimension |  | Up to 12 layers | | Up to 12 layers | |
| SU dimension |  | For 4Rx: Up to 4 layers | | For 4Rx: Up to 4 layers | |
| Codeword (CW)-to-layer mapping | For 1~4 layers, CW1; For 5 layers or more, two CWs | Aligned with reference | | Aligned with reference | |
| SRS transmission | Companies to Report: • Precoded or non-precoded SRS transmission; • SRS switch or not for 1T4R/2T4R/1T2R • SRS bandwidth • Number of OFDM symbols within 1 slot for SRS transmission per UE | N/A | | N/A | |
| CSI feedback |  | PMI, CQI: every 5 slot; RI: every 5 slot; Subband based | | PMI, CQI: every 5 slot; RI: every 5 slot; Subband based | |
| Interference measurement |  | SU-CQI; | | SU-CQI; | |
| Max CBG number | 1 | Aligned with reference | | Aligned with reference | |
| ACK/NACK delay | UE capability 1 | 4 slots | | The next available UL slot | |
| Re-transmission delay |  | The next available DL slot after receiving NACK | | The next available DL slot after receiving NACK | |
| Antenna configuration at TRxP | (M, N, P, Mg, Ng; Mp, Np) | For 32T: (M,N,P,Mg,Ng; Mp,Np) = (8,8,2,1,1;2,8) (dH, dV)=(0.5, 0.8)λ | | For 32T: (M,N,P,Mg,Ng; Mp,Np) = (8,8,2,1,1;2,8) (dH, dV)=(0.5, 0.8)λ | |
| Antenna configuration at UE | (M, N, P, Mg, Ng; Mp, Np) | For 4R: (M,N,P,Mg,Ng; Mp,Np)= (1,2,2,1,1; 1,2) (dH, dV)=(0.5, N/A)λ | | For 4R: (M,N,P,Mg,Ng; Mp,Np)= (1,2,2,1,1; 1,2) (dH, dV)=(0.5, N/A)λ | |
| Scheduling | PF | Aligned with reference | | Aligned with reference | |
| Receiver | MMSE-IRC | Aligned with reference | | Aligned with reference | |
| Channel estimation |  | Non-ideal | | Non-ideal | |
|  |  |  | |  | |
| **System configuration parameters** | Reference Value |  | |  | |
| Mechanic tilt | 90° in GCS (pointing to horizontal direction) | Aligned with reference | | Aligned with reference | |
| Electronic tilt | 105 degree | Aligned with reference | | Aligned with reference | |
| Handover margin (dB) |  | 0 | | 0 | |
| UT attachment | Based on RSRP (formula (8.1-1) in TR36.873) from port 0 | Aligned with reference | | Aligned with reference | |
| Wrapping around method | Geographical distance based wrapping | Aligned with reference | | Aligned with reference | |
| Beam set at TRxP (Constraints for the range of selective analog beams per TRxP) | - | - | | - | |
| Beam set at UE (Constraints for the range of selective analog beams for UE) | - | - | | - | |
| Criteria for selection for serving TRxP | Maximizing RSRP where the digital beamforming is not considered | Aligned with reference | | Aligned with reference | |
| Criteria for analog beam selection for serving TRxP | - | - | | - | |
| Criteria for analog beam selection for interfering TRxP | - | - | | - | |
| Other system configuration parameters align with Report ITU M.2412 | | |  | |  |

#### Uplink Simulation Parameters

|  |  |  |  |
| --- | --- | --- | --- |
| **Dense Urban - eMBB** |  |  |  |
| **Technical configuration Parameters** | Reference value |  |  |
| **FDD** | **TDD** |
| Multiple access | OFDMA | Aligned with reference | Aligned with reference |
| Duplexing |  | FDD | TDD |
| Network synchronization | Synchronized | Aligned with reference | Aligned with reference |
| Modulation | Up to 256QAM | Aligned with reference | Aligned with reference |
| Coding on PUSCH | LDPC Max code-block size=8448bit  [with BP decoding] | Aligned with reference | Aligned with reference |
| Numerology | 15KHz / 30kHz, 14 OFDM symbol slot | 15kHz SCS, 14 OFDM symbol slot | 15kHz SCS, 14 OFDM symbol slot |
| Guard band ratio on simulation bandwidth | FDD: 6.4% (for 10 MHz) TDD: 8.2% (51 RB for 30 kHz 20 MHz) TDD: 4.6% (106 RB for 15 kHz 20 MHz) | Aligned with reference | Aligned with reference |
| Simulation bandwidth | FDD: 10 MHz TDD: 20 MHz | Aligned with reference | Aligned with reference |
| Frame structure |  | Full uplink | DSUUD |
| Transmission scheme | UL codebook based SU-MIMO / MU-MIMO | UL SU-MIMO with rank adaptation | UL SU-MIMO with rank adaptation |
| UL codebook |  | For 4Tx: 4Tx codebook; | For 4Tx: 4Tx codebook; |
| MU dimension |  | N/A | N/A |
| SU dimension |  | For 4Tx: Up to 4 layers | For 4Tx: Up to 4 layers |
| Codeword (CW)-to-layer mapping | For 1~4 layers, CW1; For 5 layers or more, two CWs | Aligned with reference | Aligned with reference |
| SRS transmission | Companies to Report: • Precoded or non-precoded SRS transmission; • SRS switch or not for 1T4R/2T4R/1T2R • SRS bandwidth • Number of OFDM symbols within 1 slot for SRS transmission per UE | For UE 4 Tx ports: Non-precoded SRS, 4 SRS ports (with 4 SRS resources); 2 symbols for SRS in every 5 slots, 8 PRBs per symbol | For UE 4 Tx ports: Non-precoded SRS, 4 SRS ports (with 4 SRS resources); 2 symbols for SRS in every 5 slots, 8 PRBs per symbol |
| Antenna configuration at TRxP | (M, N, P, Mg, Ng; Mp, Np) | For 32R: (M,N,P,Mg,Ng; Mp,Np)= (8,8,2,1,1; 2,8) (dH, dV)=(0.5, 0.8)λ; | For 32R: (M,N,P,Mg,Ng; Mp,Np)= (8,8,2,1,1; 2,8) (dH, dV)=(0.5, 0.8)λ; |
| Antenna configuration at UE | (M, N, P, Mg, Ng; Mp, Np) | For 4T: (M,N,P,Mg,Ng; Mp,Np)= (1,2,2,1,1; 1,2) (dH, dV)=(0.5, N/A)λ | For 4T: (M,N,P,Mg,Ng; Mp,Np)= (1,2,2,1,1; 1,2) (dH, dV)=(0.5, N/A)λ |
| Max CBG number | 1 | Aligned with reference | Aligned with reference |
| UL re-transmission delay |  | Next available UL slot after reiving retransmission indication | Next available UL slot after reiving retransmission indication |
| Scheduling | PF | Aligned with reference | Aligned with reference |
| Receiver | MMSE-IRC | Aligned with reference | Aligned with reference |
| Channel estimation |  | Non-ideal | Non-ideal |
| Power control parameter |  | P0=-86, alpha = 0.8 | P0=-86, alpha = 0.8 |
| Power backoff model |  | Continuous RB allocation: follow T3.9038.101 for FR1; Non-continuous RB allocation: additional 2 dB reduction | Continuous RB allocation: follow T3.9038.101 for FR1; Non-continuous RB allocation: additional 2 dB reduction |
|  |  |  |  |
| **System configuration parameters** | Reference Value |  |  |
| Mechanic tilt | 90° in GCS (pointing to horizontal direction) | Aligned with reference | Aligned with reference |
| Electronic tilt | 105 degree | Aligned with reference | Aligned with reference |
| Handover margin (dB) |  | 0 | 0 |
| UT attachment | Based on RSRP from port 0 | Aligned with reference | Aligned with reference |
| Wrapping around method | Geographical distance based wrapping | Aligned with reference | Aligned with reference |
| Beam set at TRxP (Constraints for the range of selective analog beams per TRxP) | - | - | - |
| Beam set at UE (Constraints for the range of selective analog beams for UE) | - | - | - |
| Criteria for selection for serving TRxP | Maximizing RSRP where the digital beamforming is not considered | Aligned with reference | Aligned with reference |
| Criteria for analog beam selection for serving TRxP | - | - | - |
| Criteria for analog beam selection for interfering TRxP | - | - | - |

#### Simulation Results

Average spectral efficiency for TDD configuration for the Dense Urban test environment

|  |  |  |
| --- | --- | --- |
|  | ITU Requirement | TCOE INDIA |
| Downlink | 7.8 [bit/s/Hz/TRxP] | 11.1 |
| Uplink | 5.4 [bit/s/Hz/TRxP] | 7.05 |

Average spectral efficiency for FDD configuration for the Dense Urban test environment

|  |  |  |
| --- | --- | --- |
|  | ITU Requirement | TCOE INDIA |
| Downlink | 7.8 [bit/s/Hz/TRxP] | 11.5 |
| Uplink | 5.4 [bit/s/Hz/TRxP] | 7.88 |

5th-percentile spectral efficiency for TDD configuration for the Dense Urban test environment

|  |  |  |
| --- | --- | --- |
|  | ITU Requirement | TCOE INDIA |
| Downlink | 0.225 | 0.25 |
| Uplink | 0.15 | 0.17 |

5th-percentile spectral efficiency for FDD configuration for the Dense Urban test environment

|  |  |  |
| --- | --- | --- |
|  | ITU Requirement | TCOE INDIA |
| Downlink | 0.225 | 0.28 |
| Uplink | 0.15 | 0.18 |

### Rural Test Environment

The Rural Test Environment was evaluated for all the three configurations

#### Config A

The RIT was evaluated for Rural e-MBB Configuration A, i.e., a carrier frequency of 700 MHz for both FDD and TDD.

##### Downlink Simulation Parameters

|  |  |  |  |
| --- | --- | --- | --- |
| **Rural - eMBB** |  |  |  |
| **Technical configuration Parameters** | Reference value |  |  |
|  |  | **FDD** | **TDD** |
| Multiple access | OFDMA | Aligned with reference | Aligned with reference |
| Duplexing |  | FDD | TDD |
| Network synchronization |  | Aligned with reference | Aligned with reference |
| Modulation | Up to 256 QAM | Aligned with reference | Aligned with reference |
| Coding on PDSCH | LDPC Max code-block size=8448bit  [with BP decoding] | Aligned with reference | Aligned with reference |
| Numerology | 15 kHz / 30 kHz, 14 OFDM symbol slot | 15 kHz SCS, 14 OFDM symbol slot | 15 kHz SCS, 14 OFDM symbol slot |
| Guard band ratio on simulation bandwidth | FDD: 6.4% (for 10 MHz bandwidth) TDD: 8.2% (51 RB for 30kHz SCS and 20 MHz bandwidth) TDD: 4.6% (106 RB for 15kHz SCS and 20 MHz bandwidth) | Aligned with reference | Aligned with reference |
| Simulation bandwidth | FDD: 10 MHz TDD: 20 MHz | Aligned with reference | Aligned with reference |
| Frame structure |  | Full downlink | DSUUD |
| Transmission scheme | Closed SU/MU-MIMO adaptation | closed SU-MIMO adaptation | closed SU/MU-MIMO adaptation |
| DL CSI measurement |  | Non-precoded CSI-RS based | Non-precoded CSI-RS based |
| DL codebook |  | Type I codebook ; | Type I codebook ; |
| PRB bundling |  | 4 PRBs | 4 PRBs |
| MU dimension |  | Up to 8 layers | Up to 8 layers |
| SU dimension |  | For 2Rx: Up to 2 layers | For 2Rx: Up to 2 layers |
| Codeword (CW)-to-layer mapping | For 1~4 layers, CW1; For 5 layers or more, two CWs | Aligned with reference | Aligned with reference |
| SRS transmission | Companies to Report: • Precoded or non-precoded SRS transmission; • SRS switch or not for 1T4R/2T4R/1T2R • SRS bandwidth • Number of OFDM symbols within 1 slot for SRS transmission per UE | N/A | N/A |
| CSI feedback |  | PMI, CQI: every 5 slot; RI: every 5 slot; Subband based | PMI, CQI: every 5 slot; RI: every 5 slot; Subband based |
| Interference measurement |  | SU-CQI | SU-CQI |
| CBG | 1 | Aligned with reference | Aligned with reference |
| ACK/NACK delay |  | 4 slots | The next available UL slot |
| Re-transmission delay |  | The next available DL slot after receiving NACK | The next available DL slot after receiving NACK |
| Antenna configuration at TRxP | (M, N, P, Mg, Ng; Mp, Np) | For 8T: (M,N,P,Mg,Ng; Mp,Np) = (8,4,2,1,1;1,4) (dH, dV)=(0.5, 0.8)λ | For 8T: (M,N,P,Mg,Ng; Mp,Np) = (8,4,2,1,1;1,4) (dH, dV)=(0.5, 0.8)λ |
| Antenna configuration at UE | (M, N, P, Mg, Ng; Mp, Np) | For 2R: (M,N,P,Mg,Ng; Mp,Np) = (1,1,2,1,1; 1,1) | For 2R: (M,N,P,Mg,Ng; Mp,Np) = (1,1,2,1,1; 1,1) |
| Scheduling | PF | Aligned with reference | Aligned with reference |
| Receiver | MMSE-IRC | Aligned with reference | Aligned with reference |
| Channel estimation |  | Non-Ideal | Non-Ideal |
|  |  |  |  |
| **System configuration parameters** | Reference Value |  |  |
| Mechanic tilt | 90° in GCS (pointing to horizontal direction) | Aligned with reference | Aligned with reference |
| Electronic tilt | [100°] in LCS | Aligned with reference | Aligned with reference |
| Handover margin (dB) |  | 0 | 0 |
| UT attachment | Based on RSRP (formula as shown in Appendix 3 of RP-180524) from port 0 | Aligned with reference | Aligned with reference |
|
| Wrapping around method | Geographical distance based wrapping | Aligned with reference | Aligned with reference |
| Beam set at TRxP (Constraints for the range of selective analog beams per TRxP) | - | - | - |
| Beam set at UE (Constraints for the range of selective analog beams for UE) | - | - | - |
| Criteria for selection for serving TRxP | Maximizing RSRP where the digital beamforming is not considered | Aligned with reference | Aligned with reference |
| Criteria for analog beam selection for serving TRxP | - | - | - |
| Criteria for analog beam selection for interfering TRxP | - | - | - |
| Other system configuration parameters align with Report ITU-R M.2412 | |  |  |

##### Uplink Simulation Parameters

|  |  |  |  |
| --- | --- | --- | --- |
| **Rural - eMBB** |  |  |  |
| **Technical configuration Parameters** | Reference value |  |  |
|  |  | **FDD** | **TDD** |
| Multiple access | OFDMA | Aligned with reference | Aligned with reference |
| Duplexing |  | FDD | TDD |
| Network synchronization |  | Aligned with reference | Aligned with reference |
| Modulation | Up to 256QAM | Aligned with reference | Aligned with reference |
| Coding on PUSCH | LDPC Max code-block size=8448bit  [with BP decoding] | Aligned with reference | Aligned with reference |
| Numerology | 15 kHz / 30 kHz, 14 OFDM symbol slot | 15 kHz SCS, 14 OFDM symbol slot | 15 kHz SCS, 14 OFDM symbol slot |
| Guard band ratio on simulation bandwidth | FDD: 6.4% (for 10 MHz bandwidth) TDD: 8.2% (51 RB for 30kHz SCS and 20 MHz bandwidth) TDD: 4.6% (106 RB for 15kHz SCS and 20 MHz bandwidth) | Aligned with reference | Aligned with reference |
| Simulation bandwidth | FDD: 10 MHz TDD: 20 MHz | Aligned with reference | Aligned with reference |
| Frame structure |  | Full uplink | DSUUD |
| Transmission scheme |  | SU-MIMO with rank adaptation | SU-MIMO with rank adaptation |
| UL codebook |  | UL 2Tx Codebook | UL 2Tx Codebook |
| MU dimension |  | N/A | N/A |
| SU dimension |  | For 2 Tx: Up to 2 layer | For 2 Tx: Up to 2 layer |
| Codeword (CW)-to-layer mapping | For 1~4 layers, CW1; For 5 layers or more, two CWs | Aligned with reference | Aligned with reference |
| SRS transmission | Companies to Report: • Precoded or non-precoded SRS transmission; • SRS switch or not for 1T4R/2T4R/1T2R • SRS bandwidth • Number of OFDM symbols within 1 slot for SRS transmission per UE | Non-precoded SRS, 2 SRS ports (with 1 SRS resource); 2 symbols for SRS in every 5 slots. | Non-precoded SRS, 2 SRS ports (with 1 SRS resource); 2 symbols for SRS in every 5 slots. |
| Antenna configuration at TRxP | (M, N, P, Mg, Ng; Mp, Np) | For 8R: (M,N,P,Mg,Ng; Mp,Np) = (8,4,2,1,1; 1,4) (dH, dV)=(0.5, 0.8)λ | For 8R: (M,N,P,Mg,Ng; Mp,Np) = (8,4,2,1,1; 1,4) (dH, dV)=(0.5, 0.8)λ |
| Antenna configuration at UE | (M, N, P, Mg, Ng; Mp, Np) | For 2T: (M,N,P,Mg,Ng; Mp,Np)= (1,1,2,1,1; 1,1) (dH, dV)=( N/A, N/A)λ | For 2T: (M,N,P,Mg,Ng; Mp,Np)= (1,1,2,1,1; 1,1) (dH, dV)=( N/A, N/A)λ |
| Max CBG number | 1 | Aligned with reference | Aligned with reference |
| UL re-transmission delay |  | Next available UL slot after reiving retransmission indication | Next available UL slot after reiving retransmission indication |
| Scheduling | PF | Aligned with reference | Aligned with reference |
| Receiver | MMSE-IRC | Aligned with reference | Aligned with reference |
| Channel estimation |  | Non-ideal | Non-ideal |
| Power control parameter |  | P0=-76, alpha = 0.8 | P0=-76, alpha = 0.8 |
| Power backoff model |  | Continuous RB allocation: follow T3.9038.101 for FR1; Non-continuous RB allocation: additional 2 dB reduction | Continuous RB allocation: follow T3.9038.101 for FR1; Non-continuous RB allocation: additional 2 dB reduction |
|  |  |  |  |
| **System configuration parameters** | Reference Value |  |  |
| Mechanic tilt | 90° in GCS (pointing to horizontal direction) | Aligned with reference | Aligned with reference |
| Electronic tilt | [100°] in LCS | Aligned with reference | Aligned with reference |
| Handover margin (dB) |  | 0 | 0 |
| UT attachment | Based on RSRP (formula as shown in Appendix 3 of RP-180524) from port 0 | Aligned with reference | Aligned with reference |
|
| Wrapping around method | Geographical distance based wrapping | Aligned with reference | Aligned with reference |
| Beam set at TRxP (Constraints for the range of selective analog beams per TRxP) | - | - | - |
| Beam set at UE (Constraints for the range of selective analog beams for UE) | - | - | - |
| Criteria for selection for serving TRxP | Maximizing RSRP where the digital beamforming is not considered | Aligned with reference | Aligned with reference |
| Criteria for analog beam selection for serving TRxP | - | - | - |
| Criteria for analog beam selection for interfering TRxP | - | - | - |
| Other system configuration parameters align with Report ITU-R M.2412 | |  |  |

##### Simulation Results

Average spectral efficiency for TDD configuration for the Rural-eMBB test environment, Configuration A (700 MHz)

|  |  |  |
| --- | --- | --- |
|  | ITU Requirement | TCOE INDIA |
| Downlink | 3.3 [bit/s/Hz/TRxP] | 5.8 |
| Uplink | 1.6 [bit/s/Hz/TRxP] | 4.05 |

Average spectral efficiency for FDD configuration for the Rural-eMBB test environment, Configuration A (700 MHz)

|  |  |  |
| --- | --- | --- |
|  | ITU Requirement | TCOE INDIA |
| Downlink | 3.3 [bit/s/Hz/TRxP] | 6.3 |
| Uplink | 1.6 [bit/s/Hz/TRxP] | 4.7 |

5th-percentile spectral efficiency for TDD configuration for the Rural-eMBB test environment, Configuration A (700 MHz)

|  |  |  |
| --- | --- | --- |
|  | ITU Requirement | TCOE INDIA |
| Downlink | 0.12 | 0.13 |
| Uplink | 0.045 | 0.074 |

5th-percentile spectral efficiency for FDD configuration for the Rural-eMBB test environment, Configuration A (700 MHz)

|  |  |  |
| --- | --- | --- |
|  | ITU Requirement | TCOE INDIA |
| Downlink | 0.12 | 0.14 |
| Uplink | 0.045 | 0.09 |

#### Config B

The RIT was evaluated for Rural e-MBB Configuration B, i.e., a carrier frequency of 4 GHz for both FDD and TDD. The following simulation parameters were used for the evaluation.

##### Downlink Simulation Parameters

|  |  |  |  |
| --- | --- | --- | --- |
| **Rural - eMBB** |  |  |  |
| **Technical configuration Parameters** | Reference value |  |  |
|  |  | **FDD** | **TDD** |
| Multiple access | OFDMA | Aligned with reference | Aligned with reference |
| Duplexing |  | FDD | TDD |
| Network synchronization | Synchronized | Aligned with reference | Aligned with reference |
| Modulation | Up to 256 QAM | Aligned with reference | Aligned with reference |
| Coding on PDSCH | LDPC Max code-block size=8448bit  [with BP decoding] | Aligned with reference | Aligned with reference |
| Numerology | 15 kHz / 30 kHz, 14 OFDM symbol slot | 15kHz SCS, 14 OFDM symbol slot | 15kHz SCS, 14 OFDM symbol slot |
| Guard band ratio on simulation bandwidth | FDD: 6.4% (for 10 MHz bandwidth) TDD: 8.2% (51 RB for 30kHz SCS and 20 MHz bandwidth) TDD: 4.6% (106 RB for 15kHz SCS and 20 MHz bandwidth) | Aligned with reference | Aligned with reference |
| Simulation bandwidth | FDD: 10 MHz TDD: 20 MHz | Aligned with reference | Aligned with reference |
| Frame structure |  | Full downlink | DSUUD |
| Transmission scheme | closed SU/MU-MIMO adaptation | Aligned with reference | Aligned with reference |
| DL CSI measurement |  | Non-precoded CSI-RS based | Non-precoded CSI-RS based |
| DL codebook |  | Type I codebook | Type I codebook |
| PRB bundling |  | 4 PRBs | 4 PRBs |
| MU dimension |  | Up to 12 layers | Up to 12 layers |
| SU dimension |  | For 4Rx: Up to 4 layers | For 4Rx: Up to 4 layers |
| Codeword (CW)-to-layer mapping | For 1~4 layers, CW1; For 5 layers or more, two CWs | Aligned with reference | Aligned with reference |
| SRS transmission | Companies to Report: • Precoded or non-precoded SRS transmission; • SRS switch or not for 1T4R/2T4R/1T2R • SRS bandwidth • Number of OFDM symbols within 1 slot for SRS transmission per UE | N/A | N/A |
| CSI feedback |  | PMI, CQI: every 5 slot; RI: every 5 slot; Subband based | PMI, CQI: every 5 slot; RI: every 5 slot; Subband based |
| Interference measurement |  | SU-CQI; | SU-CQI; |
| CBG | 1 | Aligned with reference | Aligned with reference |
| ACK/NACK delay |  | 4 slots | The next available UL slot |
| Re-transmission delay |  | The next available DL slot after receiving NACK | The next available DL slot after receiving NACK |
| Antenna configuration at TRxP | (M, N, P, Mg, Ng; Mp, Np) | For 32T: (M,N,P,Mg,Ng; Mp,Np) = (8,8,2,1,1;2,8) (dH, dV)=(0.5, 0.8)λ | For 32T: (M,N,P,Mg,Ng; Mp,Np) = (8,8,2,1,1;2,8) (dH, dV)=(0.5, 0.8)λ |
| Antenna configuration at UE | (M, N, P, Mg, Ng; Mp, Np) | For 4R: (M,N,P,Mg,Ng; Mp,Np)= (1,2,2,1,1; 1,2) (dH, dV)=(0.5, N/A)λ | For 4R: (M,N,P,Mg,Ng; Mp,Np)= (1,2,2,1,1; 1,2) (dH, dV)=(0.5, N/A)λ |
| Scheduling | PF | Aligned with reference | Aligned with reference |
| Receiver | MMSE-IRC | Aligned with reference | Aligned with reference |
| Channel estimation |  | Non-ideal | Non-ideal |
|  |  |  |  |
| **System configuration parameters** | Reference Value |  |  |
| Mechanic tilt | 90° in GCS (pointing to horizontal direction) | Aligned with reference | Aligned with reference |
| Electronic tilt | [100°] in LCS | Aligned with reference | Aligned with reference |
| Handover margin (dB) |  | 0 | 0 |
| UT attachment | Based on RSRP (formula (8.1-1) in TR36.873) from port 0 | Aligned with reference | Aligned with reference |
| Aligned with reference | Aligned with reference |
| Wrapping around method | Geographical distance based wrapping | - | - |
| Beam set at TRxP (Constraints for the range of selective analog beams per TRxP) | - | - | - |
| Beam set at UE (Constraints for the range of selective analog beams for UE) | - | Aligned with reference | Aligned with reference |
| Criteria for selection for serving TRxP | Maximizing RSRP where the digital beamforming is not considered | - | - |
| Criteria for analog beam selection for serving TRxP | - | - | - |
| Criteria for analog beam selection for interfering TRxP | - |  |  |
| Other system configuration parameters align with Report ITU-R M.2412 | |  |  |

##### Uplink Simulation Parameters

|  |  |  |  |
| --- | --- | --- | --- |
| **Rural - eMBB** |  |  |  |
| **Technical configuration Parameters** | Reference value |  |  |
|  |  | **FDD** | **TDD** |
| Multiple access | OFDMA | Aligned with reference | Aligned with reference |
| Duplexing |  | FDD | TDD |
| Network synchronization | Synchronized | Aligned with reference | Aligned with reference |
| Modulation | Up to 256QAM | Aligned with reference | Aligned with reference |
| Coding on PUSCH | LDPC Max code-block size=8448bit  [with BP decoding] | Aligned with reference | Aligned with reference |
| Numerology | 15 kHz / 30 kHz, 14 OFDM symbol slot | 15kHz SCS, 14 OFDM symbol slot | 15kHz SCS, 14 OFDM symbol slot |
| Guard band ratio on simulation bandwidth | FDD: 6.4% (for 10 MHz bandwidth) TDD: 8.2% (51 RB for 30kHz SCS and 20 MHz bandwidth) TDD: 4.6% (106 RB for 15kHz SCS and 20 MHz bandwidth) | Aligned with reference | Aligned with reference |
| Simulation bandwidth | FDD: 10 MHz TDD: 20 MHz | Aligned with reference | Aligned with reference |
| Frame structure |  | Full uplink | DSUUD |
| Transmission scheme |  | UL SU-MIMO with rank adaptation | UL SU-MIMO with rank adaptation |
| UL codebook |  | For 4Tx: 4Tx codebook; | For 4Tx: 4Tx codebook; |
| MU dimension |  | N/A | N/A |
| SU dimension |  | For 4Tx: Up to 4 layers | For 4Tx: Up to 4 layers |
| Codeword (CW)-to-layer mapping | For 1~4 layers, CW1; For 5 layers or more, two CWs | Aligned with reference | Aligned with reference |
| SRS transmission | Companies to Report: • Precoded or non-precoded SRS transmission; • SRS switch or not for 1T4R/2T4R/1T2R • SRS bandwidth • Number of OFDM symbols within 1 slot for SRS transmission per UE | For UE 4 Tx ports: Non-precoded SRS, 4 SRS ports (with 4 SRS resources); 2 symbols for SRS in every 5 slots, 8 PRBs per symbol | For UE 4 Tx ports: Non-precoded SRS, 4 SRS ports (with 4 SRS resources); 2 symbols for SRS in every 5 slots, 8 PRBs per symbol |
| Antenna configuration at TRxP | (M, N, P, Mg, Ng; Mp, Np) | For 32R: (M,N,P,Mg,Ng; Mp,Np)= (8,8,2,1,1; 2,8) (dH, dV)=(0.5, 0.8)λ; | For 32R: (M,N,P,Mg,Ng; Mp,Np)= (8,8,2,1,1; 2,8) (dH, dV)=(0.5, 0.8)λ; |
| Antenna configuration at UE | (M, N, P, Mg, Ng; Mp, Np) | For 4T: (M,N,P,Mg,Ng; Mp,Np)= (1,2,2,1,1; 1,2) (dH, dV)=(0.5, N/A)λ | For 4T: (M,N,P,Mg,Ng; Mp,Np)= (1,2,2,1,1; 1,2) (dH, dV)=(0.5, N/A)λ |
| Max CBG number | 1 | Aligned with reference | Aligned with reference |
| UL re-transmission delay |  | Next available UL slot after reiving retransmission indication | Next available UL slot after reiving retransmission indication |
| Scheduling | PF | Aligned with reference | Aligned with reference |
| Receiver | MMSE-IRC | Aligned with reference | Aligned with reference |
| Channel estimation |  | Non-ideal | Non-ideal |
| Power control parameter |  | P0=-76, alpha = 0.8 | P0=-76, alpha = 0.8 |
| Power backoff model |  | Continuous RB allocation: follow T3.9038.101 for FR1; Non-continuous RB allocation: additional 2 dB reduction | Continuous RB allocation: follow T3.9038.101 for FR1; Non-continuous RB allocation: additional 2 dB reduction |
|  |  |  |  |
| **System configuration parameters** | Reference Value |  |  |
| Mechanic tilt | 90° in GCS (pointing to horizontal direction) | Aligned with reference | Aligned with reference |
| Electronic tilt | [100°] in LCS | Aligned with reference | Aligned with reference |
| Handover margin (dB) |  | 0 | 0 |
| UT attachment | Based on RSRP | Aligned with reference | Aligned with reference |
| Aligned with reference | Aligned with reference |
| Wrapping around method | Geographical distance based wrapping | - | - |
| Beam set at TRxP (Constraints for the range of selective analog beams per TRxP) | - | - | - |
| Beam set at UE (Constraints for the range of selective analog beams for UE) | - | Aligned with reference | Aligned with reference |
| Criteria for selection for serving TRxP | Maximizing RSRP where the digital beamforming is not considered | - | - |
| Criteria for analog beam selection for serving TRxP | - | - | - |
| Criteria for analog beam selection for interfering TRxP | - |  |  |
| Other system configuration parameters align with Report ITU-R M.2412 | |  |  |

##### Simulation Results

Average spectral efficiency for TDD configuration for the Rural-eMBB test environment, Configuration B (4 GHz)

|  |  |  |
| --- | --- | --- |
|  | ITU Requirement | TCOE INDIA |
| Downlink | 3.3 [bit/s/Hz/TRxP] | 8.01 |
| Uplink | 1.6 [bit/s/Hz/TRxP] | 3.51 |

Average spectral efficiency for FDD configuration for the Rural-eMBB test environment, Configuration B (4 GHz)

|  |  |  |
| --- | --- | --- |
|  | ITU Requirement | TCOE INDIA |
| Downlink | 3.3 [bit/s/Hz/TRxP] | 8.24 |
| Uplink | 1.6 [bit/s/Hz/TRxP] | 3.72 |

5th-percentile spectral efficiency for TDD configuration for the Rural-eMBB test environment, Configuration B (4 GHz)

|  |  |  |
| --- | --- | --- |
|  | ITU Requirement | TCOE INDIA |
| Downlink | 0.12 | 0.25 |
| Uplink | 0.045 | 0.061 |

5th-percentile spectral efficiency for FDD configuration for the Rural-eMBB test environment, Configuration B (4 GHz)

|  |  |  |
| --- | --- | --- |
|  | ITU Requirement | TCOE INDIA |
| Downlink | 0.12 | 0.22 |
| Uplink | 0.045 | 0.062 |

#### Config C (LMLC)

The RIT was evaluated for Rural e-MBB LMLC configuration for both FDD and TDD.

##### Downlink Simulation Parameters

|  |  |  |  |
| --- | --- | --- | --- |
| **Rural - eMBB** |  |  |  |
| **Technical configuration Parameters** | Reference value |  |  |
|  |  | **FDD** | **TDD** |
| Multiple access | OFDMA | Aligned with reference | Aligned with reference |
| Duplexing |  | FDD | TDD |
| Network synchronization |  | Aligned with reference | Aligned with reference |
| Modulation | Up to 256 QAM | Aligned with reference | Aligned with reference |
| Coding on PDSCH | LDPC Max code-block size=8448bit  [with BP decoding] | Aligned with reference | Aligned with reference |
| Numerology | 15 kHz / 30 kHz, 14 OFDM symbol slot | 15 kHz SCS, 14 OFDM symbol slot | 15 kHz SCS, 14 OFDM symbol slot |
| Guard band ratio on simulation bandwidth | FDD: 6.4% (for 10 MHz bandwidth) TDD: 8.2% (51 RB for 30kHz SCS and 20 MHz bandwidth) TDD: 4.6% (106 RB for 15kHz SCS and 20 MHz bandwidth) | Aligned with reference | Aligned with reference |
| Simulation bandwidth | FDD: 10 MHz TDD: 20 MHz | 10 MHz | 20 MHz |
| Frame structure |  | Full downlink | DSUUD |
| Transmission scheme | closed SU/MU-MIMO adaptation | closed SU/MU-MIMO adaptation | closed SU/MU-MIMO adaptation |
| DL CSI measurement |  | Non-precoded CSI-RS based | Non-precoded CSI-RS based |
| DL codebook |  | Type I codebook | Type 1 codebook |
| PRB bundling |  | 4 PRBs | 4 PRBs |
| MU dimension |  | Up to 8 layers | Up to 8 layers |
| SU dimension |  | For 4Rx: Up to 4 layers | For 4Rx: Up to 4 layers |
| Codeword (CW)-to-layer mapping | For 1~4 layers, CW1; For 5 layers or more, two CWs | Aligned with reference | Aligned with reference |
| SRS transmission | Companies to Report: • Precoded or non-precoded SRS transmission; • SRS switch or not for 1T4R/2T4R/1T2R • SRS bandwidth • Number of OFDM symbols within 1 slot for SRS transmission per UE | N/A | N/A |
| CSI feedback |  | PMI, CQI: every 5 slot; RI: every 5 slot; Subband based | PMI, CQI: every 5 slot; RI: every 5 slot; Subband based |
| Interference measurement |  | SU-CQI; | SU-CQI; |
| CBG | 1 | Aligned with reference | Aligned with reference |
| ACK/NACK delay |  | 4 slots later | The next available UL slot |
| Re-transmission delay |  | The next available DL slot after receiving NACK | The next available DL slot after receiving NACK |
| Antenna configuration at TRxP | (M, N, P, Mg, Ng; Mp, Np) | For 8T: (M,N,P,Mg,Ng; Mp,Np) = (8,4,2,1,1;1,4);  (dH, dV)=(0.5, 0.8)λ | For 8T: (M,N,P,Mg,Ng; Mp,Np) = (8,4,2,1,1;1,4);  (dH, dV)=(0.5, 0.8)λ |
| Antenna configuration at UE | (M, N, P, Mg, Ng; Mp, Np) | For 4R, (M,N,P,Mg,Ng; Mp,Np) = (1,2,2,1,1; 1,2) (dH, dV)=(0.5, N/A)λ | For 4R, (M,N,P,Mg,Ng; Mp,Np) = (1,2,2,1,1; 1,2) (dH, dV)=(0.5, N/A)λ |
| Scheduling | PF | Aligned with reference | Aligned with reference |
| Receiver | MMSE-IRC | Aligned with reference | Aligned with reference |
| Channel estimation |  | Non-ideal | Non-ideal |
|  |  |  |  |
| **System configuration parameters** | Reference Value |  |  |
| Mechanic tilt | 90° in GCS (pointing to horizontal direction) | Aligned with reference | Aligned with reference |
| Electronic tilt | [96°] in LCS | 96 degree | 96 degree |
| Handover margin (dB) |  | 0 | 0 |
| UT attachment | Based on RSRP (formula (8.1-1) in TR36.873) from port 0 | Aligned with reference | Aligned with reference |
|
| Wrapping around method | Geographical distance based wrapping | Aligned with reference | Aligned with reference |
| Beam set at TRxP (Constraints for the range of selective analog beams per TRxP) | - | - | - |
| Beam set at UE (Constraints for the range of selective analog beams for UE) | - | - | - |
| Criteria for selection for serving TRxP | Maximizing RSRP where the digital beamforming is not considered | Aligned with reference | Aligned with reference |
| Criteria for analog beam selection for serving TRxP | - | - | - |
| Criteria for analog beam selection for interfering TRxP | - | - | - |
| Other system configuration parameters align with Report ITU-R M.2412 | |  |  |

##### Uplink Simulation Parameters

|  |  |  |  |
| --- | --- | --- | --- |
| **Rural - eMBB** |  |  |  |
| **Technical configuration Parameters** | Reference value |  |  |
|  |  | **FDD** | **TDD** |
| Multiple access | OFDMA | Aligned with reference | Aligned with reference |
| Duplexing |  | FDD | TDD |
| Network synchronization |  | Aligned with reference | Aligned with reference |
| Modulation | Up to 256QAM | Aligned with reference | Aligned with reference |
| Coding on PUSCH | LDPC Max code-block size=8448bit  [with BP decoding] | Aligned with reference | Aligned with reference |
| Numerology | 15 kHz / 30 kHz, 14 OFDM symbol slot | 15 kHz SCS, 14 OFDM symbol slot | 15 kHz SCS, 14 OFDM symbol slot |
| Guard band ratio on simulation bandwidth | FDD: 6.4% (for 10 MHz bandwidth) TDD: 8.2% (51 RB for 30kHz SCS and 20 MHz bandwidth) TDD: 4.6% (106 RB for 15kHz SCS and 20 MHz bandwidth) | Aligned with reference | Aligned with reference |
| Simulation bandwidth | FDD: 10 MHz TDD: 20 MHz | Aligned with reference | Aligned with reference |
| Frame structure |  | Full uplink | DSUUD |
| Transmission scheme |  | SU-MIMO with rank adaptation | SU-MIMO with rank adaptation |
| UL codebook |  | For 4Tx: 4Tx codebook | For 4Tx: 4Tx codebook |
| MU dimension |  | N/A | N/A |
| SU dimension |  | For 4Tx: Up to 4 layers | For 4Tx: Up to 4 layers |
| Codeword (CW)-to-layer mapping | For 1~4 layers, CW1; For 5 layers or more, two CWs | Aligned with reference | Aligned with reference |
| SRS transmission | Companies to Report: • Precoded or non-precoded SRS transmission; • SRS switch or not for 1T4R/2T4R/1T2R • SRS bandwidth • Number of OFDM symbols within 1 slot for SRS transmission per UE | Non-precoded SRS, 2 SRS ports (with 1 SRS resource); 2 symbols for SRS in every 5 slots. | Non-precoded SRS, 2 SRS ports (with 1 SRS resource); 2 symbols for SRS in every 5 slots. |
| Antenna configuration at TRxP | (M, N, P, Mg, Ng; Mp, Np) | For 8R: (M,N,P,Mg,Ng; Mp,Np) = (8,4,2,1,1; 1,4) (dH, dV)=(0.5, 0.8)λ | For 8R: (M,N,P,Mg,Ng; Mp,Np) = (8,4,2,1,1; 1,4) (dH, dV)=(0.5, 0.8)λ |
| Antenna configuration at UE | (M, N, P, Mg, Ng; Mp, Np) | For 4T: (M,N,P,Mg,Ng; Mp,Np)= (1,2,2,1,1; 1,2) (dH, dV)=( 0.5, N/A)λ | For 4T: (M,N,P,Mg,Ng; Mp,Np)= (1,2,2,1,1; 1,2) (dH, dV)=( 0.5, N/A)λ |
| Max CBG number | 1 | Aligned with reference | Aligned with reference |
| UL re-transmission delay |  |  |  |
| Scheduling | PF | Aligned with reference | Aligned with reference |
| Receiver | MMSE-IRC | Aligned with reference | Aligned with reference |
| Channel estimation |  | Ideal | Ideal |
| Power control parameter |  | P0=-76, alpha = 0.8 | P0=-76, alpha = 0.8 |
| Power backoff model |  | For 4Tx: Up t layers | Continuous RB allocation: follow T3.9038.101 for FR1; Non-continuous RB allocation: additional 2 dB reduction |
|  |  |  |  |
| **System configuration parameters** | Reference Value |  |  |
| Mechanic tilt | 90° in GCS (pointing to horizontal direction) | Aligned with reference | Aligned with reference |
| Electronic tilt | [96°] in LCS | 96 degree | 96 degree |
| Handover margin (dB) |  | 1 | 0 |
| UT attachment | Based on RSRP from port 0 | Aligned with reference | Aligned with reference |
|
| Wrapping around method | Geographical distance based wrapping | Aligned with reference | Aligned with reference |
| Beam set at TRxP (Constraints for the range of selective analog beams per TRxP) | - | - | - |
| Beam set at UE (Constraints for the range of selective analog beams for UE) | - | - | - |
| Criteria for selection for serving TRxP | Maximizing RSRP where the digital beamforming is not considered | Aligned with reference | Aligned with reference |
| Criteria for analog beam selection for serving TRxP | - | - | - |
| Criteria for analog beam selection for interfering TRxP | - | - | - |
| Other system configuration parameters align with Report ITU-R M.2412 | |  |  |

##### Simulation Results

Average spectral efficiency for TDD configuration for the Rural-eMBB test environment, LMLC Configuration

|  |  |  |
| --- | --- | --- |
|  | ITU Requirement | TCOE INDIA |
| Downlink | 3.3 [bit/s/Hz/TRxP] | 7.47 |
| Uplink | 1.6 [bit/s/Hz/TRxP] | 3.166 |

Average spectral efficiency for FDD configuration for the Rural-eMBB test environment, LMLC Configuration

|  |  |  |
| --- | --- | --- |
|  | ITU Requirement | TCOE INDIA |
| Downlink | 3.3 [bit/s/Hz/TRxP] | 6.3 |
| Uplink | 1.6 [bit/s/Hz/TRxP] | 4.13 |

5th-percentile spectral efficiency for TDD configuration for the Rural-eMBB test environment, LMLC Configuration

|  |  |  |
| --- | --- | --- |
|  | ITU Requirement | TCOE INDIA |
| Downlink | 0.12 | 0.26 |
| Uplink | 0.045 | 0.06 |

5th-percentile spectral efficiency for FDD configuration for the Rural-eMBB test environment, LMLC Configuration

|  |  |  |
| --- | --- | --- |
|  | ITU Requirement | TCOE INDIA |
| Downlink | 0.12 | 0.22 |
| Uplink | 0.045 | 0.055 |

## Mobility

Mobility is the maximum mobile station speed at which a defined QoS can be achieved (in km/h). The QoS is defined as normalized traffic channel link data rate. Channel model B is used for all the Mobility evaluations.

### Indoor Hotspot (InH) Test Environment

Evaluation configuration A (carrier frequency = 4 GHz) are applied for the evaluations of Indoor Hotspot – eMBB test environment.

#### System Level Simulation Parameters

|  |  |  |  |
| --- | --- | --- | --- |
| **Indoor Hotspot - eMBB** |  |  |  |
| **Technical configuration Parameters** | Reference value | |  |
| Multiple access | OFDMA | | Aligned with reference |
| Duplexing | FDD/TDD | | FDD |
| Modulation | Up to 256QAM | | Aligned with reference |
| Numerology | 15 kHz / 30 kHz, 14 OFDM symbol slot | | 15 kHz SCS, 14 OFDM symbol slot |
| Simulation bandwidth |  | | 10MHz |
| Transmission scheme |  | | UL MIMO |
| UL codebook |  | | 4Tx codebook |
| MU dimension |  | | N/A |
| SU dimension |  | | Up to 4 layers |
| SRS transmission |  | | Non-precoded SRS, 4 SRS ports (with 4 SRS resources); 2 symbols for SRS in every 5 slots, 8 PRBs per symbol |
| Antenna configuration at TRxP | (M, N, P, Mg, Ng; Mp, Np) | | 32R (M,N,P,Mg,Ng; Mp,Np)= (8,8,2,1,1; 2,8) (dH, dV)=(0.5, 0.8)λ; |
| Antenna configuration at UE | (M, N, P, Mg, Ng; Mp, Np) | | 4T (M,P,Mg,Ng; Mp,Np)= (1,2,2,1,1; 1,2) (dH, dV)=(0.5, N/A)λ |
| Scheduling | PF | | Aligned with reference |
| Receiver | MMSE-IRC | | Aligned with reference |
| Power control parameter |  | | P0=-76, alpha = 0.8 |
| **SINR** | Pre-processing | | Aligned with reference |
|  |  |  |  |
|  |  |  |  |
| **System configuration parameters** | Reference Value | |  |
| Carrier frequency for evaluation |  | | 4 GHz |
| UE speeds of interest | **10km/h** | | Aligned with reference |
| TRxP number per site | 1 | 3 | Aligned with reference |
| Mechanic tilt | 180° in GCS (pointing to the ground) | [110°] in GCS | Aligned with reference |
| Electronic tilt | 90° in LCS | 90° in LCS | Aligned with reference |
| Handover margin (dB) |  |  | 1 |
| UT attachment | Based on RSRP from port 0  The UE panel with the best receive SNR is chosen. i.e. no combining is done between panels. | | Aligned with reference |
| Wrapping around method | No wrapping around | | Aligned with reference |
| Polarized antenna model | Model-2 in 3GPP document TR36.873 | | Aligned with reference |
| Beam set at TRxP (Constraints for the range of selective analog beams per TRxP) | - | | - |
| Beam set at UE (Constraints for the range of selective analog beams for UE) | - | | - |
| Criteria for selection for serving TRxP | Maximizing RSRP where the digital beamforming is not considered | | Aligned with reference |
| Criteria for analog beam selection for serving TRxP | - | | - |
| Analog beam selection for interfering TRxP | - | | - |
| Other system configuration parameters align with Report ITU-R M.2412 | | |  |

#### Link Level Simulation Parameters

|  |  |  |
| --- | --- | --- |
| **Parameters** | **Reference value** |  |
| **4 GHz (FDD)** |
| Carrier frequency |  | 4GHz |
| Waveform | CP-OFDM | Aligned with reference |
| Duplexing |  | FDD |
| TDD frame structure |  | - |
| Evaluated service profiles | Full buffer best effort | Aligned with reference |
| Simulation bandwidth | 10 MHz | Aligned with reference |
| Number of users in simulation | 1 | Aligned with reference |
| Link-level Channel model | NLOS: CDL/ TDL-i | NLOS: TDL-i |
| LOS: CDL/TDL-iv |  |
| UE speed | 10 km/h | Aligned with reference |
| Subcarrier spacing |  | 15 kHz |
| Symbols number per slot | 14 | Aligned with reference |
| Antenna configuration at TRxP |  | 32R |
| Antenna configuration at UE |  | 1T |
| TXRU pattern at TRxP |  | Option 1: 0dBi Omni-directional |
| TXRU pattern at UE |  | Option 1: 0dBi Omni-directional |
| Transmission mode |  | SIMO |
| Transmission rank |  | Rank 1 |
| UL precoder |  | - |
| TRxP receiver type | MMSE-IRC | Aligned with reference |
| Channel estimation |  | LMMSE |
| Number of subcarriers per PRB | 12 | Aligned with reference |
| Data allocation |  | 14 symbol slots, with 25 RB allocated |
| Channel coding scheme | LDPC | Aligned with reference |
| Link adaptation |  | Yes |
| HARQ |  | Max 4 HARQ transmissions |
| DMRS configuration |  | 2 symbols DMRS |
| Other overhead |  | No SRS No PUCCH |

#### Simulation Results

Mobility in Indoor Hotspot– eMBB for Configuration A with 12 TRXP

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Schema | Duplexing  Scheme | Mobility | Sub-carrier spacing (kHz) | Channel | ITU Requirement  Bits/Hz | TCOE INDIA |
| 1x32 SIMO, OFDMA | FDD | 10Km/h | 15 KHz SCS | NLOS | 1.5 | 2.59 |

### Dense Urban Test Environment

Evaluation configuration A (carrier frequency = 4 GHz) are applied for the evaluations of Dense Urban – eMBB test environment.

#### System Level Simulation Parameters

|  |  |  |
| --- | --- | --- |
| **Technical configuration Parameters** | Reference value | 4 GHz |
| Multiple access | OFDMA | Aligned with reference |
| Duplexing |  | FDD |
| Modulation | Up to 256QAM | Aligned with reference |
| Numerology | 15KHz / 30kHz, 14 OFDM symbol slot | 15kHz SCS, 14 OFDM symbol slot |
| Simulation bandwidth |  | 10MHz |
| Transmission scheme |  | UL MIMO |
| UL codebook |  | 4Tx codebook |
| MU dimension |  | N/A |
| SU dimension |  | Up to 4 layers |
| SRS transmission |  | Non-precoded SRS, 4 SRS ports (with 4 SRS resources); 2 symbols for SRS in every 5 slots, 8 PRBs per symbol |
| Antenna configuration at TRxP | (M, N, P, Mg, Ng; Mp, Np) | 32R (M,N,P,Mg,Ng; Mp,Np)= (8,8,2,1,1; 2,8) (dH, dV)=(0.5, 0.8)λ; |
| Antenna configuration at UE | (M, N, P, Mg, Ng; Mp, Np) | 4T (M,P,Mg,Ng; Mp,Np)= (1,2,2,1,1; 1,2) (dH, dV)=(0.5, N/A)λ |
| Scheduling | PF | Aligned with reference |
| Receiver | MMSE-IRC | Aligned with reference |
| Power control parameter |  | P0=-86, alpha = 0.8 |
| **SINR** | Pre-processing SINR as in Section 2.1.1 in 3GPP document R1-1805643 | Aligned with reference |
|  |  |  |
|  |  |  |
| **System configuration parameters** | Reference Value |  |
| Carrier frequency for evaluation |  | 4 GHz |
| UE speeds of interest | **30km/h** | Aligned with reference |
| TRxP number per site | 3 | Aligned with reference |
| Mechanic tilt | 90° in GCS (pointing to horizontal direction) | Aligned with reference |
| Electronic tilt |  | 105 degree |
| Handover margin (dB) |  | 0 |
| UT attachment | Based on RSRP (formula as shown in Appendix 3 of 3GPP document RP-180524) from port 0 | Aligned with reference |
| Wrapping around method | Geographical distance based wrapping | Aligned with reference |
| Polarized antenna model | Model-2 in 3GPP document TR36.873 | Aligned with reference |
| Beam set at TRxP (Constraints for the range of selective analog beams per TRxP) | - | - |
| Beam set at UE (Constraints for the range of selective analog beams for UE) | - | - |
| Criteria for selection for serving TRxP | |  | | --- | | Maximizing RSRP where the digital beamforming is not considered | | Aligned with reference |
| Criteria for analog beam selection for serving TRxP | - | - |
| Analog beam selection for interfering TRxP | - | - |

#### Link Level Simulation Parameters

|  |  |  |
| --- | --- | --- |
| **Parameters** | **Reference value** |  |
| **4 GHz (FDD)** |
| Carrier frequency |  | 4GHz |
| Waveform | CP-OFDM | Aligned with reference |
| Duplexing |  | FDD |
| TDD frame structure |  | - |
| Evaluated service profiles | Full buffer best effort | Aligned with reference |
| Simulation bandwidth | 10 MHz | Aligned with reference |
| Number of users in simulation | 1 | Aligned with reference |
| Link-level Channel model | NLOS: CDL/ TDL-iii | TDL-iii |
| LOS: CDL/TDL-v | - |
| UE speed | 30 km/h | Aligned with reference |
| Subcarrier spacing |  | 15 kHz |
| Symbols number per slot | 14 | Aligned with reference |
| Antenna configuration at TRxP |  | 8R |
| Antenna configuration at UE |  | 1T |
| TXRU pattern at TRxP |  | 0dBi Omni |
| TXRU pattern at UE |  | 0dBi Omni |
| Transmission mode |  | SIMO |
| Transmission rank |  | Rank 1 |
| UL precoder |  | N/A |
| TRxP receiver type | MMSE-IRC | Aligned with reference |
| Channel estimation |  | MMSE |
| Number of subcarriers per PRB | 12 | Aligned with reference |
| Data allocation |  | 14 symbol slots, with 25 RB allocated |
| Channel coding scheme | LDPC | Aligned with reference |
| Link adaptation |  | Yes |
| HARQ |  | max. 4 HARQ transmissions |
| DMRS configuration |  | 2 symbols DMRS |
| Other overhead |  | No SRS No PUCCH |

#### Simulation Results

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Schema | Duplexing  Scheme | Mobility | Sub-carrier spacing (kHz) | Channel | ITU Requirement  Bits/Hz | TCOE INDIA |
| 1x8 SIMO, OFDMA | FDD | 30Km/h | 15 KHz SCS | NLOS | 1.2 | 2.44 |

### Rural Test Environment

#### Config A

The evaluation results of mobility for FDD for evaluation configuration A for mobility class of 120 Kmph and 500 Kmph are provided in Section 3.2.3.1.3 for Configuration A of Rural Scenario

##### System Level Simulation Parameters

|  |  |  |
| --- | --- | --- |
| **Technical configuration Parameters** | Reference value |  |
| Multiple access | OFDMA | Aligned with reference |
| Duplexing |  | FDD |
| Modulation | Up to 256QAM | Aligned with reference |
| Numerology |  | 15 kHz SCS, 14 OFDM symbol slot |
| Simulation bandwdith |  | 10MHz |
| Transmission scheme |  | UL MIMO |
| UL codebook |  | UL 2Tx Codebook |
| MU dimension |  | N/A |
| SU dimension |  | 2 layer max |
| SRS transmission |  | Non-precoded SRS, 2 SRS ports (with 1 SRS resource); 2 symbols for SRS in every 5 slots. |
| Antenna configuration at TRxP | (M, N, P, Mg, Ng; Mp, Np) | 8R (M,N,P,Mg,Ng; Mp,Np) = (8,4,2,1,1; 1,4) (dH, dV)=(0.5, 0.8)λ |
| Antenna configuration at UE | (M, N, P, Mg, Ng; Mp, Np) | 2T (M,N,P,Mg,Ng; Mp,Np)= (1,1,2,1,1; 1,1) (dH, dV)=( N/A, N/A)λ |
| Scheduling | PF | Aligned with reference |
| Receiver | MMSE-IRC | Aligned with reference |
| Power control parameter |  | P0=-76, alpha = 0.8 |
| **SINR** | Pre-processing | Aligned with reference |
|  |  |  |
|  |  |  |
| **System configuration parameters** | Reference Value |  |
| Carrier frequency for evaluation |  | 700MHz |
| UE speeds of interest | **120km/h, 500km/h** | Aligned with reference |
| TRxP number per site | 3 | Aligned with reference |
| Mechanic tilt | 90° in GCS (pointing to horizontal direction) | Aligned with reference |
| Electronic tilt |  | 96 degree |
| Handover margin (dB) |  | 0 |
| UT attachment | Based on RSRP (formula (8.1-1) in TR36.873) from port 0 | Aligned with reference |
| Wrapping around method | Geographical distance based wrapping | Aligned with reference |
| Polarized antenna model | Model-2 in 3GPP document TR36.873 | Aligned with reference |
| Criteria for selection for serving TRxP | Maximizing RSRP where the digital beamforming is not considered | Aligned with reference |
| Other system configuration parameters align with Report ITU-R M.2412 | |  |

##### Link Level Simulation Parameters

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameters** | **Reference value** |  |  |
| **700 MHz, 120km/h** | **700 MHz, 500km/h** |
| Carrier frequency |  | 700 MHz | 700 MHz |
| Waveform | CP-OFDM | Aligned with reference | Aligned with reference |
| Duplexing |  | FDD | FDD |
| Evaluated service profiles | Full buffer best effort | Aligned with reference | Aligned with reference |
| Simulation bandwidth | 10 MHz | Aligned with reference | Aligned with reference |
| Number of users in simulation | 1 | Aligned with reference | Aligned with reference |
| Link-level Channel model | NLOS: CDL/ TDL-iii | NLOS: TDL-iii | NLOS: TDL-iii |
| LOS: CDL/TDL-v | - | - |
| UE speed | 120km/h, 500km/h | 120 km/h | 500 km/h |
| Subcarrier spacing |  | 15 kHz | 15 kHz |
| Symbols number per slot | 14 | Aligned with reference | Aligned with reference |
| Antenna configuration at TRxP |  | 4R | 4R |
| Antenna configuration at UE |  | 1T | 1T |
| TXRU pattern at TRxP |  | 0dBi Omni | 0dBi Omni |
| TXRU pattern at UE |  | 0dBi Omni | 0dBi Omni |
| Transmission mode |  | SIMO | SIMO |
| Transmission rank |  | Rank 1 | Rank 1 |
| UL precoder |  | - | - |
| TRxP receiver type | MMSE-IRC | Aligned with reference | Aligned with reference |
| Channel estimation |  | MMSE | MMSE |
| Number of subcarriers per PRB | 12 | Aligned with reference | Aligned with reference |
| Data allocation |  | 14 symbol slots, with 25 RB allocated | 14 symbol slots, with 25 RB allocated |
| Channel coding scheme | LDPC | LDPC | LDPC |
| Link adaptation |  | Yes | Yes |
| HARQ |  | Max 4 HARQ transmissions | Max 4 HARQ transmissions |
| DMRS configuration |  | 2 symbol DMRS | 2 symbol DMRS |
| Other overhead |  | No SRS No PUCCH | No SRS No PUCCH |

##### Simulation Results

Mobility in Rural – eMBB for Configuration A (700 MHz)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Schema | Duplexing  Scheme | Mobility | Sub-carrier spacing (kHz) | Channel | ITU Requirement  Bits/Hz | TCOE INDIA |
| 1x4 SIMO, OFDMA | FDD | 120Km/h | 15 KHz SCS | NLOS | 0.8 | 2.53 |
| 1x4 SIMO, OFDMA | FDD | 500Km/h | 15 KHz SCS | NLOS | 0.45 | 2.12 |

#### Config B

The evaluation results of mobility for FDD for evaluation configuration B for mobility class of 120 Kmph and 500 Kmph are provided in Table 3.2.3.2.3 for Configuration B of Rural Scenario

##### System Level Simulator Parameters

|  |  |  |
| --- | --- | --- |
| **Technical configuration Parameters** | Reference value | 4GHz |
| Multiple access | OFDMA | Aligned with reference |
| Duplexing |  | FDD |
| Modulation | Up to 256QAM | Aligned with reference |
| Numerology |  | 15 kHz SCS, 14 OFDM symbol slot |
| Simulation bandwdith |  | 10MHz |
| Transmission scheme |  | UL MIMO |
| UL codebook |  | UL 4Tx Codebook |
| MU dimension |  | N/A |
| SU dimension |  | 4 layer max |
| SRS transmission |  | Non-precoded SRS, 4 SRS ports (with 1 SRS resource); 2 symbols for SRS in every 5 slots. |
| Antenna configuration at TRxP | (M, N, P, Mg, Ng; Mp, Np) | 32R (M,N,P,Mg,Ng; Mp,Np)= (8,8,2,1,1; 2,8) (dH, dV)=(0.5, 0.8)λ; |
| Antenna configuration at UE | (M, N, P, Mg, Ng; Mp, Np) | 4T (M,N,P,Mg,Ng; Mp,Np)= (1,2,2,1,1; 1,2) (dH, dV)=(0.5, N/A)λ |
| Scheduling | PF | Aligned with reference |
| Receiver | MMSE-IRC | Aligned with reference |
| Power control parameter |  | P0=-76, alpha = 0.8 |
| **SINR** | Pre-processing SINR | Aligned with reference |
|  |  |  |
|  |  |  |
| **System configuration parameters** | Reference Value |  |
| Carrier frequency for evaluation |  | 4 GHz |
| UE speeds of interest | **120km/h, 500km/h** | Aligned with reference |
| TRxP number per site | 3 | Aligned with reference |
| Mechanic tilt | 90° in GCS (pointing to horizontal direction) | Aligned with reference |
| Electronic tilt |  | 100 degree |
| Handover margin (dB) |  | 0 |
| UT attachment | Based on RSRP (formula (8.1-1) in TR36.873) from port 0 | Aligned with reference |
| Wrapping around method | Geographical distance based wrapping | Aligned with reference |
| Polarized antenna model | Model-2 in 3GPP document TR36.873 | Aligned with reference |
| Criteria for selection for serving TRxP | Maximizing RSRP where the digital beamforming is not considered | Aligned with reference |
| Other system configuration parameters align with Report ITU-R M.2412 | |  |

##### Link Level Simulator Parameters

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameters** | **Reference value** |  |  |
| **4GHz, 120km/h** | **4GHz, 500km/h** |
| Carrier frequency |  | 4 GHz | 4 GHz |
| Waveform | CP-OFDM | Aligned with reference | Aligned with reference |
| Duplexing |  | FDD | FDD |
| Evaluated service profiles | Full buffer best effort | Aligned with reference | Aligned with reference |
| Simulation bandwidth | 10 MHz | Aligned with reference | Aligned with reference |
| Number of users in simulation | 1 | Aligned with reference | Aligned with reference |
| Link-level Channel model | NLOS: CDL/ TDL-iii | NLOS: TDL-iii | NLOS: TDL-iii |
| LOS: CDL/TDL-v | - | - |
| UE speed | 120km/h, 500km/h | 120 km/h | 500 km/h |
| Subcarrier spacing |  | 15 kHz | 15 kHz |
| Symbols number per slot | 14 | Aligned with reference | Aligned with reference |
| Antenna configuration at TRxP |  | 8R | 8R |
| Antenna configuration at UE |  | 1T | 1T |
| TXRU pattern at TRxP |  | 0dBi Omni | 0dBi Omni |
| TXRU pattern at UE |  | 0dBi Omni | 0dBi Omni |
| Transmission mode |  | SIMO | SIMO |
| Transmission rank |  | Rank 1 | Rank 1 |
| UL precoder |  | - | - |
| TRxP receiver type | MMSE-IRC | Aligned with reference | Aligned with reference |
| Channel estimation |  | MMSE | MMSE |
| Number of subcarriers per PRB | 12 | Aligned with reference | Aligned with reference |
| Data allocation |  | 14 symbol slots, with 25 RB allocated | 14 symbol slots, with 25 RB allocated |
| Channel coding scheme | LDPC | LDPC | LDPC |
| Link adaptation |  | Yes | Yes |
| HARQ |  | Max 4 HARQ transmissions | Max 4 HARQ transmissions |
| DMRS configuration |  | 2 symbol DMRS | 2 symbol DMRS |
| Other overhead |  | No SRS No PUCCH | No SRS No PUCCH |

##### Simulation Results

Mobility in Rural – eMBB for Configuration B (4GHz)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Schema | Duplexing  Scheme | Mobility | Sub-carrier spacing (kHz) | Channel | ITU Requirement  Bits/Hz | TCOE INDIA |
| 1x8 SIMO, OFDMA | FDD | 120Km/h | 15 KHz SCS | NLOS | 0.8 | 2.80 |
| 1x8 SIMO, OFDMA | FDD | 500Km/h | 15 KHz SCS | NLOS | 0.45 | 2.51 |

## Reliability

Reliability is the success probability of transmitting a layer 2/3 packet within a required maximum time, which is the time it takes to deliver a small data packet from the radio protocol layer 2/3 SDU ingress point to the radio protocol layer 2/3 SDU egress point of the radio interface at a certain channel quality. Reliability is evaluated under Urban Macro – URLLC test environment.

### Configuration A

In configuration A (carrier frequency = 4 GHz), both UL and DL are evaluated. Channel Model B is considered.

#### System Level Simulations Parameters for DL

|  |  |  |
| --- | --- | --- |
| **Urban Macro - URLLC DL** |  |  |
| **Technical configuration Parameters** | Reference value | 4 GHz |
| Multiple access | OFDMA | Aligned with reference |
| Duplexing |  | FDD |
| Modulation | Up to 256QAM | Aligned with reference |
| Numerology |  | 30 kHz SCS, 14 OFDM symbol slot |
| Simulation bandwdith |  | 10 MHz |
| DLTransmission scheme |  | DL SU-MIMO with rank adaptation |
| DL codebook |  | Type I Codebook |
| DL MU dimension |  | N/A |
| DL SU dimension |  | Up to 2 layers |
| SRS transmission |  | - |
| Antenna configuration at TRxP | (M, N, P, Mg, Ng; Mp, Np) | 2Tx, (8,1,2,1,1; 1,1) |
| Antenna configuration at UE | (M, N, P, Mg, Ng; Mp, Np) | 2Rx, (1,1,2,1,1; 1,1) |
| Scheduling | PF | Aligned with reference |
| Receiver | MMSE-IRC | Aligned with reference |
| **SINR** | Pre-processing SINR as in Section 2.1.1 in R1-1805643 | Aligned with reference |
|  |  |  |
| **System configuration parameters** | Reference Value |  |
| Carrier frequency for evaluation |  | 4GHz |
| TRxP number per site | 3 | Aligned with reference |
| Mechanic tilt | 90° in GCS (pointing to horizontal direction) | Aligned with reference |
| Electronic tilt |  | 99 degree |
| Handover margin (dB) |  | 0 |
| UT attachment | Based on RSRP from port 0 | Aligned with reference |
| Wrapping around method | Geographical distance based wrapping | Aligned with reference |
| Polarized antenna model | |  | | --- | | Model-2 in 3GPP document TR36.873 | | Aligned with reference |
| Beam set at TRxP (Constraints for the range of selective analog beams per TRxP) |  | - |
| Beam set at UE (Constraints for the range of selective analog beams for UE) |  | - |
| Criteria for selection for serving TRxP | Maximizing RSRP where the digital beamforming is not considered | Aligned with reference |
| Criteria for analog beam selection for serving TRxP |  | - |
| Criteria for analog beam selection for interfering TRxP |  | - |

#### Link Level Simulations Parameters for DL

|  |  |  |
| --- | --- | --- |
| **Urban Macro - URLLC DL** |  |  |
| **Technical configuration Parameters** | Reference value | 4 GHz |
| Carrier frequency for evaluation |  | 4 GHz |
| Waveform |  | CP-OFDM |
| Numerology |  | 30 kHz SCS |
| Simulation bandwdith |  | 10 MHz |
| Channel model | TDL-iii(NLOS),TDL-v(LOS) | Aligned with reference |
| Scaled delay spread | 363ns(NLOS),93 ns(LOS) | Aligned with reference |
| UE Speed |  | 3km/h |
| Number of symbols per slot |  | 14 |
| Antenna configuration at TRxP |  | 2Tx |
| Antenna configuration at UE |  | 2Rx |
| TXRU pattern at TRxP |  | 0dBi Omni-directional |
| TXRU pattern at UE |  | 0dBi Omni-directional |
| PDSCH Transmission mode |  | DL SU-MIMO with rank 1 |
| Channel estimation |  | Non-ideal |
| PDCCH transmission scheme |  | DCI format 1-0. 64bit payload includes CRC. Aggregation level = 16 |
| PDSCH Modulation and coding |  | LDPC MCS #0 from 64 QAM table (QPSK, CR = 120/1024) |
| Packet size |  | 256bit |
| DMRS configuration |  | Type 1 ,2 symbol DMRS |

#### System Level Simulations Parameters for UL

|  |  |  |
| --- | --- | --- |
| **Urban Macro - URLLC UL** |  |  |
| **Technical configuration Parameters** | Reference value | 4GHz |
| Multiple access | OFDMA | Aligned with reference |
| Duplexing |  | FDD |
| Modulation | Up to 256QAM | Aligned with reference |
| Numerology |  | 30kHz SCS |
| Simulation bandwdith |  | 10 MHz |
| UL Transmission scheme |  | UL MIMO with rank adaptation |
| UL codebook |  | 2 port UL codebook |
| UL MU dimension |  | N/A |
| UL SU dimension |  | Up to 2 layers |
| SRS transmission |  | Non-precoded SRS, 2 SRS ports (with 2 SRS resources); 2 symbols for SRS in every 5 slots, 8 PRBs per symbol |
| Antenna configuration at TRxP | (M, N, P, Mg, Ng; Mp, Np) | 16Rx, (8,8,2,1,1; 1,4) |
| Antenna configuration at UE | (M, N, P, Mg, Ng; Mp, Np) | 2Tx, (1,1,1,1,2; 1,1) |
| Scheduling | PF | Aligned with reference |
| Receiver | MMSE-IRC | Aligned with reference |
| UL power control parameter |  | P0=-86, alpha = 0.8 |
| **SINR** | Pre-processing SINR | Aligned with reference |
|  |  |  |
| **System configuration parameters** | Reference Value |  |
| Carrier frequency for evaluation |  | 4 GHz |
| TRxP number per site | 3 | Aligned with reference |
| Mechanic tilt | 90° in GCS (pointing to horizontal direction) | Aligned with reference |
| Electronic tilt |  | 100 degree |
| Handover margin (dB) |  | 0 |
| UT attachment | Based on RSRP  (formula as shown in Appendix  3 of 3GPP document RP-180524)  from port 0 | Aligned with reference |
| Wrapping around method | Geographical distance based wrapping | Aligned with reference |
| Minimum distance of TRxP and UE | d2D\_min=10m | Aligned with reference |
| Polarized antenna model | Model-2 in 3GPP document TR36.873 | Aligned with reference |
| Beam set at TRxP (Constraints for the range of selective analog beams per TRxP) |  | - |
| Beam set at UE (Constraints for the range of selective analog beams for UE) |  | - |
| Criteria for selection for serving TRxP | Maximizing RSRP where the digital beamforming is not considered | Aligned with reference |
| Criteria for analog beam selection for serving TRxP |  | - |
| Criteria for analog beam selection for interfering TRxP |  | - |

#### Link Level Simulations Parameters for UL

|  |  |  |
| --- | --- | --- |
| **Urban Macro - URLLC UL** |  |  |
| **Technical configuration Parameters** | Reference value | 4 GHz |
| Carrier frequency for evaluation |  | 4 GHz |
| Waveform |  | CP-OFDM |
| Numerology |  | 30 kHz SCS |
| Simulation bandwdith |  | 10 MHz |
| Channel model | TDL-iii(NLOS),TDL-v(LOS) | Aligned with reference |
| Scaled delay spread | 363ns(NLOS),93 ns(LOS) | Aligned with reference |
| UE Speed |  | 3km/h |
| Number of symbols per slot |  | 14 |
| Antenna configuration at TRxP |  | 16 Rx |
| Antenna configuration at UE |  | 1 Tx |
| TXRU pattern at TRxP |  | 0dBi Omni-directional |
| TXRU pattern at UE |  | 0dBi Omni-directional |
| Data Transmission mode |  | SIMO |
| Channel estimation |  | Non-ideal |
| PUCCH transmission scheme |  | - |
| PUSCH modulation and coding |  | LDPC MCS #0 from 64 QAM table (QPSK, CR = 120/1024) |
| Packet size |  | 256bit |
| DMRS configuration |  | Type 1, 2 symbol DMRS |

#### Simulation Results

Reliability evaluation for configuration A in Downlink

|  |  |  |  |
| --- | --- | --- | --- |
| **Scheme and antenna configuration** | **Sub-carrier spacing [kHz]** | **ITU**  **Requirement** | **Channel condition** |
| **Number of samples** | **Reliability** |
| 2x2 SU-MIMO | 30 | 99.999% | NLOS | 1 | > 99.9995% |

Reliability evaluation for configuration A in Uplink

|  |  |  |
| --- | --- | --- |
| **Scheme and antenna configuration** | **Sub-carrier spacing [kHz]** | **ITU**  **Requirement** |
| **Channel condition** | **Number of samples** | **Reliability** |
| 2x16 SIMO, OFDMA | 30 | 99.999% | NLOS | 1 | >99.99998% |

### Configuration B

For reliability with configuration B (carrier frequency = 700 MHz), uplink and downlink are evaluated.

#### System Level Simulations Parameters for DL

|  |  |  |
| --- | --- | --- |
| **Urban Macro - URLLC DL** |  |  |
| **Technical configuration Parameters** | Reference value | 700 MHz |
| Multiple access | OFDMA | Aligned with reference |
| Duplexing |  | FDD |
| Modulation | Up to 256QAM | Aligned with reference |
| Numerology |  | 30 kHz SCS, 14 OFDM symbol slot |
| Simulation bandwdith |  | 10 MHz |
| DLTransmission scheme |  | DL SU-MIMO with rank adaptation |
| DL codebook |  | Type I Codebook |
| DL MU dimension |  | N/A |
| DL SU dimension |  | Up to 2 layers |
| SRS transmission |  | - |
| Antenna configuration at TRxP | (M, N, P, Mg, Ng; Mp, Np) | 2Tx, (8,1,2,1,1; 1,1) |
| Antenna configuration at UE | (M, N, P, Mg, Ng; Mp, Np) | 2Rx, (1,1,2,1,1; 1,1) |
| Scheduling | PF | Aligned with reference |
| Receiver | MMSE-IRC | Aligned with reference |
| **SINR** | Pre-processing SINR as in Section 2.1.1 in R1-1805643 | Aligned with reference |
|  |  |  |
| **System configuration parameters** | Reference Value |  |
| Carrier frequency for evaluation |  | 700 MHz |
| TRxP number per site | 3 | Aligned with reference |
| Mechanic tilt | 90° in GCS (pointing to horizontal direction) | Aligned with reference |
| Electronic tilt |  | 100 degree |
| Handover margin (dB) |  | 0 |
| UT attachment | Based on RSRP from port 0 | Aligned with reference |
| Wrapping around method | Geographical distance based wrapping | Aligned with reference |
| Polarized antenna model | Model-2 in 3GPP document TR36.873 | Aligned with reference |
| Beam set at TRxP (Constraints for the range of selective analog beams per TRxP) |  | - |
| Beam set at UE (Constraints for the range of selective analog beams for UE) |  | - |
| Criteria for selection for serving TRxP | Maximizing RSRP where the digital beamforming is not considered | Aligned with reference |
| Criteria for analog beam selection for serving TRxP |  | - |
| Criteria for analog beam selection for interfering TRxP |  | - |

#### Link Level Simulations Parameters for DL

|  |  |  |
| --- | --- | --- |
| **Urban Macro - URLLC DL** |  |  |
| **Technical configuration Parameters** | Reference value | 700 MHz |
| Carrier frequency for evaluation |  | 700 MHz |
| Waveform |  | CP-OFDM |
| Numerology |  | 30 kHz SCS |
| Simulation bandwdith |  | 10 MHz |
| Channel model | TDL-iii(NLOS),TDL-v(LOS) | Aligned with reference |
| Scaled delay spread | 363ns(NLOS),93 ns(LOS) | Aligned with reference |
| UE Speed |  | 3km/h |
| Number of symbols per slot |  | 14 |
| Antenna configuration at TRxP |  | 2 Tx |
| Antenna configuration at UE |  | 2 Rx |
| TXRU pattern at TRxP |  | 0dBi Omni-directional |
| TXRU pattern at UE |  | 0dBi Omni-directional |
| PDSCH Transmission mode |  | DL SU-MIMO with rank 1 |
| Channel estimation |  | Non-ideal |
| PDCCH transmission scheme |  | DCI format 1-0. 64bit payload includes CRC. Aggregation level = 8 |
| PDSCH Modulation and coding |  | LDPC MCS #0 from 64 QAM table (QPSK, CR = 120/1024) |
| Packet size |  | 256bit |
| DMRS configuration |  | Type 1 ,2 symbol DMRS |

#### System Level Simulations Parameters for UL

|  |  |  |
| --- | --- | --- |
| **Urban Macro - URLLC UL** |  |  |
| **Technical configuration Parameters** | Reference value | 700 MHz |
| Multiple access | OFDMA | Aligned with reference |
| Duplexing |  | FDD |
| Modulation | Up to 256QAM | Aligned with reference |
| Numerology |  | 30 kHz SCS |
| Simulation bandwdith |  | 10 MHz |
| UL Transmission scheme |  | UL MIMO with rank adaptation |
| UL codebook |  | 2 port UL codebook |
| UL MU dimension |  | N/A |
| UL SU dimension |  | Up to 2 layers |
| SRS transmission |  | Non-precoded SRS, 2 SRS ports (with 2 SRS resources); 2 symbols for SRS in every 5 slots, 8 PRBs per symbol |
| Antenna configuration at TRxP | (M, N, P, Mg, Ng; Mp, Np) | 8Rx, (8,4,2,1,1; 1,4) |
| Antenna configuration at UE | (M, N, P, Mg, Ng; Mp, Np) | 2Tx, (1,1,1,1,2; 1,1) |
| Scheduling | PF | Aligned with reference |
| Receiver | MMSE-IRC | Aligned with reference |
| UL power control parameter |  | P0=-86, alpha = 0.8 |
| **SINR** | Pre-processing SINR | Aligned with reference |
|  |  |  |
| **System configuration parameters** | Reference Value |  |
| Carrier frequency for evaluation |  | 700 MHz |
| TRxP number per site | 3 | Aligned with reference |
| Mechanic tilt | 90° in GCS (pointing to horizontal direction) | Aligned with reference |
| Electronic tilt |  | 100 degree |
| Handover margin (dB) |  | 0 |
| UT attachment | Based on RSRP from port 0 | Aligned with reference |
| Wrapping around method | Geographical distance based wrapping | Aligned with reference |
| Minimum distance of TRxP and UE | d2D\_min=10m | Aligned with reference |
| Polarized antenna model | Model-2 in 3GPP document TR36.873 | Aligned with reference |
| Beam set at TRxP (Constraints for the range of selective analog beams per TRxP) |  | - |
| Beam set at UE (Constraints for the range of selective analog beams for UE) |  | - |
| Criteria for selection for serving TRxP | Maximizing RSRP where the digital beamforming is not considered | Aligned with reference |
| Criteria for analog beam selection for serving TRxP |  | - |
| Criteria for analog beam selection for interfering TRxP |  | - |

#### Link Level Simulations Parameters for UL

|  |  |  |
| --- | --- | --- |
| **Urban Macro - URLLC UL** |  |  |
| **Technical configuration Parameters** | Reference value | 700 MHz |
| Carrier frequency for evaluation |  | 700 MHz |
| Waveform |  | CP-OFDM |
| Numerology |  | 30 kHz SCS |
| Simulation bandwdith |  | 10 MHz |
| Channel model | TDL-iii(NLOS),TDL-v(LOS) | Aligned with reference |
| Scaled delay spread | 363ns(NLOS),93 ns(LOS) | Aligned with reference |
| UE Speed |  | 3km/h |
| Number of symbols per slot |  | 14 |
| Antenna configuration at TRxP |  | 8 RX |
| Antenna configuration at UE |  | 1 Tx |
| TXRU pattern at TRxP |  | 0dBi Omni-directional |
| TXRU pattern at UE |  | 0dBi Omni-directional |
| Data Transmission mode |  | SIMO |
| Channel estimation |  | Non-ideal |
| PUCCH transmission scheme |  | - |
| PUSCH modulation and coding |  | LDPC MCS #0 from 64 QAM table (QPSK, CR = 120/1024) |
| Packet size |  | 256bit |
| DMRS configuration |  | Type 1, 2 symbol DMRS |

#### Simulation Results

Reliability evaluation for configuration B in Downlink

|  |  |  |  |
| --- | --- | --- | --- |
| **Scheme and antenna configuration** | **Sub-carrier spacing [kHz]** | **ITU**  **Requirement** | **Channel condition** |
| **Number of samples** | **Reliability** |
| 2x2 SU-MIMO | 30 | 99.999% | NLOS | 1 | >99.9994% |

Reliability evaluation for configuration B in Uplink

|  |  |  |
| --- | --- | --- |
| **Scheme and antenna configuration** | **Sub-carrier spacing [kHz]** | **ITU**  **Requirement** |
| **Channel condition** | **Number of samples** | **Reliability** |
| 2x8 SIMO, OFDMA | 30 | 99.999% | NLOS | 1 | >99.99999% |

## Connection Density

As specified in Report ITU-R M.2410, connection density is the system capacity metric defined as the total number of devices fulfilling a specific quality of service (QoS) per unit area (per km2) with 99% grade of service (GoS). In Report ITU-R M.2412, the required QoS is that a 32-byte packet is successfully received within 10s.

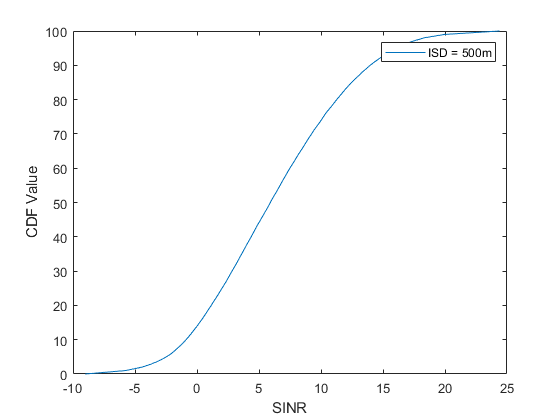
The connection density of NB-IoT are evaluated using the full buffer level simulation as defined in Report ITU-R M.2412. As indicated in Section 7.1.1, the full buffer system level simulation method targets to evaluate the connection density in terms of the capability of uplink data transmission. It does also not model synchronization and system information acquisition, control channel and downlink data channel performance. It assumes ideal resource allocation among the multiple uplink packets and users (e.g., there is no collision on resource allocation), and the delays introduced by access procedure are not considered.

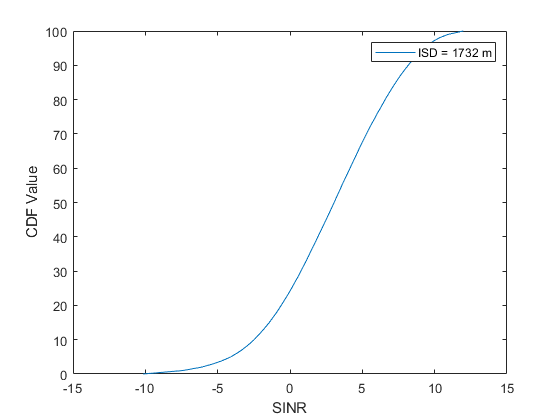
For evaluation, the Urban Macro – mMTC test environment is used. Both evaluation configuration A (ISD=500 m) and evaluation configuration B (ISD=1732 m) are considered.

The evaluation results of NB-IoT are shown in Table 3.4.1 for full buffer system level simulation.

For NB-IoT a reasonable assumption is that the overhead from NPSS, NSSS, NPBCH and SIB1-NB transmissions constitutes ~30% of one downlink PRB.

**Figure 3.4.1 SINR CDF for Configurations A and B**

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**Table 3.4.1 Evaluation results of connection density for NB-IoT   
(Full buffer SLS followed by LLS packet arrival rate: 1 packet / 2 hour / device)**

**(a) Evaluation configuration A (ISD=500 m)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Technical feature | Scheme and antenna configuration | **Sub-carrier spacing** | **ITU**  **Requirement (device/km2)** | **Channel model B** | | |
| Number of samples | Connection density (device/km2) | Required bandwidth (kHz) |
| NB-IoT | 1x2 SIMO  (Single tone) | 15 kHz | 1,000,000 | 1 | 38,841,650 | 180 |

**(b) Evaluation configuration B (ISD=1732 m)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Technical feature | Scheme and antenna configuration | **Sub-carrier spacing** | **ITU**  **Requirement (device/km2)** | **Channel model B** | | |
| Number of samples | Connection density (device/km2) | Required bandwidth (kHz) |
| NB-IoT | 1x2 SIMO (Single Tone) | 15 kHz | 1,000,000 | 1 | 2,167,241 | 180 |

It is observed that the proposed RIT fulfils the connection density requirement under full-buffer simulations.

# Analytical KPIs

## User experienced data rate

User experienced data rate is the 5% point of the cumulative distribution function (CDF) of the user throughput. User throughput (during active time) is defined as the number of correctly received bits, i.e. the number of bits contained in the service data units (SDUs) delivered to Layer 3, over a certain period of time.

The user experienced data rate, Ruser is given by:

Ruser = W(Effective Bandwidth) × SEuser (5th Percentile)

The SE is obtained from simulation results. It is assumed that for TDD with 15 kHz SCS, a component carrier with 50 MHz is used. It is assumed that for FDD with 15kHz, a component carrier with 40 MHz is used. For higher bandwidths, the overhead decreases increasing the effective spectral efficiency by a scaling factor for the downlink. Multiple component carriers are aggregated to achieve the DL target user experienced data rate.

User experienced data rate in Dense Urban – eMBB for TDD configuration

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Scheme | Assumed Bandwidth  W | 5-percentile SE  SEuser | User Experienced Data Rate  Ruser = W × SEuser | ITU Requirement |
| Downlink, TDD (DSUUD) | 800 MHz | 0.2951 | 132.16Mbps | 100 Mbps |
| Uplink, TDD  (DSUUD) | 800 MHz | 0.173 | 60.9Mbps | 50 Mbps |

Footnote:0.295 = 0.25 x 1.18, where 0.25 bps/Hz is the 5% SE for the downlink and 1.18 is the overhead scaling factor. We have considered 16 CC of 50 MHz each.

User experienced data rate Dense Urban – eMBB for FDD configuration

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Scheme | Assumed Bandwidth  W | 5-percentile SE  SEuser | User Experienced Data Rate  Ruser = W × SEuser | ITU Requirement |
| Downlink, FDD | 400 MHz | 0.341 | 136.28Mbps | 100 Mbps |
| Uplink, FDD | 400 MHz | 0.18 | 72Mbps | 50 Mbps |

Footnote: 0.34= 0.28x1.216, where 0.28 bps/Hz is the 5% SE for the downlink and 1.216 is the overhead scaling factor. We have considered 10 CC of 40 MHz each.

## Area traffic capacity

As defined in Report ITU-R M.2410, area traffic capacity is the total traffic throughput served per geographic area (in Mbit/s/m2). The throughput is the number of correctly received bits, i.e. the number of bits contained in the SDUs delivered to Layer 3, over a certain period of time.

The area traffic capacity of the RIT is evaluated using analytical way based on the downlink average spectral efficiency evaluation for Indoor Hotspot – eMBB test environment. Let W denote the channel bandwidth and the TRxP density (TRxP/m2). The area traffic capacity Carea is related to average spectral efficiency SEavg through equation Carea = ρ × W × SEavg.

Area Traffic Capacity – In-H for the TDD configuration for 12 TRXP

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Scheme | Assumed Bandwidth W | Avg. SE SEavg | TRxP density (TRxP/m2)  ρ | Area traffic capacity  Carea = ρ × W × SEavg Mbit/s/m2 | ITU Requirement  Mbit/s/m2 |
| Downlink, TDD | 800 MHz | 11.211 | 0.002 = 12/(120x50) | 10.04 | 10 |

Footnote: 11.21=9.5 x 1.18, where 9.5 bps/Hz is the Avg SE for the downlink and 1.18 is the overhead scaling factor. We have considered 16 component carriers (CC) of 50 MHz each.

Area Traffic Capacity – In-H for the FDD configuration for 12 TRXP

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Scheme | Assumed Bandwidth W | Avg. SE SEavg | TRxP density (TRxP/m2)  ρ | Area traffic capacity  Carea = ρ × W × SEavg Mbit/s/m2 | ITU Requirement  Mbit/s/m2 |
| Downlink, FDD | 480 MHz | 11.91 | 0.002 | 11.43 | 10 |

Footnote: 11.91 = 9.8 x 1.216, where 9.8 bps/Hz is the Avg SE for the downlink and 1.216 is the overhead scaling factor. We have considered 12 component carriers (CC) of 40 MHz each.

It is assumed that for TDD with 15 kHz SCS, a component carrier with 50 MHz is used. It is assumed that for FDD with 15kHz, a component carrier with 40 MHz is used. Multiple component carriers are aggregated to achieve the DL target user experienced data rate.

## Peak spectral efficiency

Peak spectral efficiency is the maximum data rate under ideal conditions divided by channel bandwidth (in bit/s/Hz), where the maximum data rate is the received data bits assuming error-free conditions assignable to a single mobile station, when all assignable radio resources for the corresponding link direction are utilized (i.e. excluding radio resources that are used for physical layer synchronization, reference signals or pilots, guard bands and guard times).

The generic formula for peak spectral efficiency for FDD and TDD for a specific component carrier (say *j-th CC (component carrier)*) is given by

(1.1)

Wherein,

* Rmax = 948/1024
* For the j-th CC,
  + A close up of a logo

    Description automatically generated is the maximum number of layers
  + A close up of a logo

    Description automatically generated is the maximum modulation order
  + A close up of a logo

    Description automatically generatedis the scaling factor
    - * The scaling factor can at least take the values 1 and 0.75.
      * A close up of a logo

        Description automatically generatedis signalled per band and per band per band combination as per UE capability signaling
  + A close up of a logo

    Description automatically generated is the numerology (as defined in T3.9038.211)
  + A close up of a logo

    Description automatically generated is the average OFDM symbol duration in a subframe for numerology A close up of a logo

    Description automatically generated, i.e. A close up of a logo

    Description automatically generated. Note that normal cyclic prefix is assumed.
  + A close up of a logo

    Description automatically generated is the maximum RB allocation in bandwidth A close up of a logo

    Description automatically generated with numerology A close up of a logo

    Description automatically generated, as given in T3.9038.104 section 5.3.2, where A close up of a logo

    Description automatically generated is the UE supported maximum bandwidth in the given band or band combination.
  + A close up of a logo

    Description automatically generatedis the overhead calculated as the average ratio of the number of REs occupied by L1/L2 control, Synchronization Signal, PBCH, reference signals and guard period (for TDD), etc. with respect to the total number of REs in effective bandwidth time product as given by α(j).BW(j).(14\*Tsu)

− α(j) is the normalized scalar considering the downlink/uplink ratio; for FDD α(j)=1 for DL and UL; and for TDD and other duplexing α(j) for DL and UL is calculated based on the DL/UL configuration.

− For guard period (GP), 50% of GP symbols are considered as downlink overhead, and 50% of GP symbols are considered as uplink overhead.

### DL Peak Spectral Efficiency

For evaluating downlink Peak Spectral Efficiency, we consider an FDD case with 50MHz bandwidth, and 15kHz subcarrier spacing, in FR1 region. In an ideal case, we can have a maximum of 8layers, using 256QAM.

For the reference signal overheads, we assume the following:

|  |  |  |
| --- | --- | --- |
|  | Applied duplexing | FR1 |
| OH | FDD | * PDCCH: CORESET of 24 PRBs (4 CCE) in every slot   + - 12 RE/PRB/slot * TRS burst of 2 slots with periodicity of 20ms and occupies 52 PRBs   + - 12 RE/PRB/20 ms * DMRS: Type 2, 16 RE/PRB/slot for 8 layers * CSI-RS: 8 CSI-RS ports with periodicity of 20ms   + - 8 RE/PRB/20 ms * 1 SS/PBCH blocks (SSB) per 20ms; one SSB occupies 960REs = 4 OFDM symbols × 20 PRB × 12 REs/PRB   NOTE1: if the channel bandwidth is less than the bandwidth of SSB, then SSB is not transmitted and the overhead of SS/PBCH block is zero.  NOTE2: If the channel bandwidth is less than TRS bandwidth, the TRS bandwidth is assumed to be equal to the channel bandwidth. |

Using these values, we get the downlink peak spectral efficiency to be 54.35\*(1-0.1) = 48.9 bits/sec/Hz which is higher than the ITU requirement of 30 bits/sec/Hz

### UL Peak Spectral Efficiency

For evaluating uplink Peak Spectral Efficiency, we consider an FDD case with 50MHz bandwidth, and 15kHz subcarrier spacing, in FR1 region. In an ideal case, we can have a maximum of 4 layers, using 256QAM.

For the reference signal overheads, we assume the following :

|  |  |  |
| --- | --- | --- |
|  | Applied duplexing | FR1 |
| OH1 | FDD, TDD (DDDSU) | * PUCCH: short PUCCH with 1 PRB and 1 symbol in every UL slot; 12 RE/slot * DMRS: Type I, one complete symbol; 12 RE/PRB/slot * SRS: 1 symbol with periodicity of 10ms for FDD; 1 symbol with periodicity of 20ms for TDD |

Using these values, we get the uplink peak spectral efficiency to be 27.18\*(1-0.08) = 25.0 bits/sec/Hz which is higher than the ITU requirement of 15 bits/sec/Hz

## Peak data rate

As defined in Report ITU-R M.2410, peak data rate is the maximum achievable data rate under ideal conditions (in bit/s), which is the received data bits assuming error-free conditions assignable to a single mobile station, when all assignable radio resources for the corresponding link direction are utilized (i.e. excluding radio resources that are used for physical layer synchronization, reference signals or pilots, guard bands and guard times).

### DL Peak Data rate

**Table 4.4.1.1 : DL peak data rate**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Duplexing** | **SCS [kHz]** | | **Per CC BW (MHz)** | **Peak data rate per CC (Gbit/s)** | **Aggregated peak data rate over 16 CCs (Gbit/s)** | **Required DL bandwidth (MHz) 1** | **Req. (Gbit/s)** |
| FDD | FR1 | 15 | 50 | 2.45 | 39.2 | 420 | 20 |
| NOTE 1: The value only indicates the required bandwidth to meet the DL peak data rate. It is not necessarily supported as the Transmission bandwidth. | | | | | | | |

### UL Peak Data rate

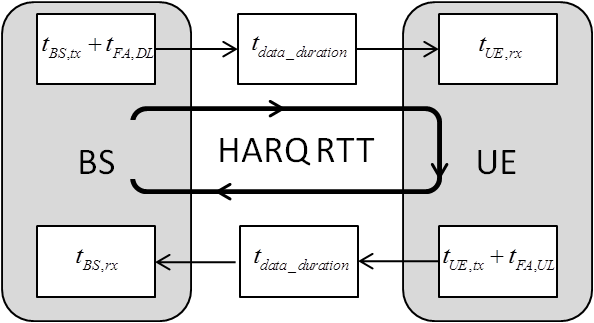
UL peak data rate is evaluated based on the evaluation results of peak spectral efficiency provided in Section 1. Table 2.2.1 provides the evaluation results for the specific component carrier (CC) bandwidth. It is observed that the RIT fulfils the UL peak data rate requirement.

**Table 4.4.2.1 : UL peak data rate**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Duplexing** | **SCS [kHz]** | | **Per CC BW (MHz)** | **Peak data rate per CC (Gbit/s)** | **Aggregated peak data rate over 16 CCs (Gbit/s)** | **Required UL bandwidth to meet the requirement (MHz)1** | **Req. (Gbit/s)** |
| FDD | FR1 | 15 | 50 | 1.25 | 20 | 400 | 10 |
| NOTE 1: The value only indicates the required bandwidth to meet the DL peak data rate. It is not necessarily supported as the Transmission bandwidth. | | | | | | | |

## User Plane Latency

As defined in Report ITU-R M.2410, user plane latency is the contribution of the radio network to the time from when the source sends a packet to when the destination receives it (in ms).



**Figure 4.5.1 UP latency diagram**

As shown in the above figure, the computation of the user plane latency is divided into number of steps. The steps involved and the corresponding assumptions are provided in the following sections.

### Downlink

Table 4.5.1.1 DL user plane procedure for NR

|  |  |  |  |
| --- | --- | --- | --- |
| ID | Component | Notations | Value |
| 1 | DL data transfer | *T*1 = (*t*BS,tx + *t*FA,DL) + *t*DL\_duration + *t*UE,rx |  |
| 1.1 | BS processing delay | *t*BS,tx  The time interval between the data is arrived, and packet is generated. | Tproc,2/2, with d2,1= d2,2= d2,3=0. (Tproc,2 is defined in Section 6.4 of T3.9038.214) |
| 1.2 | DL Frame alignment (transmission alignment) | *t*FA,DL  It includes frame alignment time, and the waiting time for next available DL slot | *T*FA + *T*wait,  It is assumed that the packet arrives at any time of any OFDM symbol. In this case, the 0.5 symbol length is added as the “average symbol alignment time” at the beginning of the procedure.  *T*FA is the frame alignment time within the current DL slot;  *T*wait is the waiting time for next available DL slot if the current slot is not DL slot.  (The transmission of PDCCH, PDSCH, PUCCH, PUSCH cannot be across the slot. Otherwise the transmission will wait for the next slot) |
| 1.3 | TTI for DL data packet transmission | *t*DL\_duration | Length of one slot (14 OFDM symbol length) or non-slot (2/4/7 OFDM symbol length), depending on slot or non-slot selected in evaluation. |
| 1.4 | UE processing delay | *t*UE,rx  The time interval between the PDSCH is received and the data is decoded; | Tproc,1/2 (Tproc,1 is defined in Section 5.3 of T3.9038.214), d1,1=0; d1,2 should be selected according to resource mapping type and UE capability. *N*1*=*the value with “No additional PDSCH DM-RS configured”. |
| 2 | HARQ retransmission | *T*HARQ = *T*1 + *T*2  *T*2 = (*t*UE,tx + *t*FA,UL)+ *t*UL\_duration + *t*BS,rx (For Steps 2.1 to 2.4) |  |
| 2.1 | UE processing delay | *t*UE,tx  The time interval between the data is decoded, and ACK/NACK packet is generated. | Tproc,1/2 (Tproc,1 is defined in Section 5.3 of T3.9038.214), d1,1=0; d1,2 should be selected according to resource mapping type and UE capability. *N*1*=*the value with “No additional PDSCH DM-RS configured”. |
| 2.2 | UL frame alignment (transmission alignment) | *t*FA,UL  It includes frame alignment time, and the waiting time for the next available UL slot | *T*FA + *T*wait,  *T*FA is the frame alignment time within the current UL slot;  *T*wait is the waiting time for next available UL slot if the current slot is not UL slot |
| 2.3 | TTI for ACK/NACK transmission | *t*UL\_duration | 1 OFDM symbol |
| 2.4 | BS processing delay | *t*BS,rx  The time interval between the ACK is received and the ACK is decoded. | Tproc, 2/2 with d2,1= d2,2= d2,3=0. |
| 2.5 | Repeat DL data transfer from 1.1 to 1.4 | *T*1 |  |
| - | Total one way user plane latency for DL | *T*UP= *T*1 + *n*×*T*HARQ  where *n* is the number of re-transmissions (*n*≥0) | |
|  | | | |

For each step, the value has been computed considering the assumptions for different slot durations, and subcarrier spacings. We have assumed a transmission error probability (p=0.1). All the results shown are for UE capability 1. The table below provides all the results.

Table 4.5.1.2 DL user plane latency results for NR

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **SCS** | **15** | **15** | **15** | **30** | **30** | **30** | **60** | **60** | **60** | **120** | **120** | **120** |
| **OS nonslot** | **2** | **4** | **7** | **2** | **4** | **7** | **2** | **4** | **7** | **2** | **4** | **7** |
| **Step ID** |  |  |  |  |  |  |  |  |  |  |  |  |
| **1** | 1.363 | 1.642 | 2.192 | 0.753 | 0.892 | 1.167 | 0.537 | 0.607 | 0.744 | 0.340 | 0.375 | 0.443 |
| **1.1** | 0.357 | 0.357 | 0.357 | 0.214 | 0.214 | 0.214 | 0.205 | 0.205 | 0.205 | 0.161 | 0.161 | 0.161 |
| **1.2.1** | 0.071 | 0.143 | 0.250 | 0.036 | 0.071 | 0.125 | 0.018 | 0.036 | 0.063 | 0.009 | 0.018 | 0.031 |
| **1.2.2** | 0.629 | 0.776 | 1.050 | 0.314 | 0.388 | 0.525 | 0.157 | 0.194 | 0.263 | 0.079 | 0.097 | 0.131 |
| **1.3** | 0.020 | 0.082 | 0.250 | 0.010 | 0.041 | 0.125 | 0.005 | 0.020 | 0.063 | 0.003 | 0.010 | 0.031 |
| **1.4** | 0.285 | 0.285 | 0.285 | 0.178 | 0.178 | 0.178 | 0.152 | 0.152 | 0.152 | 0.089 | 0.089 | 0.089 |
| **2** | 2.715 | 3.223 | 4.170 | 1.500 | 1.754 | 2.228 | 1.071 | 1.198 | 1.435 | 0.678 | 0.742 | 0.860 |
| **2** | 1.352 | 1.581 | 1.978 | 0.748 | 0.862 | 1.060 | 0.534 | 0.591 | 0.691 | 0.339 | 0.367 | 0.417 |
| **2.1** | 0.285 | 0.285 | 0.285 | 0.178 | 0.178 | 0.178 | 0.152 | 0.152 | 0.152 | 0.089 | 0.089 | 0.089 |
| **2.2.1** | 0.071 | 0.143 | 0.250 | 0.036 | 0.071 | 0.125 | 0.018 | 0.036 | 0.063 | 0.009 | 0.018 | 0.031 |
| **2.2.2** | 0.629 | 0.776 | 1.050 | 0.314 | 0.388 | 0.525 | 0.157 | 0.194 | 0.263 | 0.079 | 0.097 | 0.131 |
| **2.3** | 0.010 | 0.020 | 0.036 | 0.005 | 0.010 | 0.018 | 0.003 | 0.005 | 0.009 | 0.001 | 0.003 | 0.004 |
| **2.4** | 0.357 | 0.357 | 0.357 | 0.214 | 0.214 | 0.214 | 0.205 | 0.205 | 0.205 | 0.161 | 0.161 | 0.161 |
| **Total** | **1.664** | **2.000** | **2.656** | **0.919** | **1.087** | **1.415** | **0.656** | **0.740** | **0.904** | **0.415** | **0.457** | **0.539** |
| **ReTx** | 0.111 | 0.111 | 0.111 | 0.111 | 0.111 | 0.111 | 0.111 | 0.111 | 0.111 | 0.111 | 0.111 | 0.111 |

### Uplink

Table 4.5.2.1 UL user plane procedure for NR

|  |  |  |  |
| --- | --- | --- | --- |
| ID | Component | Notations | Value |
| 1 | UL data transfer | *T*1 = (*t*UE,tx + *t*FA,UL)+ *t*UL\_duration + *t*BS,rx |  |
| 1.1 | UE processing delay | *t*UE,tx  The time interval between the data is arrived, and packet is generated; | Tproc,2/2, with d2,1= d2,2= d2,3=0. (Tproc,2 is defined in Section 6.4 of T3.9038.214) |
| 1.2 | UL Frame alignment (transmission alignment) | *t*FA,UL  It includes frame alignment time, and the waiting time for next available UL slot | *T*FA + *T*wait,  It is assumed that the packet arrives at any time of any OFDM symbol. In this case, the 0.5 symbol length is added as the “average symbol alignment time” at the beginning of the procedure.  *T*FA is the frame alignment time within the current UL slot;  *T*wait is the waiting time for next available UL slot if the current slot is not UL slot.  (The transmission cannot be across the slot. Otherwise the transmission will wait for the next slot) |
| 1.3 | TTI for UL data packet transmission | *t*UL\_duration | Length of one slot (14 OFDM symbol length) or non-slot (2/4/7 OFDM symbol length), depending on slot or non-slot selected in evaluation. |
| 1.4 | BS processing delay | *t*BS,rx  The time interval between the PUSCH is received and the data is decoded; | Tproc,1/2 (Tproc,1 is defined in Section 5.3 of T3.9038.214), d1,1=0; d1,2 should be selected according to resource mapping type and UE capability. *N*1*=*the value with “No additional PDSCH DM-RS configured”. |
| 2 | HARQ retransmission | *T*HARQ = *T*2 + *T*1  *T*2 = (*t*BS,tx + *t*FA,DL) + *t*DL\_duration + *t*UE,rx (For Steps 2.1 to 2.4) |  |
| 2.1 | BS processing delay | *t*BS,tx  The time interval between the data is decoded, and PDCCH preparation | Tproc,1/2 (Tproc,1 is defined in Section 5.3 of T3.9038.214), d1,1=0; d1,2 should be selected according to resource mapping type and UE capability. *N*1*=*the value with “No additional PDSCH DM-RS configured”. |
| 2.2 | DL Frame alignment (transmission alignment) | *t*FA,DL  It includes frame alignment time, and the waiting time for next available DL slot | *T*FA + *T*wait,  *T*FA is the frame alignment time within the current DL slot;  *T*wait is the waiting time for next available DL slot if the current slot is not DL slot |
| 2.3 | TTI for PDCCH transmission | *t*DL\_duration | 1 OFDM symbol |
| 2.4 | UE processing delay | *t*UE,rx  The time interval between the PDCCH is received and decoded. | Tproc, 2/2 with d2,1= d2,2= d2,3=0. |
| 2.5 | Repeat DL data transfer from 1.1 to 1.4 | *T*1 |  |
| - | Total one way user plane latency for DL | *T*UP= *T*1 + *n*×*T*HARQ  where *n* is the number of re-transmissions (*n*≥0) | |
|  | | | |

For each step, the value has been computed considering the assumptions for different slot durations, and subcarrier spacings. We have assumed a transmission error probability (p=0.1). All the results shown are for UE capability 1. The table below provides all the results.

Table 4.5.2.2 UL user plane latency results for NR

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **SCS** | **15** | **15** | **15** | **30** | **30** | **30** | **60** | **60** | **60** | **120** | **120** | **120** |
| **OS nonslot** | **2** | **4** | **7** | **2** | **4** | **7** | **2** | **4** | **7** | **2** | **4** | **7** |
| **Step ID** |  |  |  |  |  |  |  |  |  |  |  |  |
| **1** | 1.363 | 1.642 | 2.192 | 0.753 | 0.892 | 1.167 | 0.537 | 0.607 | 0.744 | 0.340 | 0.375 | 0.443 |
| **1.1** | 0.357 | 0.357 | 0.357 | 0.214 | 0.214 | 0.214 | 0.205 | 0.205 | 0.205 | 0.161 | 0.161 | 0.161 |
| **1.2.1** | 0.071 | 0.143 | 0.250 | 0.036 | 0.071 | 0.125 | 0.018 | 0.036 | 0.063 | 0.009 | 0.018 | 0.031 |
| **1.2.2** | 0.629 | 0.776 | 1.050 | 0.314 | 0.388 | 0.525 | 0.157 | 0.194 | 0.263 | 0.079 | 0.097 | 0.131 |
| **1.3** | 0.020 | 0.082 | 0.250 | 0.010 | 0.041 | 0.125 | 0.005 | 0.020 | 0.063 | 0.003 | 0.010 | 0.031 |
| **1.4** | 0.285 | 0.285 | 0.285 | 0.178 | 0.178 | 0.178 | 0.152 | 0.152 | 0.152 | 0.089 | 0.089 | 0.089 |
| **2** | 2.715 | 3.223 | 4.170 | 1.500 | 1.754 | 2.228 | 1.071 | 1.198 | 1.435 | 0.678 | 0.742 | 0.860 |
| **2** | 1.352 | 1.581 | 1.978 | 0.748 | 0.862 | 1.060 | 0.534 | 0.591 | 0.691 | 0.339 | 0.367 | 0.417 |
| **2.1** | 0.285 | 0.285 | 0.285 | 0.178 | 0.178 | 0.178 | 0.152 | 0.152 | 0.152 | 0.089 | 0.089 | 0.089 |
| **2.2.1** | 0.071 | 0.143 | 0.250 | 0.036 | 0.071 | 0.125 | 0.018 | 0.036 | 0.063 | 0.009 | 0.018 | 0.031 |
| **2.2.2** | 0.629 | 0.776 | 1.050 | 0.314 | 0.388 | 0.525 | 0.157 | 0.194 | 0.263 | 0.079 | 0.097 | 0.131 |
| **2.3** | 0.010 | 0.020 | 0.036 | 0.005 | 0.010 | 0.018 | 0.003 | 0.005 | 0.009 | 0.001 | 0.003 | 0.004 |
| **2.4** | 0.357 | 0.357 | 0.357 | 0.214 | 0.214 | 0.214 | 0.205 | 0.205 | 0.205 | 0.161 | 0.161 | 0.161 |
| **Total** | **1.664** | **2.000** | **2.656** | **0.919** | **1.087** | **1.415** | **0.656** | **0.740** | **0.904** | **0.415** | **0.457** | **0.539** |
| **ReTx** | 0.111 | 0.111 | 0.111 | 0.111 | 0.111 | 0.111 | 0.111 | 0.111 | 0.111 | 0.111 | 0.111 | 0.111 |

## Control Plane Latency

As defined in Report ITU-R M.2410, control plane latency refers to the transition time from a most “battery efficient” state (e.g. Idle state) to the start of continuous data transfer (e.g. Active state).

The control plane latency is evaluated from RRC\_INACTIVE state to RRC\_CONNECTED state. The figure given below shows the steps involved in calculating the control plane latency.

The detailed assumption of each step is provided in the table below. The evaluation is for UL data transfer. It is understood that the evaluation results for DL data transfer can be further reduced because UE processing delay in Step 9 for DL data transfer does not need to handle UL grant receiving, and therefore can be reduced compared to the case of UL data transfer.

The delay values shown below do not include the waiting time for DL/UL subframe. It is only gNB or UE processing delay. The waiting time will be calculated and it depends on the detailed DL/UL configuration.

Table 4.6.1 Assumption of C-plane procedure for NR

|  |  |  |
| --- | --- | --- |
| **Step** | **Description** | **CP Latency for UL data transfer**  **[ms]** |
| 1 | Delay due to RACH scheduling period (1TTI) | 0  (the procedure for *transition from a most “battery efficient” state* has yet not begun, hence this step is not relevant for the latency of the procedure ) |
| 2 | Transmission of RACH Preamble | Length of the preamble according to the PRACH format as specified in [T3.9038.211] |
| 3 | Preamble detection and processing in gNB | Tproc,2 (assuming d2,1=0) |
| 4 | Transmission of RA response | Ts (the length of 1 slot / non-slot)  NOTE: the length of 1 slot or 1 non-slot include PDCCH and PDSCH (the first OFDM symbol of PDSCH is frequency multiplexed with PDCCH). |
| 5 | UE Processing Delay (decoding of scheduling grant, timing alignment and C-RNTI assignment + L1 encoding of RRC Resume Request) | *N*T,1*+N*T,2*+*0.5ms  (the latency of *N*T,1*+N*T,2*+*0.5ms is used according to Section 8.3 of T3.9038.213. *N*T,1 is a time duration of *N*1 symbols corresponding to a PDSCH reception time for PDSCH processing capability 1 when additional PDSCH DM-RS is configured; and *N*T,2 is a time duration of *N*2 symbols corresponding to a PUSCH preparation time for PUSCH processing capability 1. The value of *N*1 and *N*2 are shown in Table 5.3-1 and Table 6.4-1 of T3.9038.214, respectively) |
| 6 | Transmission of RRC Resume Request | Ts (the length of 1 slot / non-slot)  NOTE: the length of 1 slot or 1 non-slot is equal to PUSCH allocation length. |
| 7 | Processing delay in gNB (L2 and RRC) | 3 |
| 8 | Transmission of RRC Resume | Ts (the length of 1 slot / non-slot) |
| 9 | Processing delay in UE of RRC Resume including grant reception | 7  (UL data transfer, the processing delay in the UE (L2 and RRC) is considered, i.e., from reception of RRC Connection Resume to the reception of UL grant. The transmission of UL grant by gNB and processing delay in the UE (processing of UL grant and preparing for UL tx) are also considered. The RRCConnectionResume message only includes MAC and PHY configuration. No DRX, SPS, CA, or MIMO re-configuration will be triggered by this message. Further, the UL grant for transmission of RRC Connection Resume Complete and the data is transmitted over common search space with DCI format 0) |
| 10 | Transmission of RRC Resume Complete and UP data | 0  (the beginning of this subframe is considered to be "*the start of continuous data transfer*", hence this step is not relevant for the latency of the procedure) |
|  | | |

In addition, the following assumptions apply to the evaluation:

* The transmission duration of Step 2, 4, 6, and 8 cannot be crossing the boundary of a slot;
* The CP procedure can start from the OFDM symbols within the slot that PRACH preamble can be transmitted (assuming that the slot is UL slot; otherwise it will wait for the available UL slot).

The evaluation results are provided in the table below for different subcarrier spacings and slot duration.

Table 4.6.2 Control plane latency results for NR

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **SCS** | **15** | **15** | **15** | **30** | **30** | **30** | **60** | **60** | **60** | **120** | **120** | **120** |
| **OS nonslot** | **2** | **4** | **7** | **2** | **4** | **7** | **2** | **4** | **7** | **2** | **4** | **7** |
| **Step ID** |  |  |  |  |  |  |  |  |  |  |  |  |
| **1** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **2** | 0.143 | 0.143 | 0.143 | 0.071 | 0.071 | 0.071 | 0.036 | 0.036 | 0.036 | 0.018 | 0.018 | 0.018 |
| **3** | 0.714 | 0.714 | 0.714 | 0.428 | 0.428 | 0.428 | 0.410 | 0.410 | 0.410 | 0.321 | 0.321 | 0.321 |
| **4** | 0.843 | 1.204 | 1.800 | 0.421 | 0.602 | 0.900 | 0.211 | 0.301 | 0.450 | 0.105 | 0.151 | 0.225 |
| **5** | 1.784 | 1.784 | 1.784 | 1.285 | 1.285 | 1.285 | 1.214 | 1.214 | 1.214 | 0.999 | 0.999 | 0.999 |
| **6** | 0.843 | 1.204 | 1.800 | 0.421 | 0.602 | 0.900 | 0.211 | 0.301 | 0.450 | 0.105 | 0.151 | 0.225 |
| **7** | 3.000 | 3.000 | 3.000 | 3.000 | 3.000 | 3.000 | 3.000 | 3.000 | 3.000 | 3.000 | 3.000 | 3.000 |
| **8** | 0.843 | 1.204 | 1.800 | 0.421 | 0.602 | 0.900 | 0.211 | 0.301 | 0.450 | 0.105 | 0.151 | 0.225 |
| **9** | 7.000 | 7.000 | 7.000 | 7.000 | 7.000 | 7.000 | 7.000 | 7.000 | 7.000 | 7.000 | 7.000 | 7.000 |
| **10** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **Total** | **15.169** | **16.253** | **18.041** | **13.049** | **13.590** | **14.484** | **12.292** | **12.563** | **13.010** | **11.654** | **11.790** | **12.013** |

## Mobility interruption time

The mobility interruption time is evaluated for the following scenarios:

### Beam mobility

When moving within the same cell, the transmit-receive beam pair of the UE may need to be changed.

For DL data transmission during UE mobility, gNB can configure different beams for this UE at different slots. It ensures appropriate transmit beam allocation to the UE for continuous DL transmission. Therefore DL data packet transmission is kept during beam pair switching at different slots.

For UL data transmission, PUSCH is sent using the beam configured by SRI (SRS resource indicator) by gNB. Accordingly, an appropriate gNB-side beam is selected for UL data reception. gNB may select different beams at different slots depending on the UE mobility. Therefore UL data packet transmission is kept during beam pair switching at different slots.

Based on the above analysis, the UE can always exchange user plane packets with gNB during the mobility transitions. Therefore, 0ms mobility interruption time is achieved by the RIT for this scenario.

### CA Mobility

When moving within the same PCell with CA enabled, the set of configured SCells of the UE may change. The SCell addition procedure and SCell release procedures can occur.

During these procedures, the UE can always exchange user plane packets with the gNB during transitions, because the data transmission between the UE and the PCell is kept. Therefore, 0ms mobility interruption time is achieved by the RIT for this case.

# Inspection KPIs

## Bandwidth and scalability

As defined in Report ITU-R M.2410, bandwidth is the maximum aggregated system bandwidth. The bandwidth may be supported by single or multiple radio frequency (RF) carriers. Scalable bandwidth is the ability of the candidate RIT/SRIT to operate with different bandwidths.

According to Section 5.3.2 of T3.9038.104, the maximum bandwidth related to specific sub-carrier spacing (SCS) and frequency range (FR) for a component carrier is provided in Table 5.1.1. Besides, according to Section 6.4 of T3.9038.331, carrier aggregation of up to sixteen component carriers is supported. Accordingly, the capability of maximum aggregated system bandwidth is presented in Table 6.1. It is observed that the maximum aggregated bandwidth for FR 1 is 800 MHz to 1600 MHz; while for FR 2, the maximum aggregated bandwidth is 3200 MHz to 6400 MHz. Therefore, the bandwidth requirement of at least 100 MHz is met by the RIT under all frequency ranges for all sub-carrier spacing values.

**Table 5.1.1 RIT capability on bandwidth**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **SCS [kHz]** | **Maximum bandwidth for one component carrier (MHz)** | **Maximum number of component carriers for carrier aggregation** | **Maximum aggregated bandwidth (MHz)** |
| FR1 | 15 | 50 | 16 | 800 |
| 30 | 100 | 16 | 1600 |
| 60 | 100 | 16 | 1600 |
| FR2 | 60 | 200 | 16 | 3200 |
| 120 | 400 | 16 | 6400 |

According to Section 5.3.2 of T3.9038.104, different bandwidths are supported for a component carrier at given SCS as listed in Table 6.2. Accordingly, the bandwidth scalability capability of the RIT is summarized in Table 6.3. It is observed that up to 13 different bandwidths are supported for FR 1, and up to 4 different bandwidths are supported for FR 2. Therefore, bandwidth scalability capability is fulfilled by the RIT.

**Table 5.1.2 Transmission bandwidth configuration NRB**

(a) For FR1

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **SCS (kHz)** | **5MHz** | **10MHz** | **15MHz** | **20 MHz** | **25 MHz** | **30 MHz** | **40 MHz** | **50MHz** | **60 MHz** | **70**  **MHz** | **80 MHz** | **90 MHz** | **100 MHz** |
| **NRB** | **NRB** | **NRB** | **NRB** | **NRB** | **NRB** | **NRB** | **NRB** | **NRB** | **NRB** | **NRB** | **NRB** | **NRB** |
| 15 | 25 | 52 | 79 | 106 | 133 | 160 | 216 | 270 | N/A | N.A | N/A | N/A | N/A |
| 30 | 11 | 24 | 38 | 51 | 65 | 78 | 106 | 133 | 162 | 189 | 217 | 245 | 273 |
| 60 | N/A | 11 | 18 | 24 | 31 | 38 | 51 | 65 | 79 | 93 | 107 | 121 | 135 |

(b) For FR2

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **SCS [kHz]** | **50 MHz** | **100 MHz** | **200 MHz** | **400 MHz** |
| **NRB** | **NRB** | **NRB** | **NRB** |
| 60 | 66 | 132 | 264 | N.A |
| 120 | 32 | 66 | 132 | 264 |
|  |  |  |  |  |

**Table 5.1.3 Bandwidth scalability capability**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **SCS [kHz]** | **Minimum component carrier bandwidth (MHz)** | **Maximum component carrier bandwidth (MHz)** | **Maximum Number of supported bandwidth for a component carrier** |
| FR1 | 15 | 5 | 50 | 8 |
| 30 | 5 | 100 | 13 |
| 60 | 10 | 100 | 12 |
| FR2 | 60 | 50 | 200 | 3 |
| 120 | 50 | 400 | 4 |

## Spectrum

As defined in Report ITU-R M.2411, spectrum requirement include

* The capability of being able to utilize at least one frequency band identified for IMT in the ITU Radio Regulations, and
* The capability of being able to utilize the higher frequency range/band(s) above 24.25 GHz (NOTE: In the case of the candidate SRIT, at least one of the component RITs need to fulfil this requirement.)

The bands in which the RIT can be deployed are given in Table 7.2.1, Table 7.2.2 and Table 7.2.3 according to T3.9038.104 and T3.9036.101 (for MMTC). It is observed that the RIT supports at least one frequency band for IMT, as well as to utilize the higher frequency range/bands above 24.25 GHz. Therefore the RIT fulfils the spectrum requirement.

**Table 5.2.1: Operating bands in FR1**

|  |  |  |  |
| --- | --- | --- | --- |
| ***Operating band*** | **Uplink (UL) *operating band* BS receive / UE transmit**  **FUL\_low   – FUL\_high** | **Downlink (DL) *operating band* BS transmit / UE receive**  **FDL\_low   – FDL\_high** | **Duplex Mode** |
| n1 | 1920 MHz – 1980 MHz | 2110 MHz – 2170 MHz | FDD |
| n2 | 1850 MHz – 1910 MHz | 1930 MHz – 1990 MHz | FDD |
| n3 | 1710 MHz – 1785 MHz | 1805 MHz – 1880 MHz | FDD |
| n5 | 824 MHz – 849 MHz | 869 MHz – 894 MHz | FDD |
| n7 | 2500 MHz – 2570 MHz | 2620 MHz – 2690 MHz | FDD |
| n8 | 880 MHz – 915 MHz | 925 MHz – 960 MHz | FDD |
| n12 | 699 MHz – 716 MHz | 729 MHz – 746 MHz | FDD |
| n20 | 832 MHz – 862 MHz | 791 MHz – 821 MHz | FDD |
| n25 | 1850 MHz – 1915 MHz | 1930 MHz – 1995 MHz | FDD |
| n28 | 703 MHz – 748 MHz | 758 MHz – 803 MHz | FDD |
| n34 | 2010 MHz – 2025 MHz | 2010 MHz – 2025 MHz | TDD |
| n38 | 2570 MHz – 2620 MHz | 2570 MHz – 2620 MHz | TDD |
| n39 | 1880 MHz – 1920 MHz | 1880 MHz – 1920 MHz | TDD |
| n40 | 2300 MHz – 2400 MHz | 2300 MHz – 2400 MHz | TDD |
| n41 | 2496 MHz – 2690 MHz | 2496 MHz – 2690 MHz | TDD |
| n51 | 1427 MHz – 1432 MHz | 1427 MHz – 1432 MHz | TDD |
| n66 | 1710 MHz – 1780 MHz | 2110 MHz – 2200 MHz | FDD |
| n70 | 1695 MHz – 1710 MHz | 1995 MHz – 2020 MHz | FDD |
| n71 | 663 MHz – 698 MHz | 617 MHz – 652 MHz | FDD |
| n75 | N/A | 1432 MHz – 1517 MHz | SDL |
| n76 | N/A | 1427 MHz – 1432 MHz | SDL |
| n77 | 3300 MHz – 4200 MHz | 3300 MHz – 4200 MHz | TDD |
| n78 | 3300 MHz – 3800 MHz | 3300 MHz – 3800 MHz | TDD |
| n79 | 4400 MHz – 5000 MHz | 4400 MHz – 5000 MHz | TDD |
| n80 | 1710 MHz – 1785 MHz | N/A | SUL |
| n81 | 880 MHz – 915 MHz | N/A | SUL |
| n82 | 832 MHz – 862 MHz | N/A | SUL |
| n83 | 703 MHz – 748 MHz | N/A | SUL |
| n84 | 1920 MHz – 1980 MHz | N/A | SUL |
| n86 | 1710 MHz – 1780 MHz | N/A | SUL |

**Table 5.2.2: Operating bands in FR2**

|  |  |  |
| --- | --- | --- |
| ***operating band*** | **Uplink (UL) and Downlink (DL) *operating band* BS transmit/receive UE transmit/receive**  **FUL\_low   – FUL\_high**  **FDL\_low   – FDL\_high** | **Duplex Mode** |
| n257 | 26500 MHz – 29500 MHz | TDD |
| n258 | 24250 MHz – 27500 MHz | TDD |
| n260 | 37000 MHz – 40000 MHz | TDD |
| n261 | 27500 MHz – 28350 MHz | TDD |

**Table 5.2.3 : MMTC Operating Bands**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Operating Band** | **Uplink (UL) operating band BS receive UE transmit** | | | **Downlink (DL) operating band BS transmit  UE receive** | | | **Duplex Mode** |
| **FUL\_low   – FUL\_high** | | | **FDL\_low  – FDL\_high** | | |
| 1 | 1920 MHz | – | 1980 MHz | 2110 MHz | – | 2170 MHz | HD-FDD |
| 2 | 1850 MHz | – | 1910 MHz | 1930 MHz | – | 1990 MHz | HD-FDD |
| 3 | 1710 MHz | – | 1785 MHz | 1805 MHz | – | 1880 MHz | HD-FDD |
| 4 | 1710 MHz | – | 1755 MHz | 2110 MHz | – | 2155 MHz | HD-FDD |
| 5 | 824 MHz | – | 849 MHz | 869 MHz | – | 894MHz | HD-FDD |
| 8 | 880 MHz | – | 915 MHz | 925 MHz | – | 960 MHz | HD-FDD |
| 11 | 1427.9 MHz | – | 1447.9 MHz | 1475.9 MHz | – | 1495.9 MHz | HD-FDD |
| 12 | 699 MHz | – | 716 MHz | 729 MHz | – | 746 MHz | HD-FDD |
| 13 | 777 MHz | – | 787 MHz | 746 MHz | – | 756 MHz | HD-FDD |
| 17 | 704 MHz | – | 716 MHz | 734 MHz | – | 746 MHz | HD-FDD |
| 18 | 815 MHz | – | 830 MHz | 860 MHz | – | 875 MHz | HD-FDD |
| 19 | 830 MHz | – | 845 MHz | 875 MHz | – | 890 MHz | HD-FDD |
| 20 | 832 MHz | – | 862 MHz | 791 MHz – 821 MHz | | | HD-FDD |
| 21 | 1447.9 MHz | – | 1462.9 MHz | 1495.9 MHz | – | 1510.9 MHz | HD-FDD |
| 25 | 1850 MHz | – | 1915 MHz | 1930 MHz | – | 1995 MHz | HD-FDD |
| 26 | 814 MHz | – | 849 MHz | 859 MHz | – | 894 MHz | HD-FDD |
| 28 | 703 MHz | – | 748 MHz | 758 MHz | – | 803 MHz | HD-FDD |
| 31 | 452.5 MHz | – | 457.5 MHz | 462.5 MHz | – | 467.5 MHz | HD-FDD |
| 41 | 2496 MHz |  | 2690 MHz | 2496 MHz |  | 2690 MHz | TDD |
| 66 | 1710 MHz | – | 1780 MHz | 2110 MHz | – | 2200 MHz | HD-FDD |
| 70 | 1695 MHz | – | 1710 MHz | 1995 MHz | – | 2020 MHz | HD-FDD |
| 71 | 663 MHz | – | 698 MHz | 617 MHz | – | 652 MHz | HD-FDD |
| 72 | 451 MHz | – | 456 MHz | 461 MHz | – | 466 MHz | HD-FDD |
| 74 | 1427 MHz | – | 1470 MHz | 1475 MHz | – | 1518 MHz | HD-FDD |
| See details in Section 5.5F in  [T3.9036.101]. These systems operate in HD-FDD or TDD mode | | | | | | | |

## Energy Efficiency

As defined in Report ITU-R M.2410, network energy efficiency is the capability of a RIT/SRIT to minimize the radio access network energy consumption in relation to the traffic capacity provided. Device energy efficiency is the capability of the RIT/SRIT to minimize the power consumed by the device modem in relation to the traffic characteristics.

The RIT/SRIT shall have the capability to support a high sleep ratio and long sleep duration.

The sleep ratio is the fraction of unoccupied time resources (for the network) or sleeping time (for the device) in a period of time corresponding to the cycle of the control signaling (for the network) or the cycle of discontinuous reception (for the device) when no user data transfer takes place. The sleep duration is the continuous period of time with no transmission (for network and device) and reception (for the device).

### Device

The figure below shows the discontinuous reception (DRX) cycle which is used by the UE to reduce power consumption. For idle state and inactive state, the UE should monitor one paging occasion per DRX cycle (which equals to the paging cycle). Before paging receiving, the SSB monitoring is needed. Also RRM measurement(s), including intra- and inter-cell shall be performed.

The DRX cycle for idle state / inactive state UE consists of an “On Duration” during which the UE should perform SSB monitoring, paging monitoring and RRM measurement, and an “Off Duration” during which the UE can skip reception of downlink channels to save energy. Therefore, the sleep ratio is determined by the length of “On Duration” and the length of one paging cycle.

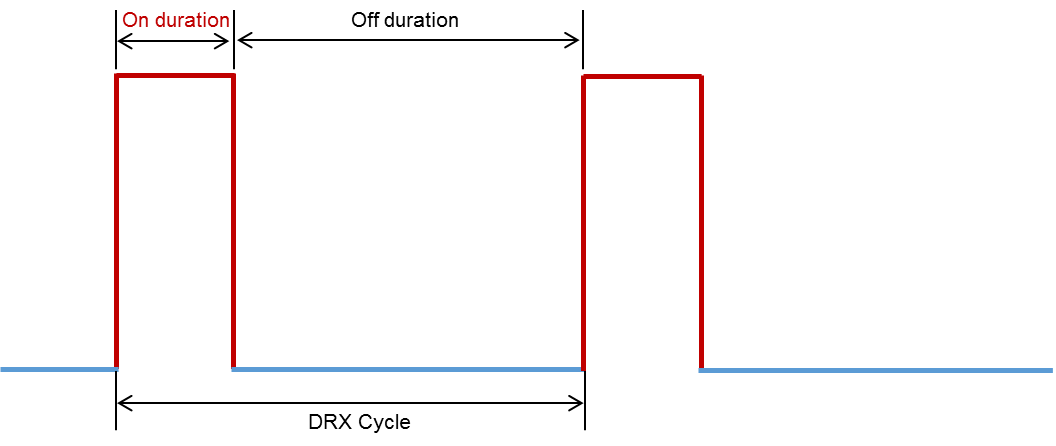


Figure 5.3.1 : DRX cycle

The tables below show the sleep ratios of the device for idle, active and inactive modes.

Table 5.3.1.1 : DRX cycle sleep ratio for idle/inactive mode

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Paging cycle *N*PC\_RF \*10 (ms) | SCS(kHz) | SSB L | SSB reception time(ms) | SSB cycle (ms) | Number of SSB burst set | RRM measurement time per DRX (ms) | Transition time(ms) | Sleep ratio |
| RRC-Idle/Inactive | 320 | 240 | 32 | 1 | -- | 1 | 3.5 | 10 | 95.50% |
| 2560 | 15 | 2 | 1 | -- | 1 | 3 | 10 | 99.50% |
| 2560 | 15 | 2 | 1 | 160 | 2 | 3 | 10 | 93.20% |

For idle/inactive mode, the paging cycle periods considered are 320 ms and 2560 ms. The values of each of the parameters are provided in the table. These values are added up to get the total on time of the device and the percentage sleep ratio has been calculated. It is assumed that one paging occasion consists of one slot and one Paging Frame contains one paging occasion. Time for paging monitoring is no longer than that of one SSB burst.

In a similar way, the sleep ratio for active mode has also been calculated.

Table 5.3.1.2 : DRX cycle sleep ratio for connected mode

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | DRX cycle *T*SC\_ms \* *M*SC (ms) | Number of SSB burst set | DRX-onDurationTimer(ms) | RRM measurement time per DRX (ms) | Transition time(ms) | Sleep ratio |
| RRC-Connected | 320 | 1 | 2 | 3.5 | 10 | 95.20% |
| 320 | 1 | 10 | 3 | 10 | 92.80% |
| 2560 | 1 | 100 | 3 | 10 | 95.60% |
| 10240 | 1 | 1600 | 3 | 10 | 84.20% |

### Network

At the network side, the sleep ratio is evaluated when no data transfer takes place. During this period, there will be periodic transmission of SSB/PBCH, RMSI and paging signal from the network side. The table below shows the sleep ratio values for different SSB periodicities, SCS and number of SSB (L). The on duration times are calculated as the summation of the time during which the network side transmits the above-mentioned signals. The periodicities of the SSB/PBCH, RMSI and paging are considered the same.

Figure 5.3.2.1 : Sleep ratio values for different SSB periodicities

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Periodicity(ms)** | **SCS** | **15** | **15** | **30** | **30** | **120** | **120** | **240** | **240** |
| **L** | **1** | **2** | **1** | **2** | **8** | **16** | **8** | **16** |
| **5** |  | 0.914 | 0.829 | 0.957 | 0.914 | 0.914 | 0.829 | 0.957 | 0.914 |
| **10** |  | 0.957 | 0.914 | 0.979 | 0.957 | 0.957 | 0.914 | 0.979 | 0.957 |
| **20** |  | 0.979 | 0.957 | 0.989 | 0.979 | 0.979 | 0.957 | 0.989 | 0.979 |
| **40** |  | 0.989 | 0.979 | 0.995 | 0.989 | 0.989 | 0.979 | 0.995 | 0.989 |
| **80** |  | 0.995 | 0.989 | 0.997 | 0.995 | 0.995 | 0.989 | 0.997 | 0.995 |
| **160** |  | 0.997 | 0.995 | 0.999 | 0.997 | 0.997 | 0.995 | 0.999 | 0.997 |

The table shows the maximum continuous sleep duration values for different periodicities of SSB and SCS.

Figure 5.3.2.2 : Sleep duration values

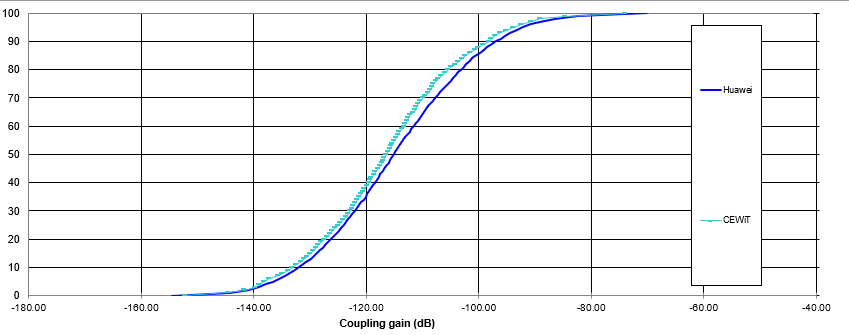
|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Periodicity (ms)** | **SCS** | **15** | **15** | **30** | **30** | **120** | **120** | **240** | **240** |
| **L** | **1** | **2** | **1** | **2** | **8** | **16** | **8** | **16** |
| **5** |  | 4 | 4 | 4.5 | 4.5 | 4.5 | 4 | 4.75 | 4.5 |
| **10** |  | 9 | 9 | 9.5 | 9.5 | 9.5 | 9 | 9.75 | 9.5 |
| **20** |  | 19 | 19 | 19.5 | 19.5 | 19.5 | 19 | 19.75 | 19.5 |
| **40** |  | 39 | 39 | 39.5 | 39.5 | 39.5 | 39 | 39.75 | 39.5 |
| **80** |  | 79 | 79 | 79.5 | 79.5 | 79.5 | 79 | 79.75 | 79.5 |
| **160** |  | 159 | 159 | 159.5 | 159.5 | 159.5 | 159 | 159.75 | 159.5 |

# Link Budgets

We have carefully looked at the link budgets of the required test environments and found them to be in order.

# Calibration Results

Calibration of the simulators used by the members of TCOE was done. As an example, the CDF for coupling gain for rural 4 GHz scenario is shown below.



# Additional Results for TSDSI RIT Enhancements

TSDSI RIT builds up on 3GPP release 15 and provides enhancements, and these details have been provided by the proponent in their earlier submissions to ITU. For better understanding of the RIT, TCOE IEG has evaluated some of these changes. These results are provided in this Section. Some of these results have been evaluated with non-ITU scenarios for understanding the specific benefits. These results are not necessary for IMT-2020 evaluation of the RIT, but provides a better understanding of the RIT.

## PTRS for DFT-s-OFDM

Phase Tracking Reference Signals (PTRS) is used to detect and correct the effects of Phase Noise (PN) occurring in a communication system. Effects of PN are prominent in mmWave range of frequencies. Therefore, PTRS is used in FR2 in NR. PTRS is employed, both in DL and UL. In case of UL, it is used in both CP-OFDM and DFT-s-OFDM transmission.

In case of DFT-s-OFDM, PTRS is inserted before the DFT operation, i.e., pre-DFT insertion is employed. Also, a chunk based pattern is used, where the chunks (X) are distributed across the OFDM symbol with multiple samples (K) in a chunk. The chunk based pattern helps in interpolation across chunks, while the multiple samples with in a chunk helps in noise averaging. The number of chunks can be from the set {2,4,8}, while each chunk can have either 2 or 4 samples. The chunk pattern is chosen based on the allocated bandwidth as shown in table below.

|  |  |
| --- | --- |
| **Scheduled BW** | **X x K** |
| NRB0 < NRB ≤ NRB1 | 2 x 2 |
| NRB1 < NRB ≤ NRB2 | 2 x 4 |
| NRB2 < NRB ≤ NRB3 | 4 x 2 |
| NRB3 < NRB ≤ NRB4 | 4 x 4 |
| NRB4 < NRB | 8 x 4 |

The threshold values of the allocated bandwidth i.e., NRBi, i=0,1,..,4 are provided using the RRC configuration. However, availability of a default table reduces the RRC overhead. Therefore, a default table is proposed taking into account the performance and overhead constraints. Each chunk can have either 2 or 4 samples. Since the samples in the chunk is used for noise averaging, a lower chunk size, i.e., chunk size = 2 is sufficient for higher SINR. Therefore, the chunk size selection is based on SINR, leading to reduction in PTRS overhead at high SINR.

### Resultant Overhead Reduction achieved through proposed method

Reduction in signaling overhead

The values of bandwidth threshold for sample density calculation are carried in RRC when UL PTRS with transform precoding is enabled. There are five threshold values (NRBi, i = 0,1,..4). Range of threshold values is specified from [0 to 276]. Therefore, 9 bits are required to indicate each value, leading to a total of (5 x 9 = 45 bits) of overhead. Using a default table reduces the 45 bits of signaling.

Reduction in PTRS overhead at high SINR

The chunk size of 4 is not used at high SINR, wherever possible. At low SINR, chunk pattern 2x4 is used for the range of allocated bandwidth, 8 < NRB ≤ 24, while at high SINR, chunk pattern of 2x2 is used. This leads to a reduction of 4 PTRS samples per pre-DFT symbol for allocated bandwidth in the range of 8< NRB­ ≤ 24. Similarly, for the range of allocated bandwidth, 24< NRB­ ≤ 96, 4x2 pattern is used for higher SINR, while 4x4 is used at low SINR. Therefore, there is a reduction of 8 PTRS samples per pre-DFT symbol. Reduction in percentage of RS overhead is given below:

|  |  |
| --- | --- |
| Range of Scheduled Bandwidth | Reduction in RS overhead (high SNR) |
| 8 < NRB ≤ 24 | 1.38 % to 4.16% |
| 24 < NRB ≤ 96 | 0.69% to 2.7% |

## Fast SRS precoding update

In UL non-codebook based precoding, the UE has to transmit precoded SRS with a precoder derived from the associated DL CSI-RS resource using beam correspondence. A fixed delay of 42 symbols irrespective of the numerology implies that the delay will be high for lower numerologies. Even if the UE is capable of faster processing, it will not be allowed to update the precoder for 3ms in case of 15kHz sub carrier spacing (it is as low as 0.250 ms in case of 120 kHz subcarrier spacing). In high doppler scenarios, the delay between the CSI-RS reception and the SRS transmission should be minimum to achieve reliable link adaptation and better performance.

The UL throughput for dense urban scenario (with all UEs mobile) for high Doppler scenario for 15 KHz sub-carrier spacing is evaluated with SRS precoder updation delay of 1, 2, 3 and 4 slots. The average per user throughput for UE speed of 30 Kmph and 60 Kmph and is tabulated below.

### Simulations based on non-ITU scenario

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| UE with speed 30 Kmph | | | | |
| CQI Updation delay in UL (in terms of slot) | 1 Slot | 2 Slot | 3 Slot | 4 Slot |
| Per user throughput  (in Mbps) | 2.4876 | 2.4739 | 2.3738 | 2.2881 |
| Spectral Efficiency  (in bps/Hz) | 1.7413 | 1.7317 | 1.66163 | 1.6017 |
| Percentage Change  (1 slot is reference) | 0 | -0.55 | -4.58 | -8.02 |

**Table 1:** UL spectral efficiency and throughput for 30km/hr UE speed

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| UE with speed 60 Kmph | | | | |
| CQI Updation delay in UL (in terms of slot) | 1 Slot | 2 Slot | 3 Slot | 4 Slot |
| Per user throughput  (in Mbps) | 1.3174 | 1.2204 | 1.1257 | 1.0764 |
| Spectral Efficiency  (in bps/Hz) | 1.5809 | 1.4645 | 1.3508 | 1.2917 |
| Percentage Change  (1 slot is reference) | 0 | -7.36 | -14.55 | -18.29 |

**Table 2:** UL spectral efficiency and throughput for 60km/hr UE speed

It can be observed from the tables that as the CQI updation in UL gets delayed, per user throughput decreases. In case of non-codebook based UL transmission, encountered delays are precoder updation based on associated CSI-RS, precoded SRS transmission and PUSCH scheduling. Hence, to maximise the throughput, these delays should be minimised.

### Simulation based on ITU Scenario

Rural configuration has been chosen because it has more high mobility users.

Case 1: Rural config A (TDD, ‘DSUUD’)

|  |  |  |
| --- | --- | --- |
|  | Avg. SE (UL) | Percentage increase |
| 4 slot delay | 5.63 | 0.5 |
| 1 slot delay | 5.66 |

Case 2: Rural config B (TDD, ‘DSUUD’)

|  |  |  |
| --- | --- | --- |
|  | Avg. SE (UL) | Percentage increase |
| 4 slot delay | 3.47 | 4.32 |
| 1 slot delay | 3.62 |

## Bandwidth partitioning

In NR, all the UEs are configured with a chunk of bandwidth of the component carrier of the gNB in the form of bandwidth parts (BWP). Any downlink or uplink transmission that happens between the gNB and the UE will be happening within the configured bandwidth part of the UE. A UE can be configured with at most 4 BWPs by the gNB and the BWPs configured will be unique for all the UEs. The BWP of a UE can span from 1RB to full carrier bandwidth of the gNB.

The frequency allocation for a UE is done in terms of Resource block group (RBG), which is a group of contiguous RBs. The RBG sizes for different UE might be different. The new method of bandwidth part partitioning makes sure that the BWPs configured for the UEs are aligned at the boundaries which is useful because resource wastage could happen if the BWPs of the UEs are misaligned. With the new type of BWP signaling to the UE, the gNB has the flexibility to configure any RBG size to the UE which is useful for reduction in the DCI payload size.

### Resource saving due to proposed method

The amount of resource saved depends on the RBG sizes configured to the UEs that are scheduled in the misaligned BWPs. The amount of resource saved is shown in the table below.

|  |  |
| --- | --- |
| RBG size | Resources saved (in RBs) |
| 2 | 1-2 |
| 4 | 1-6 |
| 8 | 1-14 |
| 16 | 1-30 |

For a BWP of size 273 RBs and RBG size of 16, the minimum and maximum gain achieved are

Minimum Gain = 1/273 = 0.36%

Maximum Gain = 30/273 = 10.98%

### Gain achieved in the DCI

Considering the minimum possible DCI payload of size 22 bits without frequency allocation field and

* Assuming BWP size of 36RBs,
* Minimum bits required for frequency allocation as per 3GPP when RBG size is 4 = 36/4 = 9 bits
* Maximum bits required for frequency allocation as per 3GPP when RBG size is 2 = 36/2 = 18 bits
* As per new RIT, any RBG size can be configured for a BWP. So, the frequency allocation field in the DCI can be reduced by using higher RBG size.
* Minimum bits required for frequency allocation as per new RIT when RBG size is 16= 36/16 = 3 bits. In this case, RBG size 16 used because it is the maximum RBG size.
* Maximum DCI payload size as per 3GPP = 22+18 = 40 bits
* Minimum DCI payload size as per 3GPP = 22+9 = 31 bits
* Minimum DCI payload size as per new RIT = 22+3 = 25 bits
* Maximum gain achieved = (40-25)/40 = 37.5%
* Minimum gain achieved = (31-25)/31 = 19.3%

## Pi/2 BPSK with spectrum shaping

In the TSDSI RIT, Pi/2 BPSK is mandatory and has to be spectrum shaped with the filter 1+D. The spectrum shaping is performed only for PUSCH and PUCCH data channels. The spectrum shaping is designed to give the maximum PAPR benefit for the resulting pi/2BPSK based DFT-s-OFDM waveform. This spectrum shaping is not done for the DMRS which is ZC sequence. Furthermore, in TDD bands with less than 50% UL duty cycle, the maximum transmission power for UL is allowed to increase to 26 dBm. It should be noted that pi/2 BPSK is not a mandatory feature in Rel-15 version of 3GPP.

The following configuration is used for generating the below results.

|  |  |
| --- | --- |
| **Configuration parameters** | **Rural (Configuration C)** |
| Multiple access | DFT-S-OFDM |
| Duplexing | TDD, 3.5 GHz |
| Network synchronization | Synchronized |
| Coding | LDPC |
| Numerology | 15 kHz |
| Simulation bandwidth | 60 MHz |
| Number of Users | 10 |
| TDD Frame structure | DDDSU |
| Transmission scheme | 1 layer per user |
| Re-transmission delay | Next available slot |
| Antenna configuration at TRxP | 2 Rx, (8,4,2,1,1; 1,1) |
| Antenna configuration at UE | (M,N,P,Mg,Ng; Mp,Np)= (1,1,1,1,1; 1,1) |
| Scheduling | PF |
| Receiver | MMSE-IRC |
| Channel estimation | Ideal |
| Power control parameter | P0=-106, alpha = 0.75 |
| TRxP number per site | 3 |
| Mechanic tilt | 90° in GCS |
| Electronic tilt | 92° in LCS |
| Wrapping around method | Geographical distance-based wrapping |
| Criteria for selection for serving TRxP | RSRP based |
| Pathloss Model | LMLC (ITU-R M.2412) |
| BS noise figure, UE antenna elements gains, Interference modelling, thermal noise levels | As per ITU-R M.2412 document |

*Note: All system configuration parameters align with Report ITU-R M.2412.*

In the evaluation, the maximum transmit power for a UE is set to 26 dBm if pi/2 BPSK is enabled in TDD. Otherwise, the maximum transmit power is set to 23 dBm. The following additional simulation setup is considered: 8 SSB Beams are considered to cover entire sector such that the azimuth angles are equally spaced and the elevation for each beam is same as down tilt angle. The user attach procedure is based on the best SSB-beam. The wideband SINR is calculated based on the beam lock, followed by spectral efficiency calculation.

|  |  |  |
| --- | --- | --- |
| ISD=12 Km  Spectral Efficiency | **Spectral Efficiency (bps/Hz)** | |
| **Without PI/2 BPSK** | **With PI/2 BPSK** |
| 5% | 0.09328 | 0.1576 |
| 10% | 0.1348 | 0.2254 |
| 50% | 0.4057 | 0.4626 |

Note that similar benefits carry forward to the NB-IoT system as well which is used for mMTC in TSDSI RIT.