**3GPP TSG-RAN WG4 Meeting #100-e R4-2113800**

**Electronic Meeting, 16th - 27th Aug, 2021**

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| *CR-Form-v12.1* |
| **CHANGE REQUEST** |
|  |
|  | **38.174** | **CR** | **-** | **rev** | **-** | **Current version:** | **16.3.0** |  |
|  |
| *For* [***HE******LP***](http://www.3gpp.org/3G_Specs/CRs.htm#_blank)*on using this form: comprehensive instructions can be found at* [*http://www.3gpp.org/Change-Requests*](http://www.3gpp.org/Change-Requests)*.* |
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| ***Proposed change affects:*** | UICC apps |  | ME |  | Radio Access Network | **x** | Core Network |  |

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| --- |
|  |
| ***Title:***  | draftCR on IAB-MT conducted performance requirements (General and Demodulation) in TS 38.174 |
|  |  |
| ***Source to WG:*** | Huawei, HiSilicon |
| ***Source to TSG:*** | R4 |
|  |  |
| ***Work item code:*** | NR\_IAB-Perf |  | ***Date:*** | 2021-08-06 |
|  |  |  |  |  |
| ***Category:*** | **F** |  | ***Release:*** | Rel-16 |
|  | *Use one of the following categories:****F*** *(correction)****A*** *(mirror corresponding to a change in an earlier release)****B*** *(addition of feature),* ***C*** *(functional modification of feature)****D*** *(editorial modification)*Detailed explanations of the above categories canbe found in 3GPP [TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm). | *Use one of the following releases:Rel-8 (Release 8)Rel-9 (Release 9)Rel-10 (Release 10)Rel-11 (Release 11)…Rel-15 (Release 15)Rel-16 (Release 16)Rel-17 (Release 17)Rel-18 (Release 18)* |
|  |  |
| ***Reason for change:*** | Provide updated draft CR for NR IAB-MT conducted performance requirements (General and Demodulation) as per work split. |
|  |  |
| ***Summary of change:*** | For introducing IAB-MT conducted performance requirements (General and Demodulation), update clause 2, 8.2, Annex I. |
|  |  |
| ***Consequences if not approved:*** | There will be inconsistence between the specification 38.174 and RAN 4 agreements. |
|  |  |
| ***Clauses affected:*** | 2, 8.2, Annex I |
|  |  |
|  | **Y** | **N** |  |  |
| ***Other specs*** |  | **x** |  Other core specifications  | TS/TR ... CR ...  |
| ***affected:*** | **X** |  |  Test specifications | TS 38.176-1, TS 38.176-2 |
| ***(show related CRs)*** |  | **x** |  O&M Specifications | TS/TR ... CR ...  |
|  |  |
| ***Other comments:*** |  |
|  |  |
| ***This CR's revision history:*** |  |

*<START OF THE CHANGE 1>*

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 38.104: “NR; Base Station (BS) radio transmission and reception”

[3] 3GPP TS 38.101-1: “NR User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone”

[4] 3GPP TS 38.101-2: “NR User Equipment (UE) radio transmission and reception: Part 2: Range 2 Standalone”

[5] 3GPP TS 38.101-3: "NR; User Equipment (UE) radio transmission and reception; Part 3: Range 1 and Range 2 Interworking operation with other radios "

[6] 3GPP TS 38.133: “NR: Requirements for support of radio resource management”

[7] 3GPP TS 38.300: "NR; Overall description; Stage-2".

[8] 3GPP TS 38.211: "NR; Physical channels and modulation”.

[9] 3GPP TS 38.212 "NR; Multiplexing and channel coding".

[10] 3GPP TS 38.213: "NR; Physical layer procedures for control".

[11] 3GPP TS 38.214: "NR; Physical layer procedures for data".

[12] 3GPP TS 38.215: "NR; Physical layer measurements".

[13] 3GPP TS 38.304: "NR; User Equipment (UE) procedures in idle mode".

[14] 3GPP TS 38.321: "NR; Medium Access Control (MAC) protocol specification".

[15] 3GPP TS 38.331: "NR; Radio Resource Control (RRC); Protocol specification".

[16] ITU-R Recommendation SM.329: "Unwanted emissions in the spurious domain".

[17] ERC Recommendation 74-01, "Unwanted emissions in the spurious domain".

[18] ITU-R Recommendation M.1545: “Measurement uncertainty as it applies to test limits for the terrestrial component of International Mobile Telecommunications – 2000”

[19] Recommendation ITU-R SM.328: "Spectra and bandwidth of emissions".

[20] "Title 47 of the Code of Federal Regulations (CFR)", Federal Communications Commission.

[21] 3GPP TS 38.141-2: "NR; Base Station (BS) conformance testing; Part 2: Radiated conformance testing".

[22] 3GPP TS 38.141-1: "NR; Base Station (BS) conformance testing; Part 1: Conducted conformance testing".

[23] 3GPP TS 38.521-1: “NR; User Equipment (UE) conformance specification; Radio transmission and reception; Part 1: Range 1 Standalone”.

[24] 3GPP TS 38.521-2: “NR; User Equipment (UE) conformance specification; Radio transmission and reception; Part 2: Range 2 Standalone”.

[25] 3GPP TR 38.901: "Study on channel model for frequencies from 0.5 to 100 GHz"

*<END OF THE CHANGE 1>*

*<START OF THE CHANGE 2>*

## 8.2 IAB-MT requirements

### 8.2.1 General

Conducted performance requirements specify the ability of the *IAB-MT type 1-H* to correctly demodulate signals in various conditions and configurations. Conducted performance requirements are specified at the *TAB connector(s)* (for *IAB-MT type 1-H*).

Conducted performance requirements for the IAB-MT are specified for the fixed reference channels defined in annex A and the propagation conditions in annex I. The requirements only apply to those FRCs that are supported by the IAB-MT.

The SNR used in this clause is specified based on a single carrier and defined as:

SNR = S / N

Where:

S is the total signal energy in the slot on a single *TAB connector* (for *IAB-MT type 1-H*).

N is the noise energy in a bandwidth corresponding to the transmission bandwidth over the duration of a slot on a single TAB connector (for *IAB-MT type 1-H*).

### 8.2.2 Demodulation performance requirements

#### 8.2.2.1 Performance requirements for PDSCH

##### 8.2.2.1.1 General

The performance requirement of PDSCH is determined by a minimum required throughput for a given SNR. The required throughput is expressed as a fraction of maximum throughput for the FRCs listed in annex A. The performance requirements assume HARQ retransmissions.

Table: 8.2.2.1.1-1 Test parameters for testing PDSCH

|  |  |
| --- | --- |
| Parameter | Value |
| Cyclic prefix | Normal |
| Default TDD UL-DL pattern (Note 1) | 7D1S2U, S=6D:4G:4U |
| HARQ | Maximum number of HARQ transmissions | 4 |
| RV sequence | 0, 2, 3, 1 |
| DM-RS | DM-RS configuration type | 1 |
| DM-RS duration | single-symbol DM-RS |
| DM-RS position (*l0*) | 2 |
| Additional DM-RS position | pos1 |
| Number of DM-RS CDM group(s) without data | 1 for Rank 1 and Rank 2 tests2 for Rank 3 and Rank 4 tests |
| DM-RS port(s) | {1000} for Rank 1 tests{1000-1001} for Rank 2 tests{1000-1002} for Rank 3 tests{1000-1003} for Rank 4 tests |
| DM-RS sequence generation | NID0=0 |
| Time domain resource assignment | PDSCH mapping type | A |
| Start symbol | 2 |
| Allocation length | 12 |
| Frequency domain resource assignment | RB assignment | Full applicable test bandwidth |
| PT-RS configuration | Not configured |
| PRB bundling size | 2 |
| VRB-to-PRB mapping type | Not interleaved |
| PDSCH & PDSCH DMRS Precoding configuration | Single Panel Type I, Random precoder selection updated per slot, with equal probability of each applicable i1, i2 combination, and with PRB bundling granularity |
| Note 1: The same requirements are applicable to TDD with different UL-DL patterns. |

##### 8.2.2.1.2 Minimum requirements

The throughput shall be equal to or larger than the fraction of maximum throughput for the FRCs stated in tables 8.2.2.1.2-1 to 8.2.2.1.2-4 at the given SNR with the test parameters stated in Table 8.2.2.1.1-1.

Table 8.2.2.1.2-1: Minimum requirements for PDSCH Type A with Rank 1

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Test number | FRC (Annex A) | Bandwidth (MHz) / Subcarrier spacing (kHz) | Propagation conditions (Annex I) | Antenna configuration | Fraction of maximum throughput (%) | SNR(dB) |
| 1-1 | M-FR1-A.3.3-1 | 40/30 | TDLA30-10 | 2x4, ULA Low | 70 | 21.6 |
| 1-2 | M-FR1-A.3.1-1 | 40/30 | TDLA30-10 | 2x4, ULA Low | 30 | -1.1 |

Table 8.2.2.1.2-2: Minimum requirements for PDSCH Type A with Rank 2

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Test number | FRC (Annex A) | Bandwidth (MHz) / Subcarrier spacing (kHz) | Propagation conditions (Annex I) | Antenna configuration | Fraction of maximum throughput (%) | SNR(dB) |
| 2-1 | M-FR1-A.3.2-1 | 40/30 | TDLA30-10 | 2x4, ULA Low | 70 | 13.6 |

Table 8.2.2.1.2-3: Minimum requirements for PDSCH Type A with Rank 3

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Test number | FRC (Annex A) | Bandwidth (MHz) / Subcarrier spacing (kHz) | Propagation conditions (Annex I) | Antenna configuration | Fraction of maximum throughput (%) | SNR(dB) |
| 3-1 | M-FR1-A.3.1-2 | 40/30 | TDLA30-10 | 4x4, ULA Low | 70 | 11.4 |

Table 8.2.2.1.2-4: Minimum requirements for PDSCH Type A with Rank 4

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Test number | FRC (Annex A) | Bandwidth (MHz) / Subcarrier spacing (kHz) | Propagation conditions (Annex I) | Antenna configuration | Fraction of maximum throughput (%) | SNR(dB) |
| 4-1 | M-FR1-A.3.1-3 | 40/30 | TDLA30-10 | 4x4, ULA Low | 70 | 15.4 |

#### 8.2.2.2 Performance requirements for PDCCH

##### 8.2.2.2.1 General

The receiver characteristics of the PDCCH are determined by the probability of miss-detection of the Downlink Scheduling Grant (Pm-dsg).

Table: 8.2.2.2.1-1 Test parameters for testing PDCCH

|  |  |
| --- | --- |
| Parameter | Value |
| Cyclic prefix | Normal |
| Default TDD UL-DL pattern (Note 1) | 7D1S2U, S=6D:4G:4U |
| DM-RS sequence generation | NID=0 |
| Frequency domain resource allocation for CORESET | Start from RB = 0 with contiguous RB allocation |
| CCE to REG mapping type | Interleaved |
| Interleaver size | 3 |
| REG bundle size | 2 for test with 1Tx6 for test with 2Tx |
| Shift Index | 0 |
| Slots for PDCCH monitoring | Each slot |
| Number of PDCCH candidates for the tested aggregation level | 1 |
| PDCCH Precoding configuration | Single Panel Type I, Random precoder selection updated per slot, with equal probability of each applicable i1, i2 combination with REG bundling granularity for number of Tx larger than 1 |
| Note 1: The same requirements are applicable to TDD with different UL-DL patterns. |

##### 8.2.2.2.2 Minimum requirements

The Pm-dsg shall be equal to or smaller than 1%, for the cases stated in Table 8.2.2.2.2-1 at the given SNR with the test parameters stated in Table 8.2.2.2.1-1.

Table 8.2.2.2.2-1: Minimum requirements for PDCCH

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Test number | Bandwidth (MHz) / Subcarrier spacing (kHz) | CORESET RB | CORESET duration | Aggregation level | FRC (Annex A) | Propagation conditions (Annex I) | Antenna configuration | Pm-dsg (%) | SNR(dB) |
| 1 | 40/30 | 102 | 1 | 2 | M-FR1-A.3.4-1 | TDLA30-10 | 1x4, ULA Low | 1 | 2.1 |
| 2 | 40/30 | 102 | 1 | 4 | M-FR1-A.3.4-1 | TDLA30-10 | 1x4, ULA Low | 1 | 0.7 |
| 3 | 40/30 | 90 | 1 | 8 | M-FR1-A.3.4-1 | TDLA30-10 | 2x4, ULA Low | 1 | -4.1 |

*<END OF THE CHANGE 2>*

*<START OF THE CHANGE 3>*

Annex I (normative):
Propagation conditions

I.1 Static propagation condition

The propagation for the static performance measurement is an Additive White Gaussian Noise (AWGN) environment. No fading or multi-paths exist for this propagation model.

I.1.1 IAB-MT receiver with 2RX

For 1 port transmission the channel matrix is defined in the frequency domain by:

.

For 2 port transmission the channel matrix is defined in the frequency domain by:

.

For 4 port transmission the channel matrix is defined in the frequency domain by:



For 8 port transmission the channel matrix is defined in the frequency domain by:



I.2 Multi-path fading propagation conditions

I.2.1 General

The multipath propagation conditions consist of several parts:

- A delay profile in the form of a "tapped delay-line", characterized by a number of taps at fixed positions on a sampling grid. The profile can be further characterized by the r.m.s. delay spread and the maximum delay spanned by the taps.

- A combination of channel model parameters that include the Delay profile and the Doppler spectrum that is characterized by a classical spectrum shape and a maximum Doppler frequency.

- Different models are used for FR1 (410 MHz - 7.125 GHz) and FR2 (24.25 GHz – 52.6 GHz).

I.2.2 Delay profiles

I.2.2.1 General

The delay profiles are simplified from the TR 38.901 [25] TDL models. The simplification steps are shown below for information. These steps are only used when new delay profiles are created. Otherwise, the delay profiles specified in I.2.2.1 can be used as such.

- Step 1: Use the original TDL model from TR 38.901 [25].

- Step 2: Re-order the taps in ascending delays.

- Step 3: Perform delay scaling according to the procedure described in clause 7.7.3 in TR 38.901 [25].

- Step 4: Apply the quantization to the delay resolution 5 ns. This is done simply by rounding the tap delays to the nearest multiple of the delay resolution.

- Step 5: If multiple taps are rounded to the same delay bin, merge them by calculating their linear power sum.

- Step 6: If there are more than 12 taps in the quantized model, merge the taps as follows:

- Find the weakest tap from all taps (both merged and unmerged taps are considered):

- If there are two or more taps having the same value and are the weakest, select the tap with the smallest delay as the weakest tap.

- When the weakest tap is the first delay tap, merge taps as follows:

- Update the power of the first delay tap as the linear power sum of the weakest tap and the second delay tap.

- Remove the second delay tap.

- When the weakest tap is the last delay tap, merge taps as follows:

- Update the power of the last delay tap as the linear power sum of the second-to-last tap and the last tap.

- Remove the second-to-last tap.

- Otherwise:

- For each side of the weakest tap, identify the neighbour tap that has the smaller delay difference to the weakest tap.

- When the delay difference between the weakest tap and the identified neighbour tap on one side equals the delay difference between the weakest tap and the identified neighbour tap on the other side.

- Select the neighbour tap that is weaker in power for merging.

- Otherwise, select the neighbour tap that has smaller delay difference for merging.

- To merge, the power of the merged tap is the linear sum of the power of the weakest tap and the selected tap.

- When the selected tap is the first tap, the location of the merged tap is the location of the first tap. The weakest tap is removed.

- When the selected tap is the last tap, the location of the merged tap is the location of the last tap. The weakest tap is removed.

- Otherwise, the location of the merged tap is based on the average delay of the weakest tap and selected tap. If the average delay is on the sampling grid, the location of the merged tap is the average delay. Otherwise, the location of the merged tap is rounded towards the direction of the selected tap (e.g. 10 ns & 20 ns 🡪 15 ns, 10 ns & 25 ns 🡪 20 ns, if 25 ns had higher or equal power; 15 ns, if 10 ns had higher power). The weakest tap and the selected tap are removed.

- Repeat step 6 until the final number of taps is 12.

- Step 7: Round the amplitudes of taps to one decimal (e.g. -8.78 dB 🡪 -8.8 dB)

- Step 8: If the delay spread has slightly changed due to the tap merge, adjust the final delay spread by increasing or decreasing the power of the last tap so that the delay spread is corrected.

- Step 9: Re-normalize the highest tap to 0 dB.

Note 1: Some values of the delay profile created by the simplification steps may differ from the values in tables I.2.2.2-2, I.2.2.2-3, and I.2.1.1-4 for the corresponding model.

Note 2: For Step 5 and Step 6, the power values are expressed in the linear domain using 6 digits of precision. The operations are in the linear domain.

I.2.2.2 Delay profiles for FR1

The delay profiles for FR1 are selected to be representative of low, medium and high delay spread environment. The resulting model parameters are specified in I.2.2.2-1 and the tapped delay line models are specified in tables I.2.2.2-2 ~ table I.2.2.2-4.

**Table I.2.2.2-1: Delay profiles for NR channel models**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Model** | **Number of channel taps** | **Delay spread****(r.m.s.)** | **Maximum excess tap delay (span)** | **Delay resolution** |
| TDLA30 | 12 | 30 ns | 290 ns | 5 ns |
| TDLB100 | 12 | 100 ns | 480 ns | 5 ns |
| TDLC300 | 12 | 300 ns | 2595 ns | 5 ns |

**Table I.2.2.2-2: TDLA30 (DS = 30 ns)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Tap #** | **Delay (ns)** | **Power (dB)** | **Fading distribution** |
| 1 | 0 | -15.5 |  |
| 2 | 10 | 0 |  |
| 3 | 15 | -5.1 |  |
| 4 | 20 | -5.1 |  |
| 5 | 25 | -9.6 |  |
| 6 | 50 | -8.2 | Rayleigh |
| 7 | 65 | -13.1 |  |
|  8 | 75 | -11.5 |  |
| 9 | 105 | -11.0 |  |
| 10 | 135 | -16.2 |  |
| 11 | 150 | -16.6 |  |
| 12 | 290 | -26.2 |  |

**Table I.2.2.2-3: TDLB100 (DS = 100ns)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Tap #** | **Delay (ns)** | **Power (dB)** | **Fading distribution** |
| 1 | 0 | 0 |  |
| 2 | 10 | -2.2 |  |
| 3 | 20 | -0.6 |  |
| 4 | 30 | -0.6 |  |
| 5 | 35 | -0.3 |  |
| 6 | 45 | -1.2 | Rayleigh |
| 7 | 55 | -5.9 |  |
| 8 | 120 | -2.2 |  |
| 9 | 170 | -0.8 |  |
| 10 | 245 | -6.3 |  |
| 11 | 330 | -7.5 |  |
| 12 | 480 | -7.1 |  |

**Table I.2.2.2-4: TDLC300 (DS = 300 ns)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Tap #** | **Delay (ns)** | **Power (dB)** | **Fading distribution** |
| 1 | 0 | -6.9 |  |
| 2 | 65 | 0 |  |
| 3 | 70 | -7.7 |  |
| 4 | 190 | -2.5 |  |
| 5 | 195 | -2.4 |  |
| 6 | 200 | -9.9 | Rayleigh |
| 7 | 240 | -8.0 |  |
| 8 | 325 | -6.6 |  |
| 9 | 520 | -7.1 |  |
| 10 | 1045 | -13.0 |  |
| 11 | 1510 | -14.2 |  |
| 12 | 2595 | -16.0 |  |

I.2.3 Combinations of channel model parameters

The propagation conditions used for the performance measurements in multi-path fading environment are indicated as a combination of a channel model name and a maximum Doppler frequency, i.e., TDLA<DS>-<Doppler>, TDLB<DS>-<Doppler> or TDLC<DS>-<Doppler> where '<DS>' indicates the desired delay spread and '<Doppler>' indicates the maximum Doppler frequency (Hz).

Table I.2.3-1 show the propagation conditions that are used for the performance measurements in multi-path fading environment for low, medium and high Doppler frequencies for FR1.

**Table I.2.3-1: Channel model parameters for FR1**

|  |  |  |
| --- | --- | --- |
| **Combination name** | **Model** | **Maximum Doppler frequency** |
| TDLA30-5 | TDLA30 | 5 Hz |
| TDLA30-10 | TDLA30 | 10 Hz |
| TDLB100-400 | TDLB100 | 400 Hz |
| TDLC300-100 | TDLC300 | 100 Hz |

I.2.4 MIMO channel correlation matrices

I.2.4.1 General

The MIMO channel correlation matrices defined in annex I.2.4 apply for the antenna configuration using uniform linear arrays at both IAB-DU/gNB and IAB-MT/UE and for the antenna configuration using cross polarized antennas.

I.2.4.2 MIMO correlation matrices using Uniform Linear Array

I.2.4.2.1 General

The MIMO channel correlation matrices defined in annex I.2.4.2 apply for the antenna configuration using uniform linear array (ULA) at both IAB-DU/gNB and IAB-MT/UE.

I.2.4.2.2 Definition of MIMO correlation matrices

Table I.2.4.2.2-1 defines the correlation matrix for the IAB-DU or gNB.

**Table I.2.4.2.2-1: IAB-DU or gNB correlation matrix**

|  |  |
| --- | --- |
|  | **IAB-DU or gNB correlation** |
| One antenna |  |
| Two antennas |  |
| Four antennas |  |
| Eight antennas |  |
| Note: The matrix applies to the IAB-DU for IAB-DU requirements and gNB for IAB-MT requirements. |

Table I.2.4.2.2-2 defines the correlation matrix for the IAB-MT or UE:

**Table I.2.4.2.2-2: IAB-MT or UE correlation matrix**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **One antenna** | **Two antennas** | **Four antennas** |
| IAB-MT / UE correlation |  |  |  |
| Note: The matrix applies to the UE for IAB-DU requirements and IAB-MT for IAB-MT requirements. |

Table I.2.4.2.2-3 defines the channel spatial correlation matrix. The parameters, *α* and *β* in table I.2.4.2.2-3 defines the spatial correlation between the antennas at the IAB-DU/gNB and IAB-MT/UE respectively.

**Table I.2.4.2.2-3: correlation matrices**

|  |  |
| --- | --- |
| 1x2 case |  |
| 1x4 case |  |
| 2x2 case |  |
| 2x4 case |  |
| 4x4 case |  |
| NOTE 1: RgNB refers to an IAB-DU for IAB-DU requirements or a gNB for IAB-MT requirements.NOTE 2: RUE refers to an UE for IAB-DU requirements or and IAB-MT for IAB-MT requirements |

For cases with more antennas at either IAB-DU/gNB or IAB-MT/UE or both, the channel spatial correlation matrix can still be expressed as the Kronecker product of  and according to****.

I.2.4.2.3 MIMO correlation matrices at high, medium and low level

The α and β for different correlation types are given in table I.2.4.2.3-1.

**Table I.2.4.2.3-1: Correlation for high, medium and low level**

|  |  |  |
| --- | --- | --- |
| **Low correlation** | **Medium correlation** | **High correlation** |
| α | β | α | β | α | β |
| 0 | 0 | 0.9  | 0.3  | 0.9  | 0.9  |

The correlation matrices for high, medium and low correlation are defined in table I.2.4.2.3-2, I.2.4.2.3-3 and I.2.4.2.3-4 as below.

The values in table I.2.4.2.3-2 have been adjusted for the 2x4 and 4x4 high correlation cases to ensure the correlation matrix is positive semi-definite after round-off to 4 digit precision. This is done using the equation:



Where the value "a" is a scaling factor such that the smallest value is used to obtain a positive semi-definite result. For the 2x4 high correlation case, a = 0.00010. For the 4x4 high correlation case, a = 0.00012.

The same method is used to adjust the 4x4 medium correlation matrix in table I.2.4.2.3-3 to insure the correlation matrix is positive semi-definite after round-off to 4 digit precision with a = 0.00012.

**Table I.2.4.2.3-2: MIMO correlation matrices for high correlation**

|  |  |
| --- | --- |
| 1x2 case |  |
| 2x2 case |  |
| 2x4 case |  |
| 4x4 case |  |

**Table I.2.4.2.3-3: MIMO correlation matrices for medium correlation**

|  |  |
| --- | --- |
| 1x2 case | [N/A] |
| 2x2 case |  |
| 2x4 case |  |
| 4x4 case |  |

**Table I.2.4.2.3-4: MIMO correlation matrices for low correlation**

|  |  |
| --- | --- |
| 1x2 case |  |
|  1x4 case |  |
| 1x8 case |  |
|  2x2 case |  |
|  2x4 case |  |
| 2x4 case |  |
|  4x4 case |  |

In table I.2.4.12.3-4,  is a  identity matrix.

NOTE: For completeness, the correlation matrices were defined for high, medium and low correlation but performance requirements exist only for low correlation.

I.2.4.3 Multi-antenna channel models using cross polarized antennas

I.2.4.3.1 General

The MIMO channel correlation matrices defined in annex I.2.4.3 apply to two cases as presented below:

- One TX antenna and multiple RX antennas case, with cross polarized antennas used at IAB-DU/gNB

- Multiple TX antennas and multiple RX antennas case, with cross polarized antennas used at IAB-MT/UE

The cross-polarized antenna elements with +/-45 degrees polarization slant angles are deployed at IAB. For one TX antenna case, antenna element with +90 degree polarization slant angle is deployed at IAB-MT/UE. For multiple TX antennas case, cross-polarized antenna elements with +90/0 degrees polarization slant angles are deployed at IAB-MT/UE.

For the cross-polarized antennas, the N antennas are labelled such that antennas for one polarization are listed from 1 to N/2 and antennas for the other polarization are listed from N/2+1 to N, where N is the number of TX or RX antennas.

I.2.4.3.2 Definition of MIMO correlation matrices using cross polarized antennas

For the channel spatial correlation matrix, the following is used:



Where

-  is the spatial correlation matrix at the UE (IAB-DU requirements) or IAB-MT (IAB-MT requirements) with same polarization,

-  is the spatial correlation matrix at the IAB-DU (IAB-DU requirements) or gNB (IAB-MT requirements) with same polarization,

-  is a polarization correlation matrix,

-  is a permutation matrix, and

- denotes transpose.

Table I.2.4.3.2-1 defines the polarization correlation matrix.

**Table I.2.4.3.2-1: Polarization correlation matrix**

|  |  |  |
| --- | --- | --- |
|  | **One TX antenna** | **Multiple TX antennas** |
| Polarization correlation matrix |  |  |

The matrixis defined as



where  and  is the number of TX and RX antennas respectively, and  is the ceiling operator.

The matrix  is used to map the spatial correlation coefficients in accordance with the antenna element labelling system described in I.2.4.3.

I.2.4.2.3 Spatial correlation matrices at IAB-MT/UE and IAB-DU/gNB sides

I.2.4.2.3.1 Spatial correlation matrices at IAB-MT/UE side

In this subclause, RUE refers to a UE for IAB-DU requirements or an IAB-MT for IAB-MT requirements.

For 1-antenna transmitter, .

For 2-antenna transmitter using one pair of cross-polarized antenna elements, .

For 4-antenna transmitter using two pairs of cross-polarized antenna elements, .

I.2.4.2.3.2 Spatial correlation matrices at IAB-DU/gNB side

In this subclause, RgNB refers to an IAB-DU for IAB-DU requirements or a gNB for IAB-MT requirements.

For 2-antenna receiver using one pair of cross-polarized antenna elements, ****.

For 4-antenna receiver using two pairs of cross-polarized antenna elements,****.

For 8-antenna receiver using four pairs of cross-polarized antenna elements,.

I.2.4.2.4 MIMO correlation matrices using cross polarized antennas

The values for parameters *α*, *β* and *γ* for low spatial correlation are given in table I.2.4.2.4-1.

**Table I.2.4.2.4-1: Values for parameters α,  and γ**

|  |
| --- |
| Low spatial correlation |
| α |  | γ |
| 0 | 0 | 0 |
| Note 1: Value of *α* applies when more than one pair of cross-polarized antenna elements at IAB-DU/gNB side.Note 2: Value of *β* applies when more than one pair of cross-polarized antenna elements at IAB-MT/UE side. |

The correlation matrices for low spatial correlation are defined in table I.2.4.2.4-2 as below.

**Table I.2.4.2.4-2: MIMO correlation matrices for low spatial correlation**

|  |  |
| --- | --- |
| 1x8 case |  |
| 2x8 case |  |

In table I.2.4.2.4-2,  is a  identity matrix.

I.3 Physical signals, channels mapping and precoding

I.3.1 General

Unless otherwise stated, the transmission on antenna port(s) is defined by using a precoder matrix  of size , where is the number of physical transmit antenna elements configured per test , is the number of ports for a reference signal or physical channel configured per test, and is the first port for that reference signal or physical channel as defined in clauses 7.3 and 7.4 in TS 38.211 [8]. This precoder takes as an input a block of signals for antenna port(s) , , , with  being the number of modulation symbols per antenna port including the reference signal symbols, and generates a block of signals the elements of which are to be mapped onto the frequency-time index pair as per the test configuration but transmitted on different physical antenna elements:

For Clause 8.2.3 and 11.2.3, the transmission of PDCCH and PDCCH DMRS on antenna port is defined by using a precoder matrix  of size 2x1. This precoder takes as an input a block of signals for antenna port(s) , and generates a block of signals the elements of which are to be mapped onto the frequency-time index pair as per the test configuration but transmitted on different physical antenna elements:

The precoder matrix is specific to the test case configuration.  is defined in Clause 5.2.2.2 of TS 38.214 [11].

The transimison on PT-RS antenna port is associated (using same precoder) with the lowest indexed DM-RS antenna port among the DM-RS antenna ports assigned for the PDSCH.

The physical antenna elements are identified by indices, where  is the number of physical antenna elements configured per test.

Modulation symbols with (i.e. PSS, SSS, PBCH and DM-RS for PBCH) are directly mapped to first physical antenna element.

Modulation symbols  for CSI-RS resources which configured for tracking with one port are directly mapped to first physical antenna element.

Modulation symbols  for CSI-RS resources which configured for beam refinement with one port are directly mapped to first physical antenna element.

Modulation symbols  for NZP CSI-RS which configured for CSI acquisition with  are mapped to the physical antenna index  where is the number of NZP CSI-RS ports configured per test.

*<END OF THE CHANGE 3>*