**3GPP TSG-RAN4 Meeting #112bis *R4-2416578***

**Hefei, China, 14th – 18th October, 2024**

**Agenda item:** 6.12.2.3

**Source:** Keysight Technologies UK Ltd, Spirent Communications

**Title:** TP on Dynamic MIMO Aspects

**Document for:** Approval

# Introduction

This contribution is incorporating additional channel model validation details and miscellaneous corrections in the TR based on [1].

# Discussion

The draft TP includes the following aspects:

* In Clause 6.3.2, define the minimum range length to match the minimum range length defined for NR FR1 MIMO OTA (with 20cm QZ) in TS 38.151.
* In Clause 8.2.2.3, define the start and end times of the time segments for UMi route
* In Clause 8.2.2.4, define the PL target values for UMa and UMi routes
* In Clause 8.2.4.5, define the SCF target values for UMa and UMi
* In Clause 8.2.4.5, define the TCF target values for UMa and UMi
* In Clause 8.2.6.4, define the XPO target values for UMa and UMi routes
* In Clause 9.3, expand the reference to 38.101-4 from 2RX (Clause 6.4.2) to 4RX (Clause 6.4.3)

It should be noted that the UMa channel model targets are aligned with those from CTIA which underwent an extensive alignment between Keysight and Spirent.

It is proposed to approve the TP with the understanding that additional changes and modifications can be made.

Proposal 1: approve the TP with the understanding that additional changes and modifications can be made

# Conclusion

The following observations and conclusions were made in this contribution.

**Proposal 1: approve the TP with the understanding that additional changes and modifications can be made**

# References

1. R4-2413536, TP on Dynamic MIMO Aspects, Keysight Technologies, Spirent Communications, 3GPP TSG-RAN4 Meeting #112, August 2024

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### 6.3.2 Minimum range length and test zone size

The minimum range length is 1.2m. While for MPAC systems, the far-field requirements do not have to apply, it was shown that the spatial correlation can be impacted significantly for distances below 1.2m.

The minimum test zone size for the NR MIMO OTA test method with dynamic link adaptation is 30cm. The DUT shall be completely contained within the test zone.

### 6.3.3 Ripple test for quiet zone

For an azimuthal boundary array, the standard phi-axis ripple test described in Clause D.1 of [4] shall be used with a cylindrical quiet zone 300 mm in diameter around the phi axis and 300 mm tall.

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# 7 Channel models

## 7.1 Dynamic channel model definition

Dynamic, i.e., non-stationary, channel models shall be used for evaluation of the CTMT MIMO TP Metric defined in Clause 5. The modelling principle is described in [5]. A DUT route is defined by a number of way points. Each way point is assigned a different 3GPP CDL model, together with orientations, speed and direction of travel (DoT) of the DUT. Parameter sets for each way point are given in tables of Clause B. For smooth/continuous channel modeling, each parameter, such as DUT speed, orientation, path delays, powers, Ricean K-factor, etc., must be linearly interpolated between two successive way points. Angles and angle spreads are interpolated in degree units, delays in nanoseconds, cluster powers and K-factors in linear units, and path losses and XPRs in decibel units. The LOS direction is an exception, being determined by linearly interpolated DUT and BS coordinates. However, ZoA is always 90.

Parameters are interpolated between way points 𝑎 and 𝑏 as

|  |  |
| --- | --- |
|  | (1) |

where 𝜀(𝑡), 𝜀(𝑎), and 𝜀(𝑏) are the parameter values in the time instant 𝑡, way point 𝑎, and 𝑏, respectively, and 𝑇\_𝑎𝑏 is the total time from way point 𝑎 to 𝑏 in seconds, such that 𝑡=0 at way point 𝑎 and 𝑡=𝑇\_𝑎𝑏 at way point 𝑏.

To avoid discontinuities, the DoT does not follow the route geometry, but instead it is continuously interpolated according to eq. (1) where the DoT varies from the arrival direction of previous way-point to the arrival direction of the next way-point.[[1]](#footnote-2) Hence, the DoT is modelled to continuously change along a straight route segment. The DoT and UE orientation equate, i.e., the UE is oriented according to its interpolated DoT at each time instant.

Direction of the LOS path is quantized to the closest probe direction and the path will be radiated through one probe at a time. The instantaneous probe used for radiating the LOS path (when present) is determined by the interpolated LOS AoA and DoT as

|  |  |
| --- | --- |
|  | (2) |

where is the azimuth angle of the *k*th probe.

Different way point may have different number of clusters. Assume way point has and has clusters. For cluster power interpolation the power of non-existing cluster in way point is set dB and the power ramp is interpolated between and as defined by the equation. In LOS condition the power of LOS ray is determined by the Ricean K-factor. Transitions between LOS and NLOS conditions are handled by defining the power of LOS ray to −100 dB for NLOS way points. These 100 dB power values correspond to the cluster parameters in tables of Annex A, i.e., 100 dB is the power before adding the distance dependent path loss. For other parameter the following rule for void clusters is applied. Parameter denotes the parameter value of cluster at way point . If cluster is void and is not, then , i.e., the value of next way point is copied to the previous. The same applies if is void and is not, then . If both the previous and the next way point are void, then the closest non-void value is selected. Here closest means the closest in way point indices, not closest in time or distance. Notice that these clusters being void in both the previous and next way point have very low gain and will have only minimal contribution to the channel.

Unwanted randomness of channel models is removed by modifications defined in Clause 7.2 of [4]. It is, by specifying fixed 2×2 initial phases for each ray, as defined in Table 7.2-8 of [4] and introducing a uniformly distributed random scalar initial phase per path instead. Moreover, the coupling of ray angles is fixed as specified in Table 7.2-6 of [4]. Finally, after having interpolated propagation parameters, fixed randomness, and base station antenna configuration as defined in Clause 7.2 the fading channel coefficients are generated using the normal procedure defined in [6].

Overview of dynamic scenario geometry, K-factor and speed profile for UMa scenario is presented in Figures 7.1-1 and 7.1-2 and for UMi scenario in Figures 7.1-3 and 7.1-4.



Figure 7.1-1 Base station and the UE route in the UMa case. The base station location is on left and DUT route starts from the rightmost way point and continues counterclockwise back to the starting point. UE is always oriented towards its direction of travel (DoT).



Figure 7.1-2 DUT speed and maximum Doppler frequency (top). LOS AoA as observed in the DUT coordinate system (middle). Narrowband Ricean K-factor (bottom). Way points are shown by vertical dotted lines. Top figure contains the CDL model scenario label A, C, D, E on the time axis. Graphs are for the UMa scenario.



Figure 7.1-3 Base station and the UE route in the UMi case. The base station location is on left and UE route starts from the rightmost way point and continues clockwise back to the starting point. UE is always oriented towards its direction of travel (DoT).



Figure 7.1-4 UE speed and maximum Doppler frequency (top). LOS AoA as observed in the UE coordinate system (middle). Narrowband Ricean K-factor (bottom). Way points are shown by vertical dotted lines. Top figure contains the CDL model scenario label A, C, D, E on the time axis. Graphs are for the UMi scenario.

The cross-polarization power ratio in a propagation channel is defined as:

where

and

*- SVV* is the coefficient for scattered/reflected power on V-polarization and incident power on V-polarization

*- SVH* is the coefficient for scattered/reflected power on V-polarization and incident power on H-polarization

*- SHV* is the coefficient for scattered/reflected power on H-polarization and incident power on V-polarization

*- SHH* is the coefficient for scattered/reflected power on H-polarization and incident power on H-polarization

## 7.2 Emulation of base station beamforming configuration

In geometry-based channel models, the antennas and propagation are specified separately. Hence, the propagation parameters specified in the annex are not dependent on the BS antenna or beam definitions. The single BS antenna element has 65 HPBW with 8 dBi gain and it is as specified in Table 7.3-1 of [6]. Moreover, no specific beamforming is included in the antenna radiation pattern. The beamforming for the PDSCH transmission is realized by the PMI-feedback based MIMO precoding by the BS emulator when the test case is configured with a dynamic link adaptation for rank and MIMO precoding. The antenna array geometry and physical antenna element mapping to logical CSI-RS antenna ports is defined and implemented in channel emulation, such that each logical CSI-RS antenna port is mapped to one channel emulation input port. The number of CSI-RS antenna ports is 4 and the CSI-RSs are non-beamformed. Therefore, only BS element radiation pattern is considered for each channel model input port. Antenna array elements are dual-polarized following polarization model 2 from [6] and the element spacing is 0.5 wavelengths. The array configuration for 4 CSI-RS antenna ports is shown in Figure 7.2-1.



Figure 7.2-1 Base station antenna array configuration.

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#### 8.2.2.3 PL Measurement Results Analysis

The measured channel gains (inverse of path loss) are averaged over time segments and normalized such that the maximum value across all segments is 0 dB. The resulting normalized channel gains are the target values.

Lengths of time segment and time increment between segments in seconds are specified separately for both models. Example values for start and end time of UMa route segments are given in Table 8.2.2.3-1 and of the UMi route segments are given in Table 8.2.2.3-2.

Table 8.2.2.3-1 Start and end times of time segments for UMa route

|  |  |  |
| --- | --- | --- |
| Segment number | Start time [s] | End time [s] |
| 1 | 1 | 5 |
| 2 | 10 | 15 |
| 3 | 21 | 42 |
| 4 | 47 | 52 |
| 5 | 62 | 67 |
| 6 | 82 | 87 |
| 7 | 90 | 95 |
| 8 | 102 | 107 |
| 9 | 115 | 120 |

Table 8.2.2.3-2 Start and end times of time segments for UMi route

|  |  |  |
| --- | --- | --- |
| Segment number | Start time [s] | End time [s] |
| 1 | 1 | 5 |
| 2 | 10 | 20 |
| 3 | 30 | 40 |
| 4 | 44 | 54 |
| 5 | 60 | 70 |
| 6 | 77 | 82 |
| 7 | 90 | 95 |
|  |  |  |
|  |  |  |

#### 8.2.2.4 PL Target Values

 The target values for the UMa route are specified in Table 8.2.2.4-1 and illustrated in Figure 8.2.2.4-1 while the target values for the UMi route are specified in Table 8.2.2.4-2 and illustrated in Figure 8.2.2.4-2.

Table 8.2.2.4-1: Dynamic Path Gain (Path Loss) Target Values for the Measured Normalized Channel Gain for the UMa Route

|  |  |
| --- | --- |
| Segment # | Target [dB] |
| 1 | [-0.8] |
| 2 | [0] |
| 3 | [-29.5] |
| 4 | [-27.6] |
| 5 | [-21.5] |
| 6 | [-30.1] |
| 7 | [-0.1] |
| 8 | [-19.8] |
| 9 | [-0.7] |



Figure 8.2.2.4-1: Dynamic Path Gain (Path Loss) Targets for the Measured Normalized Channel Gain for the UMa Route

Table 8.2.2.4-2: Dynamic Path Gain (Path Loss) Target Values for the Measured Normalized Channel Gain for the UMi Route

|  |  |
| --- | --- |
| Segment # | Target [dB] |
| 1 | [18] |
| 2 | [21.7] |
| 3 | [8.6] |
| 4 | [8.1] |
| 5 | [8.5] |
| 6 | [21.1] |
| 7 | [20.7] |



Figure 8.2.2.4-2: Dynamic Path Gain (Path Loss) Targets for the Measured Normalized Channel Gain for the UMi Route

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#### 8.2.3.6 PDP Target Values

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#### 8.2.4.5 TCF Target Values

The target values for the UMa route are specified in [Table 8.2.4.5-1](#_Hlk176087530) and illustrated in [Figure 8.2.4.5-1](#_Hlk176087417) which uses the time segments defined in [Table 8.2.2.3-1](#_Hlk176085569" \s "1,68642,68657,4094,TABLHEADER BEST,Table 4.2.1.2-1). The target values for the UMi route are specified in [Table 8.2.4.5-2](#_Hlk176087530) and illustrated in [Figure 8.2.4.5-2](#_Hlk176087417) which uses the time segments defined in [Table 8.2.2.3-2](#_Hlk176085569" \s "1,68642,68657,4094,TABLHEADER BEST,Table 4.2.1.2-1). Estimated temporal correlation values at time lag ms and ms are illustrated in the top and bottom figure, respectively. Target values are shown within time segment limits.

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Figure 8.2.4.5-1 Temporal Correlation Function of UMa Route for Two Different TFC Time Lags

Table 8.2.4.5-1 Dynamic Temporal Correlation Targets of the UMa Route

|  |  |  |
| --- | --- | --- |
| Segment # | Target TCF at ms  | Target TCF at ms |
| 1 | [0.970] | [0.876] |
| 2 | [0.961] | [0.879] |
| 3 | [0.994] | [0.886] |
| 4 | [0.440] | [0.378] |
| 5 | [0.643] | [0.351] |
| 6 | [0.521] | [0.093] |
| 7 | [0.798] | [0.221] |
| 8 | [0.864] | [0.205] |
| 9 | [0.940] | [0.616] |



Figure 8.2.4.5-2 Temporal Correlation Function of UMi Route for Two Different TFC Time Lags

Table 8.2.4.5-2 Dynamic Temporal Correlation Targets of the UMi Route

|  |  |  |
| --- | --- | --- |
| Segment # | Target TCF at ms  | Target TCF at ms |
| 1 | [0.871] | [0.437] |
| 2 | [0.952] | [0.857] |
| 3 | [0.514] | [0.195] |
| 4 | [0.698] | [0.071] |
| 5 | [0.743] | [0.372] |
| 6 | [0.959] | [0.814] |
| 7 | [0.965] | [0.854] |

### 8.2.5 Validation of Spatial Correlation

The purpose of this item is to validate the slow variation of angular power distribution as observed by the DUT due of the dynamic channel model. The variation of PAS in the reference channel model is caused by the change of path angles, path powers, and UE orientation along the route. The validation is done indirectly by observing the spatial correlation function (SCF). SCF is evaluated from the measured narrowband signal transmitted through the test system and received by a test antenna in a few spatial positions within the test zone.

#### 8.2.5.1 SCF Method of Measurement

The time domain technique (time sweep) is used for the validation. See the block diagram of the setup in Figure 8.2.1.2-1. A signal generator transmits a CW signal through the test system. The CW signal is split to two input ports of fading emulator that correspond to the two first signal streams of the gNB emulator. The signal is received by a test antenna in a specific position within the test area. Finally, the signal is collected by a signal analyser and the measured signal is stored. Signal analyser and signal generator settings are defined in Tables 4.2.3.1-1 and 4.2.3.1-2. The measurement is triggered to start with the time instant 0 of the channel model and to stop at the last time instant of the channel model. The position of test antenna is changed and the measurement is repeated. All spatial positions are illustrated in Figure 8.2.5.1-1.

Table 8.2.5.1-1 MPAC SCF Signal Generator Settings

| Item | Unit | Value |
| --- | --- | --- |
| Centre frequency | MHz | 2450 |
| Output Power | dBm | Function of the CE. Sufficiently above Noise Floor |

Table 8.2.5.1-2 MPAC SCF Signal Analyzer Settings

| Item | Unit | Value |
| --- | --- | --- |
| Centre frequency | MHz | 2450 |
| Sampling | Hz | At least 15 times bigger than the max Doppler spread (fd=v/λ) |
| Observation time | s | One full duration of the channel model route. |

The full model length is measured at once.



Figure 8.2.5.1-1 Spatial sampling points within the test zone at 2450 MHz.

Table 8.2.5.1-3 Spatial sample points, i.e., positions of test antenna for the SCF validation at 2450 MHz.

| Point number | x [mm] | y [mm] | z [mm] |
| --- | --- | --- | --- |
| #1 (reference point) | 0 | -150 | 0 |
| #2 | -22.9 | -148.3 | 0 |
| #3 | -86.3 | -122.7 | 0 |
| #4 | -149.9 | -5.7 | 0 |

#### 8.2.5.2 SCF Measurement Antenna

The measurement antenna shall be a vertically-oriented dipole

#### 8.2.5.3 SCF Measurement Results Analysis

Time segments of recorded I/Q samples are selected. For each time segment the cross correlation (with zero time lag) of I/Q samples measured in different spatial sample points is calculated. Spatial sample points picked for SFC have at maximum distance 1.7 wavelength to the reference sample point. Absolute values of estimated complex spatial correlations per time segment are chosen as the target SCF values.

#### 8.2.5.4 Target Values

 The target values for the UMa route are specified in [Table](#_Hlk176088316" \s "1,89079,89094,4094,TABLHEADER BEST,Table 4.2.4.2-1) 8.2.5.4-1 and illustrated in [Figure 8.2.5.4-1](#_Hlk176088241" \s "1,88764,88780,4094,FIGBEST,Figure 4.2.4.2-1), which uses the time segments along the dynamic UMa model proposed in [Table 8.2.2.3-1](#_Hlk176085569" \s "1,68642,68657,4094,TABLHEADER BEST,Table 4.2.1.2-1). The target values for the UMi route are specified in [Table](#_Hlk176088316" \s "1,89079,89094,4094,TABLHEADER BEST,Table 4.2.4.2-1) 8.2.5.4-2 and illustrated in [Figure 8.2.5.4-2](#_Hlk176088241" \s "1,88764,88780,4094,FIGBEST,Figure 4.2.4.2-1), which uses the time segments along the dynamic UMi model proposed in [Table 8.2.2.3-2](#_Hlk176085569" \s "1,68642,68657,4094,TABLHEADER BEST,Table 4.2.1.2-1). Estimated spatial correlation values at spatial spacing  mm and  mm are illustrated in the top and bottom figure, respectively. Target values are shown within time segment limits.

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Figure 8.2.5.4-1 Spatial Correlation Function of UMa Route for Three Different SFC Test Antenna Positions

Table 8.2.5.4-1 Dynamic Spatial Correlation Targets of the UMa Route for 2450 MHz

| Segment # | Target SCF at mm  | Target SCF at mm  | Target SCF at mm  |
| --- | --- | --- | --- |
| 1 | [0.986] | [0.908] | [0.932] |
| 2 | [0.964] | [0.620] | [0.355] |
| 3 | [0.800] | [0.171] | [0.113] |
| 4 | [0.699] | [0.729] | [0.481] |
| 5 | [0.829] | [0.414] | [0.153] |
| 6 | [0.793] | [0.390] | [0.450] |
| 7 | [0.927] | [0.464] | [0.324] |
| 8 | [0.792] | [0.213] | [0.527] |
| 9 | [0.959] | [0.578] | [0.238] |



Figure 8.2.5.4-2 Spatial Correlation Function of UMi Route for Three Different SFC Test Antenna Positions

Table 8.2.5.4-2 Dynamic Spatial Correlation Targets of the UMi Route for 2450 MHz

| Segment # | Target SCF at mm  | Target SCF at mm  | Target SCF at mm  |
| --- | --- | --- | --- |
| 1 | [0.944] | [0.758] | [0.733] |
| 2 | [0.981] | [0.937] | [0.939] |
| 3 | [0.787] | [0.228] | [0.153] |
| 4 | [0.764] | [0.328] | [0.314] |
| 5 | [0.856] | [0.572] | [0.286] |
| 6 | [0.973] | [0.809] | [0.685] |
| 7 | [0.982] | [0.950] | [0.943] |

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#### 8.2.6.4 XPO Target Values

The target values for the UMa route are specified in [Table 8.2.6.4-1](#_Hlk176088899" \s "1,93346,93361,4094,TABLHEADER BEST,Table 4.2.5.3-1) and illustrated in [Figure 8.2.6.4-1](#_Hlk176088781" \s "1,93076,93092,4094,FIGBEST,Figure 4.2.5.3-1) which uses the time segments defined in [Table 8.2.2.3-1](#_Hlk176085569" \s "1,68642,68657,4094,TABLHEADER BEST,Table 4.2.1.2-1). The target values for the UMi route are specified in [Table 8.2.6.4-2](#_Hlk176088899" \s "1,93346,93361,4094,TABLHEADER BEST,Table 4.2.5.3-1) and illustrated in [Figure 8.2.6.4-2](#_Hlk176088781" \s "1,93076,93092,4094,FIGBEST,Figure 4.2.5.3-1) which uses the time segments defined in [Table 8.2.2.3-2](#_Hlk176085569" \s "1,68642,68657,4094,TABLHEADER BEST,Table 4.2.1.2-1).



Figure 8.2.6.4-1 Simulated Dynamic Narrowband Polarization Power Ratios with Time Segment Limits for the UMa Route

Table 8.2.6.4-1 Dynamic Polarization Power Ratio Target Values for the Measured Channel Gain with V and H Polarized Test Antenna for the UMa Route

|  |  |
| --- | --- |
| Segment # | Target [dB] |
| 1 | [22.2] |
| 2 | [22.4] |
| 3 | [8.5] |
| 4 | [9.5] |
| 5 | [7.4] |
| 6 | [7.0] |
| 7 | [18.5] |
| 8 | [12.2] |
| 9 | [22.0] |



Figure 8.2.6.4-2 Simulated Dynamic Narrowband Polarization Power Ratios with Time Segment Limits for the UMi Route

Table 8.2.6.4-2 Dynamic Polarization Power Ratio Target Values for the Measured Channel Gain with V and H Polarized Test Antenna for the UMi Route

|  |  |
| --- | --- |
| Segment # | Target [dB] |
| 1 | [18] |
| 2 | [21.7] |
| 3 | [8.6] |
| 4 | [8.1] |
| 5 | [8.5] |
| 6 | [21.1] |
| 7 | [20.7] |

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## 9.3 Dynamic link adaptation for MCS, rank and MIMO precoding

In the 5G NR dynamic scenario, the DUT is moving and hence link adaptation as well as the PDSCH MIMO precoding and beam alignment needs to be considered. The dynamic scheduling for MCS and rank adaptation follows Clauses 6.4.2 and 6.4.3 of [8] for 2RX and 4RX, where the gNB emulator adjusts the MCS and Rank based on the DUT’s reporting (CQI/RI reporting). The PDCCH DCI 1\_1 and PDCCH DCI\_1\_0 transmitted by the gNB contains the link adaptation parameter for the DUT.

The PDSCH MIMO precoding and beam alignment by the gNB is configured by modifying the precoding matrix by the gNB based the PMI reporting from the DUT. Hence, the gNB emulator should adjust the MCS/RI/Precoding matrix based on the CQI/RI/PMI reporting from the DUT. The configuration for CSI configurations given in Table 9.3-1.

Table 9.3-1: CSI configuration

|  |  |  |
| --- | --- | --- |
| Parameter | Unit | Test  |
| TDD Slot Configuration (Note 1) |  | FR1.30-1 |
| SNR | dB | 22 |
| Beamforming Model |  | As defined in Clause B.4.1 in TS 38.101-4 [8] |
| CSI-IM configuration | CSI-IM resource Type |  | Periodic |
| CSI-IM RE pattern |  | Pattern 0 |
| CSI-IM Resource Mapping(kCSI-IM,lCSI-IM) |  | (4,9) |
| CSI-IM timeConfig-periodicity and offset | slot | 10/1 |
| ReportConfigType |  | Periodic |
| CQI-table (Note 3) |  | Table 2 |
| reportQuantity |  | cri-RI-PMI-CQI |
| timeRestrictionForChannelMeasurements |  | not configured |
| timeRestrictionForInterferenceMeasurements |  | not configured |
| cqi-FormatIndicator |  | Wideband |
| pmi-FormatIndicator |  | Wideband |
| Sub-band Size | RB | 16 |
| csi-ReportingBand |  | 1111111 |
| CSI-Report periodicity and offset | slot | 10/9 |
| Codebook configuration | Codebook Type |  | typeI-SinglePanel |
| Codebook Mode |  | 1 |
| (CodebookConfig-N1, CodebookConfig-N2) |  | 2-1 |
| CodebookSubsetRestriction |  | 11111111 |
| RI Restriction |  | 00001111 for follow RI |
| Physical channel for CSI report |  | PUCCH |
| CQI/RI/PMI delay (Note 2) | ms | 9.5  |
| Maximum number of HARQ transmission |  | FFS |
| Note 1: FR1.30-1 is defined in Clause A.1.2 of TS 38.101-4 [8]Note:2: Let CQI/RI/PMI delay corresponds to ‘k’ slots. Then, if the UE reports in an available uplink reporting instance at slot#n based on PMI estimation at a downlink slot not later than slot#[(n-k/2)], this reported PMI cannot be applied at the gNB downlink before slot#[(n+k/2)]. Note 3: CQI table to use for CQI calculation (see clause 5.2.2.1 of [9]) |

The gNB emulator used to execute tests at FR1 frequencies described in this document shall be configured according to the common configuration parameters

**<<< END OF CHANGES >>>**

1. DoT affects Doppler shifts and consequently the temporal correlation of the emulated channel model. DUT orientation in the internal coordinate system of the channel model affects the PAS and consequently the mapping of clusters (multi-paths of the model) onto probes. Continuous and smooth change of them both prevents discontinuities in way-point instances that would cause instantaneous spreading of Doppler spectrum, immediate obsolescence of channel estimates, and possibly artificial bursts of bit errors in the received signal. An example of interpolation: Say DoT is +30° in the location of way-point *a* and -10° in way-point *b*, then even though the route from WP*a* to WP*b* is straight, the DoT and correspondingly the orientation of UE in the model continuously and linearly changes from +30° to -10° along the route between way-points. [↑](#footnote-ref-2)