**3GPP TSG-RAN WG4 Meeting # 94-e *rev-R4-2000659***

**Online, 24 February – 6 March 2020**

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| *CR-Form-v12.0* | | | | | | | | |
| **CHANGE REQUEST** | | | | | | | | |
|  | | | | | | | | |
|  | **38.817-02** | **CR** | **0061** | **rev** | **1** | **Current version:** | **15.6.0** |  |
|  | | | | | | | | |
| *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:*** | CR to TR 38.817-02: Clarifications and corrections on receiver dynamic range and other requirements | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Source to WG:*** | Nokia, Nokia Shanghai Bell, NEC | | | | | | | | | |
| ***Source to TSG:*** | R4 | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Work item code:*** | NR\_newRAT-Core | | | | |  | ***Date:*** | | | 2020-02-14 |
|  |  | | | |  | |  | | |  |
| ***Category:*** | **F** |  | | | | | ***Release:*** | | | Rel-15 |
|  | *Use one of the following categories:* ***F*** *(correction)* ***A*** *(mirror corresponding to a change in an earlier release)* ***B*** *(addition of feature),* ***C*** *(functional modification of feature)* ***D*** *(editorial modification)*  Detailed explanations of the above categories can be found in 3GPP [TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm). | | | | | | | | *Use one of the following releases: Rel-8 (Release 8) Rel-9 (Release 9) Rel-10 (Release 10) Rel-11 (Release 11) Rel-12 (Release 12)* *Rel-13 (Release 13) Rel-14 (Release 14) Rel-15 (Release 15) Rel-16 (Release 16)* | |
|  |  | | | | | | | | | |
| ***Reason for change:*** | | 1) It is not clear in clause 7.3 that SCS in the equations for interference level and wanted signal refer to different values.  2) Works on the MSR and AAS BS specifications updates for NR have been completed in Rel-15, but they are indicated as ‘will start’ in clause 5.1. This may lead to confusion that those works are yet to be completed.  3) MSR core specification title is outdated and several references are missing in clause 2.  4) Typo in clauses 3.3, 5.1 and 5.2, 5.7, 6.5.4.3, 6.7.1, 7.2.2, 7.3, 7.8, 9.1.1, 9.2.1, 9.5.1.3, 9.7.4.2, 10.1, 10.3.2, 10.3.3.2, 10.4.1, 10.5.3.3, 10.6.1.  5) Provisional square brackets remain in clauses 5.6, 5.7, 7.4.2, 9.6.2, 9.7.5.3, 10.3.3.2, 10.3.3.5, 10.7.3. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Summary of change:*** | | 1) Clarify in clause 7.3 that SCS in the equations for interference level and wanted signal refer to different values.  2) Remove the outdated statements in clause 5.1 that indicate the works on the MSR and AAS BS specifications updates for NR are yet to be completed.  3) Update MSR core specification title and add the missing references in clause 2.  4) Correct typo in clauses 3.3, 5.1 and 5.2, 5.7, 6.5.4.3, 6.7.1, 7.2.2, 7.3, 7.8, 9.1.1, 9.2.1, 9.5.1.3, 9.7.4.2, 10.1, 10.3.2, 10.3.3.2, 10.4.1, 10.5.3.3, 10.6.1.  5) Remove provisional square brackets in clause 5.6, 5.7, 7.4.2, 9.6.2, 9.7.5.3, 10.3.3.2, 10.3.3.5, 10.7.3. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Consequences if not approved:*** | | Ambiguities and errors remain, and hence would lead to different interpretations. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Clauses affected:*** | | 2, 3.3, 5.1, 5.2, 5.6, 5.7, 6.5.4.3, 6.7.1, 7.2.2, 7.3, 7.4.2, 7.8, 9.1.1, 9.2.1, 9.5.1.3, 9.6.2, 9.7.4.2, 9.7.5.3, 10.1, 10.3.2, 10.3.3.2, 10.3.3.5, 10.4.1, 10.5.3.3, 10.6.1, 10.7.3 | | | | | | | | |
|  | |  | | | | | | | | |
|  | | **Y** | **N** |  | | | |  | | |
| ***Other specs*** | |  | **X** | Other core specifications | | | | TS/TR ... CR ... | | |
| ***affected:*** | |  | **X** | Test specifications | | | | TS/TR ... CR ... | | |
| ***(show related CRs)*** | |  | **X** | O&M Specifications | | | | TS/TR ... CR ... | | |
|  | |  | | | | | | | | |
| ***Other comments:*** | |  | | | | | | | | |
|  | |  | | | | | | | | |
| ***This CR's revision history:*** | |  | | | | | | | | |

**<Start of change>**

# 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] Recommendation ITU-R M.1036-5 (10/2015), "Frequency arrangements for implementation of the terrestrial component of International Mobile Telecommunications (IMT) in the bands identified for IMT in the Radio Regulations (RR)".

[3] 3GPP TS 38.104: "NR; Base Station (BS) radio transmission and reception".

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

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

[6] 3GPP TS 36.104: "Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) radio transmission and reception".

[7] 3GPP TS 37.105: "Active Antenna System (AAS) Base Station (BS) transmission and reception".

[8] 3GPP TR 37.842: "Evolved Universal Terrestrial Radio Access (E-UTRA) and Universal Terrestrial Radio Access (UTRA; Radio Frequency (RF) requirement background for Active Antenna System (AAS) Base Station (BS)".

[9] 3GPP TR 37.843: "Radio Frequency (RF) requirement background for Active Antenna System (AAS) Base Station (BS) radiated requirements".

[10] R4-1700305, "LS on Characteristics of terrestrial IMT systems for frequency sharing/interference analysis in the frequency range between 24.25 GHz and 86 GHz".

[11] Code of Federal Regulations, Title 47, Part 30.203, Upper Microwave Flexible Use Service; Emission limits, Federal Communications Commission.

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

[13] Void.

[14] ETSI EN 301 489: "Electromagnetic compatibility and Radio spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services".

[15] 3GPP TS 38.113: "NR; Base Station (BS) and repeater ElectroMagnetic Compatibility (EMC)".

[16] 3GPP TS 37.114: "Active Antenna System (AAS) Base Station (BS) Electromagnetic Compatibility (EMC)".

[17] 3GPP TS 38.141-1: "NR; Base Station (BS) conformance testing; Part 1: Conducted conformance testing".

[18] 3GPP TS 38.141-2: "NR; Base Station (BS) conformance testing; Part 2: Radiated conformance testing".

[19] 3GPP TS 37.104: " NR, E-UTRA, UTRA and GSM/EDGE; Multi-Standard Radio (MSR) Base Station (BS) radio transmission and reception".

[20] 3GPP TS 38.817-01: "General aspects for User Equipment (UE) Radio Frequency (RF) for NR".

[21] 3GPP TR 36.815: "Further Advancements for E-UTRA; LTE-Advanced feasibility studies in RAN WG4".

[22] 3GPP TS 36.133: "Evolved Universal Terrestrial Radio Access (E-UTRA); Requirements for support of radio resource management".

[23] 3GPP TS 37.113: "Multi-Standard Radio (MSR) Base Station (BS) Electromagnetic Compatibility (EMC)".

[24] 3GPP TR 38.803: "Study on new radio access technology: Radio Frequency (RF) and co-existence aspects".

[25] 3GPP TS 38.211: "NR; Physical channels and modulation".

[26] 3GPP TR 37.843: "Radio Frequency (RF) requirement background for Active Antenna System (AAS) Base Station (BS) radiated requirements". v15.2.0

[27] 3GPP TS 36.141: "Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) conformance testing".

[28] IEC 61000-4-3: 2006+AMD1:2007+AMD2:2010: “Electromagnetic compatibility (EMC) - Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test”

[29] ITU-T Recommendation K.114: “Electromagnetic compatibility requirements and measurement methods for digital cellular mobile communication base station equipment”

[30] ITU-T Recommendation K.48: “EMC requirements for telecommunication equipment - Product family Recommendation”

[31] 3GPP TS 38.133: "NR; Requirements for support of radio resource management".

[32] 3GPP TS 37.141: "NR, E-UTRA, UTRA and GSM/EDGE; Multi-Standard Radio (MSR) Base Station (BS) conformance testing".

[33] 3GPP TS 37.145-1: "Active Antenna System (AAS) Base Station (BS) conformance testing; Part 1: Conducted conformance testing".

[34] 3GPP TS 37.145-2: "Active Antenna System (AAS) Base Station (BS) conformance testing; Part 2: radiated conformance testing".

**<Next change>**

## 3.3 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

AA Antenna Array

AAS BS Active Antenna System Base Station

ACLR Adjacent Channel Leakage Ratio

ACS Adjacent Channel Selectivity

AoA Angle of Arrival

AWGN Additive White Gaussian Noise

BLER Block Error Rate

BS Band Category

BW Bandwidth

CA Carrier Aggregation

CACLR Cumulative ACLR

CATR Compact Antenna Test Range

CC Component Carrier

CRS Common Reference Signals

DMRS Demodulation Reference Signal

DUT Device Under Test

EIRP Equivalent Isotropic Radiated Power

EIS Equivalent Isotropic Sensitivity

EMC Electromagnetic compatibility

EMC RE EMC Radiated Emissions

EUT Equipment Under Test

EVM Error Vector Magnitude

FFT Fast Fourier Transform

FR Frequency Range

FRC Fixed Reference Channel

FSPL Free Space Path-Loss

IM Intermodulation

IMD Intermodulation

IM Implementation Margin

ISD Inter-Site Distance

ITU International Telecommunications Union

LA Local Area

MCL Minimum Coupling Loss

MR Medium Range

MRTD Maximum Receive Timing Difference

NF Noise Figure

OBUE Operating Band Unwanted Emissions

OSDD OTA Sensitivity Direction Declaration

RAT Radio Access Technology

REFSENS Reference Sensitivity

RDN Radio Distribution Network

RE Resource Element

RF RSE RF Radiated Spurious Emissions

RIB Radiated interface boundary

RoAoA Range of Angles of Arrival

RXU Receiver Unit

SCS SubCarrier Spacing

SEM Spectrum Emission Mask

SNR Signal-to-Noise Ratio

SS Synchronization Signal

TAB Transceiver Array Boundary

TAE Time Alignment Error

TRP Total Radiated Power

TRXU Transceiver Unit

TRXUA Transceiver Unit Array

TXU Transmitter Unit

UEM Unwanted Emissions Mask

WA Wide Area

**<Next change>**

## 5.1 Relationship with other core specifications

The following relations among the single RAT NR BS core specification and the MSR BS, AAS BS and EMC specifications are identified:

**RAT NR BS:** 3GPP TS 38.104 [3] is a Single RAT NR BS specification. It is expected to capture BS requirements for the following aspects:

- Tx, Rx and BS demodulation core requirements for NR BS,

- Conducted and radiated sets of core requirements for the above listed categories (i.e. Tx, Rx and BS demodulation),

- Requirements for NSA NR and SA NR deployments (with the consideration of the NSA/SA prioritization in Rel-15),

- Requirements for FR1 and FR2 frequency ranges, based on the classification defined in 3GPP TR 38.803 [24]:

- FR1: Both conducted and OTA requirements will be required for FR1. The applicability may depend on the requirements.

- Requirement set 1-C: Conducted requirements for FR1 Non-AAS BS (which doesn’t include antenna functionality).

- Requirement set 1-H: Conducted requirements and OTA requirements for FR1 hybrid AAS BS (which includes antenna functionality).

- Requirement set 1-O: OTA requirements for FR1 OTA AAS BS (which includes antenna functionality).

- FR2: Only OTA requirements will be required for FR2.

- Requirement set 2-O: OTA requirements for FR2 OTA AAS BS.

**MSR BS:** The MSR BS specification in 3GPP TS 37.104 [19] will be updated in Rel-15 for capability sets of Single RAT NR BS and LTE+NR MSR BS.

- It shall be noted that the MSR BS specification is considered as non-AAS specification, defining conducted requirements.

**AAS BS:** The AAS BS specification in 3GPP TS 37.105 [7] will be updated in Rel-15 for capability sets of Single RAT NR BS and LTE+NR MSR BS. In Rel-15, the AAS BS specification is expected to be extended with the full set of OTA requirements.

**EMC:** New EMC specification for the NR BS will be defined in 3GPP TS 38.113 [15].

- The NR BS EMC specification will reuse the eAAS WI work on the EMC requirements for the OTA AAS BS, i.e. EMC testing of DUT’s with radiating antenna elements.

- It shall be noted, that each of the EMC specifications for Single RAT refers to the MSR EMC specification in 3GPP TS 37.113 [23] for the additional optional applicability of the MSR EMC requirements.

- NR BS EMC specification shall also consider additional optional conformance requirements in the extended Rel‑15 version of the MSR EMC specification in 3GPP TS 37.113 [23].

Furthermore, relations among conformance BS specifications are identified as follows:

**Single RAT NR BS:** New conformance specifications in 3GPP TS 38.141-1 [17] and in 3GPP TS 38.141-2 [18] for the NR BS conformance for conducted and radiated testing will be defined, respectively,

**MSR BS:** 3GPP TS 37.141 [32] MSR BS conformance testing specification will be updated with the NR RAT.

**AAS BS:** AAS BS conformance testing specifications in 3GPP TS 37.145-1 [33] and 3GPP TS 37.145-2 [34] will be updated based on the AAS BS core specification modifications.

## 5.2 Relationship between minimum requirements and test requirements

While 3GPP TS 38.104 [3] describes conducted and OTA core requirements, the conformance to the requirements is demonstrated by fulfilling the test requirements specified in the conformance specification 3GPP TS 38.141-1 [17] for conducted testing and 3GPP TS 38.141-2 [18] for radiated testing. An allowance for measurement uncertainty through application of test tolerances is used to create the conformance test requirements using the shared risk principle.

This is explained through clause 4.2 in 3GPP TS 38.104 [3], in a way aligned with the specifications for E-UTRA in 3GPP TS 36.104 [6] and for AAS BS in 3GPP TS 37.105 [7]. The shared risk principle is defined in recommendation ITU‑R M.1545 [12].

For selected requirements, conducted FR1 requirements and FR1 OTA requirements are derived from the same limit, leading to the same core requirement values in 3GPP TS 38.104 [3]. Test tolerances associated with conducted and OTA testing may differ. In practice, this means that the test requirement value for a conducted requirement and an analogous OTA requirement may differ, even if both requirements have been derived from the same limit.

**<Next change>**

## 5.6 Applicability of requirements

The mapping between requirement set and individual requirement is captured in Table 5.6-1.

Table 5.6-1: Requirement set applicability

| Requirement | Requirement set | | | | Spatial applicability  of the requirements |
| --- | --- | --- | --- | --- | --- |
| 1-C | 1-H | 1-O | 2-O |
| Base station output power | 6.2 | 6.2 | NA | NA | Conducted requirement |
| Output power dynamics | 6.3 | 6.3 | NA | NA |
| Transmit ON/OFF power | 6.4 | 6.4 | NA | NA |
| Transmitted signal quality | 6.5 | 6.5 | NA | NA |
| Occupied bandwidth | 6.6.2 | 6.6.2 | NA | NA |
| ACLR | 6.6.3 | 6.6.3 | NA | NA |
| Operating band unwanted  Emissions | 6.6.4.x | 6.6.4.x | NA | NA |
| Transmitter spurious emissions | 6.6.5.x | 6.6.5.x | NA | NA |
| Transmitter intermodulation | 6.7.2 | 6.7.2 and 6.7.3 | NA | NA |
| Reference sensitivity level | 7.2 | 7.2 | NA | NA |
| Dynamic range | 7.3 | 7.3 | NA | NA |
| In-band selectivity and blocking | 7.4 | 7.4 | NA | NA |
| Out-of-band blocking | 7.5 | 7.5 | NA | NA |
| Receiver spurious emissions | 7.6 | 7.6 | NA | NA |
| Receiver intermodulation | 7.7 | 7.7 | NA | NA |
| In-channel selectivity | 7.8 | 7.8 | NA | NA |
| Performance requirements | Note | Note | NA | NA |
| Radiated transmit power | NA | 9.2 | 9.2 | 9.2 | Radiated directional requirement |
| OTA Base station output power | NA | NA | 9.3 | 9.3 | Radiated TRP requirement |
| OTA Output power dynamics | NA | NA | 9.4 | 9.4 | Radiated directional requirement |
| OTA Transmit ON/OFF power | NA | NA | 9.5 | 9.5 | Co-location requirement for 1-O  Radiated TRP requirement for 2-O |
| OTA Transmitted signal quality | NA | NA | 9.6 | 9.6 | Radiated directional requirement |
| OTA Occupied bandwidth | NA | NA | 9.7.2 | 9.7.2 | Radiated directional requirement |
| OTA ACLR | NA | NA | 9.7.3 | 9.7.3 | Radiated TRP requirement |
| OTA Operating band unwanted emission | NA | NA | 9.7.4 | 9.7.4 | Radiated TRP requirement |
| OTA Transmitter spurious emission | NA | NA | 9.7.5 | 9.7.5 | Radiated TRP requirement except for co-location requirements applicable for 1-O |
| OTA Transmitter intermodulation | NA | NA | 9.8 | NA | Co-location requirement |
| OTA sensitivity | NA | 10.2 | 10.2 | NA | Radiated directional requirement |
| OTA Reference sensitivity level | NA | NA | 10.3 | 10.3 | Radiated directional requirement |
| OTA Dynamic range | NA | NA | 10.4 | NA | Radiated directional requirement |
| OTA In-band selectivity and blocking | NA | NA | 10.5 | 10.5 | Radiated directional requirement |
| OTA Out-of-band blocking | NA | NA | 10.6 | 10.6 | Radiated directional requirement except for co-location requirements applicable for 1-O |
| OTA Receiver spurious emission | NA | NA | 10.7 | 10.7 | Radiated TRP requirement |
| OTA Receiver intermodulation | NA | NA | 10.8 | 10.8 | Radiated directional requirement |
| OTA In-channel selectivity | NA | NA | 10.9 | 10.9 | Radiated directional requirement |
| Radiated Performance requirements | NA | NA | Note | Note | Radiated directional requirement |
| NOTE: Performance requirements / radiated performance requirements were developed based on performance requirements for eAAS BS in TR 37.843 [9]. | | | | | |

## 5.7 Requirements for contiguous and non-contiguous spectrum

Requirements for contiguous and non-contiguous spectrum are well defined in existing single-RAT and MSR specifications. Both contiguous and non-contiguous operation has been requested in various NR-LTE CA/DC combinations and is considered to be completed within Rel-15 timeframe.

The text to Technical Specification for requirements for contiguous and non-contiguous spectrum Clause is as follows:

A spectrum allocation where an BS operates can either be contiguous or non-contiguous. Unless otherwise stated, the requirements in the present specification apply for BS configured for both contiguous spectrum operation and non-contiguous spectrum operation.

For BS operation in non-contiguous spectrum, some requirements apply both at the Base Station RF Bandwidth edges and inside the sub-block gaps. For each such requirement, it is stated how the limits apply relative to the Base Station RF Bandwidth edges and the sub-block edges respectively.

**<Next change>**

#### 6.5.4.3 RSTP and OSTP

The RS TX power (RSTP) is mainly used for testing the DL RS power accuracy requirement as specified for UTRA and E-UTRA system, however for NR specification, DL RS power accuracy requirement is not specified.

The OFDM symbol TX power (OSTP) is required for testing total power dynamic range. In the TS 36.141 [27] specification, the RETP and OSTP is defined as following with considerations on the supported SCS.

where is the subcarrier spacing in Hz.

In the TS 36.141 [27] specification, from RETP the OFDM Symbol TX power (OSTP) is derived as follows:



For NR system, the 4th symbol is used to explicitly indicate which OFDM symbols should be used for single RB power measurement and whole RB power measurement.

From RETP the OFDM Symbol TX power (OSTP) is derived as follows:

Where the summation accumulates RETP values of the 4th OFDM symbol. The 4th (out of 14 OFDM symbols within a slot in case of normal CP length) contains exclusively PDSCH.

**<Next change>**

### 6.7.1 General

Traditionally the transmitter intermodulation requirement was created to guarantee emission levels in a co-location scenario. The requirement is based on robustness against injection of a reverse interference signal from a co-located BS. In addition, for NR AAS BS reverse interference signals can be caused also by intra-system coupling.

Therefore, two types of transmitter intermodulation scenarios have been identified for NR BS:

1) Co-location transmitter intermodulation in which the interfering signal is from a co-located BS, and this is analogous to the existing transmitter intermodulation requirement in 3GPP TS 36.104 [6]. This scenario is applicable for requirement set 1-C and 1-H.

2) Intra-system transmitter intermodulation in which the interfering signal is determined by the sum of the co-channel leakage power coupled via the combined RDN and antenna array within the NR AAS BS. This scenario is applicable for requirement set 1-H.

For NR AAS BS following requirement set 1-H both scenarios are captured by the transmitter intermodulation requirement, where a reverse interference signal is feed to *TAB connector*, while maintaining emission levels.

The co-location transmitter intermodulation test is considered sufficient if it represents the greatest interference power at the tested antenna connector or *TAB connector*. Intra-system AAS transmitter intermodulation is only be tested where the maximum leakage power at the *transceiver unit* connector exceeds the interference signal power level at the *TAB connector* determined for co-location transmitter intermodulation.



Figure 6.7.1-1: Set-up for testing transmitter intermodulation on one TAB connector

**<Next change>**

### 7.2.2 FRCs

To specify Reference Sensitivity requirement, following agreements have been reached:

- Limit the number of FRCs to the strict minimum.

- It shall be possible to specify one requirement per *BS channel bandwidth* and per sub-carrier spacing.

- Due to the new spectrum allocation, for some *BS channel bandwidth*, it would not be possible anymore to cover all PRBs by juxtaposing FRC occurrences, some overlapping might be needed.

Following FRCs have been selected so for FR1 REFSENS:

Table 7.2.2-1: Fixed reference channel for FR1 REFSENS.

|  |  |  |  |
| --- | --- | --- | --- |
|  | BS Channel BW | Subcarrier spacing | Number of PRBS |
| G-FR1-A1-1 | 5 MHz | 15 kHz | 25 |
| G-FR1-A1-2 | 5 MHz | 30 kHz | 11 |
| G-FR1-A1-3 | 10 MHz | 60 kHz | 11 |
| G-FR1-A1-4 | 20 MHz | 15 kHz | 106 |
| G-FR1-A1-5 | 20 MHz | 30 kHz | 51 |
| G-FR1-A1-6 | 20 MHz | 60 kHz | 24 |

Following DMRS pattern (front loaded) was also selected. DMRS symbols are boosted by 3dB.



No PTRS was considered for FR1and FR2MCS index 4 was selected with target code rate equal to 308/1024 for Reference Sensitivity and In Channel Selectivity FRCs. Complete list of simulations assumptions could be found in Annex B.

## 7.3 Dynamic range

Dynamic range is specified as a measure of the capability of the receiver to receive a wanted signal in the presence of an interfering signal inside the received *BS channel bandwidth*. In this condition a throughput requirement shall be met for a specified reference measurement channel.

**FRC**

NR supports multiple numerologies as well as increased number of *BS channel bandwidth*s, e.g. up to 100MHz for frequency range 1. To better balance the spec complexity and test permutation, it was agreed to define the following FRCs for dynamic range requirement. The SNR @95% maximum throughput point for each FRC will be used for the wanted signal calculation.

Table 7.3-1: Fixed reference channel and SNR points for dynamic range

|  |  |  |
| --- | --- | --- |
| FRC | *BS channel bandwidth* (MHz) | Subcarrier spacing (kHz) |
| G-FR1-A2-1 | 5 | 15 |
| G-FR1-A2-2 | 5 | 30 |
| G-FR1-A2-3 | 10 | 60 |
| G-FR1-A2-4 | 20 | 15 |
| G-FR1-A2-5 | 20 | 30 |
| G-FR1-A2-6 | 20 | 60 |

**Interference level**

Receiver dynamic range requirement is to ensure that the base station can receive high throughput also in the presence of increased interference levels. It measures the effects of base station receiver impairments. While measuring these effects, uncertainty due to the receiver’s own thermal noise floor should be minimized. So the interference level should be increased by a certain amount of margin to mask the receiver’s own noise floor. From a scenario of view, it is reasonable to adopt the similar amount of interference signal margin for NR as for E-UTRA. The mean power of interfering signal is defined in the following method:

PIntf = -174dBm/Hz+10\*log10(NRB\*SCS\*12) + NF + 20

Where:

- NRB is the transmission bandwidth configuration NRB of the lowest SCS defined in TS 38.104 [3]for each *BS channel bandwidth*;

- SCS is the lowest sub-carrier spacing defined in TS 38.104 [3] for each *BS channel bandwidth*;

- NF is noise figure of NR BS receiver in dB, where 5dB is assumed for WA, 10dB for MR ,13dB for LA;

**Wanted signal**

The mean power of the wanted signal is defined in the following method:

Pwanted = -174dBm/Hz+10\*log10(NRB\*SCS\*12) + NF + 20+SNR+IM

Where

- NF is noise figure of NR BS receiver in dB, where 5dB is assumed for WA, 10dB for MR ,13dB for LA;

- IM is implementation margin reserved for BS manufacturer in dB; for high MCS level, IM is assumed to be 2.5dB;

- NRB depends on the FRCs defined for dynamic range requirement;

- SCS is the sub-carrier spacing of the wanted signal;

- SNR is the value to satisfy the 95% throughput of measurement channel;

**<Next change>**

### 7.4.2 In-band Blocking

The following have been agreed for conducted in-band blocking requirement in FR1:

- To specify the below 6GHz NR BS receiver in-band blocking conducted requirement for each NR BS class with an interfering signal power equal to that for the corresponding E-UTRA BS class, and the wanted signal level calculated as the BS reference sensitivity plus 6dB.

- The SNR for the BS reference sensitivity can be obtained at 95% relative throughput from link level simulations.

- The interfering signal should be defined as the same type as the interfering signal for the ACS requirement, with carrier frequency offset of two times the *BS channel bandwidth* of the interfering signal plus additional frequency offset like E-UTRA to avoid orthogonality between sub-carriers of wanted and interfering signal.

- Consider extension on the lower and upper boundaries for the in-band blocking requirements.

- Once the alignment of the boundary for both NR and E-UTRA is agreed for the transmitter the same solution is used for the receiver boundary.

For the narrowband blocking requirement, the requirement should be specified with an offset calculated for the exact position of the interfering signal such that the sub-carrier grid of the interferer is ½ of the sub-carrier spacing offset from the sub-carrier grid of the wanted signal. Furthermore, the SCS of the interferer and the wanted signal could be set the same, such that the offset is achieved for all sub-carriers of the interferer and wanted signal. However, since only the first few sub-carriers tend to impact blocking performance it is preferable to apply 15 kHz sub-carrier spacing for the interferer regardless of the wanted signal sub-carrier spacing, since the 15 kHz sub-carrier spacing has the highest spectrum utilization. Testing with the minimum distance from the active PRBs of the interferer and the wanted signal bandwidth edge is seen as more important than aligning the sub-carrier spacings. The required increment in frequency offset can be calculated using same method as the ACS requirement. Moreover, the frequency offset between the wanted signal and the interfering signal is further increased by 7.5 kHz (½ sub-carrier) considering the centre of the interfering RB refers to the frequency location between the two central sub-carriers.

For the general blocking requirement, since the requirement relates to the receiver processing a large general power level, it is not important to consider the SCS for the wanted signal or the offset. The SCS was assumed to be 15khz.

The wanted signal SCS should be the lowest SCS supported by the BS for the *BS channel bandwidth* in question.

Based on above agreements, the general blocking requirements is specified in Table 7.4.2.2-1 of 3GPP TS 38.104 [3] and the narrowband blocking requirement in Table 7.4.2.2-2 and Table 7.4.2.2-3 of 3GPP TS 38.104 [3].

**<Next change>**

## 7.8 In-channel selectivity

In-channel selectivity (ICS) is a measure of the receiver ability to receive a wanted signal at its assigned resource block locations in the presence of another in-channel wanted signal received at a much larger power spectral density.

Similar as for E-UTRA BS, the UL signal is defined for 2 users, one being the “wanted” signal and the other one being the “interfering” signal at elevated power. The wanted signal and interfering signal power level are calculated in the following way:

Interfering signal power level = -174dBm/Hz+10\*log10(BW)+NF+ICS;

Where:

- BW is interfering signal bandwidth in Hz, e.g. 10PRB for 5MHz SCS:15 kHz;

- NF is agreed as 5dB for WA, 10db for MR, 13dB for LA BS;

- ICS is agreed as 25dBc for all BS type which is the same as legacy E-UTRA ICS;

It should be noted that DFT-s-OFDM has been adopted as the interfering signal of ICS requirement, the PRB number of interfering signal should comply with basic DFT process principle specified in TS 38.211 [25].

Wanted signal power level for ICS requirement for BS type 1-C and 1-H could be calculated as following:

Wanted signal power level = -174 dBm/Hz+10\*log10(BW)+NF+SNR+IM+3;

Where:

- BW is wanted signal bandwidth in Hz, e.g. 15PRB for 5MHz SCS:15 kHz;

- NF is agreed as 5dB for WA, 10dB for MR, 13dB for LA BS;

- SNR is dependent on the link level simulation results;

- IM is implementation margin which is assumed as 2dB;

- 3dB is reference sensitivity degradation which is reused from legacy E-UTRA requirement;

Regarding the interferer level, the modulation scheme for interfering signal is assumed as 16QAM and modulation scheme for wanted signal is assumed as QPSK.

**<Next change>**

### 9.1.1 Spatial definitions

FR1 NR BS will use the same spatial definitions as AAS BS, these are further described in 3GPP TR 37.842 [8] and 3GPP TR 37.843 [9].

FR2 NR BS spatial definitions will use common spatial definitions as FR1, with few exceptions described in table 9.1.1-1.

OTA transmitter requirements can be split into either:

1. Directional requirements:

- The manufacturer to declare beam(s) and coverage ranges over which the beam can be steered.

- Directional requirement type does not imply the requirement is only in one direction as many requirements have a number of compliance directions. It implies the requirement applies to a single direction at a time.

2. TRP requirements:

- TRP can be calculated as:



where EIRP is the total EIRP of two orthogonal polarizations.

3. Co-location requirements:

- Co-location requirements are requirements which are based on assuming the *BS type 1-O* is co-located with another BS of the same base station class, they ensure that both co-located systems can operate with minimal degradation to each other.

In table 9.1.1-1 classification of the radiated Tx requirements is provided with brief justification.

Table 9.1.1-1: Classification of radiated Tx requirements

|  |  |  |
| --- | --- | --- |
| Tx requirement | Description | Classification |
| Radiated transmit power | The minimum requirements for radiated transmit power, are placed on one or more manufacturer declared beams over a declared OTA peak direction set. OTA requirements for NR BS output power are defined for directional EIRP requirements as radiated transmit power requirements.  This requirement is based on the Rel-13 AAS BS requirement for the EIRP accuracy. | Directional |
| OTA BS output power | TRP metric is used for NR BS output power limit requirement. | TRP |
| OTA output power dynamics | OTA output power dynamics consists of the Total power dynamic range, as well as the RE power control dynamic range requirements.  For E-UTRA specification, the RE power control dynamic range requirement has no specific test and it is tested together with the EVM. Furthermore, verification of the output power dynamics is not impacted by the spatial aspects around the DUT. Therefore, the OTA output power dynamics requirements are considered as directional requirements. | Directional |
| OTA transmit ON/OFF power | For AAS BS, the OTA Transmit OFF power was agreed to be a co-location requirement, defined at the co-location reference antenna conductive output side, subject to scaling.  For NR BS, the same approach is reused. | Co-location for BS type 1-O and  TRP for BS type 2-O |
| OTA transient period | Same as OTA transmit OFF power, for AAS BS, the OTA transient period was agreed to be a co-location requirement defined at the co-location reference antenna conductive output side, subject to scaling.  For NR BS, the same approach is reused. | Co-location |
| OTA transmitted signal quality | EVM: The range of directions where the EVM requirement must be met is declared by the manufacturer as OTA coverage range, while the requirement itself is considered directional.  Frequency error: The frequency error is coherent and will have a ‘flat’ response in the spatial domain, i.e. OTA frequency error will not depend on the selection of the measurement point within beam’s compliance directions set. Therefore, single directional requirement can be applied.  TAE: In terms of testing effort it is beneficial, to coordinate testing of OTA TAE with testing of other transmitter parameters such as OTA frequency error and radiated transmit power. | Directional |
| OTA occupied bandwidth | For occupied bandwidth, the beam characteristics are not important. The requirement should however cover the fact that all transmitter is active and the system is operating at the maximum declared rated total radiated power. Occupied bandwidth is specified as a directional requirement valid over the OTA coverage range. | Directional |
| OTA ACLR | ACLR requirement is the ratio of two TRP measures: the total radiated filtered mean power centred on the assigned channel frequency to the total radiated filtered mean power centred on an adjacent channel frequency. | TRP |
| OTA operating band unwanted emission | The OBUE unwanted emissions requirement in the OTA domain must capture all emissions around the DUT by application of the TRP metric. | TRP |
| OTA transmitter spurious emission | Similar to other Unwanted emissions requirements, the metric used to capture transmitter spurious emissions OTA is TRP. | TRP except for co-location requirements applicable for BS type 1-O |
| OTA transmitter intermodulation | OTA transmitter intermodulation requirement relies on Unwanted emission requirements (i.e. operating band unwanted emission, transmitter spurious emission, and ACLR; all defined as TRP) in the presence of a wanted signal and an interfering signal.  No requirement for BS type 2-O is defined. | Co-location |

Directional requirements are to be met over one of two defined directions sets, with each direction set being declared:

- the *OTA coverage range*: range of directions over which *directional requirements* associated with BS-UE communication are intended such as modulation quality, TAE and frequency error. It can be regarded as the range of directions which define the cell coverage. There is only one *OTA coverage range* per BS.

- the *OTA peak directions set*: intended for *directional requirements* which are intended for the centre of the beam for example EIRP accuracy. The *OTA peak directions set* must always be within the *OTA coverage range*. There may be more than one *OTA peak directions set* declared, the declarations cover the range of directions which a beam may be steered. As the BS may generate more than one type of beam with different beam widths and different steering capabilities the declaration allows for multiple *OTA peak direction sets* to be declared. The minimum set of declarations covers the beams with the narrowest and the widest beam widths.

**<Next change>**

### 9.2.1 General

The minimum requirements for radiated transmit power, are placed on one or more manufacturer declared beam(s) over a declared *OTA peak direction set*. OTA requirements for NR BS output power are defined for directional EIRP requirements as radiated transmit power requirements (sub-clauses 9.2.2 and 9.2.3) and for TRP requirements as OTA base station output power (sub-clauses 9.3.2 and 9.3.3).

Some NR bands have a significantly larger fractional band width than existing bands as shown in Table 9.2.1-1.

Table 9.2.1-1: NR bands

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Band | *Band Definition*  *fl* to *fh*  (MHz) | Absolute Bandwidth  *fh* – *fl*  (MHz) | Relative Bandwidth  *fh*/*fl*  (dB) | Fractional Bandwidth  100.(*fh*-*fl*)/*fc*  (%) |
| n41 | 2496 to 2690 | 194 | 0.3 | 7.5 |
| n77 | 3300 to 4200 | 900 | 1.0 | 24.0 |
| n78 | 3300 to 3800 | 500 | 0.6 | 14.1 |
| n79 | 4400 to 5000 | 600 | 0.6 | 12.8 |
| n257 | 26500 to 29500 | 3000 | 0.5 | 10.7 |
| n258 | 24250 to 27500 | 3250 | 0.5 | 12.6 |
| n260 | 37000 to 40000 | 2500 | 0.3 | 6.5 |
| n261 | 27500 to 28350 | 850 | 0.13 | 3.0 |

The fractional bandwidth FBW is given in percent as:



The radiated transmit power in a specific direction in terms of EIRP can be expressed as: EIRP = TRP + *D* in dBm, where TRP is the total radiated power in dBm and *D* is the directivity in dBi. For an array antenna the composite directivity is determined by the element directivity and the array factor directivity. From TR 38.803 [24] Annex C, the element directivity can be expressed as:



where *Aeff* is the antenna aperture in m2 and  is the wave length in m.

For a uniform rectangular array antenna, where elements as separated *d* m along both y-axis and the z-axis, the maximum area for the antenna aperture is limited to an area of (*d*)2 m2. Typically, the d is in the range of 0.5 to 0.7 and ** is derived from the highest supported frequency. Since the directivity is depending on frequency, it is interesting to analyze the directivity characteristics as function of very wide operation bands.

In Table 9.2.1-2, some wide NR bands have been analyzed with respect to directivity variations (**due to fixed antenna aperture.

Table 9.2.1-2: Directivity variation over supported frequency range

|  |  |
| --- | --- |
| Band | **  (dB) |
| n41 | -0.6 |
| n77 | -2.1 |
| n78 | -1.2 |
| n79 | -1.1 |
| n257 | -0.9 |
| n258 | -1.1 |
| n260 | -0.7 |

It’s clear that the directivity is lower at lowest supported frequency compared with the highest supported frequency as expected. For a NR base station supporting wide bands the directivity variation is managed by declaring EIRP at lowest supported frequency and highest supported frequency within a specific band.

**<Next change>**

#### 9.5.1.3 OTA Transmitter OFF power for NR BS Type 2-O

For BS Type 1-O three cases are analyzed:

- Own receiver – this is possible but, it is unlikely a TDD system will have separate Tx and Rx antennas so will be identified by the RX sensitivity requirement even for a conducted system.

- Co-located receivers – the requirement is measured for the Tx channel – however the same noise can be expected across the whole operational band. Other co-located receivers using other channels in the band are hence protected.

- Same geographical area receivers – most co-location requirements in the same geographical area assume a reasonable separation between BS’s, hence the isolation is assumed to be greater.

In the case of inter-site interference, the TDD system must be dimensioned with a Guard Period which corresponds to the cell size and its corresponding propagation delay. If we assume that the cell size corresponds to an ISD of d as illustrated in Figure 9.5.1.3-1, we can then calculate the OFF power interference at the neighboring site that can be tolerated as follows.

d

Figure 9.5.1.3-1: The inter site interference propagation case

Assume the Total Radiated Power OFF Power, , from an interfering site traverse a path loss  to reach the victim receiver. The power at the victim receiver array is then:



The OFF power into each victim transceiver equipped with an element receive gain of ,becomes:



The total OFF power fed into the whole array of *N* transceivers, then becomes:



If we assume the margin for a given noise increase in the system is *M* dB and the applicable bandwidth of *B* Hz, we get the total noise in the system as:



From equations (1) and (2) we get



The path loss  can be estimated using the 3GPP model for NLOS case:

Where:

- d is in km, and f in GHz

*=*

By assuming the following parameters for the path loss:

- *B* = 1 MHz

- *NF* = 10 dB

- *M* = 6 dB, for 1 dB noise rise

- *N* = 128 transceivers

-  = 6 dB

- *f* = 28 GHz

- *d* = 100 m

-  = 25 m

-  = 1.5 m

We get a value for = 117 dB. However, when considering interference, the NLOS case is not the limiting factor but rather the LOS case. In 3GPP we have 2 LOS models LOS1 and LOS2. The path loss  for each of these LOS models can be expressed as follows:

, at LOS1

*,* at LOS2

LOS1 model is used for the Urban environment which is characterized by shorter distance.

We get  = 101 dB and the corresponding OFF power = - 36 dBm/MHz.

This value of -36dBm/MHz can then be the requirement for the transmitter OFF power for BS type 2-O.

This value can be measured either as TRP or at the output of the colocation reference antenna.

In case of transmit power OFF measurement as a TRP, the transient time is measured as a relative EIRP measurement.

For the colocation interference scenario corresponds to when the base stations of two operators mutually interfere with each other simultaneously. A typical configuration is shown in Figure 9.5.1.3-2 where both antennas are mounted on the same vertical plane. The most difficult case is when both operators coexist in the same band.

The TDD network is synchronized to within a TSync, Cell Phase Sync requirement and the Guard Period TGUARD is dimensioned to cope with the cell size and the transient times:

TGUARD ≥ 2\* TSync + 2\*Tprop\_cell edge +max ((TBS on🡺 off), (TUE off🡺 on)) + max ((TBS off🡺 on), (TUE on🡺 off))

The synchronization assumption, the guard period and the assumptions that UL and DL TDD configurations are coordinated so that only the TDD OFF power needs to be considered.

d

Figure 9.5.1.3-2: Colocation interference scenario

This colocation scenario is governed by the OTA reference sensitivity. Equipment not conforming to reference sensitivity requirements would self desense their own transceiver array and its neighboring sectors, even in its own channel. In this colocation case we would have some additional protection, since this is a neighbor carrier, even if it is in the same band.

For the scenario of sector site example, different sectors are installed within one site. This scenario is also governed by the OTA reference sensitivity. Equipment not conforming to reference sensitivity requirements would self desense their own transceiver array and its neighboring.

In summary, the transmit OFF power spectral density for NR BS type 2-O can be specified as TRP with a value less than -36 dBm/MHz and adopted as the core requirement.

For conformance testing, when verifying TX OFF power and ON/OFF transient period, it is only necessary to measure that the power level is below the TX OFF limit value after the specified time. The absolute TX OFF power level is not explicitly measured because compliance to the OFF power level is inferred by the transient period test.

The conformance power level is measured as the maximum EIRP value assuming on-state directivity (i.e. the difference between the maximum EIRP and TRP during transmitter ON power in dB). The EIRP conformance level during TX OFF power is measured in the beam peak direction within a reference beam direction pair for the declared beam identifier with the highest EIRP.

The transmitter OFF power antenna directivity is not known explicitly and hence an assumption must be made in order to translate the transmitter OFF power TRP core requirement to an EIRP OFF conformance requirement. At the same time the test system sensitivity restrictions due to the measurement being EIRP means it is difficult to measure very low power levels.

It has been shown that it is feasible to measure TX OFF power as EIRP if it is assumed that the transmitter ON antenna directivity is equal to the transmitter OFF antenna directivity. If a lower directivity is assumed then it is not possible to measure the power. Hence it is agreed that the transmitter ON antenna directivity will be used to calculate the EIRP of transmitter OFF level. This is reasonable as the transmitter ON directivity was used as a worst case when calculating the core TRP level in equation (1) above.

As the transmitter OFF level is fixed and there is no upper bound on the TX output power there is effectively no cap on the difference between ON power and OFF power level. Currently the measurement receiver can provide a dynamic range of approximately 70 dB. As the transmitter OFF level is -36 dBm/MHz this sets an upper TRP limit of approximately +34 dBm/MHz or +51 dBm/50MHz. It is not likely that an FR2 BS will have an output power at this power level. Hence, the dynamic range is not likely to be an issue. The ON antenna directivity can be calculated using the declared values of:

- rated carrier output EIRP, PRated,c,EIRP, (clause 4.6, D.11 of TS 38.141-2 [18])

- rated carrier TRP output power, PRated,c,TRP, (clause 4.6, D.37 of TS 38.141-2 [18]),

where PRated,c,EIRP is in the value associated with the reference beam direction pair for the beam identifier with the highest EIRP.

The transmitter OFF power level for conformance testing as an EIRP TX OFF limit, PEIRP OFF, is calculated as:



**<Next change>**

### 9.6.2 OTA frequency error for FR1

The OTA frequency error requirement is defined to capture the maximum allowable difference between an assigned frequency and the actual generated frequency. The frequency error requirement is a regulatory requirement in some regions.

Based on the motivation captured in 3GPP TS 37.843 [9], the OTA frequency error will be correlated among all TRX units forming the beam, hence the frequency error is coherent, will have a ‘flat’ response in the spatial domain, i.e. OTA frequency error will not depend on the selection of the measurement point within beam’s compliance directions set.

The measurement time contributes to the frequency error. A short measurement time induces an intrinsic uncertainty of what the frequency error is. A measurement time like 1 ms in LTE is short and one has to go all the way to a one second measurement time is long enough to clear a frequency error measurement from the influence of phase noise and spurs, leaving only the contributions from the reference signal, frequency slip due to non-phase-locks and hold-over frequency drift. A frequency error requirement at ppb accuracy level must have a defined measurement duration. A 1 ms measurement time is sufficient.

As the frequency error is flat in the spatial domain it is only necessary to show conformance in a single direction. Therefore, the OTA frequency error requirement is defined as a directional requirement at the RIB and shall be met within the OTA coverage range. The requirement needs to be defined so that all transmitter units are active and the system is operating at the declared maximum rated total radiated power.

Based on considerations for conducted frequency error requirement in clause 6.5.2, conducted frequency error requirement will be reused for OTA frequency error requirement in FR1.

For the sake of minimising the number of spatial declarations and as frequency error testing is generally done at the same time as OTA EVM testing the ‘reference direction’ of the OTA compliance peak directions set is the most suitable direction to define for the conformance testing.

For conformance testing purposes, the OTA frequency error shall be tested at the maximum and minimum power settings (together with the EVM test).

**<Next change>**

#### 9.7.4.2 Radiated OBUE Requirement in FR2

The NR BS mmWave spectrum emission mask is defined taking into account following assumptions:

- Boundary between OOB and spurious domain limits should be applied according ITU-R SM.1539 recommendation.

- Masks in the Out-of-band domain should be band centric OBUE mask

- The NR emission mask should use the emission limits submitted to WP5D as a baseline

- Agreed ACLR values should be considered

- Spurious emission limits should be taken into account (when agreed)

- BS mmWave output power should be taken into account

- Frequency range up to 52.6 GHz should be covered

- The mask is linked with the total transmission bandwidth (the sum of *BS channel bandwidth*s in case of multicarrier transmission).

The BS spectrum emission mask tables will need to cover the following variations:

- Power levels

- Frequency ranges

- BS classes (see further discussion below)

For the LS response to WP5D LS on “Characteristics of terrestrial IMT systems for frequency sharing/interference analysis in the frequency range between 24.25 GHz and 86 GHz” [10], there were spectrum masks developed that were based on similar principles as listed above. The masks in [10] used the FCC limits in 30.203 [11] as a baseline and that defined a mask with lower limits for BS Total transmitted power levels (PTx) below certain levels, aligned with the ACLR defined for different frequency ranges.

For LTE, there are different masks defined for different BS classes. The BS classes are fundamentally defined for different deployment scenarios (identified by Minimum Coupling Loss MCL), but also with different BS output powers. The spectrum masks for “smaller” BS (Medium Range and Local Area) have a dependence on the BS power level.

For NR, the spectrum masks for Medium Range and Local Area would also have dependence on power level. The dependence could similar between the different BS classes, making it possible to use the same spectrum mask definition for different BS classes. That would for example be the case if similar transceiver implementation was used for the different sized BS and with the implementation scaled with the BS power level in terms of the number of transmitting elements.

For this reason, a generic set of NR Operation Band Unwanted Emission Masks is defined based on the same principles as for the WP5D LS response [10], applicable to all BS classes:

- A fixed mask, same as FCC limit applies to the highest BS power levels.

- Variable masks scaled with power level apply to BS with power level below certain thresholds:

- One mask for 24.25 – 33.4 GHz, based on ACLR = 28 dBc.

- One mask for 37 – 52.6 GHz, based on ACLR = 26 dBc.

- Masks are limited to an absolute lowest emission limit of -20 dBm as in the WP5D LS response [10]

The masks cover the frequency ranges within the present scope of the work item. It is specified in Table 9.7.4.3.2-1 to Table 9.7.4.3.2-2 of 3GPP TS 38.104 [3].

The BS power level used to distinguish and derive the FR2 OTA OBUE mask is agreed as rated total TRP output power (Prated,t,TRP), which is mean power level that the manufacturer has declared to be available at the RIB during the *transmitter ON period.* Furthermore, it is consensus that the “rated total TRP output power” means both polarizations and includes all sub-blocks in case of non-contiguous operation.

**<Next change>**

#### 9.7.5.3 AAS radiated Tx spurious emissions requirement for FR2

The Tx spurious emission requirement for *BS type 2-O* is defined at RIB for the spurious range from 30 MHz up to the 2nd harmonics of the upper frequency edge of the *operating band.*

Only Category A limits are defined for FR2 and are the same as limits defined for *basic limits* in clause 6.6.5.2. The limits are specified in table 9.7.5.3.2-1 of TS 38.104 [3].

For conformance testing of the Tx spurious emissions requirement for *BS type 2-O*, the upper frequency limit of the spurious range might be limited to 60 GHz value, considering practical OTA measurement capabilities of the OTA test ranges in the spurious range.

Table 9.7.5.3-1: (Void)

**<Next change>**

## 10.1 General

For BS type 1-H and BS type 1-O the same spatial definitions are used as for the AAS described in 3GPP TR 37.842 [8] and 3GPP TR 37.843 [9].

For BS type 2-O spatial definitions defined for BS type 1-O are reused, with few exceptions described in table 10.1-1.

For NR BS type 1-O OTA sensitivity is valid over the RoAoA(s) in the declared OSDD(s), where any number of OSDD’s may be declared by the manufacturer to describe the receiver capabilities.

Minimum sensitivity (minSENS) is defined as the lowest declared EIS value from all the declared OSDD’s and is valid over the *minSENS RoAoA*.

Absolute levels which are based on performance at minSENS are offset from the appropriate conducted absolute power level by the following:

ΔminSENS = PREFSENS – EISminSENS

OTA REFSENS is valid over the OTA REFSENS RoAoA which is declared by the manufacturer, absolute levels which are based on performance at OTA REFSENS are offset from the appropriate conducted absolute power level by the following:

ΔREFSENS = PREFSENS – EISREFSENS

In table 10.1-1 classification of the radiated Rx requirements is provided with brief justification.

Table 10.1-1: Classification of radiated Rx requirements

|  |  |  |
| --- | --- | --- |
| Rx requirement | Description and discussion | Classification |
| OTA sensitivity | Based on the Rel-13 EIS requirement declaration over the OSDD, the OTA sensitivity is directional requirement by definition.  Conformance testing for OTA sensitivity is performed for the five directions same as the Rel-13 AAS OTA sensitivity requirements. This requirement is not applicable for BS type 2-O. | Directional |
| OTA reference sensitivity level | Conformance testing for OTA reference sensitivity is performed for five directions declared by the manufacturer. | Directional |
| OTA dynamic range | It was agreed that the requirement assumes that the wanted signal and interfering signal come from the same direction. Testing is defined in the receiver target reference direction, meaning that this is directional requirement. This requirement is not applicable for BS type 2-O. | Directional |
| OTA in-band selectivity and blocking | The OTA blocking requirement is tested as follows:  - In the reference direction of the minSENS OSDD using the minSENS based requirement level  - In each of the 4 conformance directions at the extremities of the OTA REFSENS RoAoA using the REFSENS based requirement level. | Directional |
| OTA out-of-band blocking | Out of band blocking is a long test and hence it is optimum to minimize the number of conformance test directions. The antenna gain can be assumed to be maximum at the reference direction, therefore it is sufficient to show conformance at the reference direction only. | Directional, except for co-location requirement applicable for BS type 1-O |
| OTA receiver spurious emission | The Rx spurious emissions requirement follows the approach for the Tx spurious emissions, i.e. the emissions in the spurious region needs to be measured as TRP due to unknown radiation pattern. | TRP |
| OTA receiver intermodulation | Since RX sensitivity and blocking already test at all conformance directions, it is sufficient to test RX IM only in a single direction. | Directional |
| OTA in-channel selectivity | In channel selectivity requirement is tested in a single direction. | Directional |

Spatial definitions relevant for co-location requirements applicable for BS type 1-O is described in TR 37.843 [9].

**<Next change>**

### 10.3.2 BS type 1-O

For BS type 1-O OTA reference sensitivity is intended to provide equivalent protection and performance as the conducted reference sensitivity level. The OTA reference sensitivity level is calculated based on the conducted reference sensitivity level for BS type 1-C and 1-H and a hypothetical antenna gain of a passive antenna which would be used with a non-AAS BS in the same deployment scenario.

The requirement is valid over the OTA REFSENS RoAoA which is a declared by the vendor. The OTA REFSENS RoAoA is used to estimate the equivalent antenna gain using the Elliot’s formula approximation, and a number of agreed margins as follows:



Where:

- PREFSENS is the conducted reference sensitivity level in dBm.

- DRX\_OTA+MARGIN is an implementation margin to allow for errors associated with beam forming in the UL. The DRX\_OTA\_MARGIN value is 1dB.

- D0 is the estimated antenna peak directivity in dBi of a non-AAS BS, which has a beam pattern related to the OTA REFSENS RoAoA region. D0 is approximated by the Elliot’s formula and expressed as,



Where,

- BeWθ,REFSENS is the beamwidth equivalent to the OTA REFSENS RoAoA in the θ-axis in degrees.

- BeWφ,REFSENS is the beamwidth equivalent to the OTA REFSENS RoAoA in the φ-axis in degrees.*OTA REFSENS RoAoA* is declared by the vendor.

- Doff-peak is the peak directivity off-peak margin, it is defined as follows:

- The OTA REFSENS RoAoA is defined as the contour where the EIS is 3dB higher than in the reference direction, therefore by definition Doff-peak in the reference direction is 0dB. In all other directions within the OTA REFSENS RoAoA Doff-peak is 3dB.

**<Next change>**

#### 10.3.3.2 Antenna gain and loss assumptions

For WA BS the antenna gain (G) has been identified for the 28GHz band to be the range 10 to 33 dB.

G includes the antenna directivity and the antenna loss.

Losses may arise from a number of factors, including array related aspects such as scan loss, mutual coupling, steering loss, RF phase error, beam straddling, allowances for beam shaping algorithms, drop towards the coverage edge, radome related losses, antenna mismatch, and any other antenna array related RF losses.

The antenna mismatch may be different between the Rx and Tx the antenna mismatch discussed here is for Rx only. If we need to discuss Tx antenna gain and mismatch, this can be discussed separately.

The current agreements assume there are no filter losses included, if band filtering is needed between the LNA and the antenna then additional loss may be added the value of this is FFS.

The exact distribution of directivity and loss is not formally agreed however the max and min values are based on the approximate extreme cases (based on 28GHz):

Low gain case:

The minimum usable low gain for a wide area BS can be approximated based on the minimum cell size for a wide area BS. The minimum distance for a UE to the antenna for a wide area BS is 35m (assuming a 23.5m vertical separation). It is reasonable to expect that high throughput and hence high SINR should be achievable at distances greater than this. To achieve and UL SINR of 15 dBi for a 200MHz channel at 100m at least 10dB antenna gain is required.

This is equivalent to antenna of approx. 4x4 elements (0.5λ spacing) with 3dB off peak margin and 4dB losses.

High gain case:

The high gain is limited by practical implementation of the antenna, a 64x32 element (0.5λ spacing) antenna would consist of 2048 elements and have a directivity of 38.1dBi. With some many elements it is likely the losses would be higher than for a smaller antenna, hence 3dB off peak margin and 5dB losses result in a gain of 30 dBi. Two such panels are considered and hence the upper gain limits 33dBi.

For higher frequencies as the noise figure is higher (see sub-clause 10.3.3.3) the antenna gain required to maintain the same OTA REFSENS value is higher. As the low gain case is based on a reasonable minimum cell size it is reasonable that the OTA REFSENS is not reduced further for the higher frequencies, so for the 45GHz range the minimum expectation for G will be 12dB rather than 10dB.

Note this does not take into account the effect of higher FSPL on the cell size at higher frequencies.

Table 10.3.3.2-1: G assumptions for calculating FR2 WA OTA REFSENS range

|  |  |  |
| --- | --- | --- |
| BS class | G | |
| 30 GHz  (24.25 – 33.4 GHz) | 45GHz  (37 – 52.6 GHz) |
| WA | 10 to 33 dBi | 12 to 35 dBi |

Medium range and local area BS are intended to cover smaller cell sizes and hence the antenna gain requirements are lower, for medium range and local area BS the following assumptions for G have been agreed.

Table 10.3.3.2-2: G assumptions for calculating FR2 MR and LA OTA REFSENS range

|  |  |  |
| --- | --- | --- |
| BS class | G | |
| 30 GHz  (24.25 – 33.4 GHz) | 45GHz  (37 – 52.6 GHz) |
| MR | 5 to 28 dBi | 7 to 30 dBi |
| LA | 0 to 23 dBi | 2 to 25 dBi |

**<Next change>**

#### 10.3.3.5 OTA Reference sensitivity ranges

Considering the gain range is adjusted to account of the higher NF at the higher frequencies a single range is defined for all bands as follows:

OTA reference sensitivity level for FR2 is:

- 1 dB step within the range -96 to -119 dBm dB for WA

- 1 dB step within the range -91 to -114 dBm for MR

- 1 dB step within the range -86 to -109 dBm dB for LA

**<Next change>**

### 10.4.1 Dynamic range requirements for Range 2 NR BS

In the table below, we summarize investigations from different companies related to mmWave receiver noise floor rise requirements.

Table 10.4.1-1: Investigations related to mmWave receiver noise floor rise

|  |  |
| --- | --- |
| R4-1706752: BS receiver dynamic range for mmWave bands  Source: Huawei, HiSilicon | Proposal:  The dynamic range simulation result for mmWave bands is small and no need to specify the requirement. |
| R4-1705097, Simulation results for receiver dynamic range of NR BS receiver with different deployment scenarios  Source: Ericsson | Observation-1:  Noise floor rise for dynamic range of NR receiver is ~0dB for all scenarios at 50 percentile UL interference.  Observation-2:  Noise floor rise for dynamic range of NR receiver is ~0dB for UMa and UMi scenarios at 90 percentile UL interference.  Observation-3:  Noise floor rise for dynamic range of NR receiver for InH scenario at 99 percentile UL interference is not substantial.  Proposal:  There is no need to specify dynamic range requirement for NR BS. |
| R4-1705430: Proposal on mmWave NR BS Receiver Dynamic Range  Source: Nokia, Alcatel-Lucent Shanghai Bell | Proposal:  To specify the mmWave NR BS receiver dynamic range requirement with the interference level of 15dB over the receiver thermal noise floor, and the wanted signal level calculated as the interference signal level plus the required UL 16QAM SNR and implementation margin. Here the SNR can be obtained at 95% relative throughput from link level simulations, and the implementation margin can be defined as 2.5dB. |
| R4-1706813: Simulation results for receiver dynamic range of NR BS receiver without array gain for different deployment scenarios,  Source: Ericsson | Observation:  Noise floor rise for dynamic range of NR receiver without including the array gain is ~0dB for all scenarios at 50 and 99 percentile UL interference.  Proposal:  There is no need to specify dynamic range requirement for NR BS. |
| R4-1706774: Discussion on receiver dynamic range and ICS requirement of range2 NR BS  Source: ZTE Corporation | Proposal 1:  not to specify the dynamic range requirement for rang2 NR BS. |
| R4-1704930: Discussion on NR BS dynamic range,  Source: CATT | Observation 1: Due to the considerable path loss in mmW frequency range, the interference signals reach to the BS side will be much lower in NR system than in LTE system.  Observation 2: The UE specific BF will bring on significant rejections to the interference signals in the directions other than the direction of wanted signal.  Observation 3: The large *BS channel bandwidth* of NR will result in a higher noise floor.  Observation 4: Considering that there has been the REFSENS requirement which is aims to measure the receiver capability to receive the wanted signal in the level of noise floor, it seems unnecessary to define a similar requirement, say dynamic range requirement.  Observation 5: For sub-6GHz NR BS dynamic requirement, it’s acceptable to reuse the same requirement of LTE except that the reference measurement channel may need to be further investigated for the new numerologies, *BS channel bandwidth* and coding schemes. |
| R4-1709427: Further simulation results for range2 NR BS Dynamic Range  Source: CATT | Additional simulation results |

As it is seen from the above summary, most of the investigations point to a common conclusion that there is no need to define NR BS receiver dynamic range requirement for mmWave base station, considering the noise floor rise for NR BS receiver dynamic range in the simulated scenarios.

In addition to the above investigations, it also been discussed whether other requirements implicitly demonstrate compliance to a small (e.g. 5dB) dynamic range.

For LTE, the demodulation requirements are set well above the noise floor. It is reasonable to assume that a similar approach may be adopted for NR demodulation, then the demodulation requirements will be set well above the receiver noise floor.

In case of LTE, with 5MHz channel bandwidth, the noise floor is -103dBm with a 5dB Noise Figure. So, the 5dB noise floor rise would result in -98dBm in AWGN. As seen in Table 8.2.1.4.2-1 of TS 36.141 [27], the AWGN power level at the BS input is specified as -80.4dBm/18MHz for 20MHz channel bandwidth. For receiver dynamic range test, 16-QAM is used, the SINR in that case is around 10.3dB, which results in absolute signal level around -75dBm. This is well above 5dB from the noise floor.

In NR, the AWGN noise level will be higher compared to LTE levels, due to channel bandwidth and noise figure levels. However, if we follow same approach in defining the demodulation requirements as it is done for LTE, the absolute levels for demodulation requirements will be well above the AWGN noise floor. Thus, we do not see any need for testing dynamic range requirements in the order of 5dB.

Based on the above discussions and based on proposals from multiple companies, the following is agreed:

***Agreement: There is no need to specify dynamic range requirement for range2 NR BS.***

The absolute levels for demodulation requirements shall be well above (e.g. at least ~5dB) the AWGN noise floor, thus the small dynamic range shall be handled via demodulation requirements.

**<Next change>**

#### 10.5.3.3 FR2

BS type 2-O has a number of differences when considering the OTA blocking levels.

- There are no conducted requirements, so simulation of conducted interferer power levels do not give a final OTA power level.

- Beam forming is necessary in order to overcome the path loss.

- A wide range of implementations with varying antenna maximum beam forming gain are envisaged.

- Different beam forming architectures result in different statistical spread of interferer power at the active Rx input (i.e. the LNA).

Traditionally the in-band blocking level has been analysis on a statistical basis based on the 99.99% probability of an interferer being possible. This has been used since UTRA where WCDMA modulation was susceptible to blocking and the entire system would be blocked if such an event occurred. The NR OFDMA scheme does not suffer so greatly due to a blocking event hence such a high probability is not required, probabilities between 99% and 99.9% have also been considered.

In the past the wanted signal has not been considered when studying the interferer level, however with an OTA requirement and a beam forming system when considering a statistical worst case, it is important to consider both the wanted and the interfering signal. This is due to the fact that blocking arises when a low power wanted signal and a high-power blocking signal occur simultaneously (the likelihood of this occurring depends on instantaneous power control, scheduling and beam directions) Hence the difference between the wanted signal and the interferer is also important.

Initially the probability of the interferer alone was simulated looking at the same scenarios identified in the co-existence simulation in 3GPP TR 38.803 [24].

The probability of the blocking signal level and also the probability of simultaneous low wanted signal and high blocking signal were both considered. Simulations of both of these aspects suggested that the blocking signal is typically 33dB above the reference sensitivity level. This result was consistent when considering different architectures.

It was agreed that the specification for the interferer power level will be 33dB higher than the OTA REFSENS power level.

As for FR2 there is only a single sensitivity requirement, a 6dB offset from OTA reference sensitivity is used for the wanted signal and a 33dB offset from reference sensitivity is used for the interferer.

**<Next change>**

### 10.6.1 FR1 OTA out-of-band blocking

The OTA out-of-band blocking requirement derivation for NR is the same as that for AAS and is documented in 3GPP TR 37.843 [9], in summary the OTA out of band blocking is difficult to translate directly from the conducted out of band blocking requirement as

- The gain characteristics of an antenna is not known in the out-of-band frequency region.

- The free space path-loss at high frequencies (i.e. up to 12.75 GHz) means that the radiated power levels required to provide -15 dBm at conducted point are unfeasibly high.

Clearly the interferers are present irrespective of the victim *antenna gain*, the original levels assumed that the victim *antenna gain* was the same as the in-band gain, this assumption is not required when considering an OTA requirement and the interferer levels can be represented as a field strength at the antenna array.

The field strength is derived from the conducted out of band interfere level and the in-band antenna gain assumptions:

EIRP(30m) = Prx – Gant + FSPL(30m) = -15dBm – 17dBi + 68dB(frequency=2 GHz, FSPL 30m) = 36dBm

And



**<Next change>**

### 10.7.3 Radiated Rx spurious emissions requirement in FR2

The Rx spurious emission requirement for *BS type 2-O* is defined at RIB over the same spurious range as defined for the radiated Tx spurious requirement for *BS type 2-O*, i.e. from 30 MHz up to the 2nd harmonics of the upper frequency edge of the *operating band.*

Rx spurious emission limits for FR2 are reused from the FR1 range above 1GHz, i.e. - 47 dBm. Please note, that comparing to the FR1 spurious requirements, there is no emissions scaling applied for the spurious emissions in FR2.

Measurement BW is based on the value from SM.329 recommendation [4].

Considering that FR2 frequency bands are expected to be TDD only, the conformance testing of the OTA RX spurious emissions for *BS type 2-O* could be applied during TX OFF period only.

Similar to the OTA Tx spurious emissions, for conformance testing of the Rx spurious emissions requirement for *BS type 2-O*, the upper frequency limit of the spurious range might be limited to 60 GHz value, considering practical OTA measurement capabilities of the OTA test ranges in the spurious range.

**<End of change>**