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Technical Report

3rd Generation Partnership Project;

Technical Specification Group Radio Access Network;

General aspects for User Equipment (UE) Radio Frequency (RF) for NR

(Release 16)

** 

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# Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

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y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

# 1 Scope

The present document is a technical report for the work item on Work Item on New Radio (NR) Access Technology, covering the general aspects for RF, RRM and demodulation for NR.

# 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 36.101: "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception".

[4] 3GPP TS 38.101-1: "NR; User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone".

[5] 3GPP TS 38.101-2: "NR; User Equipment (UE) radio transmission and reception; Part 2: Range 2 Standalone".

[6] 3GPP TS 38.101-3: "NR; User Equipment (UE) radio transmission and reception; Part 3: Range 1 and Range 2 Interworking operation with other radios".

[7] 3GPP TS 38.104: "NR; Base Station (BS) radio transmission and reception".

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

[9] 3GPP TR 36.942: "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Frequency (RF) system scenarios".

[10] 3GPP TR 38.803: "Study on new radio access technology: Radio Frequency (RF) and co-existence aspects".

[11] Void.

[12] 47 CFR Part 30, "UPPER MICROWAVE FLEXIBLE USE SERVICE, §30.202   Power limits", FCC.

[13] ITU Provisional Final Acts WRC-19, Resolution 750 (REV.WRC-19), Table 1-1 FN 5 (a) and (b), page 349 (https://www.itu.int/dms\_pub/itu-r/opb/act/R-ACT-WRC.13-2019-PDF-E.pdf)

# 3 Definitions, symbols and abbreviations

## 3.1 Definitions

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

**Operating band**: frequency range in which NR operates (paired or unpaired), that is defined with a specific set of technical requirements.

**BS Channel bandwidth**: RF bandwidth supporting a single NR RF carrier with the transmission bandwidth configured in the uplink or downlink.

NOTE: The channel bandwidth is measured in MHz and is used as a reference for transmitter and receiver RF requirements.

NOTE: It is possible for the BS to transmit to and/or receive from one or more UE Bandwidth parts that are smaller than or equal to the BS transmission bandwidth configuration, in any part of the BS transmission bandwidth configuration.

**UE Channel bandwidth:** The RF bandwidth supporting a single NR RF carrier with the transmission bandwidth configured in the uplink or downlink of a cell. The channel bandwidth is measured in MHz and is used as a reference for transmitter and receiver RF requirements.

## 3.2 Symbols

ΔfOOB Δ Frequency of Out Of Band emission

BWChannel Channel bandwidth

BWChannel\_CA Aggregated channel bandwidth, expressed in MHz.

BWChannel,max Maximum channel bandwidth supported among all bands in a release

FDL\_low The lowest frequency of the downlink operating band

FDL\_high The highest frequency of the downlink operating band

FUL\_low The lowest frequency of the uplink operating band

FUL\_high The highest frequency of the uplink operating band

LCRB Transmission bandwidth which represents the length of a contiguous resource block allocation

expressed in units of resources blocks

LCRB,Max Maximum number of RB for a given Channel bandwidth and sub-carrier spacing

NRACLR NR ACLR

NRB Transmission bandwidth configuration, expressed in units of resource blocks

RBSTART Indicates the lowest RB index of transmitted resource blocks.

## 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].

ACLR Adjacent Channel Leakage Ratio

ACS Adjacent Channel Selectivity

BW Bandwidth

CA Carrier Aggregation

CC Component Carrier

CA\_nX-nY Inter-band CA of component carrier(s) in one sub-block within Band X and component carrier(s) in one sub-block within Band Y where X and Y are the applicable NR operating band

EIRP Equivalent Isotropic Radiated Power

EVM Error Vector Magnitude

FR Frequency Range

RAT Radio Access Technology

REFSENS Reference Sensistivity

SCS Subcarrier spacing

SEM Spectrum Emission Mask

SUL Supplementary uplink

MPR Allowed maximum power reduction

# 4 General and common aspects

## 4.1 Operating bands

While requirements are often generic and band agnostic, there may in many cases be separate requirements for different bands. In some cases, these are identified directly using the band number. They will also be references to different frequency ranges covering many bands, identified as requirements for sub-6 GHz bands (Frequency Range 1) and mmWave bands (Frequency Range 2). These ranges are for the purpose of the specification defined as follows:

- FR1: 450 – 6000 MHz

NOTE 1: the lower frequency limit of FR1 has been extended down to 410 MHz, from Rel-15 onwards. In order to align with the LTE410\_Europe\_PPDR work item introducing new band in the frequency range 410 – 430 MHz.

NOTE 2: the upper frequency limit of FR1 has been extended up to 7125 MHz, from Rel-15 onwards. Irrespective of this decision, in this report the FR1 is referred to as “sub‑6GHz”, reflecting previous agreements on NR spectrum.

- FR2: 24250 – 52600 MHz.

The lowest frequency in FR1 is selected as the lowest frequency identified for IMT by the ITU-R [2]. FR2 is defined starting from the lowest frequency under study for IMT under WRC Agenda item 1.13, up to the highest frequency within the scope of the present work item. In the future when new operating bands may be added outside the frequency ranges of FR1 and FR2, those can be incorporated by extending FR1 or FR2, or by adding new ranges (FR3, etc.).

The definitions of FR1 and FR2 are common the UE and BS and should be specified within clause 4 of the specifications.

As for UTRA and LTE, bands for NR are identified by band numbers. A number of different aspects are considered for developing an NR band numbering scheme:

1) For NR in LTE “refarming” bands, whether to re-use the LTE band numbers for NR.

2) For new NR bands, different alternative options are considered:

a) To put new NR bands above 6 GHz in a new separate numbering range within existing signaling capability.

b) To group new NR bands below 6 GHz with the LTE bands, resulting in separate band numbering ranges for below 6 GHz and above 6 GHz bands.

c) To assign unused numbers to all new bands on a “first come first served” basis, regardless of frequency range, duplex mode or RAT (LTE, NR, etc.)

3) How to consider “Duplex mode” for different types of bands

The final NR band numbering scheme is based on the following:

1) For NR in LTE “refarming” bands, LTE band numbers are reused for NR. This will be consistent with the scheme for UTRA and LTE, where the same number was used for the same frequency range, while written in a different way. It also conserves band numbers.

2) NR band numbers will be written with a prefix “n”, to distinguish from band numbers for other RATs. For example, NR Band n7 will correspond to LTE Band 7 and UTRA Band VII.

3) New bands should be assigned band numbers on a “first come first served” basis in reserved frequency ranges as follows:

- 65 to 256 is reserved for new LTE and new NR bands in FR1.

- 257 to 512 is reserved for new NR bands in FR2. By avoiding LTE bands in this number range, the present LTE band definition is preserved and will most likely not need any changes in the future.

- New LTE only TDD band can use band number from existing LTE TDD numbering space until all numbers up to 64 are used and after that from the reserved 65-256 space.

4) For both re-farming LTE bands and new NR bands, duplex mode should be assigned and described in band defining table (e.g. in TS 38.101 and TS 38.104 [7])

- TDD for unpaired bands and FDD for paired bands

- FFS identifies options under study, such as flexible duplexing for paired bands

- If multiple duplexing modes are allowed in a specific frequency range, separate bands will be introduced with each duplexing mode

NR DC and CA band combination are defined using a notation similar to LTE, but using the distinct notations for the different RATs: A number (Arabic) for LTE and a number with prefix “n” for NR. The CA bandwidth classes (postfix of the bands) for NR are defined in section 5.1.1 for FR1 and section 7.1.1 for FR2 respectively. Examples for notations of NR CA, DC and EN-DC are given in Table 4.1-1a, 4.1-1b and 4.1-1c.

Table 4.1-1a: Example notation for DC and CA.

|  |  |
| --- | --- |
| **Representation** | **Corresponding functionality** |
| CA\_n77-n78 | NR CA of band n77 and band n78 |
| DC\_1-2\_n77 | NR-LTE DC with LTE CA of band 1 and band 2 and NR band n77. |
| DC\_1-2\_n77-n78 | NR-LTE DC with LTE CA of band 1 and band 2 and NR CA of band n77 and band n78. |

Table 4.1-1b: Example notation for EN-DC bandwidth class.

|  |  |  |  |
| --- | --- | --- | --- |
| **Type** | | **Notation** | **Note** |
| EN-DC | Intraband contiguous | DC\_(n)XAA | 1 CC LTE Band X + 1 CC NR Band nX with max BW ≤ max LTE BW + max NR BW |
| DC\_(n)XB | 1 CC LTE Band X + 1 CC NR Band nX with max BW ≤ 20 MHz |
| DC\_(n)XJK | LTE Band X with class J + NR Band nX with class K |
| Intraband non-contiguous | DC\_XA\_nXA | Intraband non-contiguous EN-DC with 2 sub-blocks |
| DC\_XC\_nXC | Intraband non-contiguous EN-DC with 2 contiguous LTE sub blocks and 2 contiguous NR sub-blocks |
| DC\_XA-XA\_nX(3A) | Intraband non-contiguous EN-DC with 2 non-contiguous LTE sub blocks and 3 non-contiguous NR sub-blocks |
| Interband | DC\_XA\_nYA | Interband EN-DC with 1CC LTE Band X + 1CC NR Band nY |
| NOTE: LTE CA and NR CA bandwidth classes are used in EN-DC respectively | | | |

Table 4.1-1c: Example notation for NR DC bandwidth class.

|  |  |  |  |
| --- | --- | --- | --- |
| **Type** | | **Notation** | **Note** |
| NR DC | Interband | DC\_nXA-nYA | NR DC with 1CC NR Band nX + 1CC NR Band nY |

*Editor’s note:It is FFS how to handle BCS for NR  
- Reuse exiting BCS concept or adopt simplified BS concept or no BCS*

For SUL and NR-LTE co-existence, example of notation is given in Table 4.1-2.

Table 4.1-2: Example notation for SUL and NR-LTE coexistence.

|  |  |
| --- | --- |
| **Representation** | **Corresponding functionality** |
| SUL\_n78-n81 | Band combination of NR band n78 and band n81(SUL) for NR operation. |
| DC\_3-SUL\_n78-n80 | LTE-NR DC between LTE Band 3, and NR bands n80 (SUL) and n78 including NR-LTE coexistence with UL sharing. |

The definition of operating band can be inherited from LTE. In TS 38.101 and TS 38.104 [7], there should be separate tables defining the band numbers in FR1 and FR2. This exploits the commonality within frequency ranges and reduces table size. For FR2, the table will only contain unpaired frequency ranges, assuming that there will be no FDD operation. To be consistent, all frequencies are defined in MHz.

For the first version of the spec, bands listed as part of the NR WID should be included. The new bands in Tables 4.1-3 and 4.1-4 are defined for NR.

Table 4.1-3: New NR bands in FR1.

|  |  |  |  |
| --- | --- | --- | --- |
| **Band number** | **UL** | **DL** | **Duplex mode** |
| n1 | 1920 – 1980 MHz | 2110 – 2170 MHz | FDD |
| n2 | 1850 – 1910 MHz | 1930 – 1990 MHz | FDD |
| n3 | 1710 – 1785 MHz | 1805 – 1880 MHz | FDD |
| n5 | 824 – 849 MHz | 869 – 894MHz | FDD |
| n7 | 2500 – 2570 MHz | 2620 – 2690 MHz | FDD |
| n8 | 880 – 915 MHz | 925 – 960 MHz | FDD |
| n13 | 777 – 787 MHz | 746 – 756 MHz | FDD |
| n20 | 832 – 862 MHz | 791– 821MHz | FDD |
| n25 | 1850 – 1915 MHz | 1930 – 1995 MHz | FDD |
| n26 | 814 – 849 MHz | 859 – 894 MHz | FDD |
| n28 | 703 – 748 MHz | 758 – 803 MHz | FDD |
| n34 | 2010 – 2025 MHz | 2010 – 2025 MHz | TDD |
| n38 | 2570 – 2620 MHz | 2570 – 2620 MHz | TDD |
| n39 | 1880 – 1920 MHz | 1880 – 1920 MHz | TDD |
| n40 | 2300 – 2400 MHz | 2300 – 2400 MHz | TDD |
| n41 | 2496 – 2690 MHz | 2496 – 2690 MHz | TDD |
| n50 | 1432 – 1517 MHz | 1432 – 1517 MHz | TDD |
| n51 | 1427 – 1432 MHz | 1427 – 1432 MHz | TDD |
| n66 | 1710 – 1780 MHz | 2110 – 2200 MHz | FDD |
| n70 | 1695 – 1710 MHz | 1995– 2020 MHz | FDD |
| n71 | 663 – 698 MHz | 617 – 652 MHz | FDD |
| n74 | 1427 –1470 MHz | 1475 – 1518 MHz | FDD |
| n75 | N/A | 1432 – 1517 MHz | SDL |
| n76 | N/A | 1427 – 1432 MHz | SDL |
| n77 | 3300 – 4200 MHz | 3300 – 4200 MHz | TDD |
| n78 | 3300 – 3800 MHz | 3300 – 3800 MHz | TDD |
| n79 | 4400 – 5000 MHz | 4400 – 5000 MHz | TDD |
| n80 | 1710 – 1785 MHz | N/A | SUL |
| n81 | 880 – 915 MHz | N/A | SUL |
| n82 | 832 – 862 MHz | N/A | SUL |
| n83 | 703 – 748 MHz | N/A | SUL |
| n84 | 1920 – 1980 MHz | N/A | SUL |
| n86 | 1710 – 1780 MHz | N/A | SUL |

Table 4.1-4: New NR bands in FR2.

|  |  |  |
| --- | --- | --- |
| **Band number** | **UL and DL** | **Duplex mode** |
| n257 | 26500 –29500 MHz | TDD |
| n258 | 24250 – 27500 MHz | TDD |
| n259 | [40500 –43500 MHz] | TDD |
| n260 | 37000–40000 MHz | TDD |
| n261 | 27500 – 28350 MHz | TDD |

## 4.2 Channel bandwidth

NR channel bandwidths for FR1 and FR2 are shown in Table 4.2-1 and Table 4.2-2. The channel bandwidths are defined as both *BS channel bandwidths* and *UE channel bandwidths* except where indicated.

Table 4.2-1: NR channel bandwidth for FR1

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **NR band / SCS / Channel bandwidth** | | | | | | | | | | | | | | |
| **NR Band** | **SCS**  **kHz** | **5 MHz** | **102,3  MHz** | **153 MHz** | **203 MHz** | **253 MHz** | **30 MHz** | **40 MHz** | **50 MHz** | **60 MHz** | **70 MHz** | **80 MHz** | **90 MHz** | **100 MHz** |
| n1 | 15 | Yes | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 30 |  | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 60 |  | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| n2 | 15 | Yes | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 30 |  | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 60 |  | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| n3 | 15 | Yes | Yes | Yes | Yes | Yes | Yes |  |  |  |  |  |  |  |
| 30 |  | Yes | Yes | Yes | Yes | Yes |  |  |  |  |  |  |  |
| 60 |  | Yes | Yes | Yes | Yes | Yes |  |  |  |  |  |  |  |
| n5 | 15 | Yes | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 30 |  | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 60 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| n7 | 15 | Yes | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 30 |  | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 60 |  | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| n8 | 15 | Yes | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 30 |  | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 60 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| n20 | 15 | Yes | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 30 |  | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 60 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| n25 | 15 | Yes | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 30 |  | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 60 |  | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| n26 | 15 | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |  |
| 30 |  | Yes | Yes |  |  |  |  |  |  |  |  |  |  |
| 60 |  | Yes | Yes |  |  |  |  |  |  |  |  |  |  |
| n28 | 15 | Yes | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 30 |  | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 60 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| n34 | 15 | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |  |
| 30 |  | Yes | Yes |  |  |  |  |  |  |  |  |  |  |
| 60 |  | Yes | Yes |  |  |  |  |  |  |  |  |  |  |
| n38 | 15 | Yes | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 30 |  | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 60 |  | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| n39 | 15 | Yes | Yes | Yes | Yes | Yes | Yes | Yes |  |  |  |  |  |  |
| 30 |  | Yes | Yes | Yes | Yes | Yes | Yes |  |  |  |  |  |  |
| 60 |  | Yes | Yes | Yes | Yes | Yes | Yes |  |  |  |  |  |  |
| n40 | 15 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |  |  |  |  |  |
| 30 |  | Yes | Yes | Yes | Yes | Yes | Yes | Yes |  |  |  |  |  |
| 60 |  | Yes | Yes | Yes | Yes | Yes | Yes | Yes |  |  |  |  |  |
| n41 | 15 |  | Yes | Yes | Yes |  |  | Yes | Yes |  |  |  |  |  |
| 30 |  | Yes | Yes | Yes |  |  | Yes | Yes | Yes | Yes1 | Yes | Yes1 | Yes |
| 60 |  | Yes | Yes | Yes |  |  | Yes | Yes | Yes | Yes1 | Yes | Yes1 | Yes |
| n50 | 15 | Yes | Yes | Yes | Yes |  |  | Yes | Yes |  |  |  |  |  |
| 30 |  | Yes | Yes | Yes |  |  | Yes | Yes | Yes |  |  |  |  |
| 60 |  | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| n51 | 15 | Yes |  |  |  |  |  |  |  |  |  |  |  |  |
| 30 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 60 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| n66 | 15 | Yes | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 30 |  | Yes | Yes | Yes |  |  | Yes |  |  |  |  |  |  |
| 60 |  | Yes | Yes | Yes |  |  | Yes |  |  |  |  |  |  |
| n70 | 15 | Yes | Yes | Yes | Yes | Yes |  |  |  |  |  |  |  |  |
| 30 |  | Yes | Yes | Yes | Yes |  |  |  |  |  |  |  |  |
| 60 |  | Yes | Yes | Yes | Yes |  |  |  |  |  |  |  |  |
| n71 | 15 | Yes | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 30 |  | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 60 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| n74 | 15 | Yes | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 30 |  | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 60 |  | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| n75 | 15 | Yes | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 30 |  | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 60 |  |  | Yes | Yes |  |  |  |  |  |  |  |  |  |
| n76 | 15 | Yes |  |  |  |  |  |  |  |  |  |  |  |  |
| 30 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 60 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| n77 | 15 |  | Yes | Yes | Yes |  | Yes1 | Yes | Yes |  |  |  |  |  |
| 30 |  | Yes | Yes | Yes |  | Yes1 | Yes | Yes | Yes | Yes1 | Yes | Yes1 | Yes |
| 60 |  | Yes | Yes | Yes |  | Yes1 | Yes | Yes | Yes | Yes1 | Yes | Yes1 | Yes |
| n78 | 15 |  | Yes | Yes | Yes |  | Yes1 | Yes | Yes |  |  |  |  |  |
| 30 |  | Yes | Yes | Yes |  | Yes1 | Yes | Yes | Yes | Yes1 | Yes | Yes1 | Yes |
| 60 |  | Yes | Yes | Yes |  | Yes1 | Yes | Yes | Yes | Yes1 | Yes | Yes1 | Yes |
| n79 | 15 |  |  |  |  |  |  | Yes | Yes |  |  |  |  |  |
| 30 |  |  |  |  |  |  | Yes | Yes | Yes |  | Yes |  | Yes |
| 60 |  |  |  |  |  |  | Yes | Yes | Yes |  | Yes |  | Yes |
| n80 | 15 | Yes | Yes | Yes | Yes | Yes | Yes |  |  |  |  |  |  |  |
| 30 |  | Yes | Yes | Yes | Yes | Yes |  |  |  |  |  |  |  |
| 60 |  | Yes | Yes | Yes | Yes | Yes |  |  |  |  |  |  |  |
| n81 | 15 | Yes | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 30 |  | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 60 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| n82 | 15 | Yes | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 30 |  | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 60 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| n83 | 15 | Yes | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 30 |  | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 60 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| n84 | 15 | Yes | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 30 |  | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 60 |  | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| n86 | 15 | Yes | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 30 |  | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 60 |  | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| NOTE 1: The channel bandwidth is defined only as a BS channel bandwidth in these bands.  NOTE 2: 90% spectrum utilization may not be achieved for 30kHz SCS.  NOTE 3: 90% spectrum utilization may not be achieved for 60kHz SCS. | | | | | | | | | | | | | | |

Table 4.2-2: NR channel bandwidth for FR2

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **NR band / SCS / Channel bandwidth** | | | | | |
| **NR Band** | **SCS**  **kHz** | **50 MHz** | **100 MHz** | **200 MHz** | **400 MHz** |
| n257 | 60 | Yes | Yes | Yes |  |
| 120 | Yes | Yes | Yes | Yes |
| n258 | 60 | Yes | Yes | Yes |  |
| 120 | Yes | Yes | Yes | Yes |
| n260 | 60 | Yes | Yes | Yes |  |
| 120 | Yes | Yes | Yes | Yes |

### 4.2.1 BS and UE channel bandwidth

For NR, the term *BS channel bandwidth* has been defined. A contiguous block of transmit / receive spectrum may consist of one or more *BS channel bandwidths*.

For E-UTRA, the channel bandwidth related to the transmit and receive bandwidths of both the BS and all of the UEs with which the BS communicates. For NR, however different *UE channel bandwidths* may be supported within the same spectrum.

The *BS channel bandwidth* is understood to be a range of spectrum which can be used to transmit to UEs with different bandwidths. The essential characteristic of the *BS channel bandwidth* is that placing UEs within the *BS channel bandwidth* is flexible; it is equally possible to assign a single carrier to a UE covering most or all of the *BS channel bandwidth,* to transmit a carrier to a UE with less than the *BS channel bandwidth*, but placed anywhere within the *BS channel bandwidth* or to transmit multiple carriers to a UE.

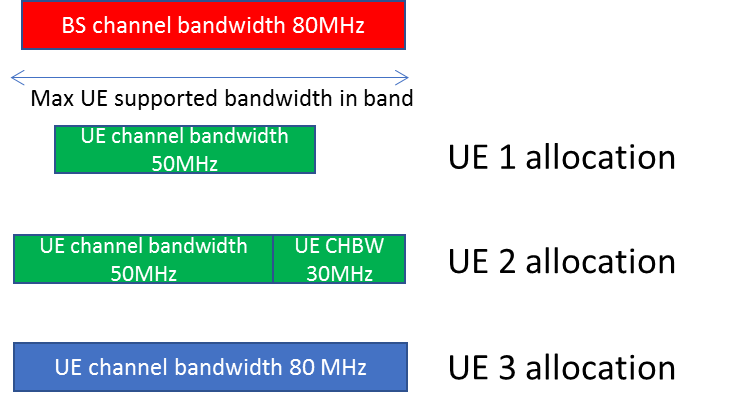


Figure 4.2.1-1: Example of allocation to UEs with different UE channel bandwidth within a BS channel bandwidth

It is not, on the other hand possible to transmit a carrier to a UE that crosses the boundary between two *BS channel bandwidths.*

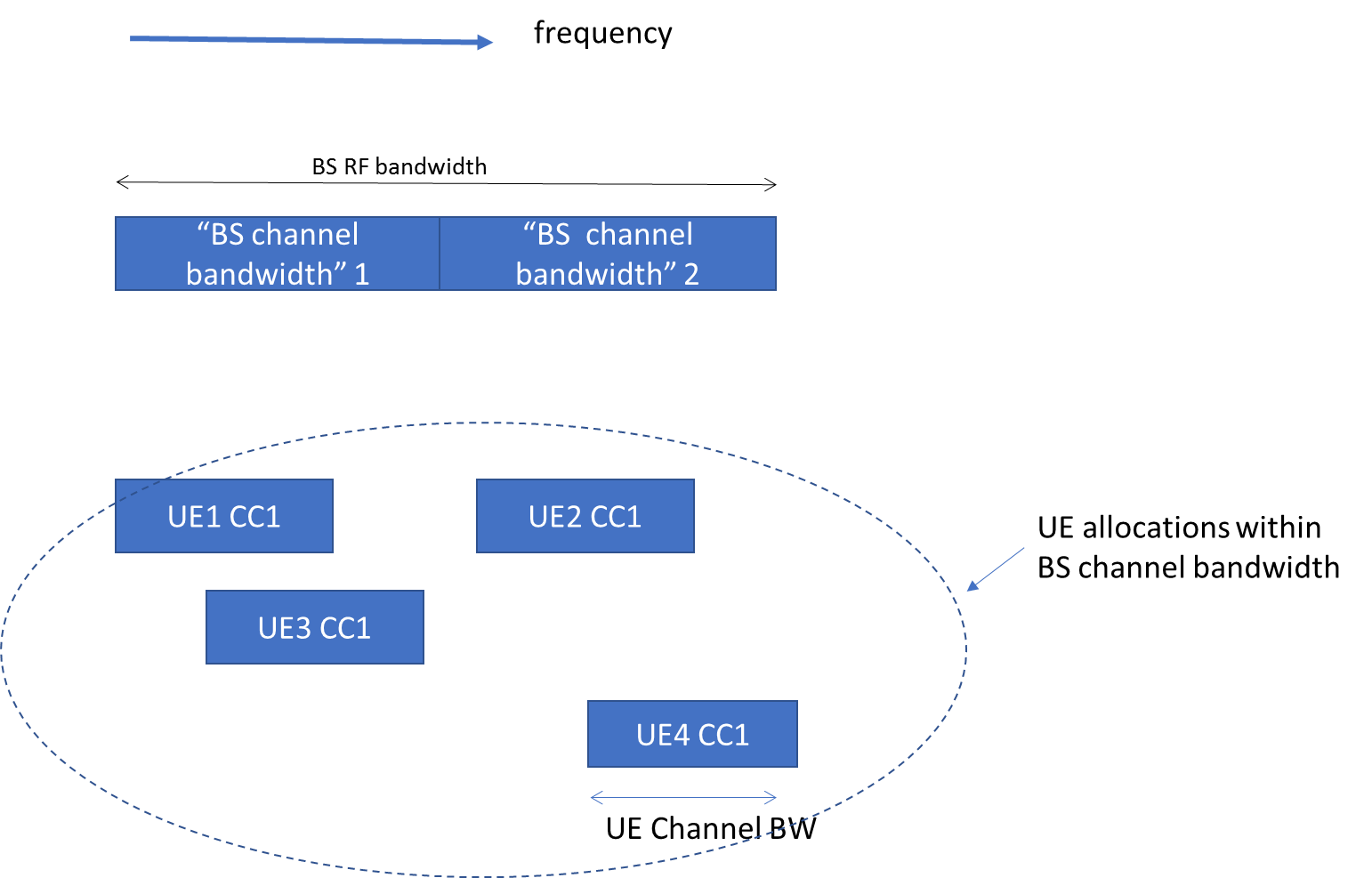


Figure 4.2.1-2: Example of allocation to UEs where there are multiple contiguous BS channel bandwidths. UE carriers may not straddle across BS channel bandwidths.

How RBs used by the BS may be allocated within a BS bandwidth are defined in the SU section 4.5 of this report.

### 4.2.2 Bandwidth combination sets

Following agreements have been made for NR Bandwidth combination sets (BCSs):

**Considering NR bands in inter-band LTE-NR DC:**

- BCSs are not specified for NR bands part of LTE-NR inter-band DC configurations

- When UE operates in LTE-NR DC configuration it supports same NR channel bandwidths as it supports for that NR band in standalone operation

- Where IMD is an issue only for a subset of channel bandwidths within a band/band combination, the bandwidths for which MSD is applicable shall be specified in receiver characteristics section.

**Considering LTE bands in inter-band LTE-NR DC:**

- The need for BCS for LTE band in LTE-NR DC is discussed separately from NR BCS

- LTE-NR DC UE shall signal BCS information to eNodeB (to reduce changes to LTE UE and eNodeB design)

- LTE-NR DC UE shall signal support for all specified LTE BCSs that belong to the LTE CA configuration part of LTE – NR DC (to reduce UE fragmentation and make RAN4 specification effort smaller as no LTE BCS information is needed in NR specs)

- When operating in DC band combinations of LTE 1DL/1UL + NR band(s) UE will support all LTE channel bandwidths that are specified to the LTE band (otherwise LTE bandwidth capability is unknown as single CC operation does not have BCS)

**Considering LTE/NR bands in intra-band LTE-NR DC:**

- BCSs would reduce the number of permutations of channel bandwidths that need to be supported for intra-band EN-DC

- BCSs shall be supported for intra-band EN-DC band combinations and specified in TS 38.101-3 [6]

**Considering NR bands in intra-band LTE-NR DC:**

- BCSs are allowed for NR bands part of LTE-NR intra-band DC configurations

- If one or more BCS is defined for a given LTE-NR DC configuration the a UE supports the specified channel bandwidths in the BCS(s) that it supports.

- If a BCS is not defined for a given LTE-NR DC configuration, the UE supports all the NR channel bandwidths as it supports for that NR band in standalone operation

- Where IMD is an issue only for a subset of channel bandwidths within a band/band combination, the bandwidths for which MSD is applicable shall be specified in receiver characteristics section.

**Considering LTE bands in intra-band LTE-NR DC:**

- LTE-NR DC UE shall signal BCS information to eNodeB (to reduce changes to LTE UE and eNodeB design)

- LTE-NR DC UE shall signal support for all specified LTE bandwidth combinations sets that belong to the LTE CA configuration part of LTE – NR DC (to reduce UE fragmentation and make RAN4 specification effort smaller as no LTE BCS information is needed in NR specs)

- When operating in DC band combinations of LTE 1DL/1UL + NR band(s) where one or more BCS are specified UE will support all LTE channel bandwidths that are specified for the supported BCS(s).

- When operating in DC band combinations of LTE 1DL/1UL + NR band(s) where no BCS are specified UE will support all LTE channel bandwidths that are specified to the LTE band (otherwise LTE bandwidth capability is unknown as single CC operation does not have BCS)

**Considering NR bands in standalone operation:**

- BCSs are specified for CA configuration in NR bands in standalone operation

- UE should support all specified aggregated bandwidths which are smaller than the indicated aggregated bandwidth and are part of same BCS indicated

- UE should support all specified lower order CA configurations which have same BCS as indicated

- BCS with same number (e.g. BCS0) need to be aligned between lower and higher order fallback configuration

## 4.3 Channel arrangement

### 4.3.1 RF channel and sync channel raster

#### 4.3.1.1 Background

The concept of referring to a carrier frequency in UTRA and E-UTRA is based on a channel raster defining possible carrier centre frequencies and a numbering scheme that identifies the raster points. In E-UTRA there are EARFCN (E-UTRA Absolute Radio Frequency Channel Number) for all possible uplink and downlink frequencies. The numbers are mapped to the corresponding UL and DL carrier frequencies through formulas:

FDL = FDL\_low + 0.1(NDL – NOffs-DL)

FUL = FUL\_low + 0.1(NUL – NOffs-UL)

The possible EARFCN ranges for each E-UTRA operating band are tabulated together with the parameters for the formula. The resulting RF channel raster identifies all possible RF carrier centre frequencies, which are the same as the potential frequencies that a UE must scan when performing initial access.

The concept has many differences in NR compared to UTRA and E-UTRA, giving a higher complexity. The main difference is that there is a need for two channel rasters for NR:

- **RF channel raster:** Identifies the set of possible frequency locations of the full RF carrier transmitted by the base station.

- **Synchronization channel raster**: Identifies the set of possible frequency location of the SS Block, consisting the synchronization channels PSS/SSS and the PBCH.

The SS block is not in a fixed position within the configured bandwidth of the RF carrier, but can be placed anywhere on the RF carrier. This enables a Sync channel raster that is more “sparse” than the RF channel raster. The advantage of having a more sparse sync channel raster is a reduced search time for the initial access. It relies on the SS block bandwidth being smaller than full channel BW of the RF carrier transmitted from the BS and that it is not in a fixed position within the configured bandwidth. It is the width of the PBCH being 240 subcarriers (20 RBs) that will define the flexibility of how to place the sync channel. The SS block will use a predetermined SCS and minimum channel BW in each operating band.

The relation between the RF channel raster and sync channel raster is demonstrated with an example in Figure 4.3.1.1-1. In the example, two carrier positions 1 and 2 are shown leading to two different placements of the PBCH. The PBCH (and SS) can be placed on a raster that is more sparse than the RF carrier raster and those sync channel raster positions are called FSC,i. Position 1 is the highest (rightmost) position of BWConfi on the RF channel raster where the PBCH can be related to the sync channel position FSC,1, thus the PBCH occurs as far left as possible on the carrier. Position 2 is the next position on the RF channel raster, thus shifted by ΔFCH,Raster from Position 1. The sync channel raster spacing ΔFSC,Raster will be limited by the following equation:

ΔFSC,Raster ≤ BWConfig – BWPBCH + ΔFCH,Raster (4.3.1.1-1)

where BWConfig (Tx BW configuration) is the width of the transmitted Resource Blocks, BWPBCH is the width of the PBCH and ΔFCH,Raster is the channel raster spacing.

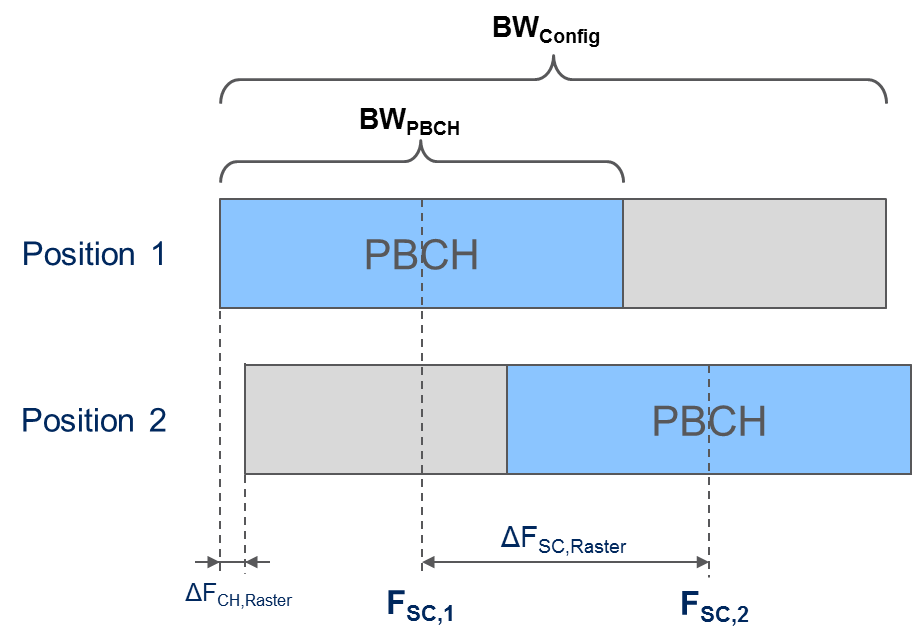


Figure 4.3.1.1-1: Possible shifts for the PBCH as the transmitted carrier is shifted   
on the RF carrier raster.

#### 4.3.1.2 Overall raster concept

The RF channel raster and sync channel raster need to be defined in relation to one or more of the following parameters:

- **Spectrum blocks**: These are the spectrum block allocations where the RF carriers will be placed. It is essential that the Channel BW is fully contained within an allocated block defined and/or permitted by a regulator, not risking “Channel BW spill-over”. The regulation varies across regions and often sets limits on emissions outside the block assigned to an operator. The 200 kHz/100 kHz rasters used for UTRA and E-UTRA are fundamentally adapted to spectrum blocks.

- **Subcarrier spacing (SCS)**: The RF channel consists of subcarriers and the subcarrier spacing becomes important for carrier aggregation and when forming wider channel bandwidths, since the RF channel spacing needs to be a multiple of SCS to keep orthogonality.

- **Physical resource blocks (RB)**: The RF carrier is an integer number of RBs and the physical channels are defined based on RBs in the frequency domain.

The definition of the channel raster will be limited by a number of aspects, also considering the relation between the RF channel and Sync channel raster defined in Equation (4.3.1.1-1). The following aspects are considered:

- The relation to the E-UTRA **100 kHz raster** for LTE re-farming bands.

- How to manage the **asymmetric guard band** if the RF carrier cannot placed in the centre of a spectrum block.

- In case of asymmetric guard band, a **minimum guard band** needs to be defined for different RF Channel bandwidths and SCS

- The achievable **spectral utilization** may be affected, if the guard band is not sufficient and an edge RB cannot be transmitted (“blanking”)

- How to achieve **CA operation** and **Wideband operation** with forward compatibility for addition of new channel bandwidths. This should preferably be achieved with zero guard band between carriers.

- The achievable **synchronisation raster granularity** may be affected by the choice of raster scheme.

NR Bands should have the same RF channel raster for both UL and DL. It is noted however that the channel raster for UL sharing band can be decoupled from the NR DL band raster (e.g. UL sharing band can be on 100kHz raster while the NR DL band can use 100kHz raster or RB based raster)

#### 4.3.1.3 RF Channel raster

NR Bands should have the same raster for both UL and DL (for both UL and DL 100kHz or RB based raster is used). Channel raster could also be different for different bands and only a single raster should be defined per band.

The following raster granularity is agreed:

- Channel raster for LTE re-farming bands up to 2.4GHz (frequency range below Band 41) is based on 100kHz(same as LTE)

- Potential optimization for of the placement of secondary carrier including RB-alignment between primary and secondary carrier is ffs

- Channel raster for Bands above 2.6GHz (above and including Band 41) is tentatively agreed to be a subcarrier based raster (i.e 15kHz for range 1 and 60kHz for range 2), pending further check at AN4 NR AH#3 and RAN1 decision

- Band n85 (SUL band covering the same frequency range as n41) will use the channel raster defined for SUL bands which is ffs.

“Floating sync” enables SCS based raster and down selection of the sync raster for bands using 100kHz raster as described in subclause 4.3.1.4.

For the 100 kHz based raster:

- Raster entries are given by the following equation for each band

- Lower band edge(MHz)+ N\*0.1MHz, N chosen such that last entry is at Upper band

- Raster to subcarrier position mapping

- Raster points to the center of the channel

- SC#0 of RB# NRB/2 for even number of RBs

- SC#6 of RB# floor(NRB/2) for odd number of RBs

For the SCS-based raster:

- Raster will be based on absolute frequency values

- The raster positions will be integer multiples of 15kHz for sub6 bands

- The raster positions will be integer multiples of 60kHz for mmWave range bands

- Raster entries are indexed from 0kHz

- Raster to subcarrier position mapping

- Raster points to the center of the channel

- SC#0 of RB# NRB/2 for even number of RBs

- SC#6 of RB# floor(NRB/2) for odd number of RBs

NR-ARFCN defines the absolute radio frequency of the channel raster points and is globally defined; The frequency band and duplex (uplink or downlink) are not distinguished by the NR-ARFCN. It is for RAN2 to decide how to signal the frequency of Pcell, Scell, SUL, and/or the reference frequency for PRB grid, etc, using NR-ARFCN or other means.NR-ARFCN for FR1 are defined as one global set from 0 Hz to 24 GHz:

- An integer multiple of 5kHz from 0 to 3GHz

- An integer multiple of 15kHz from 3 to 24GHz

NR-ARFCN for FR2 are defined as one global set from 24 GHz to 100 GHz

- An integer multiple of 60kHz

NR-ARFCN range for each frequency band is tabulated in RAN4 specs. The corresponding signalling is for RAN2 to design.

#### 4.3.1.4 Synchronization Channel raster

Sync raster is defined such that there is a minimum number of entries for each band. Sync raster entries will be included in the specifications for each band. Sync raster entries will be defined for initial system acquisition, sync blocks can be transmitted in other frequency locations if the position is signalled to the UE

The sync block is not RB aligned with the data RBs in the channel as shown in Figure 4.3.1.4-1. Instead, there is an arbitrary offset between the edge of the sync block RBs and the edge of the data RBs in the channel, this offset can be up to 11 REs. This enables multiple channels that are subcarrier grid aligned but not RB grid aligned to use the same sync block location. Different channels that are offset by up to 11 REs in frequency can re-use the same sync block frequency location.

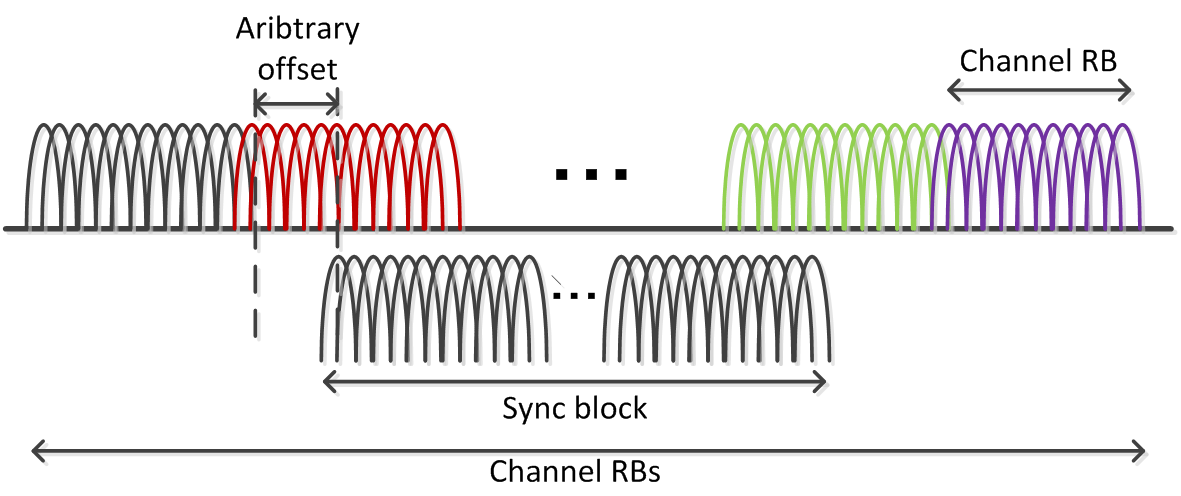


Figure 4.3.1.4-1: Alignment between SS block and channel RBs.

Subcarrier mapping:

- Sync raster will indicate the position of RE=#0(subcarrier #0) of RB#10 of the SS block.

SS Raster Definition for the 0 – 3.0 GHz range:

- SS Raster is defined as

- Raster entry = N \* 1200 kHz + M \* 50 kHz, N=1:2499, M ϵ {1,3,5}  
(For operating bands with SCS spaced channel raster, the value M=3 is used.)

- Raster entry numbering in this range is in increasing order of frequency, starting numbering at #2 (entry #2=1250 kHz, entry #3=1350 kHz, entry #4=1450 kHz, entry#5=2450 kHz…)

- Total number of entries 7497

- Raster applies to bands with 100 kHz channel raster and 15 kHz channel raster with 5 MHz minimum bandwidth (bands might be defined in the future) in this frequency range

SS Raster Definition for the 3.0 - 24.25 GHz range:

- SS Raster is defined as:

- Raster entry = 3000 MHz + N \* 1.44 MHz, N= 0: 14756

- Raster entry numbering is in increasing order of frequency, starting at 7499

- Total number of entries 14757

- Raster applies to bands with 15 kHz channel raster and 10 MHz minimum bandwidth (n77,n78, n79, etc) in this frequency range

SS Raster Definition for the 24.25-100GHz range

- SS Raster is defined as:

- Raster entry = 24250.08 MHz + N \* 17.28 MHz, N= 0:4383

- Raster entry numbering is in increasing order of frequency, starting at 22256

- Total number of entries 4384

- Raster applies to bands with 60 kHz channel raster in this frequency range

#### 4.3.1.5 Calculations of sync raster GSCN per operating band

For each operating band, the GSCN that can be used in the band are tabulated in subclause 5.4.3.3 of TS 38.104 [7], TS 38.101-1 [4] and TS 38.101-2 [5]. Selection of GSCN for Table(s) is done the following way:

- Include GSCN that correspond to SS block that completely fit within the channel bandwidth, accounting for guard bands needed.

- Guard bands are calculated based on the minimum channel BW in table 5.3.5-1 and table 5.3.5-2 of TS 38.104 [7], the SCS for the SS block and the corresponding NRB (spectrum utilization), assuming that the SS block can be in any position within the transmission BW configuration, including at positions adjacent to the edges.

- For GSCN ranges with step size <N>, the GSCN numbers selected should be multiples of N (this ensures that overlapping bands will have the same GSCN sequences)

For specific combinations of minimum channel bandwidth and SS block SCS, the GSCN ranges are down-selected using a step size <N>, as shown in Table 4.3.1.5-1.

Table 4.3.1.5-1: Down selection factors (step size).

|  |  |  |  |
| --- | --- | --- | --- |
| Frequency range | Minimum channel bandwidth | SS block SCS | Down selection factor (step size) |
| 0 – 3.0 GHz | 10 MHz | 15 kHz | <3> |
| 3.0 - 24.25 GHz | 40 MHz | 30 kHz | <16> |
| 24.25 – 100 GHz | 100 MHz | 240 kHz | <2> |

To determine the GSCN range, let *f*min denote the lowest frequency location of the SS block within a band after accounting for the guard band *G* in subclause 5.3.3 of TS 38.104 [7] corresponding to the minimum channel BW and the bandwidth encompassing the width of all subcarriers from RE#0 of RB#0 to the centre of RE#0 of RB#10 of the SS block. Let *f*max denote the high frequency location of the SS block within a band after accounting for the guard band and the bandwidth from the centre of RE#0 of RB#10 and encompassing the width of all subcarriers until RE#11 of RB#19 of the SS block. Let *F*low represent the lowest frequency of the frequency range in subclause 4.3.1.4, Δ*F*raster represent the raster spacing in MHz, Δ*F*shift represent the raster shift in MHz (applicable for the frequency range 0 to 3000MHz).

The lowest frequency location *f*min is computed as

where is the subcarrier spacing, is the number of REs per RB, is the number of RBs in the SS block.

The highest frequency location *f*max is computed as

where *WBand* is the width of the operating band.

The first possible raster location within a band (prior to applying the step size) is given by

while the last possible raster location within a band (prior to applying the step size) is given by

where Δ*F*shift is defined to be 0 outside the frequency range 0 to 3000MHz and where N (and M) are defined in subclause 4.3.1.4.

For the first possible raster location, *N*min is the smallest integer satisfying

and the corresponding value of M (if defined and if multiple values are defined)

For the last possible raster location, *N*max is the largest integer satisfying

and the corresponding value of M (if defined and if multiple values are defined)

For the frequency ranges in subclause 4.3.1.4, table 4.3.1.5-2 indicates the formulas used to compute the values of N and M (if necessary).

Table 4.3.1.5-2: Formulas to compute the minimum and maximum values of GSCN

|  |  |  |  |
| --- | --- | --- | --- |
| Type | Parameter | Range | Formula |
| For GSCNmin | N (compute first) | 0-3000 MHz |  |
| ≥ 3000 MHz |  |
| M | 0-3000 MHz |  |
| 0-3000 MHz, NOTE | 3 |
| ≥ 3000 MHz | N/A |
| For GSCNmax | N (compute first) | 0-3000 MHz |  |
| ≥ 3000 MHz |  |
| M | 0-3000 MHz |  |
| 0-3000 MHz, NOTE | 3 |
| ≥ 3000 MHz | N/A |
| NOTE: Refers to Note in Table 5.4.3.1-1 in TS 38.101-1 [4] for bands with SCS-based raster below 3000 MHz. | | | |

To compute the GSCN ranges with step size <N>, the N and M (when defined) values computed with the formulas in table 4.3.1.5-2 are used to determine GSCNmin′ and GSCNmax′ according to the appropriate raster entry formula from subclause 4.3.1.4. The first entry in the GSCN range, GSCNmin, is determined by

and the last entry in the range, GSCNmax, is determined by

.

Note that GSCN in some bands may be defined according to deployment need instead of using the equations in this clause.

### 4.3.2 Channel spacing for adjacent NR carriers

The spacing between carriers will depend on the deployment scenario, the size of the frequency block available and the channel bandwidths. The nominal channel spacing between two adjacent NR carriers shall be multiple of channel raster. As such, the channel spacing should be specified separately for different channel raster and additional offset may be needed pending on channel raster and different channel bandwidth combination for adjacent NR carriers.

### 4.3.3 Channel spacing for intra-band CA

For LTE intra-band contiguous CA, the following assumptions are considered:

- the aggregated bandwidth shall be no more than BWChannel(1) +BWChannel(2)

- the outer guard bands of the two CCs are symmetric.

- the channel spacing shall be multiple of LCM (least common multiple) of channel raster and SCS ( i.e. 300 kHz of 100kHz channel raster and 15kHz SCS for LTE), this is to be compatible with the channel raster and at the same time to maintain the orthogonality of the sub-carriers spacing.

Above three assumptions could be reused for NR intra-band contiguous CA although there are some following differences between LTE and NR:

- Minimum guard band of the outermost carriers should be used, rather than fixed guard bands (= 0.05\*BW) for each channel bandwidth

- The channel raster of 100kHz, 15kHz and 60kHz are supported.

- Several SCSs are supported

Considering the combination of channel raster and SCS for each carrier, the NR intra-band contiguous CA channel spacing should be separately defined correspondingly. In order to be compatible with the channel raster and the orthogonality of the sub-carriers spacing, the NR CA channel spacing shall be multiple of LCM of channel raster and SCS, listed in table 4.3.3-1.

Table 4.3.3-1. LCM {channel raster, SCS} for NR intra-band contiguous CA

| Frequency range | Channel raster | Data SCS for carrier(s) | LCM {channel raster, SCS} |
| --- | --- | --- | --- |
| FR1 | 100 kHz | 15 kHz, 30 kHz, 60 kHz | 300 kHz |
| 15 kHz | 15 kHz, 30 kHz, 60 kHz | 15\*2n kHz |
| FR2 | 60 kHz | 60kHz, 120 kHz | 60\*2n kHz |
| Note 1: The SCS for component carrier can be different. In this case, the SCS in the LCM {channel raster, SCS} is the maximum SCS of the carriers.  Note 2: *µ*1 and *µ*2 are the subcarrier spacing configurations of the component carriers as defined in TS 38.211 [8]. | | | |

The channel spacing for intra-band contiguous carrier aggregation can be adjusted to any multiple of least common multiple of channel raster and sub-carrier spacing less than the nominal channel spacing to optimize performance in a particular deployment scenario.

## 4.4 Subcarrier spacing

### 4.4.1 Non-SS channels

NR supports operation of different numerologies involving different sub-carrier spacings, as well as operation in different parts of the frequency domain.

The subcarrier spacing used for non-SS transmission impacts several aspects of performance, including:

- The maximum channel bandwidth that can be supported using a feasible FFT size

- Larger subcarrier spacing implies larger bandwidth

- The inter-carrier interference due to phase noise

- Larger subcarrier spacing implies greater phase noise robustness

- The symbol length and hence delay characteristics

- Larger subcarrier spacing implies shorter symbols

The characteristics of range 1 and range 2 in terms of achievable phase noise, channel delay profiles and expected bandwidths differ considerably and hence the supported SCS options were decided separately for range 1 and range 2. Several options for SCS are supported for each range. The SCS supported for each band will be selected on a band specific basis from the options defined for the corresponding range.

The SCS options were decided to be as follows:

Table 4.4-1 Non-SS subcarrier spacing options

|  |  |
| --- | --- |
| **Frequency range** | **SCS options (Non-SS)** |
| Range 1 (Below 1GHz) | 15, 30 kHz |
| Range 1 (Above 1GHz) | 15, 30, 60 kHz |
| Range 2 | 60, 120 kHz |

## 4.5 Spectrum utilization

### 4.5.1 General

In order to settle spectrum utilization for NR, a number of factors have been taken into account, including:

- Increasing the spectrum utilization compared to E-UTRA

- The spectrum efficiency gains corresponding to the spectrum utilization increase

- The impact of the spectrum utilization on implementations, including both filtering and windowing solutions to spectrum confinement

- The impact of the spectrum confinement technique needed for achieving the spectrum utilization on signal quality (EVM), both across the band and at the band edges

- The impact of the spectrum utilization on receiver performance considering ACS, phase noise reciprocity

- Relevant requirements on SEM, ACS etc.

- Expected transmitter power

Whilst defining a single set of spectrum utilization values in Rel-15 for both UL and DL, three co-existence scenarios were considered for spectrum utilization as depicted in figure 4.5.1-1. In the figure, X% is defined as utilization required to be achievable with the Rel-15 requirements. Y% is defined as utilization not required to be achievable with the Rel-15 requirements.



Figure 4.5.1-1 Coexistence scenarios for two adjacent NR channels

From TX side, BS/UE is expected to always meet all TX requirements such as EVM, out-of-band emission requirements (SEM and ACLR) and spurious requirements for the Rel-15 utilization X%. Thus, BS/UE TX and RX requirements were developed for scenario 1.

In addition, it was noted that for a co-ordinated operator deployment, scenarios 2 and 3 may be possible on a “system level” (i.e. from BS perspective). Operating in such a manner could potentially cause interference to other operators, this depends on the scenario.

- Note that this does not require higher spectrum utilization from the UE perspective. More specifically, for such scenarios UE TX / RX baseband processing capabilities are limited by the X% resource utilization and UE may not support higher utilization.

- The impacts to interference, blocking etc. to neighbouring operators will need to be considered and managed by the operator taking into account the specific deployments of the different operators.

Consideration was also given to how to accommodate future potential RAN4 minimum requirements for Y% utilization in scenarios 2 and 3.

- A RAN4 minimum requirement for higher spectrum utilization Y% would be considered only if it could improve system and/or user throughput compared to X% . How to evaluate system and user throughput would need study.

- Feasibility and complexity cost would also need to be considered when evaluating RAN4 minimum requirement for higher spectrum utilisation in a future release

- If future analyses would justify the introduction of minimum higher spectrum utilization Y%:

- Later release specification and requirements impact is FFS

- The same BS/UE Tx Rel-15 requirements will continue to be applicable. (i.e. No impact on BS/UE TX and RX Rel-15 requirements defined for X% ).

- If needed, relevant BS/UE RX minimum requirements could be revised/added.

- Whether Y% would be mandatory for BS/UE or not would be FFS in the future release

EVM requirements measured over edge PRBs is FFS. RB values for NR spectrum utilization are agreed based on the assumption of no edge PRB EVM requirements in Rel-15.

RAN1 and RAN2 confirmed that physical layer and L2/3 signalling supports allocation of PRBs up to the theoretical maximum number for the channel bandwidth.

### 4.5.2 Maximum RB Allocation, Transmission Bandwidth and Spectrum Utilization for FR1

#### 4.5.2.1 CP-OFDM waveform

Spectrum Utilization refers to the proportion of the channel bandwidth that can be used for transmission. RAN4 defined a single set spectrum utilization values in Rel-15 for both UL and DL. The following maximum RB allocation defines the minimum spectrum utilization to be realized per channel bandwidths and valid sub-carrier spacing.

Table 4.5.2.1-1: Range 1 NR UE and BS maximum RB allocation for CP-OFDM

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| SCS [kHz] | BS / UE Channel bandwidths [MHz] | | | | | | | | | | | | |
| 5 | 10 | 15 | 20 | 25 | 30 | 40 | 50 | 60 | 701 | 80 | 901 | 100 |
| 15 | 25 | 52 | 79 | 106 | 133 | [160] | 216 | 270 | N.A | N.A | N.A | N.A | N.A |
| 30 | 11 | 24 | 38 | 51 | 65 | [78] | 106 | 133 | 162 | [189] | 217 | [245] | 273 |
| 60 | N.A | 11 | 18 | 24 | 31 | [38] | 51 | 65 | 79 | [93] | 107 | [121] | 135 |
| NOTE 1: 70MHz and 90MHz are defined only as BS channel bandwidths in release 15. | | | | | | | | | | | | | |

Table 4.5.2.1-2: Range 1 NR UE and BS transmission bandwidths in MHz for CP-OFDM

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| SCS [kHz] | BS / UE Channel bandwidths [MHz] | | | | | | | | | | | | |
| 5 | 10 | 15 | 20 | 25 | 30 | 40 | 50 | 60 | 701 | 80 | 901 | 100 |
| 15 | 4.5 | 9.36 | 14.22 | 19.08 | 23.94 | [28.80] | 38.88 | 48.6 | N.A | N.A | N.A | N.A | N.A |
| 30 | 3.96 | 8.64 | 13.68 | 18.36 | 23.40 | [28.08] | 38.16 | 47.88 | 58.32 | [68.04] | 78.12 | [88.20] | 98.28 |
| 60 | N.A | 7.92 | 12.96 | 17.28 | 22.32 | [27.36] | 36.72 | 46.8 | 56.88 | [66.96] | 77.04 | [87.12] | 97.20 |
| NOTE 1: 70MHz and 90MHz are defined only as BS channel bandwidths in release 15. | | | | | | | | | | | | | |

Transmit bandwidth for CP-OFDM can be significantly different across the different sub-carrier spacing for a given channel bandwidth, this must be taken into account for UE REFSENS thermal noise integration bandwidth as it results in some cases into close to 1dB REFSENS improvement for the higher numerologies.

Table 4.5.2.1-3: Range 1 NR UE and BS spectrum utilization for CP-OFDM

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| SCS [kHz] | BS / UE Channel bandwidths [MHz] | | | | | | | | | | | | |
| 5 | 10 | 15 | 20 | 25 | 30 | 40 | 50 | 60 | 701 | 80 | 901 | 100 |
| 15 | 90.0% | 93.6% | 94.8% | 95.4% | 95.8% | [96.0]% | 97.2% | 97.2% | N.A | N.A | N.A | N.A | N.A |
| 30 | 79.2% | 86.4% | 91.2% | 91.8% | 93.6% | [93.6]% | 95.4% | 95.8% | 97.2% | [97.2]% | 97.7% | [98.0]% | 98.3% |
| 60 | N.A | 79.2% | 86.4% | 86.4% | 89.3% | [91.2]% | 91.8% | 93.6% | 94.8% | [95.7]% | 96.3% | [96.8]% | 97.2% |
| NOTE 1: 70MHz and 90MHz are defined only as BS channel bandwidths in release 15. | | | | | | | | | | | | | |

The minimum requirements in RAN4 are met with the agreed spectral occupancy under the condition that the BS or UE channel bandwidth centre is placed at SC 0 or SC 6 of the PRB grid such that the PRB utilization is symmetrical around the channel centre for the SCS under test.

For the UE, both the channel bandwidth and the position of the PRB grid with respect to the UE channel bandwidth centre depend upon configuration. In some configurations, the centre of the UE channel bandwidth may not align with the PRB grid in a manner that enables symmetric PRB utilization around the centre. For the BS, when multiple SCS are transmitted then the rule that SC 0 should align over all SCS at a point A can mean that the PRB alignment with the channel centre is not ideal for some SCS and asymmetry may arise.

In these cases, the PRB utilization is the set of PRBs that fall within the UE or BS channel bandwidth and do not violate the minimum guard band, as captured in the tables below, and depicted in figure 4.5.2.1-1.

The minimum guard bands have been calculated using the following equation: (CBW x 1000 (kHz) - RB value x SCS x 12) / 2 - SCS/2



Figure 4.5.2.1-1 UE or BS can use all PRBs that do not overlap with the minimum guard band, considering the centre PRB alignment

Table 4.5.2.1-4: Range 1 NR UE and BS minimum guard band sizes (kHz) for CP-OFDM

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| SCS [kHz] | BS / UE Channel bandwidths [MHz] | | | | | | | | | | | | |
| 5 | 10 | 15 | 20 | 25 | 30 | 40 | 50 | 60 | 701 | 80 | 901 | 100 |
| 15 | 242.5 | 312.5 | 382.5 | 452.5 | 522.5 | [592.5] | 552.5 | 692.5 | N.A | N.A | N.A | N.A | N.A |
| 30 | 505 | 665 | 645 | 805 | 785 | [945] | 905 | 1045 | 825 | [965] | 925 | [885] | 845 |
| 60 | N.A | 1010 | 990 | 1330 | 1310 | [1290] | 1610 | 1570 | 1530 | [1490] | 1450 | [1410] | 1370 |
| NOTE 1: 70MHz and 90MHz are defined only as BS channel bandwidths in release 15. | | | | | | | | | | | | | |

#### 4.5.2.2 DFT-s-OFDM waveform

The following RB allocation is the closest number lower or equal to CP-OFDM maximum RB allocation satisfying the following equation, partial RB allocations shall also conform to this equation:

number of RB=2^X\*3^Y\*5^Z

Table 4.5.2.2-1: Range 1 NR UE maximum RB allocation for DFT-s-OFDM

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| SCS [kHz] | Channel bandwidths [MHz] | | | | | | | | | | |
| 5 | 10 | 15 | 20 | 25 | 30 | 40 | 50 | 60 | 80 | 100 |
| 15 | 25 | 50 | 75 | 100 | 128 | [160] | 216 | 270 | N.A | N.A | N.A |
| 30 | 10 | 24 | 36 | 50 | 64 | [75] | 100 | 128 | 162 | 216 | 270 |
| 60 | N.A | 10 | 18 | 24 | 30 | [36] | 50 | 64 | 75 | 100 | 135 |

RB numbering for DFT-s-OFDM waveforms is the same than the RB number for CP-OFDM it is aligned with. In the case where DFT-s-OFDM maximum RB allocation is smaller than the CP-OFDM maximum allocation, all positions within the CP-OFDM allocation are valid. This implies that RBstart values can be higher than the maximum allocation for DFT-s-OFDM. The valid RB start values follow the following equation:

RBstart DFT-s-OFDM range = 0 to (CP-OFDM maxRB) – (DFT-s-OFDM #RB)

Table 4.5.2.2-2: Range 1 NR UE transmission bandwidths in MHz for DFT-s-OFDM

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| SCS [kHz] |  | | Channel bandwidths [MHz] | | | | | | | | | |
| 5 | 10 | | 15 | 20 | 25 | 30 | 40 | 50 | 60 | 80 | 100 |
| 15 | 4.5 | 9 | | 13.5 | 18 | 23.04 | [28.80] | 38.88 | 48.6 | N.A | N.A | N.A |
| 30 | 3.6 | 8.64 | | 12.96 | 18 | 23.04 | [27.00] | 36 | 46.08 | 58.32 | 77.76 | 97.2 |
| 60 | N.A | 7.2 | | 12.96 | 17.28 | 21.6 | [25.92] | 36 | 46.08 | 54 | 72 | 97.2 |

For DFT-s-OFDM, when the maximum allocation is smaller than for CP-OFDM the transmit bandwidth is smaller, as a consequence the UE spectrum utilization can be smaller for DFT-s-OFDM than for CP-OFDM and in most cases equivalent to LTE.

Table 4.5.2.2-3: Range 1 NR UE spectrum utilization for DFT-s-OFDM

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| SCS [kHz] |  | Channel bandwidths [MHz] | | | | | | | | | |
| 5 | 10 | 15 | 20 | 25 | 30 | 40 | 50 | 60 | 80 | 100 |
| 15 | 90.0% | 90.0% | 90.0% | 90.0% | 92.2% | 96.0% | 97.2% | 97.2% | N.A | N.A | N.A |
| 30 | 72.0% | 86.4% | 86.4% | 90.0% | 92.2% | 90.0% | 90.0% | 92.2% | 97.2% | 97.2% | 97.2% |
| 60 | N.A | 72.0% | 86.4% | 86.4% | 86.4% | 86.4% | 90.0% | 92.2% | 90.0% | 90.0% | 97.2% |

### 4.5.3 Maximum RB Allocation, Transmission Bandwidth and Spectrum Utilization for FR2

#### 4.5.3.1 CP-OFDM Waveform

The following maximum RB allocation defines the minimum spectrum utilization to be realized per channel bandwidths and valid sub-carrier spacing.

Table 4.5.3.1-1: Range 2 NR UE and BS maximum RB allocation for CP-OFDM

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SCS [kHz] | BS / UE Channel bandwidths [MHz] | | | |
| 50 | 100 | 200 | 400 |
| 60 | 66 | 132 | 264 | N.A |
| 120 | 32 | 66 | 132 | 264 |

Table 4.5.3.1-2: Range 2 NR UE and BS transmission bandwidths in MHz for CP-OFDM

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SCS [kHz] | BS / UE Channel bandwidths [MHz] | | | |
| 50 | 100 | 200 | 400 |
| 60 | 47.52 | 95.04 | 190.08 | N.A |
| 120 | 46.08 | 95.04 | 190.08 | 380.16 |

Table 4.5.3.1-3: Range 2 NR UE and BS spectrum utilization for CP-OFDM

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SCS [kHz] | BS / UE Channel bandwidths [MHz] | | | |
| 50 | 100 | 200 | 400 |
| 60 | 95.0% | 95.0% | 95.0% | N.A |
| 120 | 92.2% | 95.0% | 95.0% | 95.0% |

Table 4.5.3.1-4: Range 2 NR UE and BS minimum guard band sizes (kHz) for CP-OFDM

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SCS [kHz] | BS / UE Channel bandwidths [MHz] | | | |
| 50 | 100 | 200 | 400 |
| 60 | 1210 | 2450 | 4930 | N.A |
| 120 | 1900 | 2420 | 4900 | 9860 |

#### 4.5.3.2 DFT-s-OFDM waveform

The following RB allocation is the closest number lower or equal to CP-OFDM maximum RB allocation satisfying the following equation, partial RB allocations shall also conform to this equation:

number of RB=2^X\*3^Y\*5^Z

Table 4.5.3.2-1: Range 2 NR UE maximum RB allocation for DFT-S-OFDM

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SCS [kHz] | BS / UE Channel bandwidths [MHz] | | | |
| 50 | 100 | 200 | 400 |
| 60 | 64 | 128 | 264 | N.A |
| 120 | 32 | 64 | 128 | 264 |

RB numbering for DFT-s-OFDM waveforms is the same than the RB number for CP-OFDM it is aligned with. In the case where DFT-s-OFDM maximum RB allocation is smaller than the CP-OFDM maximum allocation, all positions within the CP-OFDM allocation are valid. This implies that RBstart values can be higher than the maximum allocation for DFT-s-OFDM. The valid RB start values follow the following equation:

RBstart DFT-s-OFDM range = 0 to (CP-OFDM maxRB) – (DFT-s-OFDM #RB)

Table 4.5.3.2-2: Range 2 NR UE transmission bandwidths in MHz for DFT-S-OFDM

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SCS [kHz] | BS / UE Channel bandwidths [MHz] | | | |
| 50 | 100 | 200 | 400 |
| 60 | 46.08 | 92.16 | 190.08 | N.A |
| 120 | 46.08 | 92.16 | 184.32 | 380.16 |

Table 4.5.3.2-3: Range 2 NR UE spectrum utilization for DFT-S-OFDM

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SCS [kHz] | BS / UE Channel bandwidths [MHz] | | | |
| 50 | 100 | 200 | 400 |
| 60 | 92.2% | 92.2% | 95.0% | N.A |
| 120 | 92.2% | 92.2% | 92.2% | 95.0% |

### 4.5.4 Sub-carrier alignment with DC and between numerologies and their impact to guard bands for FR1

From RAN1 agreement, the lowest valid SCS allocation must be such that one sub-carrier is aligned with DC (channel centre). This results in a shift of ½ SCS for the lowest valid SCS for a given channel bandwidth. Similarly, the different SCS in a given channel bandwidth, must have their sub-carrier 0 aligned for all numerologies. The following table provides the lowest numerology RB number for which the RB0 sub carrier 0 aligns with the lowest numerology sub carrier 0. This alignment is valid for the case where the reference SCS is the lowest valid SCS.

Table 4.5.4-1: Lowest SCS RB number for which the first SC0 are aligned

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| SCS [kHz] | Channel bandwidths [MHz] | | | | | | | | | |
| 5 | 10 | 15 | 20 | 25 | 40 | 50 | 60 | 80 | 100 |
| 15 | RB0 | RB0 | RB0 | RB0 | RB0 | RB0 | RB0 | N.A | N.A | N.A |
| 30 | RB2 | RB2 | RB2 | RB2 | RB2 | RB2 | RB2 | RB0 | RB0 | RB0 |
| 60 | N.A | RB4 | RB4 | RB6 | RB4 | RB6 | RB6 | RB2 | RB2 | RB2 |

The following table provides the frequency shift for all the numerologies based on lowest SCS alignment with DC and the SC0 alignment rule between SCS.

Table 4.5.4-2: allocation shift in KHz

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| SCS [kHz] | Channel bandwidths [MHz] | | | | | | | | | |
| 5 | 10 | 15 | 20 | 25 | 40 | 50 | 60 | 80 | 100 |
| 15 | -7.5 | -7.5 | -7.5 | -7.5 | -7.5 | -7.5 | -7.5 | NA | NA | NA |
| 30 | 75 | -15 | 75 | -15 | 75 | -15 | -15 | -15 | -15 | -15 |
| 60 | NA | -30 | 60 | 150 | -120 | -30 | 150 | -30 | 150 | 150 |

From these alignments, the lower and upper guard-bands can be calculated and are provided in the table below.

Table 4.5.4-3: Lower and upper channel guard-bands in kHz

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | SCS [kHz] | Channel bandwidths [MHz] | | | | | | | | | |
| 5 | 10 | 15 | 20 | 25 | 40 | 50 | 60 | 80 | 100 |
| Lower  Guard  Band | 15 | 242.5 | 312.5 | 382.5 | 452.5 | 522.5 | 552.5 | 692.5 | N.A | N.A | N.A |
| 30 | 595 | 665 | 735 | 805 | 875 | 905 | 1045 | 825 | 925 | 845 |
| 60 | N.A | 1010 | 1080 | 1510 | 1220 | 1610 | 1750 | 1530 | 1630 | 1550 |
| Upper  Guard  Band | 15 | 257.5 | 327.5 | 397.5 | 467.5 | 537.5 | 567.5 | 707.5 | N.A | N.A | N.A |
| 30 | 445 | 695 | 585 | 835 | 725 | 935 | 1075 | 855 | 955 | 875 |
| 60 | N.A | 1070 | 960 | 1210 | 1460 | 1670 | 1450 | 1590 | 1330 | 1250 |

### 4.5.5 Spectrum utilization when operating multiple numerologies

The flexible NR design enables optional frequency multiplexing of transmissions with different subcarrier spacing within the same carrier. If this is the case, then a spectrum occupancy must be calculated taking into account both numerologies. In release 15, for the UE this agreement relates to determining spectrum utilization where SRB and PDSCH have different numerologies and are frequency division multiplexed. For the BS, transmission or reception may be made with multiple numerologies.

In such cases, at each side of the carrier, the guard size is selected corresponding to the numerology operated immediately adjacent to the carrier edge and the bandwidth of the whole carrier. In the example below, if the carrier bandwidth would be e.g. 20MHz, then on the left hand side the guard would be the guard corresponding to 15kHz SCS and 20MHz bandwidth and the guard on the left hand side would be the guard corresponding to 60k SCS and 20MHz bandwidth. The guard sizes would not depend on the proportion of the carrier allocated to each numerology. (Note that the figure does not imply anything about the size of any guard between the numerologies; the inter-numerology guard within the same carrier is implementation dependent).

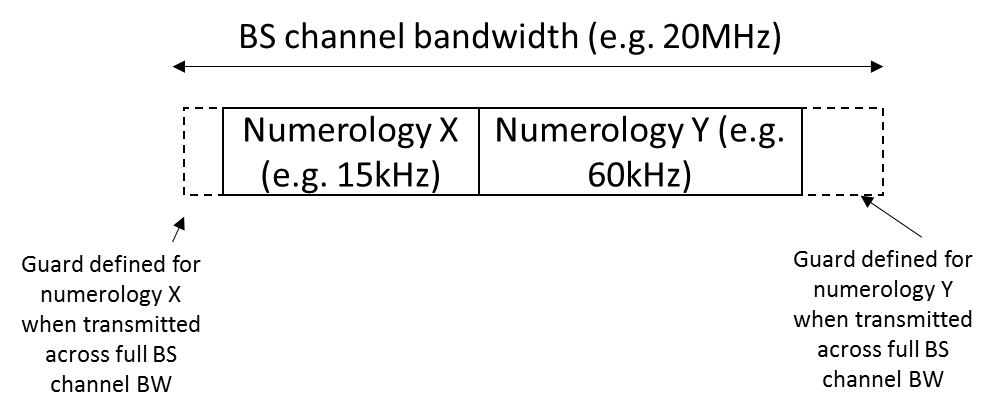


Figure 4.5.x-1 Example of multiple numerology transmission

When following this agreement, the possibility exists that the BS or UE channel bandwidth may be larger than the maximum bandwidth supported by one of the numerologies that is next to the carrier edge. For example, a 100MHz carrier may be transmitted with a 10MHz, 15kHz SCS allocation adjacent to the edge of the carrier. For these situations, a guard band size is defined as follows:

- For FR1, if multiple numerologies are multiplexed in the same symbol and the BS channel bandwidth is >50MHz, the guardband applied adjacent to 15k SCS shall be the same as the guardband defined for 30k SCS for the same BS channel bandwidth.

- For FR2, if multiple numerologies are multiplexed in the same symbol and the BS channel bandwidth is >200MHz, the guardband applied adjacent to 60k SCS shall be the same as the guardband defined for 120k SCS for the same BS channel bandwidth.

## 4.6 Mixed numerology requirements

### 4.6.1 Mixed Numerologies FDM operation use cases

A potential feature of NR is that the BS may transmit data using multiple numerologies in the same sub-frame using frequency division multiplexing. It has been agreed that in release 15, UEs will not be required to be able to receive data on multiple numerologies. If different parts of the same carrier are used for transmitting different numerologies, then the numerologies will not be fully orthogonal. Potentially, filtering or windowing could be used to achieve isolation between numerologies. In band emissions or EVM requirements, and receiver selectivity requirements could be considered to improve the inter-numerology isolation.

Two use cases for mixed numerology operation were discussed:

- Use Case #1: Data and Data mixed numerology FDM

- FDM’ed transmission or reception of physical channels (e.g. NR PDSCH, PDCCH, PUSCH, PUCCH) with different numerologies at the same instance in DL or UL

- Use Case #2: Data and SS block (SS, PBCH) mixed numerology FDM

- FDM’ed transmission or reception of SS block (SS/PBCH) and other physical channels (e.g. NR PDSCH, PDCCH) with different numerologies in DL

### 4.6.2 Data/Data mixed numerology FDM operation

The need for introducing RF requirements for isolating numerologies in such scenarios was investigated. The following conclusions were reached:

BS requirements:

- FDMed mixed numerologies for downlink and uplink data channel from BS perspective can be supported without additional in-band RF requirements compared to single numerology.

- UE shall be able to TX and RX with one of these numerologies.

UE requirements:

- Case 1 mixed numerology FDM can be supported without additional UE in-band RF requirements compared to single numerology (e.g. via using inter-numerology guard bands)

- Do not define in-band UE RF requirements for Case 1 mixed numerology FDM in Rel-15

- FFS if any additional mixed numerologies requirements need to be introduced in future releases

The decision was based around the following observations:

- For systems performing beamforming, spatial isolation between different users/numerologies may be achieved

- Inter-numerology interference does not impact performance at low to medium SINR

- At high SINR, the gNB scheduler can mitigate inter-numerology interference by means of allocating a guard between the numerologies; this would be an implementation decision

RAN4 also made the following working assumption: Rel-15 NR UE is not mandated to support simultaneous DL reception or UL transmission of multiple FDM’ed physical channels (e.g. NR PDSCH, PDCCH, PUSCH, PUCCH) with different numerologies at the same time instance.

### 4.6.3 Data/SS mixed numerology FDM operation

Transmission of SS and data using different numerologies is needed in systems supporting a different data numerology to the SS. Similar to the data/data case, there may exist interference between the SS and data numerologies. The following decisions were made:

- Data/SS mixed numerology FDM operation can be supported for both BS/UE without additional in-band RF requirements compared to single numerology.

- Do not define dedicated BS and UE in-band RF requirements in Rel-15 related to Data/SS mixed numerology FDM.

- Support of simultaneous reception of Data/SS with mixed numerologies is optional from UE implementation perspective.

- RAN4 will investigate further how UE RRM requirements will take this into account

- Case 1: Intra-frequency cell identification and measurements on the target cell while receiving Data from the serving cell with different numerology from SS

- Other cases are not precluded

The decision was based around the following observations about interference of data onto SS:

- The SS is designed for cell search to function at low SINR. In general, inter-numerology interference is not significant

- One potential case in which the interference could be more significant is the case in which data is transmitted using a very narrow beam in the same direction as a user who is attempting to detect SS from the same basestation, and the SS beam is wider. In this case, data may be received with higher power than the SS. However, this scenario only occurs when the user performing cell search is in the same direction as the user to whom data is transmitted, which is low probability and the associated degradation is not seen as significant.

and following observations around the degradation on data caused by SS

- Since the SS beam sweeps and is not transmitted in all subframes, any interference from SS onto data is only for a limited portion of the time

- Data is likely to be always transmitted with the same or grater beamforming gain than SS

- Any interference from SS is only significant at high SINR

- If there is any risk of interference to a high SINR user from SS during a subframe, the gNB scheduler can mitigate the interference by leaving a guard between the two as an implementation decision.

## 4.7 TRx test metrics

### 4.7.1 TRx test metrics and link direction in FR2

Table 4.7.1-1 summarizes test metrics and link direction for TRx requirements.

Table 4.7.1-1: Summary of test metrics and link direction in FR2

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Requirement | | Metrics in TR 38.803 [10] (Range 2 / OTA) | Assumed Link Direction | Assumed Metrics |
| TX | Transmitter Maximum Output Power | EIRP CDF | Each beam peak search grid (NOTE 1) | EIRP (Link=Beam peak search grids, Meas=Link angle) |
| TRP | TX beam peak direction obtained from above | TRP (Link=TX beam peak direction) |
| TX | Tx Spherical coverage | EIRP CDF | Each beam peak search grid (NOTE 1) | EIRP (Link=Beam peak search grids, Meas=Link angle) |
| TX | Maximum Power Reduction (MPR) | EIRP | TX beam peak direction (Reuse the result of MOP) | EIRP (Link=TX beam peak direction, Meas=Link angle) |
| TX | Additional Maximum Power Reduction (A-MPR) | EIRP | TX beam peak direction (Reuse the result of MOP) | EIRP (Link=TX beam peak direction, Meas=Link angle) |
| TX | Configured transmitted Output Power | EIRP | TX beam peak direction (Reuse the result of MOP) | EIRP (Link=TX beam peak direction, Meas=Link angle) |
| TX | Minimum Output Power | EIRP | TX beam peak direction (Reuse the result of MOP) | EIRP (Link=TX beam peak direction, Meas=Link angle) |
| TX | Transmit OFF power | TRP | TX beam peak direction (Reuse the result of MOP) | TRP (Link=TX beam peak direction) |
| TX | ON/OFF time mask | Beam peak | TX beam peak direction (Reuse the result of MOP) | EIRP (Link=TX beam peak direction, Meas=Link angle) |
| TX | Power Control tolerance (Absolute) | Beam peak | TX beam peak direction (Reuse the result of MOP) | EIRP (Link=TX beam peak direction, Meas=Link angle) |
| TX | Power Control tolerance (Relative) | Beam peak | TX beam peak direction (Reuse the result of MOP) | EIRP (Link=TX beam peak direction, Meas=Link angle) |
| TX | Power Control tolerance (Aggregated) | Beam peak | TX beam peak direction (Reuse the result of MOP) | EIRP (Link=TX beam peak direction, Meas=Link angle) |
| TX | Frequency error | Beam peak | TX beam peak direction (Reuse the result of MOP) | Frequency (Link=TX beam peak direction, Meas=Link angle) |
| TX | Error Vector Magnitude (EVM) | Beam peak | TX beam peak direction (Reuse the result of MOP) | EVM (Link=TX beam peak direction, Meas=Link angle) |
| TX | Error Vector Magnitude (EVM) - Spectrum Flatness | Beam peak | TX beam peak direction (Reuse the result of MOP) | EVM SF (Link=TX beam peak direction, Meas=Link angle) |
| TX | Carrier leakage | Beam peak | TX beam peak direction (Reuse the result of MOP) | Carrier Leakage (Link=TX beam peak direction, Meas=Link angle) |
| TX | In-band emissions ( non allocated RB ) | Beam peak | TX beam peak direction (Reuse the result of MOP) | In-band emission (Link=TX beam peak direction, Meas=Link angle) |
| TX | Occupied bandwidth | TRP -> Beam peak (NOTE 2) | TX beam peak direction (Reuse the result of MOP) | OBW (Link=TX beam peak direction, Meas=Link angle) |
| TX | Spectrum Emission Mask | TRP | TX beam peak direction (Reuse the result of MOP) | TRP (Link=TX beam peak direction) |
| TX | Adjacent Channel Leakage power Ratio | TRP | TX beam peak direction (Reuse the result of MOP) | TRP (Link=TX beam peak direction) |
| TX | General Spurious emissions | TRP | TX beam peak direction (Reuse the result of MOP) | TRP (Link=TX beam peak direction) |
| TX | Spurious emission UE-to-UE coexistence | TRP | TX beam peak direction (Reuse the result of MOP) | TRP (Link=TX beam peak direction) |
| TX | Additional spurious emissions | TRP | TX beam peak direction (Reuse the result of MOP) | TRP (Link=TX beam peak direction) |
| TX | [Beam correspondence] | [TBD] | [TBD] | [TBD] |
| RX | Reference sensitivity level | EIS CDF | Each beam peak search grid (NOTE 1) | EIS (Link=Beam peak search grids, Meas=Link Angle) |
| RX | Maximum input level | Beam peak | RX beam peak direction (Reuse the result of REFSENS) | EIS (Link=RX beam peak direction, Meas=Link angle) |
| RX | Adjacent Channel Selectivity (ACS) | Beam peak | RX beam peak direction (Reuse the result of REFSENS) | EIS (Link=RX beam peak direction, Meas=Link angle) |
| RX | In-band blocking | Beam peak | RX beam peak direction (Reuse the result of REFSENS) | EIS (Link=RX beam peak direction, Meas=Link angle) |
| RX | [Out-of-band blocking and Spurious response] | [TBD] | [TBD] | [TBD] |
| RX | Receiver Spurious emissions | TRP | TX beam peak direction (Reuse the result of MOP) | TRP (Link=TX beam peak direction) |
| RX | Receiver image | [TBD] | [TBD] | [TBD] |
| RX | In-channel selectivity | [TBD] | [TBD] | [TBD] |
| NOTE 1: Total number of points for measurement grid is up to TE vendors or test houses as far as it guarantees the agreement on the deviation (0.5 dB).  NOTE 2: Metric of OBW was changed from TRP to Beam peak to align BS specification. | | | | |

# 5 UE Transmitter characteristics (frequency range 1)

## 5.1 General

### 5.1.1 CA Bandwidth Class

For intra-band contiguous carrier aggregation, a carrier aggregation configuration is a single operating band supporting a carrier aggregation bandwidth class with associated bandwidth combination sets. For each carrier aggregation configuration, requirements are specified for all aggregated channel bandwidths contained in a bandwidth combination set, A UE can indicate support of several bandwidth combination sets per carrier aggregation configuration.

For intra-band non-contiguous carrier aggregation, a carrier aggregation configuration is a single operating band supporting two or more sub-blocks, each supporting a carrier aggregation bandwidth class.

For inter-band carrier aggregation, a carrier aggregation configuration is a combination of operating bands, each supporting a carrier aggregation bandwidth class.

Table 5.1.1-1 gives the proposed NR CA bandwidth class for FR1.

Table 5.1.1-1: NR CA Bandwidth Class for FR1

|  |  |  |
| --- | --- | --- |
| **NR CA bandwidth class** | **Aggregated channel bandwidth** | **Number of contiguous CC** |
| A | BWChannel\_CA ≤BWChannel,max | 1 |
| B | 20 MHz ≤ CBW ≤ 100 MHz | 2 |
| C | 100 MHz < BWChannel\_CA ≤ 2 x BWChannel,max | 2 |
| D | 200 MHz < BWChannel\_CA≤ 3 x BWChannel,max | 3 |
| E | 300 MHz < BWChannel\_CA≤ 4 x BWChannel,max | 4 |
| NOTE: BWChannel,max is maximum channel bandwidth supported among all bands in a release | | |

## 5.2 Transmit power

### 5.2.1 Power Class

The following NR UE Power Classes define the maximum output power for any transmission bandwidth within the channel bandwidth for non-CA configuration unless otherwise stated.

Table 5.2.1-1: NR UE power classes

|  |  |  |  |
| --- | --- | --- | --- |
| **NR Operating band** | **Class 2** | **Class 3** | **Comments** |
| n1 |  | 23 dBm ± 2 dB | LTE refarming band |
| n2 |  | 23 dBm ± 2 dB | LTE refarming band |
| n3 |  | 23 dBm ± 2 dB | LTE refarming band |
| n5 |  | 23 dBm ± 2 dB | LTE refarming band |
| n7 |  | 23 dBm ± 2 dB | LTE refarming band |
| n8 |  | 23 dBm ± 2 dB | LTE refarming band |
| n20 |  | 23 dBm ± 2 dB | LTE refarming band |
| n25 |  | 23 dBm ± 2 dB | LTE refarming band |
| n26 |  | 23 dBm ± 2 dB | LTE refarming band |
| n28 |  | 23 dBm +2/-2.5 dB | LTE refarming band |
| n34 |  | 23 dBm ± 2 dB | LTE refarming band |
| n38 |  | 23 dBm ± 2 dB | LTE refarming band |
| n39 |  | 23 dBm ± 2 dB | LTE refarming band |
| n40 |  | 23 dBm ± 2 dB | LTE refarming band |
| n41 | 26 dBm +2/-3 dB | 23 dBm ± 2 dB | LTE refarming band |
| n50 |  | 23 dBm ± 2 dB | LTE refarming band |
| n51 |  | 23 dBm ± 2 dB | LTE refarming band |
| n66 |  | 23 dBm ± 2 dB | LTE refarming band |
| n70 |  | 23 dBm ± 2 dB | LTE refarming band |
| n71 |  | 23 dBm +2/-2.5 dB | LTE refarming band |
| n74 |  | 23 dBm ± 2 dB | LTE refarming band |
| n77 | 26 dBm +2/-3 dB | 23 dBm +2/-3 dB | 3.3 - 4.2 GHz |
| n78 | 26 dBm +2/-3 dB | 23 dBm +2/-3 dB | 3.3 - 3.8 GHz |
| n79 | 26 dBm +2/-3 dB | 23 dBm +2/-3 dB | 4.4 - 5 GHz |
| n80 |  | 23 dBm ± 2 dBTBD | SUL 1710 - 1785 MHz |
| n81 |  | 23 dBm ± 2 dBTBD | SUL 880 - 915 MHz |
| n82 |  | 23 dBm ± 2 dBTBD | SUL 832 - 862 MHz |
| n83 |  | 23 dBm +2/-2.5 dB | SUL 703 - 748 MHz |
| n84 |  | 23 dBm ± 2 dB | SUL 1920 - 1980 MHz |
| n86 |  | 23 dBm ± 2 dB | SUL 1710 - 1780 MHz |
| NOTE: If the uplink/downlink configuration is 0 or 6, the requirements for power class 2 are not applicable, and the corresponding requirements for a power class 3 UE shall apply. | | | |

For UE with two transmit antenna connectors in closed-loop spatial multiplexing scheme, the maximum output power for any transmission bandwidth within the channel bandwidth is specified in Table 5.2.1-2.

Table 5.2.1-2: NR UE Power Class for UL-MIMO in closed loop spatial multiplexing scheme

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **EUTRA band** | **Class 1 (dBm)** | **Tolerance (dB)** | **Class 2 (dBm)** | **Tolerance (dB)** | **Class 3 (dBm)** | **Tolerance (dB)** | **Class 4 (dBm)** | **Tolerance (dB)** |
| n1 |  |  |  |  | 23 | +2/-3 |  |  |
| n2 |  |  |  |  | 23 | +2/-31 |  |  |
| n3 |  |  |  |  | 23 | +2/-31 |  |  |
| n5 |  |  |  |  | 23 | +2/-3 |  |  |
| n7 |  |  |  |  | 23 | +2/-31 |  |  |
| n8 |  |  |  |  | 23 | +2/-31 |  |  |
| n20 |  |  |  |  | 23 | +2/-31 |  |  |
| n25 |  |  |  |  | 23 | +2/-31 |  |  |
| n26 |  |  |  |  | 23 | +2/-31 |  |  |
| n28 |  |  |  |  | 23 | +2/-3 |  |  |
| n34 |  |  |  |  | 23 | +2/-3 |  |  |
| n38 |  |  |  |  | 23 | +2/-3 |  |  |
| n39 |  |  |  |  | 23 | +2/-3 |  |  |
| n40 |  |  |  |  | 23 | +2/-3 |  |  |
| n41 |  |  | 26 | +2/-31 | 23 | +2/-31 |  |  |
| n50 |  |  |  |  | 23 | +2/-3 |  |  |
| n51 |  |  |  |  | 23 | +2/-3 |  |  |
| n66 |  |  |  |  | 23 | +2/-3 |  |  |
| n70 |  |  |  |  | 23 | +2/-3 |  |  |
| n71 |  |  |  |  | 23 | +2/-3 |  |  |
| n74 |  |  |  |  | 23 | +2/-3 |  |  |
| n77 |  |  | 26 | +2/-3 | 23 | +2/-3 |  |  |
| n78 |  |  | 262 | +2/-3 | 23 | +2/-3 |  |  |
| n79 |  |  | 26 | +2/-3 | 23 | +2/-3 |  |  |
| NOTE 1: 1 refers to the transmission bandwidths confined within FUL\_low and FUL\_low + 4 MHz or FUL\_high – 4 MHz and FUL\_high, the maximum output power requirement is relaxed by reducing the lower tolerance limit by 1.5 dB  NOTE 2: How to mandate Power Class 2 UE in certain regions is FFS. | | | | | | | | |

If UE is configured for transmission on single-antenna port, the requirements in Table 5.2.1-1 apply.

### 5.2.2 MPR /A-MPR

### 5.2.3 UE maximum output power for modulation / RB allocation

For UE Power Class 3, the allowed Maximum Power Reduction (MPR) for the maximum output power in Table 5.2.1-1, due to higher order modulation and transmit bandwidth configuration (resource blocks) is specified in Table 5.2.3-1. The Maximum Power Reduction is constant across channel bandwidths up to 100MHz and all valid sub-carrier spacing and only depends on modulation type and order and RB allocation type: Outer RB allocations see higher MPR than Inner RB allocations, except for 64QAM and 256QAM where a single MPR value applies to any RB allocation.

Table 5.2.3-1: Maximum Power Reduction (MPR) for Power Class 3, Channel bandwidths up to 100MHz

|  |  |  |
| --- | --- | --- |
| Modulation | MPR (dB) | |
| Outer RB allocations | Inner RB allocations |
| DFT-s-OFDM PI/2 BPSK | ≤ [TBD] | ≤ [TBD] |
| DFT-s-OFDM QPSK | ≤ [TBD] | ≤ [TBD] |
| DFT-s-OFDM 16 QAM | ≤ [TBD] | ≤ [TBD] |
| DFT-s-OFDM 64 QAM | ≤ [TBD] | |
| DFT-s-OFDM 256 QAM | ≤ [TBD] | |
| CP-OFDM QPSK | ≤ [TBD] | ≤ [TBD] |
| CP-OFDM 16 QAM | ≤ [TBD] | ≤ [TBD] |
| CP-OFDM 64 QAM | ≤ [TBD] | |
| CP-OFDM 256 QAM | ≤ [TBD] | |

Where the following parameters are defined to specify valid RB allocation ranges for Outer and Inner RB allocations:

LCRBmax is the maximum number of RB for a given Channel bandwidth and sub-carrier spacing derived from from spectrum utilization.

RBstartLow = LCRB/2 rounded down to next integer with floor at 1

RBstartHigh = LCRBmax – RBstartLow – LCRB

Where Inner RB allocation range is specified as follows: Inner RB allocation are LCRB/2 away from each edge of the maximum RB allocation for all LCRB ≤ LCRBmax/2 rounded up to the next integer.

RBstartInner : valid RBstart values for Inner RB allocations

For LCRB ≤ LCRBmax/2 rounded up to the next integer, RBstartLow ≤ RBstartInner ≤ RBstartHigh

Where Outer RB allocation range is all allocations which are not Inner RB allocation

### 5.2.4 Inner RB allocation range for all 5MHz – 100MHz channel bandwidths and SCS

Figure 5.2.4-1 is illustrating Outer RB allocations in orange and Inner RB allocation in yellow for the two valid SCS for 5MHz channel. On the left side the two triangles correspond to the CP-OFDM allocations with 15kHz SCS in the lower left and 30kHz on the upper right, similarly, the same triangles for DFT-s-OFDM allocation can be found on the right side of the figure.

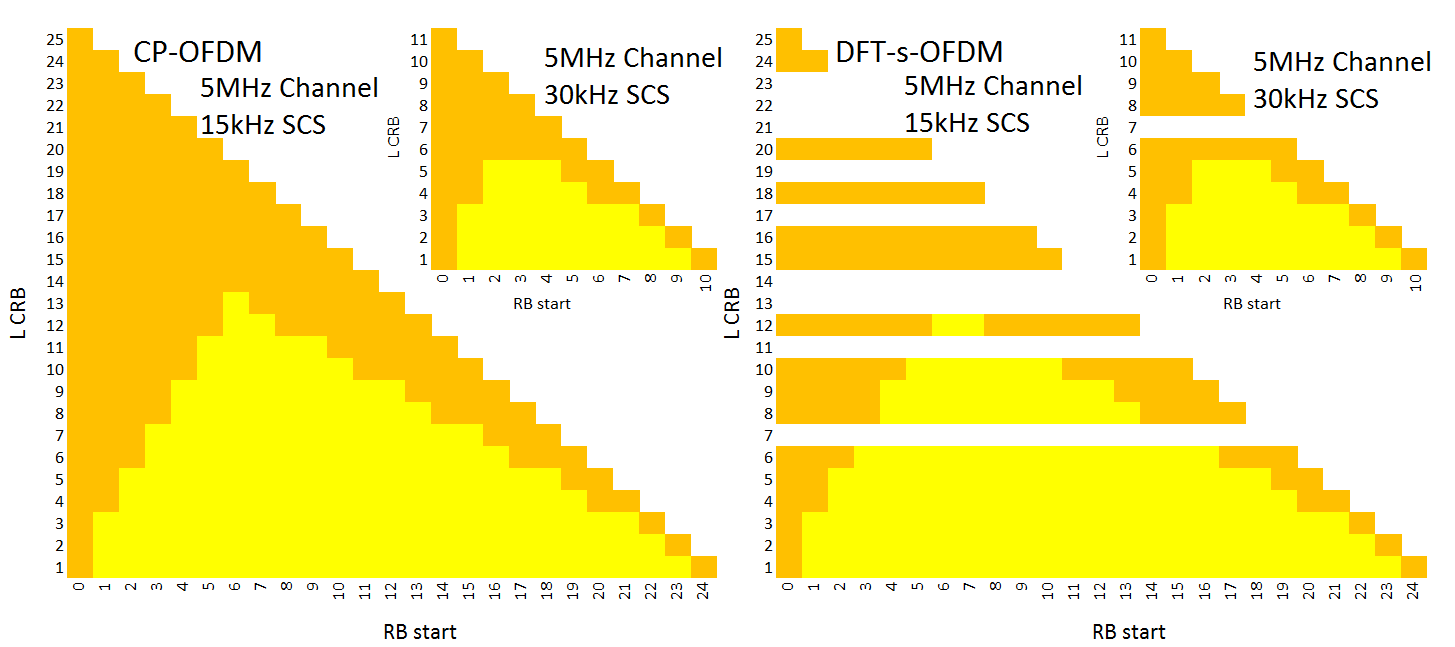


Figure 5.2.4-1: Inner and outer RB allocations of 15kHz and 30kHz 5MHz channel bandwidth for CP-OFDM and DFT-s-OFDM

Table 5.2.4-1 provides the valid Inner RB allocation RBstart range for channel bandwidths and SCS having a LCRBmax range of 11 to 51 for the different RB allocation lengths LCRB ≤ LCRBmid. The yellow highlighted column corresponds to the inner RB allocation of the 15kHz and 30kHz SCS 5MHZ channels described in Figure 5.2.4-1.

Table 5.2.4-2 provides the valid Inner RB allocation RBstart range for channel bandwidths and SCS having a LCRBmax range of 52 to 133 for the different RB allocation lengths LCRB ≤ LCRBmid.

Table 5.2.4-3 provides the valid Inner RB allocation RBstart range for channel bandwidths and SCS having a LCRBmax range of 135 to 273 for the different RB allocation lengths LCRB ≤ LCRBmid.

RBsL is the lowest valid RBstart value for Inner RB allocations

RBsH is the highest valid RBstart value for Inner RB allocations

Table 5.2.4-1: RBstart range for inner RB allocations, LCRBmax range 11-51

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Channel bandwidth and SCS | | | | | | | | | | | | | |
| 20/40 MHz 30/60 kHz | | 15 MHz 30 kHz | | 25 MHz 60 kHz | | 5 MHz 15 kHz | | 10/20 MHz 30/60 kHz | | 15 MHz 60 kHz | | 5/10 MHz 30/60 kHz | |
| LCRBmax | 51 | | 38 | | 31 | | 25 | | 24 | | 18 | | 11 | |
| LCRBmid | 26 | | 19 | | 16 | | 13 | | 12 | | 9 | | 6 | |
| LCRB | RBsL | RBsH | RBsL | RBsH | RBsL | RBsH | RBsL | RBsH | RBsL | RBsH | RBsL | RBsH | RBsL | RBsH |
| 1 | 1 | 49 | 1 | 36 | 1 | 29 | 1 | 23 | 1 | 22 | 1 | 16 | 1 | 9 |
| 2 | 1 | 48 | 1 | 35 | 1 | 28 | 1 | 22 | 1 | 21 | 1 | 15 | 1 | 8 |
| 3 | 1 | 47 | 1 | 34 | 1 | 27 | 1 | 21 | 1 | 20 | 1 | 14 | 1 | 7 |
| 4 | 2 | 45 | 2 | 32 | 2 | 25 | 2 | 19 | 2 | 18 | 2 | 12 | 2 | 5 |
| 5 | 2 | 44 | 2 | 31 | 2 | 24 | 2 | 18 | 2 | 17 | 2 | 11 | 2 | 4 |
| 6 | 3 | 42 | 3 | 29 | 3 | 22 | 3 | 16 | 3 | 15 | 3 | 9 | NA | |
| 7 | 3 | 41 | 3 | 28 | 3 | 21 | 3 | 15 | 3 | 14 | 3 | 8 | NA | |
| 8 | 4 | 39 | 4 | 26 | 4 | 19 | 4 | 13 | 4 | 12 | 4 | 6 | NA | |
| 9 | 4 | 38 | 4 | 25 | 4 | 18 | 4 | 12 | 4 | 11 | 4 | 5 | NA | |
| 10 | 5 | 36 | 5 | 23 | 5 | 16 | 5 | 10 | 5 | 9 | NA | | NA | |
| 11 | 5 | 35 | 5 | 22 | 5 | 15 | 5 | 9 | 5 | 8 | NA | | NA | |
| 12 | 6 | 33 | 6 | 20 | 6 | 13 | 6 | 7 | 6 | 6 | NA | | NA | |
| 13 | 6 | 32 | 6 | 19 | 6 | 12 | 6 | 6 | NA | | NA | | NA | |
| 14 | 7 | 30 | 7 | 17 | 7 | 10 | NA | | NA | | NA | | NA | |
| 15 | 7 | 29 | 7 | 16 | 7 | 9 | NA | | NA | | NA | | NA | |
| 16 | 8 | 27 | 8 | 14 | NA | | NA | | NA | | NA | | NA | |
| 17 | 8 | 26 | 8 | 13 | NA | | NA | | NA | | NA | | NA | |
| 18 | 9 | 24 | 9 | 11 | NA | | NA | | NA | | NA | | NA | |
| 19 | 9 | 23 | 9 | 10 | NA | | NA | | NA | | NA | | NA | |
| 20 | 10 | 21 | NA | | NA | | NA | | NA | | NA | | NA | |
| 21 | 10 | 20 | NA | | NA | | NA | | NA | | NA | | NA | |
| 22 | 11 | 18 | NA | | NA | | NA | | NA | | NA | | NA | |
| 23 | 11 | 17 | NA | | NA | | NA | | NA | | NA | | NA | |
| 24 | 12 | 15 | NA | | NA | | NA | | NA | | NA | | NA | |
| 25 | 12 | 14 | NA | | NA | | NA | | NA | | NA | | NA | |

Table 5.2.4-2: RBstart range for inner RB allocations, LCRBmax range 52-133

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Channel bandwidth and SCS | | | | | | | | | | | |
| 25/50 MHz 15/30 kHz | | 80 MHz 60 kHz | | 20/40 MHz 15/30 kHz | | 15/60 MHz 15/60 kHz | | 25/50 MHz 30/60 kHz | | 10 MHz 15 kHz | |
| LCRBmax | 133 | | 107 | | 106 | | 79 | | 65 | | 52 | |
| LCRBmid | 67 | | 54 | | 53 | | 40 | | 33 | | 26 | |
| LCRB | RBsL | RBsH | RBsL | RBsH | RBsL | RBsH | RBsL | RBsH | RBsL | RBsH | RBsL | RBsH |
| 1 | 1 | 131 | 1 | 105 | 1 | 104 | 1 | 77 | 1 | 63 | 1 | 50 |
| 2 | 1 | 130 | 1 | 104 | 1 | 103 | 1 | 76 | 1 | 62 | 1 | 49 |
| 3 | 1 | 129 | 1 | 103 | 1 | 102 | 1 | 75 | 1 | 61 | 1 | 48 |
| 4 | 2 | 127 | 2 | 101 | 2 | 100 | 2 | 73 | 2 | 59 | 2 | 46 |
| 5 | 2 | 126 | 2 | 100 | 2 | 99 | 2 | 72 | 2 | 58 | 2 | 45 |
| 6 | 3 | 124 | 3 | 98 | 3 | 97 | 3 | 70 | 3 | 56 | 3 | 43 |
| 7 | 3 | 123 | 3 | 97 | 3 | 96 | 3 | 69 | 3 | 55 | 3 | 42 |
| 8 | 4 | 121 | 4 | 95 | 4 | 94 | 4 | 67 | 4 | 53 | 4 | 40 |
| 9 | 4 | 120 | 4 | 94 | 4 | 93 | 4 | 66 | 4 | 52 | 4 | 39 |
| 10 | 5 | 118 | 5 | 92 | 5 | 91 | 5 | 64 | 5 | 50 | 5 | 37 |
| 11 | 5 | 117 | 5 | 91 | 5 | 90 | 5 | 63 | 5 | 49 | 5 | 36 |
| 12 | 6 | 115 | 6 | 89 | 6 | 88 | 6 | 61 | 6 | 47 | 6 | 34 |
| 13 | 6 | 114 | 6 | 88 | 6 | 87 | 6 | 60 | 6 | 46 | 6 | 33 |
| 14 | 7 | 112 | 7 | 86 | 7 | 85 | 7 | 58 | 7 | 44 | 7 | 31 |
| 15 | 7 | 111 | 7 | 85 | 7 | 84 | 7 | 57 | 7 | 43 | 7 | 30 |
| 16 | 8 | 109 | 8 | 83 | 8 | 82 | 8 | 55 | 8 | 41 | 8 | 28 |
| 17 | 8 | 108 | 8 | 82 | 8 | 81 | 8 | 54 | 8 | 40 | 8 | 27 |
| 18 | 9 | 106 | 9 | 80 | 9 | 79 | 9 | 52 | 9 | 38 | 9 | 25 |
| 19 | 9 | 105 | 9 | 79 | 9 | 78 | 9 | 51 | 9 | 37 | 9 | 24 |
| 20 | 10 | 103 | 10 | 77 | 10 | 76 | 10 | 49 | 10 | 35 | 10 | 22 |
| 21 | 10 | 102 | 10 | 76 | 10 | 75 | 10 | 48 | 10 | 34 | 10 | 21 |
| 22 | 11 | 100 | 11 | 74 | 11 | 73 | 11 | 46 | 11 | 32 | 11 | 19 |
| 23 | 11 | 99 | 11 | 73 | 11 | 72 | 11 | 45 | 11 | 31 | 11 | 18 |
| 24 | 12 | 97 | 12 | 71 | 12 | 70 | 12 | 43 | 12 | 29 | 12 | 16 |
| 25 | 12 | 96 | 12 | 70 | 12 | 69 | 12 | 42 | 12 | 28 | 12 | 15 |
| 26 | 13 | 94 | 13 | 68 | 13 | 67 | 13 | 40 | 13 | 26 | 13 | 13 |
| 27 | 13 | 93 | 13 | 67 | 13 | 66 | 13 | 39 | 13 | 25 | NA | |
| 28 | 14 | 91 | 14 | 65 | 14 | 64 | 14 | 37 | 14 | 23 | NA | |
| 29 | 14 | 90 | 14 | 64 | 14 | 63 | 14 | 36 | 14 | 22 | NA | |
| 30 | 15 | 88 | 15 | 62 | 15 | 61 | 15 | 34 | 15 | 20 | NA | |
| 31 | 15 | 87 | 15 | 61 | 15 | 60 | 15 | 33 | 15 | 19 | NA | |
| 32 | 16 | 85 | 16 | 59 | 16 | 58 | 16 | 31 | 16 | 17 | NA | |
| 33 | 16 | 84 | 16 | 58 | 16 | 57 | 16 | 30 | 16 | 16 | NA | |
| 34 | 17 | 82 | 17 | 56 | 17 | 55 | 17 | 28 | NA | | NA | |
| 35 | 17 | 81 | 17 | 55 | 17 | 54 | 17 | 27 | NA | | NA | |
| 36 | 18 | 79 | 18 | 53 | 18 | 52 | 18 | 25 | NA | | NA | |
| 37 | 18 | 78 | 18 | 52 | 18 | 51 | 18 | 24 | NA | | NA | |
| 38 | 19 | 76 | 19 | 50 | 19 | 49 | 19 | 22 | NA | | NA | |
| 39 | 19 | 75 | 19 | 49 | 19 | 48 | 19 | 21 | NA | | NA | |
| 40 | 20 | 73 | 20 | 47 | 20 | 46 | NA | | NA | | NA | |
| 41 | 20 | 72 | 20 | 46 | 20 | 45 | NA | | NA | | NA | |
| 42 | 21 | 70 | 21 | 44 | 21 | 43 | NA | | NA | | NA | |
| 43 | 21 | 69 | 21 | 43 | 21 | 42 | NA | | NA | | NA | |
| 44 | 22 | 67 | 22 | 41 | 22 | 40 | NA | | NA | | NA | |
| 45 | 22 | 66 | 22 | 40 | 22 | 39 | NA | | NA | | NA | |
| 46 | 23 | 64 | 23 | 38 | 23 | 37 | NA | | NA | | NA | |
| 47 | 23 | 63 | 23 | 37 | 23 | 36 | NA | | NA | | NA | |
| 48 | 24 | 61 | 24 | 35 | 24 | 34 | NA | | NA | | NA | |
| 49 | 24 | 60 | 24 | 34 | 24 | 33 | NA | | NA | | NA | |
| 50 | 25 | 58 | 25 | 32 | 25 | 31 | NA | | NA | | NA | |
| 51 | 25 | 57 | 25 | 31 | 25 | 30 | NA | | NA | | NA | |
| 52 | 26 | 55 | 26 | 29 | 26 | 28 | NA | | NA | | NA | |
| 53 | 26 | 54 | 26 | 28 | 26 | 27 | NA | | NA | | NA | |
| 54 | 27 | 52 | NA | | NA | | NA | | NA | | NA | |
| 55 | 27 | 51 | NA | | NA | | NA | | NA | | NA | |
| 56 | 28 | 49 | NA | | NA | | NA | | NA | | NA | |
| 57 | 28 | 48 | NA | | NA | | NA | | NA | | NA | |
| 58 | 29 | 46 | NA | | NA | | NA | | NA | | NA | |
| 59 | 29 | 45 | NA | | NA | | NA | | NA | | NA | |
| 60 | 30 | 43 | NA | | NA | | NA | | NA | | NA | |
| 61 | 30 | 42 | NA | | NA | | NA | | NA | | NA | |
| 62 | 31 | 40 | NA | | NA | | NA | | NA | | NA | |
| 63 | 31 | 39 | NA | | NA | | NA | | NA | | NA | |
| 64 | 32 | 37 | NA | | NA | | NA | | NA | | NA | |
| 65 | 32 | 36 | NA | | NA | | NA | | NA | | NA | |
| 66 | 33 | 34 | NA | | NA | | NA | | NA | | NA | |
| 67 | 33 | 33 | NA | | NA | | NA | | NA | | NA | |

Table 5.2.4-3: RBstart range for inner RB allocations, LCRBmax range 135-273

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Channel bandwidth and SCS | | | | | | | | | | | |
| 100 MHz 30 kHz | | 50 MHz 15 kHz | | 80 MHz 30 kHz | | 40 MHz 15 kHz | | 60 MHz 30 kHz | | 100 MHz 60 kHz | |
| LCRBmax | 273 | | 270 | | 217 | | 216 | | 162 | | 135 | |
| LCRBmid | 137 | | 135 | | 109 | | 108 | | 81 | | 68 | |
| LCRB | RBsL | RBsH | RBsL | RBsH | RBsL | RBsH | RBsL | RBsH | RBsL | RBsH | RBsL | RBsH |
| 1 | 1 | 271 | 1 | 268 | 1 | 215 | 1 | 214 | 1 | 160 | 1 | 133 |
| 2 | 1 | 270 | 1 | 267 | 1 | 214 | 1 | 213 | 1 | 159 | 1 | 132 |
| 3 | 1 | 269 | 1 | 266 | 1 | 213 | 1 | 212 | 1 | 158 | 1 | 131 |
| 4 | 2 | 267 | 2 | 264 | 2 | 211 | 2 | 210 | 2 | 156 | 2 | 129 |
| 5 | 2 | 266 | 2 | 263 | 2 | 210 | 2 | 209 | 2 | 155 | 2 | 128 |
| 6 | 3 | 264 | 3 | 261 | 3 | 208 | 3 | 207 | 3 | 153 | 3 | 126 |
| 7 | 3 | 263 | 3 | 260 | 3 | 207 | 3 | 206 | 3 | 152 | 3 | 125 |
| 8 | 4 | 261 | 4 | 258 | 4 | 205 | 4 | 204 | 4 | 150 | 4 | 123 |
| 9 | 4 | 260 | 4 | 257 | 4 | 204 | 4 | 203 | 4 | 149 | 4 | 122 |
| 10 | 5 | 258 | 5 | 255 | 5 | 202 | 5 | 201 | 5 | 147 | 5 | 120 |
| 11 | 5 | 257 | 5 | 254 | 5 | 201 | 5 | 200 | 5 | 146 | 5 | 119 |
| 12 | 6 | 255 | 6 | 252 | 6 | 199 | 6 | 198 | 6 | 144 | 6 | 117 |
| 13 | 6 | 254 | 6 | 251 | 6 | 198 | 6 | 197 | 6 | 143 | 6 | 116 |
| 14 | 7 | 252 | 7 | 249 | 7 | 196 | 7 | 195 | 7 | 141 | 7 | 114 |
| 15 | 7 | 251 | 7 | 248 | 7 | 195 | 7 | 194 | 7 | 140 | 7 | 113 |
| 16 | 8 | 249 | 8 | 246 | 8 | 193 | 8 | 192 | 8 | 138 | 8 | 111 |
| 17 | 8 | 248 | 8 | 245 | 8 | 192 | 8 | 191 | 8 | 137 | 8 | 110 |
| 18 | 9 | 246 | 9 | 243 | 9 | 190 | 9 | 189 | 9 | 135 | 9 | 108 |
| 19 | 9 | 245 | 9 | 242 | 9 | 189 | 9 | 188 | 9 | 134 | 9 | 107 |
| 20 | 10 | 243 | 10 | 240 | 10 | 187 | 10 | 186 | 10 | 132 | 10 | 105 |
| 21 | 10 | 242 | 10 | 239 | 10 | 186 | 10 | 185 | 10 | 131 | 10 | 104 |
| 22 | 11 | 240 | 11 | 237 | 11 | 184 | 11 | 183 | 11 | 129 | 11 | 102 |
| 23 | 11 | 239 | 11 | 236 | 11 | 183 | 11 | 182 | 11 | 128 | 11 | 101 |
| 24 | 12 | 237 | 12 | 234 | 12 | 181 | 12 | 180 | 12 | 126 | 12 | 99 |
| 25 | 12 | 236 | 12 | 233 | 12 | 180 | 12 | 179 | 12 | 125 | 12 | 98 |
| 26 | 13 | 234 | 13 | 231 | 13 | 178 | 13 | 177 | 13 | 123 | 13 | 96 |
| 27 | 13 | 233 | 13 | 230 | 13 | 177 | 13 | 176 | 13 | 122 | 13 | 95 |
| 28 | 14 | 231 | 14 | 228 | 14 | 175 | 14 | 174 | 14 | 120 | 14 | 93 |
| 29 | 14 | 230 | 14 | 227 | 14 | 174 | 14 | 173 | 14 | 119 | 14 | 92 |
| 30 | 15 | 228 | 15 | 225 | 15 | 172 | 15 | 171 | 15 | 117 | 15 | 90 |
| 31 | 15 | 227 | 15 | 224 | 15 | 171 | 15 | 170 | 15 | 116 | 15 | 89 |
| 32 | 16 | 225 | 16 | 222 | 16 | 169 | 16 | 168 | 16 | 114 | 16 | 87 |
| 33 | 16 | 224 | 16 | 221 | 16 | 168 | 16 | 167 | 16 | 113 | 16 | 86 |
| 34 | 17 | 222 | 17 | 219 | 17 | 166 | 17 | 165 | 17 | 111 | 17 | 84 |
| 35 | 17 | 221 | 17 | 218 | 17 | 165 | 17 | 164 | 17 | 110 | 17 | 83 |
| 36 | 18 | 219 | 18 | 216 | 18 | 163 | 18 | 162 | 18 | 108 | 18 | 81 |
| 37 | 18 | 218 | 18 | 215 | 18 | 162 | 18 | 161 | 18 | 107 | 18 | 80 |
| 38 | 19 | 216 | 19 | 213 | 19 | 160 | 19 | 159 | 19 | 105 | 19 | 78 |
| 39 | 19 | 215 | 19 | 212 | 19 | 159 | 19 | 158 | 19 | 104 | 19 | 77 |
| 40 | 20 | 213 | 20 | 210 | 20 | 157 | 20 | 156 | 20 | 102 | 20 | 75 |
| 41 | 20 | 212 | 20 | 209 | 20 | 156 | 20 | 155 | 20 | 101 | 20 | 74 |
| 42 | 21 | 210 | 21 | 207 | 21 | 154 | 21 | 153 | 21 | 99 | 21 | 72 |
| 43 | 21 | 209 | 21 | 206 | 21 | 153 | 21 | 152 | 21 | 98 | 21 | 71 |
| 44 | 22 | 207 | 22 | 204 | 22 | 151 | 22 | 150 | 22 | 96 | 22 | 69 |
| 45 | 22 | 206 | 22 | 203 | 22 | 150 | 22 | 149 | 22 | 95 | 22 | 68 |
| 46 | 23 | 204 | 23 | 201 | 23 | 148 | 23 | 147 | 23 | 93 | 23 | 66 |
| 47 | 23 | 203 | 23 | 200 | 23 | 147 | 23 | 146 | 23 | 92 | 23 | 65 |
| 48 | 24 | 201 | 24 | 198 | 24 | 145 | 24 | 144 | 24 | 90 | 24 | 63 |
| 49 | 24 | 200 | 24 | 197 | 24 | 144 | 24 | 143 | 24 | 89 | 24 | 62 |
| 50 | 25 | 198 | 25 | 195 | 25 | 142 | 25 | 141 | 25 | 87 | 25 | 60 |
| 51 | 25 | 197 | 25 | 194 | 25 | 141 | 25 | 140 | 25 | 86 | 25 | 59 |
| 52 | 26 | 195 | 26 | 192 | 26 | 139 | 26 | 138 | 26 | 84 | 26 | 57 |
| 53 | 26 | 194 | 26 | 191 | 26 | 138 | 26 | 137 | 26 | 83 | 26 | 56 |
| 54 | 27 | 192 | 27 | 189 | 27 | 136 | 27 | 135 | 27 | 81 | 27 | 54 |
| 55 | 27 | 191 | 27 | 188 | 27 | 135 | 27 | 134 | 27 | 80 | 27 | 53 |
| 56 | 28 | 189 | 28 | 186 | 28 | 133 | 28 | 132 | 28 | 78 | 28 | 51 |
| 57 | 28 | 188 | 28 | 185 | 28 | 132 | 28 | 131 | 28 | 77 | 28 | 50 |
| 58 | 29 | 186 | 29 | 183 | 29 | 130 | 29 | 129 | 29 | 75 | 29 | 48 |
| 59 | 29 | 185 | 29 | 182 | 29 | 129 | 29 | 128 | 29 | 74 | 29 | 47 |
| 60 | 30 | 183 | 30 | 180 | 30 | 127 | 30 | 126 | 30 | 72 | 30 | 45 |
| 61 | 30 | 182 | 30 | 179 | 30 | 126 | 30 | 125 | 30 | 71 | 30 | 44 |
| 62 | 31 | 180 | 31 | 177 | 31 | 124 | 31 | 123 | 31 | 69 | 31 | 42 |
| 63 | 31 | 179 | 31 | 176 | 31 | 123 | 31 | 122 | 31 | 68 | 31 | 41 |
| 64 | 32 | 177 | 32 | 174 | 32 | 121 | 32 | 120 | 32 | 66 | 32 | 39 |
| 65 | 32 | 176 | 32 | 173 | 32 | 120 | 32 | 119 | 32 | 65 | 32 | 38 |
| 66 | 33 | 174 | 33 | 171 | 33 | 118 | 33 | 117 | 33 | 63 | 33 | 36 |
| 67 | 33 | 173 | 33 | 170 | 33 | 117 | 33 | 116 | 33 | 62 | 33 | 35 |
| 68 | 34 | 171 | 34 | 168 | 34 | 115 | 34 | 114 | 34 | 60 | NA | |
| 69 | 34 | 170 | 34 | 167 | 34 | 114 | 34 | 113 | 34 | 59 | NA | |
| 70 | 35 | 168 | 35 | 165 | 35 | 112 | 35 | 111 | 35 | 57 | NA | |
| 71 | 35 | 167 | 35 | 164 | 35 | 111 | 35 | 110 | 35 | 56 | NA | |
| 72 | 36 | 165 | 36 | 162 | 36 | 109 | 36 | 108 | 36 | 54 | NA | |
| 73 | 36 | 164 | 36 | 161 | 36 | 108 | 36 | 107 | 36 | 53 | NA | |
| 74 | 37 | 162 | 37 | 159 | 37 | 106 | 37 | 105 | 37 | 51 | NA | |
| 75 | 37 | 161 | 37 | 158 | 37 | 105 | 37 | 104 | 37 | 50 | NA | |
| 76 | 38 | 159 | 38 | 156 | 38 | 103 | 38 | 102 | 38 | 48 | NA | |
| 77 | 38 | 158 | 38 | 155 | 38 | 102 | 38 | 101 | 38 | 47 | NA | |
| 78 | 39 | 156 | 39 | 153 | 39 | 100 | 39 | 99 | 39 | 45 | NA | |
| 79 | 39 | 155 | 39 | 152 | 39 | 99 | 39 | 98 | 39 | 44 | NA | |
| 80 | 40 | 153 | 40 | 150 | 40 | 97 | 40 | 96 | 40 | 42 | NA | |
| 81 | 40 | 152 | 40 | 149 | 40 | 96 | 40 | 95 | 40 | 41 | NA | |
| 82 | 41 | 150 | 41 | 147 | 41 | 94 | 41 | 93 | NA | | NA | |
| 83 | 41 | 149 | 41 | 146 | 41 | 93 | 41 | 92 | NA | | NA | |
| 84 | 42 | 147 | 42 | 144 | 42 | 91 | 42 | 90 | NA | | NA | |
| 85 | 42 | 146 | 42 | 143 | 42 | 90 | 42 | 89 | NA | | NA | |
| 86 | 43 | 144 | 43 | 141 | 43 | 88 | 43 | 87 | NA | | NA | |
| 87 | 43 | 143 | 43 | 140 | 43 | 87 | 43 | 86 | NA | | NA | |
| 88 | 44 | 141 | 44 | 138 | 44 | 85 | 44 | 84 | NA | | NA | |
| 89 | 44 | 140 | 44 | 137 | 44 | 84 | 44 | 83 | NA | | NA | |
| 90 | 45 | 138 | 45 | 135 | 45 | 82 | 45 | 81 | NA | | NA | |
| 91 | 45 | 137 | 45 | 134 | 45 | 81 | 45 | 80 | NA | | NA | |
| 92 | 46 | 135 | 46 | 132 | 46 | 79 | 46 | 78 | NA | | NA | |
| 93 | 46 | 134 | 46 | 131 | 46 | 78 | 46 | 77 | NA | | NA | |
| 94 | 47 | 132 | 47 | 129 | 47 | 76 | 47 | 75 | NA | | NA | |
| 95 | 47 | 131 | 47 | 128 | 47 | 75 | 47 | 74 | NA | | NA | |
| 96 | 48 | 129 | 48 | 126 | 48 | 73 | 48 | 72 | NA | | NA | |
| 97 | 48 | 128 | 48 | 125 | 48 | 72 | 48 | 71 | NA | | NA | |
| 98 | 49 | 126 | 49 | 123 | 49 | 70 | 49 | 69 | NA | | NA | |
| 99 | 49 | 125 | 49 | 122 | 49 | 69 | 49 | 68 | NA | | NA | |
| 100 | 50 | 123 | 50 | 120 | 50 | 67 | 50 | 66 | NA | | NA | |
| 101 | 50 | 122 | 50 | 119 | 50 | 66 | 50 | 65 | NA | | NA | |
| 102 | 51 | 120 | 51 | 117 | 51 | 64 | 51 | 63 | NA | | NA | |
| 103 | 51 | 119 | 51 | 116 | 51 | 63 | 51 | 62 | NA | | NA | |
| 104 | 52 | 117 | 52 | 114 | 52 | 61 | 52 | 60 | NA | | NA | |
| 105 | 52 | 116 | 52 | 113 | 52 | 60 | 52 | 59 | NA | | NA | |
| 106 | 53 | 114 | 53 | 111 | 53 | 58 | 53 | 57 | NA | | NA | |
| 107 | 53 | 113 | 53 | 110 | 53 | 57 | 53 | 56 | NA | | NA | |
| 108 | 54 | 111 | 54 | 108 | 54 | 55 | 54 | 54 | NA | | NA | |
| 109 | 54 | 110 | 54 | 107 | 54 | 54 | NA | | NA | | NA | |
| 110 | 55 | 108 | 55 | 105 | NA | | NA | | NA | | NA | |
| 111 | 55 | 107 | 55 | 104 | NA | | NA | | NA | | NA | |
| 112 | 56 | 105 | 56 | 102 | NA | | NA | | NA | | NA | |
| 113 | 56 | 104 | 56 | 101 | NA | | NA | | NA | | NA | |
| 114 | 57 | 102 | 57 | 99 | NA | | NA | | NA | | NA | |
| 115 | 57 | 101 | 57 | 98 | NA | | NA | | NA | | NA | |
| 116 | 58 | 99 | 58 | 96 | NA | | NA | | NA | | NA | |
| 117 | 58 | 98 | 58 | 95 | NA | | NA | | NA | | NA | |
| 118 | 59 | 96 | 59 | 93 | NA | | NA | | NA | | NA | |
| 119 | 59 | 95 | 59 | 92 | NA | | NA | | NA | | NA | |
| 120 | 60 | 93 | 60 | 90 | NA | | NA | | NA | | NA | |
| 121 | 60 | 92 | 60 | 89 | NA | | NA | | NA | | NA | |
| 122 | 61 | 90 | 61 | 87 | NA | | NA | | NA | | NA | |
| 123 | 61 | 89 | 61 | 86 | NA | | NA | | NA | | NA | |
| 124 | 62 | 87 | 62 | 84 | NA | | NA | | NA | | NA | |
| 125 | 62 | 86 | 62 | 83 | NA | | NA | | NA | | NA | |
| 126 | 63 | 84 | 63 | 81 | NA | | NA | | NA | | NA | |
| 127 | 63 | 83 | 63 | 80 | NA | | NA | | NA | | NA | |
| 128 | 64 | 81 | 64 | 78 | NA | | NA | | NA | | NA | |
| 129 | 64 | 80 | 64 | 77 | NA | | NA | | NA | | NA | |
| 130 | 65 | 78 | 65 | 75 | NA | | NA | | NA | | NA | |
| 131 | 65 | 77 | 65 | 74 | NA | | NA | | NA | | NA | |
| 132 | 66 | 75 | 66 | 72 | NA | | NA | | NA | | NA | |
| 133 | 66 | 74 | 66 | 71 | NA | | NA | | NA | | NA | |
| 134 | 67 | 72 | 67 | 69 | NA | | NA | | NA | | NA | |
| 135 | 67 | 71 | 67 | 68 | NA | | NA | | NA | | NA | |
| 136 | 68 | 69 | NA | | NA | | NA | | NA | | NA | |
| 137 | 68 | 68 | NA | | NA | | NA | | NA | | NA | |

## 5.3 Output power dynamics

### 5.3.1 Minimum output power

#### 5.3.1.1 Current LTE requirement

Current LTE singe carrier requirement is defined as the same output level as shown in the following table which is copied from TS 36.101 [3].

Table 5.3.1.1-1: Minimum output power (Table 6.3.2.1-1 of TS 36.101 [3])

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Channel bandwidth / Minimum output power/ Measurement bandwidth** | | | | | |
| **1.4**  **MHz** | **3.0**  **MHz** | **5**  **MHz** | **10**  **MHz** | **15**  **MHz** | **20**  **MHz** |
| Minimum output power | -40 dBm | | | | | |
| Measurement bandwidth | 1.08 MHz | 2.7 MHz | 4.5 MHz | 9.0 MHz | 13.5 MHz | 18 MHz |

For the CA requirement, the following is the current definition.

*For inter-band carrier aggregation with uplink assigned to two E-UTRA bands and intra-band contiguous and non-contiguous carrier aggregation, the minimum controlled output power of the UE is defined as the transmit power of the UE per component carrier, i.e., the power in the channel bandwidth of each component carrier for all transmit bandwidth configurations (resource blocks), when the power on both component carriers are set to a minimum value.*

And each carrier requirement is defined as the single carrier requirement, i.e. -40 dBm.

For the minimum output power, it should be noted that -30 dBm is the minimum output power that can support 256QAM modulation.

Table 5.3.1.1-2: Parameters for Error Vector Magnitude (Table 6.5.2.1.1-2 of TS 36.101 [3])

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Unit** | **Level** |
| UE Output Power | dBm | ≥ -40 |
| UE Output Power for 256 QAM | dBm | ≥ -30 |
| Operating conditions |  | Normal conditions |

#### 5.3.1.2 NR requirement

For the NR requirement, there could be two approaches being considered. The first is that all of the CBW reuses the same level requirement as LTE. The second is that the CBW enlarge can be treated as the LTE CA then the minimum output power can be defined as the same PSD with LTE 20MHz.

The first approach tightens the UE implementation if UL SNR is considered. If 100MHz reuses 20MHz absolute level, i.e. -40 dBm for QPSK, 16QAM, 64QAM modulation and -30 dBm for 256QAM modulation, the SNR decreases 7 dB which is a large improvement request to the link design. When LTE UL256QAM was discussed, the link budget was very tough that 7 dB improvement is a big challenge.

According to current TS 36.101 [3] arrangement, the UL 256QAM challenge was not reflected in the minimum output power section but in the EVM clause. Therefore, the same approach was used in the requirement. The following requirements were agreed for NR minimum output power.

Table 5.3.1.2-1: NR minimum output power

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Channel bandwidth / Minimum output power/ Measurement bandwidth** | | | | | | | | | |
| **5 MHz** | **10 MHz** | **15 MHz** | **20 MHz** | **25 MHz** | **40MHz** | **50MHz** | **60MHz** | **80MHz** | **100MHz** |
| Minimum output power (dBm) | -40 | | | | -39 | -37 | -36 | -35.2 | -34 | -33 |
| Measurement bandwidth | SeeTransmission bandwidth configuration defined in 4.2 | | | | | | | | | |

Table 5.3.1.2-2: Parameters for Error Vector Magnitude

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Parameters** | **Channel bandwidth / Minimum output power/ Measurement bandwidth** | | | | | | | | | |
| **5 MHz** | **10 MHz** | **15 MHz** | **20 MHz** | **25 MHz** | **40MHz** | **50MHz** | **60MHz** | **80MHz** | **100MHz** |
| UE output power (dBm) | ≥ -40 | | | | ≥ -39 | ≥ -37 | ≥ -36 | ≥ -35.2 | ≥ -34 | ≥ -33 |
| UE output power for UL 256QAM (dBm) | ≥ -30 | | | | ≥ -29 | ≥ -27 | ≥ -26 | ≥ -25.2 | ≥ -24 | ≥ -23 |

## 5.4 Transmit signal quality

### 5.4.1 IQ-Image and Carrier leakage

IQ Image and Carrier leakage for NR Range 1 are specified as follows.

Table 5.4.1-1: NR range 1 IQ Image and Carrier leakage requirement

|  |  |  |  |
| --- | --- | --- | --- |
| **IQ Image** | dB | -28 | Image frequencies when carrier center frequency < 6 GHz and Output power > 10 dBm |
| -25 | Image frequencies when carrier center frequency < 6 GHz and Output power ≤ 10 dBm |
| **Carrier leakage** | dBc | -28 | Output power > 10 dBm and carrier center frequency < 6 GHz |
| -25 | 0 dBm ≤ Output power ≤10 dBm |
| -20 | -30 dBm ≤ Output power ≤ 0 dBm |
| -10 | -40 dBm ≤ Output power < -30 dBm |
| Note: Positions of carrier leakage will be captured later. | | | |

### 5.4.2 Error vector magnitude

Error vector magnitude presented in Table 5.4.2-1 is specified as a minimum requirement for NR range 1 UE. pi/2 BPSK value subject to change due to spectrum shaping discussion.

Table 5.4.2-1: EVM per modulation for NR range 1 UE

|  |  |
| --- | --- |
| **Modulation** | **EVM** |
| pi/2 BPSK | [25%] |
| QPSK | 17.5% |
| 16QAM | 12.5% |
| 64QAM | 8% |
| 256QAM | 3.5% |

### 5.4.3 In-band emissions

Based on analysis general section of LTE in-band emission mask requirement can be largely re-used for NR when the evaluation period is changed to be longer and the interference power is measured average power. Reason for this is that when OFDM becomes clipped by the PA, the caused IBE spikes are basically impulsive noise. Hence the IBE of a single slot is quite noisy and vary between the slots. When multiple slots are measured and average value is calculated this instantaneous variation between the slots is averaged out. Impact of using 10 subframe test time vs one slot test time can be seen in Figure 5.4.3-1 which shows the histogram of in-band emission at a single RB as offset from the limit value. Hence, positive values indicate violation of the in-band limit. Without averaging, the standard deviation of the measurement result is large, and the measurement is unreliable. Therefore, NR Range 1 in-band emission measurement period is specified to be 10 sub-frames. The in-band emission is averaged over slots.



Figure 5.4.3-1: Effect of averaging in-band emission over one slot vs.10 subframes, i.e., 20 slots.

The third expression of the general IBE limit (-57 dBm/180 kHz) takes into account the subcarrier spacing. In LTE, the -57 dB refers to the 180 kHz bandwidth of a single RB. In NR, this must be scaled to maintain the same spectral density for all SCSs. This modification is established by adding +10Log10(SCS/15 kHz) term into the IBE formula, see Table 5.4.3-1 where SCS is the applicaple subcarrier spacing.

Table 5.4.3-1: general section of LTE in-band emission mask

|  |  |  |
| --- | --- | --- |
| General | dB |  |

## 5.5 Output RF spectrum emissions

### 5.5.1 Occupied bandwidth

### 5.5.2 Spectrum emission mask

#### 5.5.2.1 General spectrum emission mask

LTE general SEM and LTE CA general SEM the emission requirement for the first MHz outside the channel edge is scaled proportionately to the channel bandwidth. Logic behind this is that as transmission bandwidth gets larger the PSD of fully populated channel gets lower and UE can meet the tighter requirement. It is noted than from co-existence perspective this is not needed as smaller channel bandwidths are anyways allowed to emit more and system must work also with those channels.

However scaling cannot continue forever due to the fact that some small allocations (1RB) inside the channel are mixing with LO and image and create IMD3 that lands on the first MHz outside the channel. It can be seen from simulations that with 25 dBc IQ-Image performance IMD3 created by 1 RB transmission is in the order of -22 dBm/30 kHz. This would violate then SEM for larger channel bandwidth if scaling is continued to all channel bandwidths.

Thus it is safest that scaling is not used for channel bandwidths > 40 MHz for NR general SEM for sub-6 GHz bands. For those regions that have regulatory requirements for emissions to first MHz outside the channel region specific SEMs can be defined similarly as for LTE.

NR Sub-6 GHz general emission mask is presented in Table 5.5.2.1-1.

Table 5.5.2.1-1: NR spectrum target emission mask

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **ΔfOOB**  **(MHz)** | **5**  **MHz** | **10**  **MHz** | **15**  **MHz** | **20**  **MHz** | **25**  **MHz** | **40**  **MHz** | **50**  **MHz** | **60**  **MHz** | **80**  **MHz** | **100**  **MHz** | **Measurement bandwidth** |
| ± 0-1 | -15 | -18 | -20 | -21 | -22 | -24 | -24 | -24 | -24 | -24 | 30 kHz |
| ± 1-5 | -10 | -10 | -10 | -10 | -10 | -10 | -10 | -10 | -10 | -10 | 1 MHz |
| ± 5-6 | -13 | -13 | -13 | -13 | -13 | -13 | -13 | -13 | -13 | -13 |
| ± 6-10 | -25 |
| ± 10-15 |  | -25 |
| ± 15-20 |  |  | -25 |
| ± 20-25 |  |  |  | -25 |
| ± 25-30 |  |  |  |  | -25 |
| ± 30-40 |  |  |  |  |  |
| ± 40-45 |  |  |  |  |  | -25 |
| ± 45-50 |  |  |  |  |  |  |
| ± 55-60 |  |  |  |  |  |  | -25 |
| ± 60-65 |  |  |  |  |  |  |  | -25 |
| ± 65-80 |  |  |  |  |  |  |  |  |
| ± 80-85 |  |  |  |  |  |  |  |  | -25 |
| ± 85-100 |  |  |  |  |  |  |  |  |  |
| ± 100-105 |  |  |  |  |  |  |  |  |  | -25 |

#### 5.5.2.2 Additional spectrum emission requirements

Additional spectrum emission requirements are signalled by the network with network signalling value indicated by the field *additionalSpectrumEmission*.

##### 5.5.2.2.1 Requirements for network signalled value "NS\_04"

Additional spectrum emission requirements are signalled by the network to indicate that the UE shall meet an additional requirement for a specific deployment scenario as part of the cell handover/broadcast message.

The n41 SEM transition point from -13 dBm/MHz to -25 dBm/MHz is based on the emission bandwidth. The emission bandwidth is defined as the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, outside of which all emissions are attenuated at least 26 dB below the transmitter power. Since the 26 dB emission bandwidth is implementation dependent, the transmission bandwidths occupied by RBs is used for the SEM.

Table 5.5.2.2.1-1: n41 transmission bandwidths for CP-OFDM

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **SCS [kHz]** | **Channel bandwidths [MHz]** | | | | | | | |
| **10** | **15** | **20** | **40** | **50** | **60** | **80** | **100** |
| 15 | 9.36 | 14.22 | 19.08 | 38.88 | 48.6 | N.A | N.A | N.A |
| 30 | 8.64 | 13.68 | 18.36 | 38.16 | 47.88 | 58.32 | 78.12 | 98.28 |
| 60 | 7.92 | 12.96 | 17.28 | 36.72 | 46.8 | 56.88 | 77.04 | 97.20 |

Table 5.5.2.2.1-2: n41 transmission bandwidths for DFT-S-OFDM

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **SCS [kHz]** | **Channel bandwidths [MHz]** | | | | | | | |
| **10** | **15** | **20** | **40** | **50** | **60** | **80** | **100** |
| 15 | 9.00 | 13.50 | 18.00 | 38.88 | 48.60 | N/A | N/A | N/A |
| 30 | 8.64 | 12.96 | 18.00 | 36.00 | 46.08 | 58.32 | 77.76 | 97.20 |
| 60 | 7.20 | 12.96 | 17.28 | 36.00 | 46.08 | 54.00 | 72.00 | 97.20 |

When "NS\_04" is indicated in the cell, the power of any UE emission shall not exceed the levels specified in Table 5.5.2.2.1-3.

Table 5.5.2.2.1-3: n41 SEM with NS\_04

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Spectrum emission limit (dBm)/ measurement bandwidth**  **for each channel bandwidth** | | | | | | | | |
| **ΔfOOB MHz** | **10  MHz** | **15  MHz** | **20  MHz** | **40  MHz** | **50  MHz** | **60  MHz** | **80  MHz** | **100  MHz** | **Measurement bandwidth** |
| ± 0 - 1 | -18 | -20 | -21 | -24 | -25 | | | | 30 kHz |
| ± 1 - 5 | -10 | | | | | | | | 1 MHz |
| ± 5 - X | -13 | | | | | | | |
| ± X - (BWChannel + 5 MHz) | -25 | | | | | | | |
| Note 1: X is defined in Table 6.5.2.3.2-1 for CP-OFDM or 6.5.2.3.2-2 for DFT-S-OFDM | | | | | | | | | |

### 5.5.3 Adjacent Channel Leakage ratio

Concerning NR Range 1 UE ACLR requirement following agreements have been made

#### 5.5.3.1 NR ACLR

ACLR is the ratio of power of wanted signal to the power falling into Adjacent Channel. ACLR measurement bandwidth for both the wanted and adjacent channels is the maximum transmission bandwidth among the different SCSs of CP-OFDM SU for a channel BW with addition of one SCS to account for half SCS shift due to SCS alignment to DC, this measurement bandwidth is centred within the channels.

Offset for the adjacent measurement BW centre is +/- Channel BW from wanted channel centre (in the middle of the Channel).

For PC3 requirement is NRACLR = 30 dBc for channel bandwidths up to 100 MHz.

For PC2 requirement is NRACLR = 31 dBc for channel bandwidths up to 100 MHz.

Table below provides measurement BWs in the last row

Table 5.5.3.1-1: ACLR measurement bandwidth

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sub-6GHz** | **SCS [kHz]** | **5 MHz** | **10 MHz** | **15 MHz** | **20 MHz** | **25 MHz** | **40 MHz** | **50 MHz** | **60 MHz** | **80 MHz** | **100 MHz** |
| NRB | NRB | NRB | NRB | NRB | NRB | NRB | NRB | NRB | NRB |
| SU\_CP-OFDM [#RB] | 15 | 25 | 52 | 79 | 106 | 133 | 216 | 270 | N.A | N.A | N.A |
| 30 | 11 | 24 | 38 | 51 | 65 | 106 | 133 | 162 | 217 | 273 |
| 60 | N.A | 11 | 18 | 24 | 31 | 51 | 65 | 79 | 107 | 135 |
| RX&TXBW CP [MHz] | 15 | 4.5 | 9.36 | 14.22 | 19.08 | 23.94 | 38.88 | 48.6 | NA | NA | NA |
| 30 | 3.96 | 8.64 | 13.68 | 18.36 | 23.4 | 38.16 | 47.88 | 58.32 | 78.12 | 98.28 |
| 60 | NA | 7.92 | 12.96 | 17.28 | 22.32 | 36.72 | 46.8 | 56.88 | 77.04 | 97.2 |
| TXBWsym [MHz] | 15 | 4.515 | 9.375 | 14.235 | 19.095 | 23.955 | 38.895 | 48.615 | NA | NA | NA |
| 30 | 3.99 | 8.67 | 13.71 | 18.39 | 23.43 | 38.19 | 47.91 | 58.35 | 78.15 | 98.31 |
| 60 | NA | 7.98 | 13.02 | 17.34 | 22.38 | 36.78 | 46.86 | 56.94 | 77.1 | 97.26 |
| **maxTXBWsym [MHz]** | **lowest** | **4.515** | **9.375** | **14.235** | **19.095** | **23.955** | **38.895** | **48.615** | **58.35** | **78.15** | **98.31** |

#### 5.5.3.2 E-UTRA ACLR

For E-UTRA ACLR it has been agreed that if EUTRA CHBW = NR CHBW only the NR ACLR of 30 dBc shall be measured. This means that for channel bandwidths up to 20 MHz it is not necessary to measure E-UTRA ACLR as NR ACLR is tighter because the requirements in same 30 dBc but measurement bandwidth is larger.

Considering recent agreement on NR ACLR which stated that ACLR MBW is same as the bandwidth of transmitted NR signal it is evident that E-UTRA ACLR is always more relaxed thus is not necessary.

Therefore, no E-UTRA ACLR requirement is not specified for NR as NR ACLR requirement will be always more stringent.

#### 5.5.3.3 UTRA ACLR

For bands defined also for UTRA, adopt UTRAACLR1 = 33dB and UTRAACLR2 =36dB for power class 3.

UTRA ACLR requirement is indicated to the UE by NS-signalling when applicable. Dedicated NS-value is assigned to UTRA ACLR requirement and it is used when no other additional requirement needs to indicated to the UE.

In case power reduction is necessary to meet the UTRA ACLR requirement it will be defined as A-MPRUTRA\_ACLR. A-MPRUTRA\_ACLR is only allowed only in case other power reductions such as MPR and A-MPR coming from other requirement than UTRA ACLR are not sufficient. Allowed power reduction = Max (A-MPRUTRA\_ACLR, (MPR+A-MPRother).

### 5.5.4 Spurious emission

#### 5.5.4.1 General requirements

Spurious emissions are emissions which are caused by unwanted transmitter effects such as harmonics emission, parasitic emissions, intermodulation products and frequency conversion products, but exclude out of band emissions unless otherwise stated.

In the same way as was described for UTRA and E-UTRA, the spurious emission limits shall be specified in terms of general requirements in line with SM.329.And the stricter Category B limits defined in SM.329 shall be applied for UE considering that UEs are intended for global circulation, there cannot be any regional requirements. Thus, the following spurious emission limits for E-TRUA would be reused in NR.

Table 5.5.4-1: Spurious emissions limits

|  |  |  |  |
| --- | --- | --- | --- |
| Frequency Range | Maximum Level | Measurement bandwidth | NOTE |
| 9 kHz ≤ f < 150 kHz | -36 dBm | 1 kHz |  |
| 150 kHz ≤ f < 30 MHz | -36 dBm | 10 kHz |  |
| 30 MHz ≤ f < 1000 MHz | -36 dBm | 100 kHz |  |
| 1 GHz ≤ f < 12.75 GHz | -30 dBm | 1 MHz |  |
| 1 GHz ≤ f < 12.75 GHz | -25 dBm | 1 MHz | 3 |
| 12.75 GHz ≤ f < 5th harmonic of the upper frequency edge of the UL operating band in GHz | -30 dBm | 1 MHz | 1 |
| 12.75 GHz < f < 26GHz | -30dBm | 1MHz | 2 |
| NOTE 1: Applies for Band that the upper frequency edge of the UL Band more than [2.69] GHz  NOTE 2: Applies for Band that the upper frequency edge of the UL Band more than [5.2] GHz  NOTE 3: Applies for n41 and EN-DC combinations that include n41 only when NS\_04 is signalled. | | | |

In LTE, the boundary between out of band and Spurious emission is BWChannel + 5MHz for all bandwidth (channel bandwidth and CA bandwidth) more than 5 MHz, which is derived from the table 5.5.4-2 cited from ITU-R SM.1541 by assigning *BU* to be 5 MHz and changing the starting position of the offset from the centre of channel bandwidth to the edge of channel bandwidth.

Table 5.5.4-2: Start and end of OOB domain

|  |  |  |  |
| --- | --- | --- | --- |
| Type of emission | If necessary bandwidth *BN* is: | Offset (±) from the centre of the necessary bandwidth for the start of the OoB domain | Frequency separation between the centre frequency and the spurious boundary |
| *Narrow-band* | *<BL(see Note1)* | *0.5 BN* | *2.5 BL* |
| *Normal* | *BL to BU* | *0.5 BN* | *2.5 BN* |
| *Wideband* | *>BU* | *0.5 BN* | *BU + (1.5 BN)* |
| NOTE 1: When BN < BL, no attenuation of unwanted emissions is recommended at frequency separations between 0.5 BN to 0.5 BL.  NOTE 2: BL and BU are given in Recommendation ITU-R SM.1539 and SM.329 | | | |

The above guideline in SM.1541 and SM.329 should be also followed to define spurious domain for NR range 1. In NR, the minimum channel bandwidth is 5 MHz, thus similar to E-UTRA, the boundary (FOOB) between OOB and spurious for NR Range 1 shall be also BWChannel + 5 MHz for all possible channel bandwidth for NR range 1.

#### 5.5.4.2 Spurious emission band UE co-existence

#### 5.5.4.3 Additional spurious emissions

These requirements are specified in terms of an additional spectrum emission requirement. Additional spurious emission requirements are signalled by the network to indicate that the UE shall meet an additional requirement for a specific deployment scenario as part of the cell handover/broadcast message.

NOTE: For measurement conditions at the edge of each frequency range, the lowest frequency of the measurement position in each frequency range should be set at the lowest boundary of the frequency range plus MBW/2. The highest frequency of the measurement position in each frequency range should be set at the highest boundary of the frequency range minus MBW/2. MBW denotes the measurement bandwidth defined for the protected band.

##### 5.5.4.3.1 Minimum requirement (network signalled value "NS\_04")

When "NS 04" is indicated in the cell, the power of any UE emission shall not exceed the levels specified in Table 5.5.4.3.1-1. This requirement also applies for the frequency ranges that are less than FOOB (MHz) in Table 5.5.2.2.1-3 from the edge of the channel bandwidth.

Table 5.5.4.3.1-1: Additional requirements

|  |  |  |
| --- | --- | --- |
| **Frequency band**  **(MHz)** | **Channel bandwidth / Spectrum emission limit (dBm)** | **Measurement bandwidth** |
| **10, 15, 20, 40, 50, 60, 80, 100 MHz** |
| 2495 ≤ f < 2496 | -13 | 1% of Channel BW |
| 2490.5 ≤ f < 2495 | -13 | 1 MHz |
| 0 < f < 2490.5 | -25 | 1 MHz |

## 5.6 Transmit intermodulation

UE transmitting in close vicinity of each other can produce intermodulation products, which can fall into the UE, or eNode B receive band as an unwanted interfering signal. Although various uplink signals from other UEs in the same area, for instance NR UL signal, LTE UL signal, UMTS UL (FDD or TDD) or GSM/GPRS signal, can be an interference signal for the interested UE, interference signal of CW (continuous wave signal) would give a good indication on UE intermodulation .thus ,similar to LTE, The UE intermodulation attenuation shall be defined by the ratio of the mean power of the wanted signal to the mean power of the intermodulation product on wanted signal when an interfering CW signal is added at a level below the wanted signal at each of the transmitter antenna port with the other antenna port(s) if any is terminated. In addition, considering the similar deployment scenario of the NR and E-UTRA for sub 6GHz,it is reasonable the level of the CW Interference signal should be kept as -40dBc (same as in LTE).

Similar with UMTS and LTE, the transmitter intermodulation requirements should be specified in conjunction with ACLR requirements. Namely Tx intermodulation level measured in the interested adjacent channel is not masked by the contribution of the ACLR. In that case, the intermodulation requirements can be estimated through ACLR requirement and inherent Tx intermodulation, which can be shown by the following equation:

Intermodulation requirement=10lg (10-ACLR/10+10inherent TX IM/10)

For UMTS and LTE case, inherent Tx intermodulation of -35 dBc (with interferer CW at 20 MHz offset) and -45 dBc (with interferer CW at 40 MHz offset) are assumed. considering most of LTE RF equipment (such as PA, front-end filter, duplexer) shall be reused for NR especially when reframing LTE band, the nonlinearity characteristic will be roughly the same between LTE signal and NR signal. Thus, it can be expected above inherent Tx intermodulation values could be reused for NR. Since the requirements of NR ACLR is defined as NR ACLR= 30 dBc for channel bandwidth up to 100 MHz, the following intermodulation level (Tx IM [measured]) would be applied. it shall be noted that the intermodulation product level in the table is aligned with LTE. The measurement bandwidth of intermodulation product and wanted signal should follow the same principle as NR ACLR MPR assumption i.e. an available maximum transmission bandwidth among the SCSs for a channel BW.

Table 5.6-1,Tx IM level for NR

|  |  |  |  |
| --- | --- | --- | --- |
|  | **1st adjacent channel** | **2nd adjacent channel** |  |
| Interference signal frequency offset | BWChannel | 2\*BWChannel | dBc |
| ACLR | 30 | 36 | dBc |
| Tx IM [inherent] | -35 | -45 | dBc |
| Tx IM [measured] | -29 | -35 | dBc |
| Note 1: BWChannel is the channel bandwidth of NR wanted signal.  Note 2: Measure bandwidth should follow the same principle as NR ACLR. MPR assumption i.e. an available maximum transmission configuration bandwidth among the SCSs for a channel bandwidth. | | | |

## 5.7 ON/OFF time mask

### 5.7.1 UE transient time

For NR, the following three different transient time parameters are defined as below:

- **ON-to-ON time**: ON-to-ON time refers to switching time related to change of power between consecutive UL transmissions. Other switching time requirements due to e.g. antenna switching, frequency hopping which require PLL retuning, beam switching, etc are discussed separately.

- **ON-to-OFF time**: ON-to-OFF time refers to time required for switching from ON state to OFF state for a transmitter.

- **OFF-to-ON time**: OFF-to-ON time refers to time required for switching from OFF state to ON state for a transmitter.

Following transient times are defined for FR1 in Table 5.7.1-1:

Table 5.7.1-1: Transient times for FR1

|  |  |
| --- | --- |
|  | **FR1** |
| ON-to-ON | 10µs |
| OFF-to-ON | 10µs |
| ON-to-OFF | 10µs |

## 5.8 Additional UE RF Tx requirements for SUL and LTE-NR co-existence

It should be noted that simultaneously LTE and NR UL transmission in one carrier or one band is almost unfeasible in Rel-15 because MPR is very hard to determine for this case. So in the following, it is assumed that LTE and NR transmissions are not simultaneously configured in one carrier or one band.

### 5.8.1 Transmit power

For standalone SUL with non-simultaneous transmission, transmit power requirement can be applied separately for UL and SUL carrier. Then for configured transmit power, as the UL carrier and SUL carrier share a same cell, the configured transmit power should be specified for each UL carrier in a serving cell. The requirement for each UL carrier can reuse the definition of configured transmit power for serving cell in general NR.

For LTE-NR DC with SUL, the transmit power related requirements can reuse the general DC transmit power related requirements, only the configured transmit power for the serving cell with SUL carrier shall apply the configured transmit power for each UL carrier in the serving cell for non-simultaneous transmission.

### 5.8.2 Output power dynamics

As LTE and NR should not be simultaneously transmitted in one carrier or one band, the requirements of minimum/OFF output power, time mask and power control should be kept unchanged, and LTE and NR requirements can be applied separately.

In addition, a new requirement of time mask between LTE and NR slot/subframe boundary needs to be specified for DC scenarios since UE needs to switch from LTE to NR and vice versa to maintain two connections for both LTE and NR on the shared carrier when operating in TDM based UL sharing from the UE perspective.

For LTE, 20us transient period is needed for each slot at the boundary. And for NR, only 5us is needed for each slot at the boundary. For LTE, there is difference between the mask with PUSCH and SRS in the last symbol because SRS is high priority and need to be protected. However, for LTE to NR switching in TDM based UL sharing from the UE perspective, this kind of protection of SRS is not needed because LTE can configure no SRS in this specific subframe. So there is no need to specify multiple time masks for LTE to NR switching in UL sharing from the UE perspective.

For TDM based UL sharing from the UE perspective with LTE/NR switching at slot boundary, time masks combined with LTE and NR requirements are illustrated in Figure 5.8.2-1 for almost 0us switching time.

LTE subframe

NR slot

20us

10us

NR slot

LTE subframe

20us

10us

Figure 5.8.2-1 Slot/subframe boundary time mask between LTE and NR in TDM based UL sharing from the UE perspective for type1 UE with switching time 0.5us

By ways of configuring cell-specific SRS subframes in LTE, we can make the LTE last symbol vacant with no transmission of either PUSCH or SRS. In LTE, SRS does not have to be configured for transmission in all cell-specific SRS subframes. In which subframe SRS is transmitted by a UE is according to UE specific SRS configuration. Therefore, the 20us switching time can be placed in LTE subframe for LTE/NR switching in the TDM based UL sharing from the UE perspective because it will not degrade either LTE or NR performance through certain configuration.

For TDM based UL sharing from the UE perspective with LTE/NR switching on the shared carrier at slot boundary, time masks combined with LTE and NR requirements are illustrated in Figure 5.8.2-2 for less than 20us switching time.

LTE subframe

NR slot

40us

10us

NR slot

LTE subframe

30us

20us

Figure 5.8.2-2 Slot/subframe boundary time mask between LTE and NR in TDM based UL sharing from the UE perspective for type2 UE with switching time <20us

### 5.8.3 Transmit signal quality

On the condition that LTE and NR transmissions are not simultaneously configured in one carrier or one band, the requirement of frequency error, EVM and in-band emission should be kept unchanged, and LTE and NR requirements can be applied separately.

It should be noted that for SUL, the downlink reference comes from another band. However, as the local crystal oscillator should be calibrated with the relative error of 0.1ppm, all the output of the PLL including the TX RF PLL should be also locked with the relative frequency error of 0.1ppm. So the maximum allowed frequency error for SUL can be defined as 0.1ppm.

For the carrier leakage requirement, the carrier leakage rejection should be kept unchanged, and LTE and NR requirements can be applied separately. However, it should be noted that the carrier leakage frequency is still under discussion for NR, and whether it still should be at the carrier frequency is FFS.

For NR-LTE co-existence, in order to achieve sub-carrier alignment between LTE and NR, the channel raster for NR may be shifted by 7.5kHz compared to general NR channel raster, in this case the carrier leakage frequency may or may not at the carrier frequency in order not to exclude any implementations.

### 5.8.4 Output RF spectrum emissions

On the condition that LTE and NR transmissions are not simultaneously configured in one carrier or one band, these requirements should be kept unchanged, and LTE and NR requirements can be applied separately.

### 5.8.5 Transmit intermodulation

On the condition that LTE and NR transmissions are not simultaneously configured in one carrier or one band, these requirements should be kept unchanged, and LTE and NR requirements can be applied separately.

# 6 UE Receiver characteristics (frequency range 1)

## 6.1 General

## 6.2 Receiver Sensitivity

For below 6GHz, the REFSENS level can be calculated by the equation below:

Sensitivity = -174dBm(kT) + 10\*log(RX BW) + NF + SNR +IM – diversity gain

It is noted that the Rx BW is identical to the transmission bandwidth configuration, which is determined by the spectrum utilization. The RB values in the analysis of this contribution are based on the agreed SU for NR.

SNR in Nagoya meeting was tentatively agreed as -1dB, the tentative value is the same as that for LTE. However, SNR will be further evaluated by link level simulation. Actually, the SNR under AWGN channel has no difference for different SCS and the demodulation performance for DFT-s-OFDM and CP-OFDM is the same as well. Therefore, the same SNR will be used to calculate REFSENS for different SCS.

The REFSENS for E-UTRA assumes that the receiver is equipped with two Rx port as a baseline. If 2Rx is considered, the diversity gain is 3dB and the Implementation Margin (IM) uses 2.5dB. In the following calculation, same assumptions are used for LTE refarming bands for NR.

The NF for the NR bands can reuse those for E-UTRA. For the three new NR bands, i.e. Bands n77~79, the agreed NR values are 10.5dB, 10dB and 10dB respectively.

The REFSENS values for 15kHz, 30kHz and 60kHz SCS are provided in Table 6.2-1 to Table 6.2-3. It is noted that the REFSENS values are subjected to changes due to the final determined SNR.

Table 6.2-1: Reference sensitivity QPSK PREFSENS for 15 kHz SCS

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Channel bandwidth** | | | | | | | | | | | | |
| **Operating Band** | **5 MHz** | **10 MHz** | **15 MHz** | **20 MHz** | **25 MHz** | **30 MHz** | **40 MHz** | **50 MHz** | **60 MHz** | **80 MHz** | **100 MHz** | **Duplex Mode** |
| **(dBm)** | **(dBm)** | **(dBm)** | **(dBm)** | **(dBm)** | **(dBm)** | **(dBm)** | **(dBm)** | **(dBm)** | **(dBm)** | **(dBm)** |
| n1 | -100.0 | -96.8 | -95.0 | -93.8 |  |  |  |  |  |  |  | FDD |
| n2 | [-98.0] | [-94.8] | [-93.0] | [-91.8] |  |  |  |  |  |  |  | FDD |
| n3 | [-97.0 | [-93.8] | [-92.0] | [-90.8] | [-89.7] | [-88.9] |  |  |  |  |  | FDD |
| n5 | [-98.0] | [-94.8] | [-93.0] | [-91.8] |  |  |  |  |  |  |  | FDD |
| n7 | -98.0 | -94.8 | -93.0 | -91.8 |  |  |  |  |  |  |  | FDD |
| n8 | [-97.0 | [-93.8] | [-92.0] | [-90.8] |  |  |  |  |  |  |  | FDD |
| n20 | [-97.0 | [-93.8] | [-91.0] | [-89.8] |  |  |  |  |  |  |  | FDD |
| n25 | [-96.5] | [-93.3] | [-91.5] | [-90.3] |  |  |  |  |  |  |  | FDD |
| n26 | [-97.5]1 | [-94.3]1 | [-92.5]1 |  |  |  |  |  |  |  |  | FDD |
| n28 | [-98.5 | [-95.5] | [-93.5] | [-90.8] |  |  |  |  |  |  |  | FDD |
| n34 | -100.0 | -96.8 | -95.0 |  |  |  |  |  |  |  |  | TDD |
| n38 | -100.0 | -96.8 | -95.0 | -93.8 |  |  |  |  |  |  |  | TDD |
| n39 | -100.0 | -96.8 | -95.0 | -93.8 | -92.7 | [-91.9] | -90.6 |  |  |  |  | TDD |
| n40 | -100.0 | -96.8 | -95.0 | -93.8 | -92.7 | [-91.9] | -90.6 | -89.6 |  |  |  | TDD |
| n41 |  | -94.8 | -93.0 | -91.8 |  |  | -88.6 | -87.6 |  |  |  | TDD |
| n50 | -100.0 | -96.8 | -95.0 | -93.8 |  |  | -90.6 | -89.6 |  |  |  | TDD |
| n51 | -100.0 |  |  |  |  |  |  |  |  |  |  | TDD |
| n66 | -99.5 | -96.3 | -94.5 | -93.3 |  |  |  |  |  |  |  | FDD |
| n70 | -100.0 | -96.8 | -95.0 | -93.8 | -92.7 |  |  |  |  |  |  | FDD |
| n71 | -97.2 | -94.0 | -91.6 | -86 |  |  |  |  |  |  |  | FDD |
| n74 | -99.5 | -96.3 | -94.5 | -93.3 |  |  |  |  |  |  |  | FDD |
| n77 |  | -95.8 | -94.0 | -92.7 |  |  | -89.6 | -88.6 |  |  |  |  |
| n77(3.8-4.2GHz) |  | -95.3 | -93.5 | -92.2 |  |  | -89.1 | -88.1 |  |  |  | TDD |
| n78 |  | -95.8 | -94.0 | -92.7 |  |  | -89.6 | -88.6 |  |  |  | TDD |
| n79 |  |  |  |  |  |  | -89.6 | -88.6 |  |  |  | TDD |
| Note 1: Indicates that the requirement is modified by -0.5 dB when the carrier frequency of the assigned E-UTRA channel bandwidth is within 865-894 MHz. | | | | | | | | | | | | |

Table 6.2-2: Reference sensitivity QPSK PREFSENS for 30 kHz SCS

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Channel bandwidth** | | | | | | | | | | | | |
| **Operating Band** | **5 MHz** | **10 MHz** | **15 MHz** | **20 MHz** | **25 MHz** | **30 MHz** | **40 MHz** | **50 MHz** | **60 MHz** | **80 MHz** | **100 MHz** | **Duplex Mode** |
| **(dBm)** | **(dBm)** | **(dBm)** | **(dBm)** | **(dBm)** | **(dBm)** | **(dBm)** | **(dBm)** | **(dBm)** | **(dBm)** | **(dBm)** |
| n1 |  | -97.1 | -95.1 | -94.0 |  |  |  |  |  |  |  | FDD |
| n2 |  | [-95.1] | [-93.1] | [-92.0] |  |  |  |  |  |  |  | FDD |
| n3 |  | [-94.1] | [-92.1] | [-91.0] | [-89.8] | [-89] |  |  |  |  |  | FDD |
| n5 |  | [-95.1] | [-93.1] | [-92.0] |  |  |  |  |  |  |  | FDD |
| n7 |  | -95.1 | -93.1 | -92.0 |  |  |  |  |  |  |  | FDD |
| n8 |  | [-94.1] | [-92.1] | [-91.0] |  |  |  |  |  |  |  | FDD |
| n20 |  | [-94.1] | [-91.1] | [-90.0] |  |  |  |  |  |  |  | FDD |
| n25 |  | [-93.6] | [-91.6] | [-90.5] |  |  |  |  |  |  |  | FDD |
| n26 |  | [-94.7]1 | [-92.7]1 |  |  |  |  |  |  |  |  | FDD |
| n28 |  | [-95.6] | [-93.6] | [-91.0] |  |  |  |  |  |  |  | FDD |
| n34 |  | -97.1 | -95.1 |  |  |  |  |  |  |  |  | TDD |
| n38 |  | -97.1 | -95.1 | -94.0 |  |  |  |  |  |  |  | TDD |
| n39 |  | -97.0 | -95.1 | -94.0 | -92.8 | [-92.0] | -90.7 |  |  |  |  | TDD |
| n40 |  | -97.0 | -95.1 | -94.0 | -92.8 | [-92.0] | -90.7 | -89.7 | -88.9 | -87.6 |  | TDD |
| n41 |  | -95.1 | -93.1 | -92.0 |  |  | -88.7 | -87.7 | -86.9 | -85.6 | -84.7 | TDD |
| n50 |  | -97.1 | -95.1 | -94.0 |  |  | -90.7 | -89.7 | -88.9 |  |  | TDD |
| n51 |  |  |  |  |  |  |  |  |  |  |  | TDD |
| n66 |  | -96.6 | -94.6 | -93.5 |  |  | -90.2 |  |  |  |  | FDD |
| n70 |  | -97.1 | -95.1 | -94.0 | -92.8 |  |  |  |  |  |  | FDD |
| n71 |  | [-94.3] | [-91.9] | [-87.5] |  |  |  |  |  |  |  | FDD |
| n74 |  | -96.6 | -94.6 | -93.5 |  |  |  |  |  |  |  | FDD |
| n77 |  | -96.1 | -94.1 | -92.9 |  |  | -89.7 | -88.7 | -87.9 | -86.6 | -85.6 | TDD |
| n77 (3.8-4.2GHz) |  | -95.6 | -93.6 | -92.4 |  |  | -89.2 | -88.2 | -87.4 | -86.1 | -85.1 | TDD |
| n78 |  | -96.1 | -94.1 | -92.9 |  |  | -89.7 | -88.7 | -87.9 | -86.6 | -85.6 | TDD |
| n79 |  |  |  |  |  |  | -89.7 | -88.7 | -87.9 | -86.6 | -85.6 | TDD |
| NOTE 1: Indicates that the requirement is modified by -0.5 dB when the carrier frequency of the assigned E-UTRA channel bandwidth is within 865-894 MHz. | | | | | | | | | | | | |

Table 6.2-3: Reference sensitivity QPSK PREFSENS for 60 kHz SCS

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Channel bandwidth** | | | | | | | | | | | | |
| **Operating Band** | **5 MHz** | **10 MHz** | **15 MHz** | **20 MHz** | **25 MHz** | **30 MHz** | **40 MHz** | **50 MHz** | **60 MHz** | **80 MHz** | **100 MHz** | **Duplex Mode** |
| **(dBm)** | **(dBm)** | **(dBm)** | **(dBm)** | **(dBm)** | **(dBm)** | **(dBm)** | **(dBm)** | **(dBm)** | **(dBm)** | **(dBm)** |
| n1 |  | -97.5 | -95.4 | -94.2 |  |  |  |  |  |  |  | FDD |
| n2 |  | [-95.5] | [-93.4] | [-92.2] |  |  |  |  |  |  |  | FDD |
| n3 |  | [-94.5] | [-92.4] | [-91.2] | [-90.0] | [-89.1] |  |  |  |  |  | FDD |
| n5 |  |  |  |  |  |  |  |  |  |  |  | FDD |
| n7 |  | -95.5 | -93.4 | -92.2 |  |  |  |  |  |  |  | FDD |
| n8 |  |  |  |  |  |  |  |  |  |  |  | FDD |
| n20 |  |  |  |  |  |  |  |  |  |  |  | FDD |
| n25 |  | [-94.0] | [-91.9] | [-90.7] |  |  |  |  |  |  |  | FDD |
| n26 |  | [-95.0]1 | [-92.9]1 |  |  |  |  |  |  |  |  | FDD |
| n28 |  |  |  |  |  |  |  |  |  |  |  | FDD |
| n34 |  | -97.5 | -95.4 |  |  |  |  |  |  |  |  | TDD |
| n38 |  | -97.5 | -95.4 | -94.2 |  |  |  |  |  |  |  | TDD |
| n39 |  | -97.5 | -95.4 | -94.2 | -93.0 | [-92.1] | -90.9 |  |  |  |  | TDD |
| n40 |  | -97.5 | -95.4 | -94.2 | -93.0 | [-92.1] | -90.9 | -89.8 | -89.1 | -87.6 |  | TDD |
| n41 |  | -95.5 | -93.4 | -92.2 |  |  | -88.9 | -87.8 | -87.1 | -85.6 | -84.7 | TDD |
| n50 |  | -97.5 | -95.4 | -94.2 |  |  |  |  |  |  |  | TDD |
| n51 |  |  |  |  |  |  |  |  |  |  |  | TDD |
| n66 |  | -97.0 | -94.9 | -93.7 |  |  |  |  |  |  |  | FDD |
| n70 |  | -97.5 | -95.4 | -94.2 | -93.0 |  |  |  |  |  |  | FDD |
| n71 |  |  |  |  |  |  |  |  |  |  |  | FDD |
| n74 |  | -97.0 | -94.9 | -93.7 |  |  |  |  |  |  |  | FDD |
| n77 |  | -96.5 | -94.4 | -93.1 |  |  | -89.9 | -88.8 | -88.0 | -86.7 | -85.7 | TDD |
| n77 (3.8-4.2GHz) |  | -96 | -93.9 | -92.6 |  |  | -89.4 | -88.3 | -87.5 | -86.2 | -85.2 | TDD |
| n78 |  | -96.5 | -94.4 | -93.1 |  |  | -89.9 | -88.8 | -88.0 | -86.7 | -85.7 | TDD |
| n79 |  |  |  |  |  |  | -89.9 | -88.8 | -88.0 | -86.7 | -85.7 | TDD |
| Note 1: indicates that the requirement is modified by -0.5 dB when the carrier frequency of the assigned E-UTRA channel bandwidth is within 865-894 MHz. | | | | | | | | | | | | |

When we define the REFSENS for these values for E-UTRA, due to the close frequency range between UL and DL, REFSENS for some CBWs are relaxed, i.e. 1 dB relaxation for 15MHz and 20MHz CBW for Band 20, 1.5dB relaxation for 20MHz CBW for Band 28, and 0.4dB relaxation for 15MHz and 3.7dB for 20MHz for Band 71.

As SU for NR is increased compared to that of E-UTRA, the relaxation for these bands may need to be further enlarged. Currently, the same relaxation values are tentatively used for these NR bands, thus the values are put in brackets in the tables.

The other aspect needs to be considered for REFSENS is the uplink configuration. For NR bands, the similar constrains on the UL RB allocation as those for E-UTRA can be considered as well, however, the new SU shall be considered in determine the uplink configurations. Some principles are considered to derive the UL RB allocation in Table 6.2-4:

1. The full RB allocation for counterpart E-UTRA CBW will be extended for NR based on new SU

2. For the CBW with RB allocation constraints but without REFSENS relaxation, the RBs will be adjusted based on NR SU, e.g. for E-UTRA Band 3, 50 RB is utilized for 15MHz CBW, thus the RB will be adjusted to 52RB for NR Band n3 for the same CBW.

3. For the E-UTRA band with REFSENS relaxation for some CBWs, the same RB allocations for 15kHz SCS will be kept for the counterpart NR band.

4. For 30kHz and 60kHz SCS, if full RB allocation cannot be supported for the CBW, the floor value most close to the transmission BW configuration of 15kHz SCS will be adopted.

Table 6.2-4 gives the uplink configuration for NR REFSENS for the proposed NR bands.

Table 6.2-4: Uplink configuration for NR reference sensitivity

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **NR Band / Channel bandwidth / NRB / Duplex mode** | | | | | | | | | | | | | |
| **Operating Band** | **SCS** | **5 MHz** | **10 MHz** | **15 MHz** | **20 MHz** | **25 MHz** | **30 MHz** | **40 MHz** | **50 MHz** | **60 MHz** | **80 MHz** | **100 MHz** | **Duplex Mode** |
| **(kHz)** | **(NRB)** | **(NRB)** | **(NRB)** | **(NRB)** | **(NRB)** | **(NRB)** | **(NRB)** | **(NRB)** | **(NRB)** | **(NRB)** | **(NRB)** |
| n1 | 15 | 25 | 52 | 79 | 106 |  |  |  |  |  |  |  | FDD |
| 30 |  | 24 | 38 | 51 |  |  |  |  |  |  |  |
| 60 |  | 11 | 18 | 24 |  |  |  |  |  |  |  |
| n2 | 15 | 25 | 52 | 521 | 521 |  |  |  |  |  |  |  | FDD |
| 30 | 11 | 24 | 241 | 241 |  |  |  |  |  |  |  |
| 60 |  | 11 | 111 | 111 |  |  |  |  |  |  |  |
| n3 | 15 | 25 | 52 | 521 | 521 | TBD | TBD |  |  |  |  |  | FDD |
| 30 |  | 24 | 241 | 241 | TBD | TBD |  |  |  |  |  |
| 60 |  |  | 111 | 111 | TBD | TBD |  |  |  |  |  |
| n5 | 15 | 25 | 251 | TBD | TBD |  |  |  |  |  |  |  | FDD |
| 30 |  | 111 | TBD | TBD |  |  |  |  |  |  |  |
| 60 |  |  |  |  |  |  |  |  |  |  |  |
| n7 | 15 | 25 | 52 | 79 | 791 |  |  |  |  |  |  |  | FDD |
| 30 |  | 24 | 38 | 381 |  |  |  |  |  |  |  |
| 60 |  | 11 | 18 | 181 |  |  |  |  |  |  |  |
| n8 | 15 | 25 | 251 | TBD | TBD |  |  |  |  |  |  |  | FDD |
| 30 |  | 111 | TBD | TBD |  |  |  |  |  |  |  |
| 60 |  |  |  |  |  |  |  |  |  |  |  |
| n20 | 15 | 25 | 201 | 202 | 202 |  |  |  |  |  |  |  | FDD |
| 30 |  | 101 | 102 | 102 |  |  |  |  |  |  |  |
| 60 |  |  |  |  |  |  |  |  |  |  |  |
| n25 | 15 | 25 | 52 | 521 | 521 |  |  |  |  |  |  |  | FDD |
| 30 | 11 | 24 | 241 | 241 |  |  |  |  |  |  |  |
| 60 |  |  | 111 | 111 |  |  |  |  |  |  |  |
| n26 | 15 | 25 | 251 | 251 |  |  |  |  |  |  |  |  | FDD |
| 30 |  | 111 | 111 |  |  |  |  |  |  |  |  |
| 60 |  | 51 | 51 |  |  |  |  |  |  |  |  |
| n28 | 15 | 25 | 251 | 251 | 251 |  |  |  |  |  |  |  | FDD |
| 30 |  | 111 | 111 | 111 |  |  |  |  |  |  |  |
| 60 |  |  |  |  |  |  |  |  |  |  |  |
| n34 | 15 | 25 | 52 | 79 |  |  |  |  |  |  |  |  | TDD |
| 30 |  | 24 | 38 |  |  |  |  |  |  |  |  |
| 60 |  | 11 | 18 |  |  |  |  |  |  |  |  |
| n38 | 15 | 25 | 52 | 79 | 106 |  |  |  |  |  |  |  | TDD |
| 30 |  | 24 | 38 | 51 |  |  |  |  |  |  |  |
| 60 |  | 11 | 18 | 24 |  |  |  |  |  |  |  |
| n39 | 15 | 25 | 52 | 79 | 106 | 133 | [160] | 206 |  |  |  |  | TDD |
| 30 |  | 24 | 38 | 51 | 65 | [78] | 106 |  |  |  |  |
| 60 |  | 11 | 18 | 24 | 31 | [38] | 51 |  |  |  |  |
| n40 | 15 | 25 | 52 | 79 | 106 | 133 | [160] | 206 | 270 |  |  |  | TDD |
| 30 |  | 24 | 38 | 51 | 65 | [78] | 106 | 133 | 162 | 217 |  |
| 60 |  | 11 | 18 | 24 | 31 | [38] | 51 | 65 | 79 | 107 |  |
| n41 | 15 |  | 52 | 79 | 106 |  |  | 216 | 270 |  |  |  | TDD |
| 30 |  | 24 | 38 | 51 |  |  | 106 | 133 | 162 | 217 | 273 |
| 60 |  | 11 | 18 | 24 |  |  | 51 | 65 | 79 | 107 | 135 |
| n50 | 15 | 25 | 52 | 79 | 106 |  |  | 216 | 270 |  |  |  | TDD |
| 30 | 11 | 24 | 38 | 51 |  |  | 106 | 133 | 162 |  |  |
| 60 |  | 11 | 18 | 24 |  |  |  |  |  |  |  |
| n51 | 15 | 25 |  |  |  |  |  |  |  |  |  |  | TDD |
| 30 |  |  |  |  |  |  |  |  |  |  |  |
| 60 |  |  |  |  |  |  |  |  |  |  |  |
| n66 | 15 | 25 | 52 | 79 | 106 |  |  |  |  |  |  |  | FDD |
| 30 |  | 24 | 38 | 51 |  |  |  |  |  |  |  |
| 60 |  |  | 18 | 24 |  |  |  |  |  |  |  |
| n70 | 15 | 25 | 52 | 79 | 106 | 133 |  |  |  |  |  |  | FDD |
| 30 |  | 24 | 38 | 51 | 65 |  |  |  |  |  |  |
| 60 |  | 11 | 18 | 24 | 31 |  |  |  |  |  |  |
| n71 | 15 | 25 | 251 | 201 | 201 |  |  |  |  |  |  |  | FDD |
| 30 |  | 121 | 101 | 101 |  |  |  |  |  |  |  |
| 60 |  |  |  |  |  |  |  |  |  |  |  |
| n74 | 15 | 25 | 251 | 251 | 251 |  |  |  |  |  |  |  | FDD |
| 30 |  | 111 | 111 | 111 |  |  |  |  |  |  |  |
| 60 |  | 51 | 51 | 51 |  |  |  |  |  |  |  |
| n77 | 15 |  | 52 | 79 | 106 |  |  | 216 | 270 |  |  |  | TDD |
| 30 |  | 24 | 38 | 51 |  |  | 106 | 133 | 162 | 217 | 273 |
| 60 |  | 11 | 18 | 24 |  |  | 51 | 65 | 79 | 107 | 135 |
| n78 | 15 |  | 52 | 79 | 106 |  |  | 216 | 270 |  |  |  | TDD |
| 30 |  | 24 | 38 | 51 |  |  | 106 | 133 | 162 | 217 | 273 |
| 60 |  | 11 | 18 | 24 |  |  | 51 | 65 | 79 | 107 | 135 |
| n79 | 15 |  |  |  |  |  |  | 216 | 270 |  |  |  | TDD |
| 30 |  |  |  |  |  |  | 106 | 133 | 162 | 217 | 273 |
| 60 |  |  |  |  |  |  | 51 | 65 | 79 | 107 | 135 |
| NOTE 1: 1 refers to the UL resource blocks shall be located as close as possible to the downlink operating band but confined within the transmission bandwidth configuration for the channel bandwidth.  NOTE 2: 2 refers to Band 20; for 15kHz SCS, in the case of 15MHz channel bandwidth, the UL resource blocks shall be located at RBstart 11 and in the case of 20MHz channel bandwidth, the UL resource blocks shall be located at RBstart 16; for 30kHz SCS, in the case of 15MHz channel bandwidth, the UL resource blocks shall be located at RBstart 6 and in the case of 20MHz channel bandwidth, the UL resource blocks shall be located at RBstart 8; for 60kHz SCS, in the case of 15MHz channel bandwidth, the UL resource blocks shall be located at RBstart 3 and in the case of 20MHz channel bandwidth, the UL resource blocks shall be located at RBstart 4; | | | | | | | | | | | | | |

### 6.2.1 MSD (Maximum sensitivity degradation)

## 6.3 Selectivity

## 6.4 Blocking performance

## 6.5 Spurious response

## 6.6 Intermodulation performance

## 6.7 Spurious emission

## 6.8 Additional UE RF Rx requirements for SUL and LTE-NR co-existence

### 6.8.1 REFSENS

Reference sensitivity for NR band with uplink configured in LTE refarming band is a band combination specific requirement.

### 6.8.2 Other receiver requirements

Other receiver requirements will be kept unchanged for NR band.

# 7 UE Transmitter characteristics (frequency range 2)

## 7.1 General

### 7.1.1 CA Bandwidth Class

For intra-band contiguous carrier aggregation, a carrier aggregation configuration is a single operating band supporting a carrier aggregation bandwidth class with associated bandwidth combination sets. For each carrier aggregation configuration, requirements are specified for all aggregated channel bandwidths contained in a bandwidth combination set, A UE can indicate support of several bandwidth combination sets per carrier aggregation configuration.

For intra-band non-contiguous carrier aggregation, a carrier aggregation configuration is a single operating band supporting two or more sub-blocks, each supporting a carrier aggregation bandwidth class.

For inter-band carrier aggregation, a carrier aggregation configuration is a combination of operating bands, each supporting a carrier aggregation bandwidth class.

Table 7.1.1-1 gives the proposed NR CA bandwidth class for FR2.

Table 7.1.1-1: NR CA Bandwidth Class for FR2

|  |  |  |  |
| --- | --- | --- | --- |
| **NR CA bandwidth class** | **Aggregated channel bandwidth** | **Number of contiguous CC** | **Fallback group** |
| A | BWChannel ≤ 400 MHz | 1 | - |
| B | 400 MHz < BWChannel\_CA ≤ 800 MHz | 2 | 1 |
| C | 800 MHz < BWChannel\_CA ≤ 1200 MHz | 3 |
| D | 200 MHz < BWChannel\_CA ≤ 400 MHz | 2 | 2 |
| E | 400 MHz < BWChannel\_CA ≤ 600 MHz | 3 |
| F | 600 MHz < BWChannel\_CA ≤ 800 MHz | 4 |
| G | 100 MHz < BWChannel\_CA ≤ 200 MHz | 2 | 3 |
| H | 200 MHz < BWChannel\_CA ≤ 300 MHz | 3 |
| I | 300 MHz < BWChannel\_CA ≤ 400 MHz | 4 |
| J | 400 MHz < BWChannel\_CA ≤ 500 MHz | 5 |
| K | 500 MHz < BWChannel\_CA ≤ 600 MHz | 6 |
| L | 600 MHz < BWChannel\_CA ≤ 700 MHz | 7 |
| M | 700 MHz < BWChannel\_CA ≤ 800 MHz | 8 |
| O | 100 MHz ≤ BWChannel\_CA ≤ 200 MHz | 2 | 4 |
| P | 150 MHz ≤ BWChannel\_CA ≤ 300 MHz | 3 |
| Q | 200 MHz ≤ BWChannel\_CA ≤ 400 MHz | 4 |
| NOTE 1: Maximum supported component carrier bandwidths for fallback groups 1, 2, 3 and 4 are 400 MHz, 200 MHz, 100 MHz and 100 MHz respectively.  NOTE 2: It is mandatory for a UE to be able to fallback to lower order CA bandwidth class configuration within a fallback group. It is not mandatory for a UE to be able to fallback to lower order CA bandwidth class configuration that belong to a different fallback group. | | | |

## 7.2 Transmit power

### 7.2.1 Power Class

Power class of FR2 UEs is specified as a package of the minimum peak EIRP, maximum allowed TRP, maximum allowed EIRP and spherical coverage.

Minimum Peak EIRP Requirement:

The peak EIRP is the maximum EIRP capability of UE to all directions and represents the beam forming capability of UE. Unlike LTE, where each UE power class is specified as a nominal value with +/- tolerance, mmWave UE peak EIRP requirement only specifies a lower limit, i.e., no power class-dependent peak EIRP upper limit is specified. UE meets the requirement as long as it exceeds the defined limit in one direction and, since the requirement is only lower limit, no tolerance is specified.

Maximum TRP/EIRP Requirement:

On the other hand, an upper limit of TRP requirement is introduced in conjunction with EIRP-based power class to constrain UL co-channel interference. This encourages UE to achieve as better as possible EIRP performance by implementation improvement without causing additional co-channel interference. Some countries/regions have regulatory requirement on the maximum allowed EIRP for the mmWave UE. The requirement depends on UE types. For handheld UE that is supposed to be carried by people, a lower maximum allowed EIRP is required. But a higher EIRP is allowed for other UE types to enable higher data rates and better coverage. To meet the regulatory requirement, the requirement for the maximum allowed EIRP is captured. The requirement varies depending on UE type and the peak EIRP shall not exceed the maximum allowed value.

Spherical Coverage Requirement

The spherical coverage requirement is defined by EIRP value at certain percentile on the CDF curve, where the percentile depends on power class (i.e., UE type). The reason to specify UE type-dependent percentile is because different UE types may have different applicable sphere area, e.g. for some UE types, a specific portion of its radiation sphere may be blocked and the spatial coverage requirement on the blocked directions should be excluded.

The CDF curve is obtained by plotting the measured EIRP on test directions with uniform surface density over the whole sphere even if the target beam coverage area for certain UE type is less than 100% sphere. The spherical coverage requirement assures that UE can transmit EIRP no lower than the defined EIRP limit over the required percentile.

The power class is used to distinguish different UE types and each power class corresponds to a single UE type. Several UE types were identified and their power class were specified as summarized in Table 7.2.1-1.

Table 7.2.1-1: Classification of UE Types

|  |  |
| --- | --- |
| UE Power class | UE type |
| 1 | Fixed Wireless Access (FWA) UE following US FCC 55dBm EIRP power limit |
| 2 | Vehicle mounted UE following US FCC 43dBm EIRP power limit |
| 3 | Handheld UE following US FCC 43dBm EIRP power limit |
| 4 | High power non- handheld UE following US FCC 43dBm EIRP power limit |

#### 7.2.1.1 UE Power class 1

Power class 1 is specified, assuming to be applied for FWA UE.

Table 7.2.1.1-1: (Void)

Table 7.2.1.1-1: (Void)

##### 7.2.1.1.1 Minimum Peak EIRP requirement

**How to derive the requirement**

Proposal for FWA peak EIRP evaluation which contributes to the peak EIRP link budget is shown in Table 7.2.1.1.1-1 below. After discussion, Minimum peak EIRP is defined as 40dBm for 28GHz and as 38.0dBm for 39GHz.

Table 7.2.1.1.1-1: Proposal for FWA peak EIRP evaluation

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter | Unit | Freq. range 24.25-29.5 GHz | | | Freq. range 37.0-40.0 GHz | | |
| Source 1 | Source 2 | Source 3 | Source 1 | Source 2 | Source 3 |
| P\_out per element | dBm | 14 | 14 | 14 | 14 | 14 | 14 |
| # of antennas in array |  | 16 | 16 | 16 | 16 | 16 | 16 |
| Total conducted power per polarization | dBm | 26 | 26 | 26 | 26 | 26 | 24.6 |
| Avg. antenna element gain | dBi | 4.5 | 5 | 5 | 4.5 | 4 | 5 |
| Antenna roll-off loss vs frequency | dB | -1.0 | -2.0 | -1 | -1.5 | -2.5 | -0.7 |
| Realized antenna array gain | dBi | 15.5 | 14 | 17 | 15.0 | 13.5 | 17 |
| Polarization gain | dB | 2.5 | 2.80 | 2.50 | 2.8 | 2.80 | 2.50 |
| Mismatch and transmission line loss  including load pull | dB | -2.1 | -3.00 | -- | -2.7 | -3.50 | -- |
| Beam forming loss (phase shifter and amplitude error) | dB | -0.5 | -0.5 | -- | -0.5 | -0.5 | -- |
| Finite beam table | dB | -0.25 | -0.25 | -- | -0.25 | -0.25 | -- |
| Beam forming loss (one beam table fits all) | dB | -0.25 | -0.25 | -- | -0.25 | -0.25 | -- |
| Form-factor integration losses | dB | -4.5 | -3.5 | -- | -5.5 | -4.5 | -- |
| Total implementation loss (worst-case) | dB | -7.6 | -7.5 | -5.00 | -9.2 | -9.00 | -7.00 |
| Peak EIRP (Minimum) | dBm | 36.4 | 35.3 | 39.5 | 34.6 | 33.3 | 36.4 |

**Conclusion**

The minimum Peak EIRP values is specified in Table 7.2.1.1.1-2.

Table 7.2.1.1.1-2: UE Minimum Peak EIRP for Power class 1

|  |  |
| --- | --- |
| Operating Band | Min Peak EIRP (dBm) |
| n257 | 40.0 |
| n258 | 40.0 |
| n260 | 38.0 |
| n261 | 40.0 |
| NOTE 1: minimum peak EIRP is defined as the lower limit without tolerance | |

##### 7.2.1.1.2 Maximum TRP/EIRP requirement

The maximum output power values for TRP and EIRP are found in Table 7.2.1.1.2-1 below. The maximum allowed EIRP is derived from regulatory requirements [12].

Table 7.2.1.1.2-1: UE Maximum Output Power Limits for Power class 1

|  |  |  |
| --- | --- | --- |
| **Operating Band** | **Max TRP (dBm)** | **Max EIRP (dBm)** |
| n257 | 35 | 55 |
| n258 | 35 | 55 |
| n260 | 35 | 55 |
| n261 | 35 | 55 |

##### 7.2.1.1.3 Spherical coverage requirement

**How to derive the requirement**

Fixed Wireless Access UE is installed on outside wall of building by professional, who can guarantee the direction difference between ideal boresight beam direction and LOS direction from FWA UE to gNB be well controlled within the angle of half beam width. Therefor the target beam coverage of power class 1 was allowed limited area of sphere.

Specifically, based on knowledge of FR2 CPE device deployment, it is expected that the beam coverage area should be +/-50 degree, i.e., the top sphere area with in elevation direction provided that the boresight direction is along with z-coordinate.



Figure 7.2.1.1.3-1: Beam coverage area, i.e., top sphere area with θ≤50°in elevation direction

With the simple math for sphere area, the beam coverage area is 17.8% of total surface area of sphere i.e., . To reserve certain margin for the outer range of beam coverage area, it was derived to use 85%-tile requirement for EIRP CDF of FWA’s spherical coverage performance.

The minimum allowed min Peak EIRP at 85%-tile CDF is derived from the simulation which evaluate an achievable Spherical Coverage Performance. Based on the 4x4 array panel by which one direction is covered, the following beamforming pattern can be simulated, where beams with 39 directions are utilized for the beam coverage area with θ≤50°in elevation direction. Two observation angles are shown in below figures.

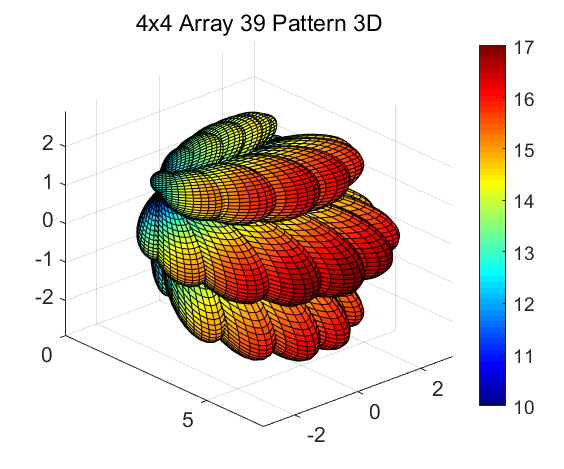
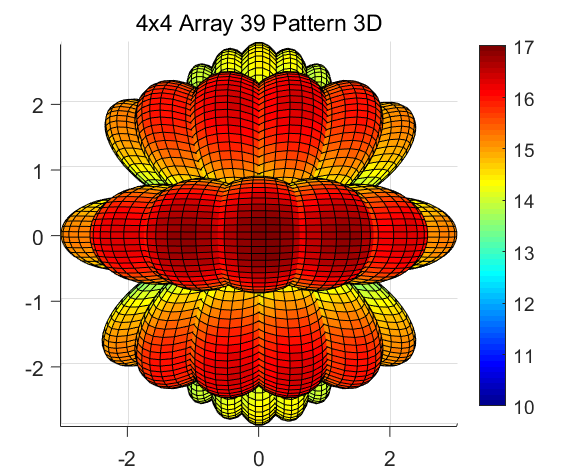


Figure 7.2.1.1.3-2: Beam coverage area, i.e., top sphere area with θ≤50°in elevation direction

It can be observed that the antenna gain achieved by beams in the outermost beam layer can be at least 3dB less than the center boresight direction, while the boundary areas between individual beams can be further degraded with the amount as much as around 6-7 dB.

CDF plot of achievable antenna gain based on ideal simulation environment is provided in the following figure, in which around 4dB degradation from peak direction can be observed at 85%-tile CDF point, i.e., 13.18dB at 85%-tile from 17dB in peak direction. In other words, the beam scanning loss without radome into account could be 4dB.

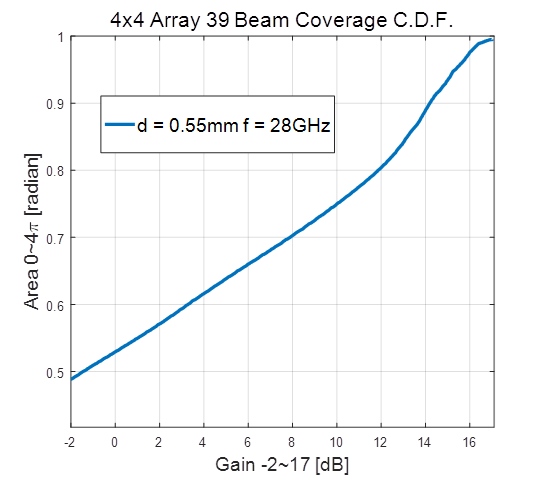


Figure 7.2.1.1.3-3: CDF of ideal antenna gain for 4x4 panel at 28GHz, 5.5mm element-spacing in both x- & y-directions

Furthermore, additional radome loss should also be considered, which arises when beam is steered away from boresight direction considering radome material can be beam-direction dependent and this loss has not been reflected in above simulation for ideal propagation environment. Based on our understanding and experience, at least 2.5dB should be reserved for this additional radome loss. Finally, additional 1.5dB should be reserved for implementation margin, to account for mmWave radiation distortion, practical design options for directional beam book design, and inaccuracy of pre-coder implementation etc.

As a summary, it was proposed to have 8.0dB at 85%-tile from peak EIRP value, with the breakdown of 8.0 dB as below:

Scan Loss w/o Radome: ~4 dB

Additional Radome Loss: 2.5 dB

Implementation Margin: ~1.5 dB

**Conclusion**

The minimum EIRP at the 85th percentile of the distribution of radiated power measured over the full sphere around the UE is defined as the spherical coverage requirement and is found in Table 7.2.1.1.3-1 below.

Table 7.2.1.1.3-1: UE spherical coverage requirement for Power class 1

|  |  |
| --- | --- |
| **Operating Band** | **Min EIRP at 85%-tile CDF [dBm]** |
| n257 | 32.0 |
| n258 | 32.0 |
| n260 | 32.0 |
| n261 | 32.0 |
| NOTE 1: Minimum EIRP at 85 %-tile CDF is defined as the lower limit without tolerance  NOTE 2: The requirements in this table are only applicable for UE which supports single band in FR2 | |

#### 7.2.1.2 (Void)

#### 7.2.1.3 UE Power class 2

Power class 2 is specified, assuming to be applied for only Vehicle mounted UE, which is installed on a motor vehicle like a car.

##### 7.2.1.3.1 Minimum Peak EIRP requirement

**How to derive the requirement**

Several companies proposed the minimum allowed Peak EIRP for Power class 2 as shown in following Table 7.2.1.3.1-1. After discussion, minimum peak EIRP for power class 2 was defined as 29 dBm at band n257, n258, n261.

Table 7.2.1.3.1-1: survey of reported UE Minimum Peak EIRP for Power class 2

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parameter | Unit | Source 1 | Source 2 | Source 3 |
| Pout per element | dBm | 12 | 13 | 16 |
| # of antennas in array |  | 8 | 8 | 8 |
| Total conducted power per polarization | dBm | 21 | 22 | 25 |
| Avg. antenna element gain | dBi | 4.5 | 4 | 5 |
| Antenna roll-off loss vs frequency | dB | -1.0 | -2.0 | -1 |
| Realized antenna array gain | dBi | 12.5 | 11 | 14 |
| Polarization gain | dB | 2.5 | -- | -- |
| Mismatch and transmission line loss including load pull | dB | -2.5 | -- | -- |
| Beam forming loss (phase shifter and amplitude error) | dB | -0.5 | -- | -- |
| Finite beam table | dB | -0.25 | -- | -- |
| Beam forming loss (one beam table fits all) | dB | -0.25 | -1 | -- |
| Form-factor integration losses | dB | -4.5 | -1.5 | -- |
| Total implementation loss (worst-case) | dB | -8.0 | -4 | -5 |
| **Peak EIRP (Minimum)** | **dBm** | **28** | **29** | **29.5** |

**Conclusion**

The minimum Peak EIRP values is found in Table 7.2.1.3.1-2 below.

Table 7.2.1.3.1-2: UE Minimum Peak EIRP for Power class 2

|  |  |
| --- | --- |
| **Operating Band** | **Min Peak EIRP (dBm)** |
| n257 | 29.0 |
| n258 | 29.0 |
| n261 | 29.0 |
| NOTE 1: minimum peak EIRP is defined as the lower limit without tolerance | |

##### 7.2.1.3.2 Maximum TRP/EIRP requirement

The maximum output power values for TRP and EIRP are found in Table 7.2.1.3.2-1 below. The maximum allowed EIRP is derived from regulatory requirements [12].

Table 7.2.1.3.2-1: UE Maximum Output Power Limits for Power class 2

|  |  |  |
| --- | --- | --- |
| **Operating Band** | **Max TRP (dBm)** | **Max EIRP (dBm)** |
| n257 | 23 | 43 |
| n258 | 23 | 43 |
| n261 | 23 | 43 |

##### 7.2.1.3.3 Spherical coverage requirement

**How to derive the requirement**

Vehicle Mounted UE is attached on a body or a rooftop of a motor vehicle. Therefor the target beam coverage is limited half sphere because the body of vehicle blocks off radiation from vehicle mounted UE at the body side of the contact face. The spherical coverage requirement is originally agreed as 20%-tile on half spherical coverage. However, the definition of spherical coverage is full sphere so that spherical coverage of power class 2 is redefined at 60%-tile on full spherical coverage. This does not mean to relax the requirement. Practically EIRP at blocked side of vehicle should be sufficiently small and original requirement of half spherical coverage should be satisfied.

The value at CDF percentile of 20% (for half spherical) coverage was obtain to evaluate CDF of antenna gain for 28GHz based on the half sphere as show in Figure 7.2.1.3.3-1.



Figure 7.2.1.3.3-1: Antenna gain for Power class 2 UE

Based on the above CDF curves, it was proposed to define the required EIRP corresponding to 20% CDF percentile of the half spherical coverage considering some implementation margin, it was defined as 11dB at 20%-tile from peak EIRP value for half spherical coverage, i.e. 18dBm.

**Conclusion**

The minimum EIRP at the 60th percentile of the distribution of radiated power measured over the full sphere around the UE is defined as the spherical coverage requirement and is found in Table 7.2.1.3.3-1 below.

Table 7.2.1.3.3-1: UE spherical coverage requirement for Power class 2

|  |  |
| --- | --- |
| **Operating Band** | **Min EIRP at 60%-tile CDF [dBm]** |
| n257 | 18.0 |
| n258 | 18.0 |
| n261 | 18.0 |
| NOTE 1: Minimum EIRP at 60 %-tile CDF is defined as the lower limit without tolerance  NOTE 2: The requirements in this table are only applicable for UE which supports single band in FR2 | |

#### 7.2.1.4 UE Power class 3

Power class 3 is specified, assuming to be applied for Handheld UE like a smartphone.

##### 7.2.1.4.1 Minimum Peak EIRP requirement

**How to derive the requirement**

Several companies have provided minimum peak EIRP numbers based on feasible implementation assumptions. A summary of the reported minimum peak EIRP values is found in Table 7.2.1.4.3. After discussion, minimum peak EIRP was agreed as 22.4dBm for 28GHz and as 20.6dBm for 39GHz.

Table 7.2.1.4.1-1: Survey of reported minimum peak EIRP for Power class

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter | Unit | Source 1 | | Source 2 | | Source 3 | | Source 4 | | Source 5 | | Source 6 | | Source 7 | |
| Frequency range | GHz | 24.2-29.5 | 37-40 | 24.2-29.5 | 37-40 | 24.2-29.5 | 37-40 | 24.2-29.5 | 37 - 40 | 24.2-29.5 | 37 – 40 | 24.2-29.5 | 37 – 40 | 24.2-29.5 | 37-40 |
| # ant elements |  | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Avg. element gain (per polarization) | dBi | 4.00 | 4.00 | 5.00 | 4.0 | 4.50 | 4.50 | 4.0 | 4.50 | 4.50 | 4.50 | 2.50 | 1.50 | 4.00 | 4.00 |
| Antenna roll-off loss vs frequency | dB | -2.00 | -2.50 | -1.00 | -1.50 | -3.00 | -1.50 | -1.00 | -1.00 | -1.00 | -1.50 | -0.50 | -0.50 | -1.00 | -1.50 |
| Realized antenna array gain | dBi | 8.00 | 7.50 | 10.00 | 8.5 0 | 7.50 | 9.00 | 9.00 | 9.50 | 9.50 | 9.00 | 8.00 | 7.00 | 9.00 | 8.50 |
| Polarization gain | dB | 2.80 | 2.80 | 2.50 | 2.50 | 2.50 | 2.50 | 2.00 | 2.00 | 2.50 | 2.80 | 2.80 | 2.80 | 2.80 | 2.80 |
| Total implementation loss (nominal) | dB | -6.75 | -7.95 | -7.25 | -8.50 | -5.10 | -6.10 | -4.85 | -5.85 | -6.75 | -7.75 | -4.25 | -4.25 | -7.95 | -9.15 |
| Total implementation loss (worst-case) | dB | -9.60 | -10.90 | -10.00 | -11.45 | -7.45 | -8.55 | -8.70 | -8.80 | -9.60 | -10.20 | -6.10 | -6.70 | -10.80 | -12.10 |
| P1d per PA (nominal) | dBm | 14.00 | 14.00 | 14.00 | 14.00 | 14.00 | 12.50 | 14.00 | 12.00 | 14.00 | 12.50 | 14.00 | 14.00 | 14.00 | 14.00 |
| P1d per PA (minimum) | dBm | 14.00 | 14.00 | 14.00 | 14.00 | 14.00 | 12.50 | 14.00 | 12.00 | 14.00 | 12.50 | 14.00 | 14.00 | 14.00 | 14.00 |
| **Peak EIRP (nominal)** | **dBm** | **24.05** | **22.35** | **25.25** | **22.5** | **24.90** | **23.90** | **26.15** | **23.65** | **25.25** | **24.05** | **26.55** | **25.55** | **23.85** | **22.15** |
| Tolerance | dB | 3.85 | 3.95 | 3.75 | 3.95 | 3.85 | 3.45 | 3.85 | 3.95 | 2.85 | 3.45 | 2.85 | 3.45 | 3.85 | 3.95 |
| **Peak EIRP (minimum)** | **dBm** | **20.20** | **18.40** | **21.50** | **18.55** | **21.05** | **20.45** | **22.30** | **19.70** | **22.40** | **20.60** | **23.70** | **22.10** | **20.00** | **18.20** |
| NOTE 1: We encourage companies to provide implementation losses and P1d numbers for nominal and worst cases to facilitate the analysis of nominal and minimum definitions of max EIRP; the current RAN4 agreement is to define power class as the minimum of the max EIRP without tolerance | | | | | | | | | | | | | | | |

**Conclusion**

The minimum Peak EIRP values are found in Table 7.2.1.4.1-2 below.

Table 7.2.1.4.1-2: UE Minimum Peak EIRP for Power class 3

|  |  |
| --- | --- |
| Operating Band | Min Peak EIRP (dBm) |
| n257 | 22.4 |
| n258 | 22.4 |
| n260 | 20.6 |
| n261 | 22.4 |
| NOTE 1: minimum peak EIRP is defined as the lower limit without tolerance | |

##### 7.2.1.4.2 Maximum TRP/EIRP requirement

The maximum output power values for TRP and EIRP are found in Table 7.2.1.4.2-1 below. The maximum allowed EIRP is derived from regulatory requirements [12].

Table 7.2.1.4.2-1: UE Maximum Output Power Limits for Power class 3

|  |  |  |
| --- | --- | --- |
| Operating Band | Max TRP (dBm) | Max EIRP (dBm) |
| n257 | 23 | 43 |
| n258 | 23 | 43 |
| n260 | 23 | 43 |
| n261 | 23 | 43 |

##### 7.2.1.4.3. Spherical coverage requirement

**How to derive the requirement**

Due to study the sensitivity of the network performance to the EIRP percentile, outage performance and throughput performance were evaluated through system simulation. Network simulation assumptions are found in Table 7.2.1.4.3-1.

Table 7.2.1.4.3-1: Network simulation assumptions used to derive Rel-15 PC3 requirements

|  |  |  |  |
| --- | --- | --- | --- |
| Scenario (in TR 38.803 [10]) | Indoor hotspots | Dense Urban | Urban Macro |
| UE Elevation distribution | Uniform from 0 to 180 degree. | | |
| Indoor ratio | 100% | 0%(baseline), 20%, 100% | |
| Resource Allocation (UL) | ・20 MHz for outage evaluation  ・200 MHz for mean throughout evaluation | | |
| Blockage Modeling | No body blockage and hand grip modelling | | |
| Target UL SNR | 22 dB | | |
| Antenna pattern Modeling | Option 1: Based on mathematical modelling  Option 2: Based on measured simulated pattern | | |

Following the adoption of the MPR = 0 dB region in the specification, the UL resource allocation of the network simulation assumptions is updated as shown in Table 7.2.1.4.3-2.

Table 7.2.1.4.3-2: Updated network simulation assumptions

|  |  |  |  |
| --- | --- | --- | --- |
| Scenario (in TR 38.803 [10]) | Indoor hotspots | Dense Urban | Urban Macro |
| UE Elevation distribution | Uniform from 0 to 180 degree. | | |
| Indoor ratio | 100% | 0%(baseline), 20%, 100% | |
| Resource Allocation (UL) | ・15 MHz for outage evaluation  ・60 MHz for mean throughout evaluation | | |
| Blockage Modeling | No body blockage and hand grip modelling | | |
| Target UL SNR | 22 dB | | |
| Antenna pattern Modeling | Option 1: Based on mathematical modelling  Option 2: Based on measured simulated pattern | | |

To understand the sensitivity of the network performance to the 50%-tile value, the EIRP was degraded by several dB for all UEs whose EIRP percentile is lower than 50%. In another sets of simulations, the EIRP was reduced as same for all UEs whose EIRP percentile is lower than 20%. By comparing the outage and throughput loss performances, it was observed that thenetwork performance was less sensitive to the variations of EIRP at 20%-tile and slightly decreased at 50%-tile case. Therefor several companies suggested that defining the spherical coverage requirement at 20%-tile value for Power class 3 is impractical but should be specified at not smaller than 50%-tile value. On the other hand, due to lack of sufficient measurement experience, there was the opinion not to be specified below 50%-tile. After discussion, percentile of spherical coverage for Power class 3 was agreed as 50%-tile.

Based on above evaluation, several companies proposed 50%-tile value. But there was a variety of assumptions for the reported data and some was based of simulations, while a few were based on measurements. To help analyze the data, two tables are provided below summarizing the 50%-tile values for 1 panel and 2 panels. After discussion, spherical coverage in one power class is one specification. Finally, minimum EIRP at 50%-tile CDF is defined as 11.5dBm for 28GHz and as 8dBm for 39Hz.

Table 7.2.1.4.3-2: Summary of 50%-tile values – 1 panel

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Source | Data type | 28GHz | | 39GHz | |
| Drop | EIRP | Drop | EIRP |
| Source 1 | Simulated | -14.50 | 8.00 | -18.0 | 2.5 |
| Source 2 | Measured | -14.00 | 8.40 | -15.4 | 5.2 |
| Source 3 | Simulated | -11.60 | 10.8 | -13.6 | 7.0 |
| Source 4 | Measured | -13.10 | 9.30 | - | - |
| Source 5 | Simulated | -11.70 | 10.7 | - | - |
| **Average** |  | **-12.98** | **9.44** | **[-18 to**  **-13.6]** | **[2.5-7.0]** |

Table 7.2.1.4.3-3: Summary of 50%-tile values – 2 panel

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Source | Data type | 28GHz | | 39GHz | |
| Drop | EIRP | Drop | EIRP |
| Source 1 | Simulated | -13.0 | 9.5 | -16.5 | 4.0 |
| Source 2 | Simulated | -8.00 | 14.4 | -10.0 | 10.6 |
| Source 3 | Measured | -11.6 | 10.8 | -11.6 | 9.0 |
| Source 4 | Measured | -9.10 | 13.3 | -9.20 | 11.4 |
| Source 5 | Simulated | -10 | 12.4 | -12.2 | 8.4 |
| Source 6 | Simulated | -7.40 | 15.0 | **[-8.90]** | **[11.7]** |
| Source 7 | Simulated | -10.3 | 12.1 | - | - |
| Source 8 | Simulated | -12.2 | 10.2 | - | - |
| Source 9 | Simulated | -9.0 | 13.4 |  |  |
| **Average** |  | **-10.1** | **12.3** | **[-11.4]** | **[9.2]** |

**Conclusion**

The minimum EIRP at the 50th percentile of the distribution of radiated power measured over the full sphere around the UE is defined as the spherical coverage requirement and is found in Table 7.2.1.4.3-3 below.

Table 7.2.1.4.3-4: UE spherical coverage requirement for Power class 3

|  |  |
| --- | --- |
| Operating Band | Min EIRP at 50%-tile CDF [dBm] |
| n257 | 11.5 |
| n258 | 11.5 |
| n260 | 8 |
| n261 | 11.5 |
| NOTE 1: Minimum EIRP at 50 %-tile CDF is defined as the lower limit without tolerance  NOTE 2: The requirements in this table are only applicable for UE which supports single band in FR2 | |

#### 7.2.1.5 UE Power class 4

Power class 4 is specified, assuming to be applied for High power non-handheld UE

##### 7.2.1.5.1 Minimum Peak EIRP requirement

**How to derive the requirement**

Proposal for Power class 4 peak EIRP evaluation which contributes to the peak EIRP link budget is shown in Table 7.2.1.5.1-1 below.

Table 7.2.1.5.1-1: Power class 4 EIRP budgets for 24-30GHz frequency bands

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter | Unit | Case 1 | | | | Case 2 | | | |
| 08 patches | 16 patches | 32 patches | 64 patches | 08 patches | 16 patches | 32 patches | 64 patches |
| Pout per element | dBm | 16 | 10 | 4 | -1.5 | 19 | 13 | 7 | 1 |
| # of antennas in array |  | 8 | 16 | 32 | 64 | 8 | 16 | 32 | 64 |
| Total conducted power per polarization | dBm | 25 | 22 | 19 | 16.5 | 28 | 25 | 22 | 19 |
| Avg. antenna element gain | dBi | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Antenna roll-off loss vs frequency | dB | -1.5 | -1.5 | -1.5 | -1.5 | -1.5 | -1.5 | -1.5 | -1.5 |
| Realized antenna array gain | dBi | 11.5 | 14.5 | 17.5 | 20.5 | 11.5 | 14.5 | 17.5 | 20.5 |
| Polarization gain | dB | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 |
| Total implementation loss | dB | -4 | -4 | -4 | -4 | -7 | -7 | -7 | -7 |
| **Peak EIRP (Minimum)** | **dBm** | **35.3** | **35.3** | **35.3** | **35.8** | **35.3** | **35.3** | **35.3** | **35.3** |

After discussion, Minimum peak EIRP is defined as 34dBm for 28GHz and as 31.0dBm for 39GHz.

**Conclusion**

The minimum Peak EIRP values is found in Table 7.2.1.5.1-3 below.

Table 7.2.1.5.1-2: UE Minimum Peak EIRP for Power class 4

|  |  |
| --- | --- |
| **Operating Band** | **Min Peak EIRP (dBm)** |
| n257 | 34.0 |
| n258 | 34.0 |
| n260 | 31.0 |
| n261 | 34.0 |
| NOTE 1: minimum peak EIRP is defined as the lower limit without tolerance | |

##### 7.2.1.5.2 Maximum TRP/EIRP requirement

The maximum output power values for TRP and EIRP are found in Table 7.2.1.5.2-1 below. The maximum allowed EIRP is derived from regulatory requirements [12].

Table 7.2.1.5.2-1: UE Maximum Output Power Limits for Power class 4

|  |  |  |
| --- | --- | --- |
| **Operating Band** | **Max TRP (dBm)** | **Max EIRP (dBm)** |
| n257 | 23 | 43 |
| n258 | 23 | 43 |
| n260 | 23 | 43 |
| n261 | 23 | 43 |

##### 7.2.1.5.3 Spherical coverage requirement

**How to derive the requirement**

The spherical coverage requirement is originally agreed as 20%-tile on half spherical coverage. The value at CDF percentile of 20% coverage was obtain to evaluate CDF of antenna gain for 28GHz as show in Figure 7.2.1.5.3-1.

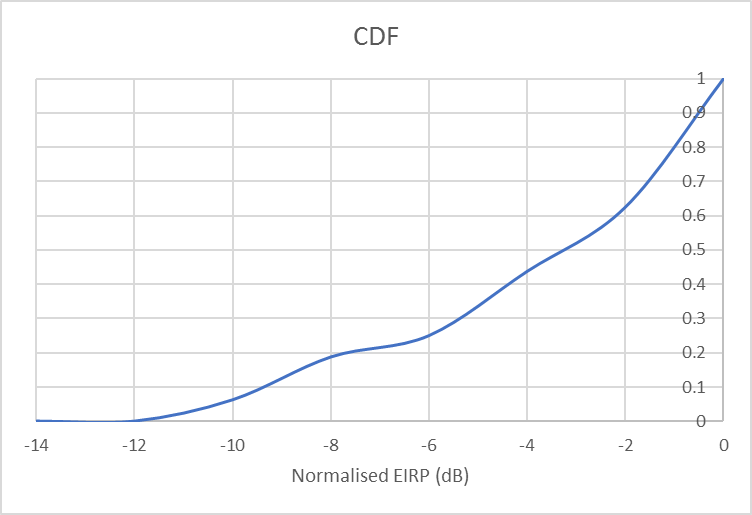


Figure 7.2.1.5.3-1: Simulated CDF of EIRP at 28GHz

Based on the above CDF curves, it was proposed to define the required EIRP corresponding to 20% CDF percentile considering some implementation margin, it was defined as 9dB at 20%-tile from peak EIRP value. Similar approach has been undertaken for 39GHz band.

**Conclusion**

The minimum EIRP at the 20th percentile of the distribution of radiated power measured over the full sphere around the UE is defined as the spherical coverage requirement and is found in Table 7.2.1.5.3-1 below.

Table 7.2.1.5.3-2: UE spherical coverage requirement for Power class 4

|  |  |
| --- | --- |
| **Operating Band** | **Min EIRP at 20%-tile CDF [dBm]** |
| n257 | 25 |
| n258 | 25 |
| n260 | 19 |
| n261 | 25 |
| NOTE 1: Minimum EIRP at 20 %-tile CDF is defined as the lower limit without tolerance  NOTE 2: The requirements in this table are only applicable for UE which supports single band in FR2 | | |

## 7.2A Transmit power for CA

### 7.2A.1 Void

### 7.2A.2 Maximum power reduction for CA

FR2 enables very wideband aggregated channel bandwidths for CA. For Release 15, RAN4 has agreed to limit contiguous UL CA to 800 MHz of aggregated bandwidth, and up to 8 CCs. Non-contiguous intra-band UL CA was deemed out of Rel-15 scope, but non-contiguous DL CA is defined with frequency separation of up to 1400 MHz (see Table 6.2A.2.2-1 of TS 38.101-2 [5]). In the FR2 UE, because of the wide bandwidths, most stages of analog cricuitry have gain that is not constant over frequency. The baseband section in particular has gain droop which increases as a function of baseband BW. These gain slopes and droops play a prominent part in determining MPR, especially for wide baseband BWs.

Some UEs employ a common LO for both, UL and DL, for frequency translation of the signal between RF and baseband. Since, in FR2 CA, a CC can be configured either only for DL, or for both, UL and DL, the configured frequency span from the lowest edge of the lowest CC edge to the highest edge of the highest CC (‘instantaneous bandwidth’) in the UL may be significantly different from that of the DL. For these UEs, the baseband BW is not determined by the individual instantaneous bandwidths in either the UL or DL, but by the *aggregate* of the instantaneous bandwidths. This quantity is termed the *cumulative aggregated channel bandwidth,* and is defined in TS 38.101-2 [5] as the frequency band from the lowest edge of the lowest CC to the upper edge of the highest CC of all UL and DL configured CCs.

Note that for UEs that employ a common LO for both, UL and DL, CA MPR is applicable even when the UL is not configured for CA, but the DL is configured for CA. Figure 7.2A.2-1 shows the principle.



Figure 7.2A.2-1: Gain limitation in TX lineup for large *cumulative aggregated channel bandwidth*

Consider a UE with a common LO for UL and DL, sized to deliver full power when a single 400 MHz channel is configured. This operation corresponds to a baseband BW of 200MHz. In a CA mode that supports 1400 MHz of DL instantaneous bandwidth, the required operational baseband BW is 700 MHz for both UL and DL. This UE will suffer power droop ‘∆G’ for UL CCs that happen to be configured at one of the edges as shown, which in turn drives MPR for this condition.

UEs with other LO implementations are not precluded. MPR requierments derived for UEs with common LO are automatically inclusive of UEs with other LO implementations.The justification is below:

For UEs with fast LO switching, or with dedicated LOs for Tx and Rx paths, UL signal path bandwidth can cover only the configured UL component carreirs instead of cumulative aggregate bandwidth. For these UEs, with CA configured per figure 7.2A.2-1, UL signal path is centered at the frequency range covering only the UL component carriers , as shown in figure 7.2A.2-2. These UEs do not have larger gain droop in the UL path, which in turn represents one less factor that forces PA back off by having tigher LO retuning implementation or doubling the number of LOs, compared to UEs with common LO.



Figure 7.2A.2-2: ΔG gain between large *cumulative aggregated channel bandwidth vs small UL aggregate bandwidth*

## 7.3 Output power dynamics

### 7.3.1 Minimum output power

For the NR requirement on frequency range 2, it is agreed that

- 13dBm for EIRP regardless of channel bandwidth up to 400MHz from system level perspective.

- Considering efficiently, linearity for mmWave PA implementation, the minimum output power level is relaxed by [3] dB and [7] dB for EVM test for 16QAM and 64QAM.

The NR UE minimum output power requirement for frequency range 2 is defined in Table 7.3.1-1 and 7.3.1-2.

Table 7.3.1-1: NR minimum output power

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Channel bandwidth / Minimum output power / Measurement bandwidth** | | | | |
| **50 MHz** | **100 MHz** | **200 MHz** | **[300] MHz** | **400 MHz** |
| Minimum output power (EIRP) | -13dBm | | | | |
| Measurement bandwidth | See Transmission bandwidth configuration defined in 4.2 | | | | |

Table 7.3.1-2: Parameters for Error Vector Magnitude

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Parameters** | **Channel bandwidth / Minimum output power / Measurement bandwidth** | | | | |
| **50 MHz** | **100 MHz** | **200 MHz** | **[300] MHz** | **400 MHz** |
| UE output power (EIRP) | ≥ -13 dBm | | | | |
| UE output power for UL 16QAM (EIRP) | ≥ [-10] dBm | | | | |
| UE output power for UL 64QAM (EIRP) | ≥ [-6] dBm | | | | |

## 7.4 Transmit signal quality

## 7.5 Output RF spectrum emissions

### 7.5.1 Occupied bandwidth

### 7.5.2 Spectrum emission mask

### 7.5.3 Adjacent Channel Leakage ratio

### 7.5.4 Spurious emission

#### 7.5.4.1 Protection of earth exploration-satellite service

The International Telecommunication Union World Radiocommunication Conference 2019 (WRC-19) created an internationally recognized 24.25 to 27.5 GHz band aiming at primary mobile allocation for licensed/IMT networks deployments. In addition to it, the limits of unwanted emission power from active service stations in that band were specified to protect 23.6-24 GHz EESS (passive) band.

A summary of the WRC-19 agreement related to EESS unwanted emission limits is given below [13]:

For 5G Base stations:

- -33 dBW in any 200 MHz of the EESS (passive) band for IMT/5G base stations brought into use before 1st September 2027.

- -39 dBW in any 200 MHz of the EESS (passive) band for IMT/5G base stations brought into use after 1st September 2027.

- The -39 dBW/200 MHz limit will not apply to 5G base stations which have been brought into use prior to this date.

- For those base stations, the limit of -33 dBW/200 MHz will continue to indefinitely apply after this date.

For 5G User equipment:

- -29 dBW in any 200 MHz of the EESS (passive) band for IMT/5G user equipment brought into use before 1st September 2027.

- -35 dBW in any 200 MHz of the EESS (passive) band for IMT/5G user equipment brought into use after 1st September 2027.

- The -35 dBW/200 MHz limit will not apply to UEs which have been brought into use prior to this date.

- For those UEs, the limit of -29 dBW/200 MHz will continue to indefinitely apply after this date.

NOTE 1: these out-of-band emission limits are equally applicable to all license holders within the band.

The relation between "active service band" and 3GPP bands is illustrated in Figure 7.5.4.1-1 below. NR band n258 frequency ranges from 24.25 to 27.5 GHz, which is identical to the aforementioned WRC active service band. Furthermore, 3GPP band n257 partially overlaps with "active service band", and thus ideally should be also considered while analysing potential specification impact.



Figure 7.5.4.1-1: EESS passive band, active service band, and 3GPP bands n257 and n258.

Combining the WRC-19 outcome with the existing spurious emissions requirements in TS38.101-2, Table 7.5.4.1-1 summarizes the common understanding of emissions requirements globally and regionally.

Table 7.5.4.1-1: Summary of emissions requirements applicable to FR2 devices

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Region | Requirement 1 | Requirement 2 | Requirement 3 | Requirement 4 | Requirement 5 | Requirement 6 |
| Global, US, Japan | Protected range: spurious  Band applicability: all  Limit:  -13 dBm/MHz | Protected range: 23.6 - 24.0 GHz  Band applicability: n258, n257  Limit:  +1 dBm/200 MHz | Protected range: 23.6 - 24.0 GHz  Band applicability: n258, n257  Limit:  -5 dBm/200 MHz | N/A | Protected range: 36.0 to 37.0 GHz  Band applicability: n259  Limit:  +7 dBm/1000 MHz | Protected range: 36.0 to 37.0 GHz  Band applicability: n260, n259  Limit:  -13 dBm/1 MHz |
| Europe | Protected range: 7.25 GHz ≤ f ≤ 2nd harmonic  Band applicability: all bands  Limit:  -10 dBm/100 MHz |

The A-MPR needed to comply with these requirements is summarized in Table 7.5.4.1-2.

Table 7.5.4.1-2: Summary of A-MPR needed to comply with the regulatory requirements in Table 7.5.4.1-1

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Band | Requirement | A-MPR for PC1 | A-MPR for PC2 | A-MPR for PC3 | A-MPR for PC4 |
| n258 | (Case A)  Protected range: 23.6 - 24.0 GHz  Limit:  +1 dBm/200 MHz | 3.0 if Offset frequency < BWchannel, 0.0 otherwise | 0 | 0 | 0 |
| n257 | 0 (absorb as general requirement) | 0 (absorb as general requirement) | 0 (absorb as general requirement) | 0 (absorb as general requirement) |
| n258 | (Case B)  Protected range: 23.6 - 24.0 GHz  Limit:  -5 dBm/200 MHz | 7.0 if Offset frequency < BWchannel, 6.0 otherwise | 1.0 if Offset frequency < BWchannel, 0.0 otherwise | 1.0 if Offset frequency < BWchannel, 0.0 otherwise | 1.0 if Offset frequency < BWchannel, 0.0 otherwise |
| n257 |
| n259 | (Case C)  Limit:  +7 dBm/1000 MHz  and -13 dBm/1 MHz | 0 (absorb as general requirement) | 0 (absorb as general requirement) | 0 (absorb as general requirement) | 0 (absorb as general requirement) |

Where Case A represents Requirements 1 and 2 from Table 7.5.4.1-1 applied to bands n258 and n257; Case B represents Requirements 1 and 3 applied to bands n258 and n257; Case C represents Requirements 1, 5, and 6 applied to band n259.

Because of the delayed implementation of Requirement 3 from Table 7.5.4.1-1, RAN4 will incorporate the new NS value structure in a future release, such that the timing of UEs achieving certification according to that release and the timing of the WRC-19 regulation coming into effect is aligned.

To assist such future discussions, Table 7.5.4.1-3 below captures the recommended NS value structure.

Table 7.5.4.1-3: Summary of NS values aligned with the WRC-19 outcome

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | n257 | n258 | n259 | n260 | Status of each NSs |
| NS\_200 | 1dBm/200MHz into general | No change | 7dBm/1GHz into general | No change | Completed |
| NS\_2011 |  |  |  |  | Completed |
| NS\_2022 | -10dBm/100MHz (Harmonic) and  +1dBm/200MHz | -10dBm/100MHz (Harmonic) and  +1dBm/200MHz |  |  | Completed |
| NS\_2033 |  | 1dBm/200MHz |  |  | Completed |
| NS\_20X4 | -5 dBm/200 MHz | -5 dBm/200 MHz |  |  | To be introduced in TS 38.101-2 |
| NS\_20Y5 | -10dBm/100MHz (Harmonic) and  -5dBm/200MHz | -10dBm/100MHz (Harmonic) and  -5dBm/200MHz |  |  | To be introduced in TS 38.101-2 |
| NOTE 1: NS\_201 is Obsolate  NOTE 2: Applicable before 01 January 2024  NOTE 3: Applicable before 01 September 2027  NOTE 4: Applicable after 01 September 2027  NOTE 5: Applicable after 01 January 2024 | | | | | |

When we introduce new NS(s) into already existing band(s), there would be two types of UE existing in a real environment: one is UE working with an existing NS and the other is UE working with a new NS. In such a case, two issues were indentified [R4-2000220, R4-2003241]. One issue is if BS cannot know which NS values each of UEs can support, there would be connectivity issues for the cases of Pscell addition in NSA and handover in both SA and NSA. Another issus is that if BS cannot set appropriate NS to UE, then the UE may violate regulation.

To address this issue, WF [R4-2005738] approved the direction that BS should know which NS values each of the UEs can support, and listed possible solutions. In RAN4#95-e, it was approved to take Alt 1-2(Explicit signaling for a UE to report newly supported NS value(s) for a legacy band to the network (reuse modifiedMPR bits)) described in WF [R4-2009141]. By using Alt 1-2, connectivity issues can be avoided. In addition, it was also agreed that newly introduced NS is mandatory for UE brought into use at least after the changeover date, which can avoid the situation where UE may violate regulation.

In RAN4#97-e, CR was agreed to introduce NS\_203 and explicit signaling for a UE to report newly supported NS value(s) for a legacy band to the network through modifiedMPR bits [R4-2016785]. The description of modifiedMPRbehavior indication for NS\_203 is captured in table 7.5.4.1-4. Note that NS\_20X and NS\_20Y described in Table 7.5.4.1-3 have not yet been specified in TS 38.101-2 v15.14.0. The same approach with introduction of NS\_203 should apply to these NSs according to approved WF [R4-2009141], i.e., Alt 1-2(Explicit signaling for a UE to report newly supported NS value(s) for a legacy band to the network (reuse modifiedMPR bits)) should be used and newly introduced NS is mandatory for UE brought into use at least after the changeover date. And when these NSs should be introduced can be discussed in the future if requesed.

able 7.5.4.1-4: *modifiedMPRbehavior* indication for NS\_203

|  |  |  |  |
| --- | --- | --- | --- |
| NR Band | Index of field  (bit number) | Definition  (description of the supported functionality if indicator set to one) | Notes |
| n258 | 0 | … | … |
|  | 1 | … | … |
|  | 2 | - NS\_203 as defined in clause 6.5.3.2.4 or both NS\_203 and CA\_NS\_203 as defined in clause 6.5A.3.2.4 of 38.101-2 v15.11.0 | - This bit shall be set to 1 by a UE supporting n258 or both n258 and CA\_n258 |

## 7.6 Transmit intermodulation

## 7.7 ON/OFF time mask

### 7.7.1 UE transient time

Similar to FR1, three different transient times are defined for FR2. The definition of these three transient time parameters is described in the section 5.7.1.

The following transient times are defined for FR2 in Table 7.7.1-1:

Table 7.7.1-1: Transient times for FR2

|  |  |
| --- | --- |
|  | **FR1** |
| ON-to-ON | 5µs |
| OFF-to-ON | 5µs |
| ON-to-OFF | 5µs |

## 7.8 Beam correspondence

### 7.8.1 General

Beam correspondence is the ability of the UE to select a suitable beam for UL transmission based on DL measurements with or without relying on UL beam sweeping. The beam correspondence requirement is satisfied assuming the presence of both SSB and CSI-RS signals and Type D QCL is maintained between SSB and CSI-RS.

### 7.8.2 Beam correspondence for PC1

### 7.8.3 Beam correspondence for PC2

### 7.8.4 Beam correspondence for PC3

The detailed formulation of the general beam correspondence requirement for PC3 and the beam correspondence tolerance requirement for PC3 is provided in TS 38.101-2 [5]. This clause contains the simulation assumptions and simulation results that are used to derive the beam correspondence tolerance requirement.

The simulation assumptions are shown in Table 7.8.4-1 below.

Table 7.8.4-1: Simulation assumptions for beam correspondence tolerance derivation

|  |  |  |  |
| --- | --- | --- | --- |
| UE RF parameters | Unit | Value | Notes |
| Frequency band |  | n257/n258/n260/n261 | Antenna performance can be different |
| Measurement grid | deg | 7.5º or 15º | Peak EIRP is 7.5  Spherical EIRP is 15 |
| Number of antenna elements in a module/set  (number of panels, number of analog beam(K), etc.) |  | 4  (2 panels, # total beam: 8, 16, 32) | Consider switched 2 panels.  These parameters will be depend on UE implementation. Other values are not precluded |
| Polarization |  | 2 polarizations |  |
| Antenna location  (front, back, top-side, left-side, right-side, bottom-side) |  | left/right | combination of the lists are not precluded |
| Phase error per antenna element (δpk)  Amplitude error per antenna element (δak) | deg /  dB | δpk ~ N(0,σ2) with σ=[0~30]º  δak ~ N(0,σ2) with σ=[0~2] dB | Used in Model 1  Other distributions are not precluded |
| Phase error per beam (δpk)  Amplitude error per beam (δak) | deg /  dB | δpk ~ N(0,σ2) with σ=[10~45]º  δak ~ N(0,σ2) with σ=[1~3] dB | Used in Model 2  Other distributions are not precluded |
| Error in RSRP estimation (∆k) | dB | ∆k ~ N(0,∆k2) with ∆k=[1.5, 2] dB |  |
| Front cover (plastic, glass, ceramic, metal) |  | Glass | This information is meaningful only if it’s the same with the material which covers antennas |
| Back cover (plastic, glass, ceramic, metal) |  | Glass |
| Side cover / frame (plastic, glass, ceramic, metal) |  | Metal |
| Display panel – full (Y) or partial (N) | Y/N | Y |  |
| Bezel margin | mm | 1.5 | Module can’t be placed outer edge of UE to secure mechanical reliability |

The procedure to model the beam correspondence impairments and to generate the CDF of ∆EIRP is as follows:

- Set ideal analog beam weight table (AWT) for K beams, where the number of beams depends on UE implementation

- AWT = [**W**1 **W**2 **W**3 … **W**K]

- Let the composite antenna pattern for given Q direction with Wk beam vector, as defined in TR 38.803 [10], be A(Q, **W**k)

- For each P UEs, where P is the number of UEs to be simulated:

- Generate Tx/Rx AWT considering phase and amplitude error per element (if using Model 1):

- Tx AWT = [**W**T1 **W**T2 **W**T3 … **W**TK], where K is one of [8, 16, 32]

**- W**TK = **W**K \* δak \* exp(i δpk)

- Rx AWT = [**W**R1 **W**R2 **W**R3 … **W**RK] = [**W**1 **W**2 **W**3 … **W**K]

- Generate Tx/Rx AWT considering phase and amplitude error per beam (if using Model 2):

- Tx AWT with error = [**W**T1 **W**T2 **W**T3 … **W**TK], where K is one of [8, 16, 32]

- Rx AWT = [**W**R1 **W**R2 **W**R3 … **W**RK] = [**W**1 **W**2 **W**3 … **W**K]

- Relationship between Tx/Rx AWT: A(Q, **W**k) = A(Q+δpk, **W**Rk) + δak

- For given measure point (Q) within EIRP measurement grid (iterate until statistically meaningful measurement values are obtained)

- Determine UE autonomous DL (Rx) beam selection (EIRP1)

- Beam Index(k) = index of max(RSRP1+∆1, RSRP2+∆2, RSRP3+∆3, … RSRPK+∆K)

- Beam Index(k) = index of max(A(Q, **W**R1)+∆1, A(Q, **W**R2)+∆2, A(Q, **W**R3)+∆3, … A(Q, **W**RK)+∆K)

- EIRP1 = A(Q, **W**TK)

- Determine UE EIRP2:

- Size of SRS AWT is restricted by *SRS-resource* of M = 8

- The common understanding for UL beam sweeping operation is the following:

- If UE does not configure the *spatialRelationInfo* from NW, then the UE can consider the UL beam sweeping.

- If UE has configure the *spatialRelationInfo* from NW, then the UE consider autonomous beam selection

- *spatialRelationInfo* contain the ID of a reference ‘ssb-Index’ or ‘csi-Rs-Index’ for SRS resource

- SRS AWT = [**W**SRS\_T1 **W**SRS\_T2 **W**SRS\_T3 … **W**SRS\_TM] is a subset of Tx AWT; how to select the subset is up to UE implementation

- EIRP2 = max(A(Q, **W**SRS\_T1), …, A(Q, **W**SRS\_TM)) (beam sweeping and select best)

- ∆EIRP = EIRP2 – EIRP1

- After calculating ∆EIRP at all measurement grid points, generate CDF of ∆EIRP

- Correction for the sine of the elevation angle is used when generating the CDF of ∆EIRP (same approach as the EIRP CDF generation)

- Company should guarantee EIRP2 can fulfill all applicable requirements (Clause 6.6 of TS 38.101-2 [5])

- The impact on the 50%-tile of the EIRP CDF can be estimated as the average difference in the 50%-tile values between EIRP1 CDF and EIRP2 CDF over the P simulation trials

- The beam correspondence tolerance value Y is defined as the 85%-tile of the ∆EIRP CDF

The summary of simulation results is provided in Table 7.8.4-2 below.

Table 7.8.4-2: Summary of simulation results

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Company / Parameter | A | B | C | D | E | F | G |
| Model type | Model 2 | Model 2 | Model 1 | Model 1 | Model 1 | Model 1 | Model 1 |
| Amplitude error δak (dB) | 2.0 | 2.0 | 2.0 |  | 2.0 | 2.0 | 2.0 |
| Phase error δpk (º) | 10 | 10 | 16 | 16 | 16 | 16 | 16 |
| RSRP error ∆k (dB) | 2.0 | 2.0 | 1.5 | 2.0 | 2.0 | 1.5 |  |
| SNR (dB) |  | High enough | Range of [6.4, 19.4] | 10 |  |  |  |
| BC tolerance (Y dB @ 85%-tile) | 6.0 | [5.8] | 3.5 (n257/n258/n261)  3.9 (n260) | 3.5 | 3.0 | 2.5 | 3.5 |

### 7.8.5 Beam correspondence for PC3

# 8 UE Receiver characteristics (frequency range 2)

## 8.1 General

## 8.2 Receiver Sensitivity

### 8.2.1 MSD (Maximum sensitivity reduction)

## 8.3 Selectivity

## 8.4 Blocking performance

## 8.5 Spurious response

## 8.6 Intermodulation performance

## 8.7 Spurious emission

# 9 UE Transmitter characteristics (NSA and interworking between frequency ranges 1 and 2)

# 10 UE Receiver characteristics (NSA and interworking between frequency ranges 1 and 2)

Annex A:  
Environmental conditions

# A.1 General

This annex specifies the environmental requirements of the UE. Within these limits the requirements of the present documents shall be fulfilled.

# A.2 Environmental

The requirements in this clause apply to all types of UE(s).

## A.2.1 Temperature

All RF requirements for UEs operating in FR2 are defined over the air and can only be tested in an OTA chamber.

The UE shall fulfil all the requirements in the temperature range defined in Table A.2.1-1.

Table A.2.1-1: Temperature conditions

|  |  |
| --- | --- |
| + 25 °C ± [10] °C | For normal (room temperature) conditions |

Whether additional temperatures are defined is FFS.

## A.2.2 Voltage

Annex B:  
Coexistence studies for 55dBm CPE deployment in FR2

# B.1 Introduction

In RAN4#84, a WF has been agreed on conducting simulations related to 55dBm CPE in mmWave scenario. This section summarizes the conclusions of the studies.

# B.2 Network layout model

## B.2.1 Urban macro

### B.2.1.1 Single operator layout

|  |  |  |  |
| --- | --- | --- | --- |
| Parameters | | Values | Remark |
| Network layout | | hexagonal grid, 19 macro sites, 3 sectors per site with wrap around |  |
| Inter-site distance | | 300m | Note 1 |
| BS antenna height | | 25 m |  |
| CPE location | Outdoor/indoor | Outdoor and indoor |  |
| Indoor CPE ratio | 20% | Note 1 |
| Low/high Penetration loss ratio | 50% low loss, 50% high loss |  |
| LOS/NLOS | LOS and NLOS | Specified in TR 38.803 [10] |
| CPE antenna height | Same as 3D-UMa in TR 36.873 | Elevation height is 4.5m for both indoor and outdoor scenario |
| CPE distribution (horizontal) | | Uniform |  |
| Minimum BS - CPE distance (2D) | | 35 m | Note 1 |
| Channel model | | UMa | Specified in TR 38.803 [10] |
| Shadowing correlation | | Between cells: 1.0  Between sites: 0.5 |  |
| Note: If we find any issue, then we can revisit parameters. | | | |

### B.2.1.2 Multi operators layout

|  |  |  |
| --- | --- | --- |
| **Parameters** | **Values** | **Remark** |
| Multi operators layout | coordinated operation (0% Grid Shift) |  |
| uncoordinated operation (100% Grid Shift) |  |

|  |  |
| --- | --- |
| **Coordinated Operation: each network with co-location of sites** | zero grade shift macro |
| **Non-coordinated operation** | cell_layout2  **100% grid shift** |

## B.2.2 Dense urban

Companies can provide simulations results for dense urban micro scenario in both 30GHz and 45GHz. The deployment parameters are same as dense urban scenario as described in TR 38.803 [10] except CPR antenna elevation height is 4.5m.-

# B.3 Propagation model

## B.3.1 Path loss

Path loss models are based on TR 38.803 [10].

## B.3.2 LOS probability

LOS probability models are based on TR 38.803 [10].

## B.3.3 O-to-I penetration loss

The pathloss incorporating O-to-I building penetration loss is modelled as in 38.803 [10].

# B.4 Transmission power control model

For uplink, TPC model specified in Section 9.1 TR 36.942 [9] is applied with following parameters.

- CL-xile = 100+ 10\*log10(200/X)

- X: UL transmission BW

- Gamma = 1

Note: we need discuss KPI based on simulation results.

# B.5 Received signal power model

The following model is applied.

**RX\_PWR = TX\_PWR – pathloss + G\_TX + G\_RX**

where:

RX\_PWR is the received signal power

TX\_PWR is the transmitted signal power

G\_TX is the transmitter antenna gain (directional array gain)

G\_RX is the receiver antenna gain (directional array gain).

# B.6 Other simulation parameters

|  |  |  |
| --- | --- | --- |
| **Parameters** | **Urban macro** | **Dense Urban micro** |
| **Channel bandwidth** | 200MHz | 200MHz |
| **Scheduled channel bandwidth per CPE (UL)** | 200MHz | 200MHz |
| **The number of active CPE (UL)** | Same as the number of BS beam | Same as the number of BS beam |
| **Traffic model** | Full buffer | Full buffer |
| **UL power control** | YES | YES |
| **CPE max TX power in dBm** | 35dBm | 35dBm |
| **CPE min TX power in dBm** | -40dBm | -40dBm |
| **BS Noise figure in dB** | 10 | 10 for 30GHz  12 for 45GHz |
| **Handover margin** | 3dB | 3dB |

# B.7 Simulation description

Adopt following simulation steps. If companies find issues in the following simulation steps, we can revisit in RAN4#80bis. Note: detailed simulation description is captured in Section 5.1.5 TR25.942.

1) Aggressor and victim network are generated.

2) CPE associations: CPE are associated to base station based on coupling loss.

- Associations are made assuming a single element at both CPE and BS.

3) Once association is done, round robin scheduling is used. BF weights are adjusted to point to the LOS direction between BS-CPE. This done for both victim and aggressor networks.

4) SINR Throughput are measured in the victim systems without considering ACI, i.e., where is the inter-cell interference.

5) SINR and throughput are computed considering ACI: , where is the adjacent channel interference.

6) RF parameters are determined based degradation cause by ACI: .

# B.8 Evaluation metric

Assume scaled Shannon's formula specified in TR 36.942 [9] with following parameters.

|  |  |  |
| --- | --- | --- |
| **Parameter** | **UL** | **Notes** |
| α, attenuation | 0.4 | Represents implementation losses |
| SINRMIN, dB | -10 | Based on QPSK, 1/5 rate (UL) |
| SINRMAX, dB | 22 | Based on 64QAM 0.93 (UL) |

# B.9 Antenna configuration

## B.9.1 Base station

Assumptions captured in page 8 - 11 of [R4-168794] are assumed as BS antenna configurations. For UMa and UMi base stations, we keep this same antenna model.

## B.9.2 CPE

For CPE, we consider the following:

- Baseline: (NV,NH) = (4, 8).

- (dV,dH) = (0.5, 0.5)λ.

- An additional 3dB gain is added to the total beamforming gain to account for the two polarization directions.

- 5dBi element gain, 90 degree HPBW in Azimuth and zenith, Am=25dB, SLAv=25dB

# B.10 Evaluated ACIR range

ACIR range: 5 ~ 45dB, with 5dB as step. Note that: we do not have simulation per 1dB step.

# B.11 Co-existence scenarios

Evaluate following scenarios for 55dBm CPE:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **No.** | **Aggressor** | **Victim** | **Simulation freqCPEncy** | **Direction** | **Usage scenario** | **Deployment Scenario** |
| 1 | NR, 200MHz | NR, 200MHz | 30 GHz | UL to UL | eMBB | Urban macro |
| 2 | NR, 200MHz | NR, 200MHz | 30 GHz | UL to UL | eMBB | Dense Urban |
| 3 | NR, 200MHz | NR, 200MHz | 45 GHz | UL to UL | eMBB | Dense Urban |

# B.12 Summary of co-existence simulations

During RAN4 NR-AH#3 and RAN4#84bis, following contributions provide simulation results based on agreed WF related to 55dBm CPE in mmWave spectrum simulation assumptions, as detailed in this annex:

- R4-1719701, Urban Macro Simulation Results at 30GHz for 55dBm EIRP Transportable Stations, Nokia, Nokia Shanghai Bell

- R4-1719702, Dense Urban Simulation Results at 30GHz for 55dBm EIRP Transportable Stations, Nokia, Nokia Shanghai Bell

- R4-1719703, Dense Urban Simulation Results at 45GHz for 55dBm EIRP Transportable Stations, Nokia, Nokia Shanghai Bell

- R4-1710487, Co-existence study for 55dBm EIRP Transportable Stations for urban macro scenario, Huawei, HiSilicon

- R4-1710488, Co-existence study for 55dBm EIRP Transportable Stations for dense urban scenario, Huawei, HiSilicon

- R4-1710859, Coexistence evaluation results for 55dBm EIRP transportable stations, LG Electronics Inc.

- R4-1711031, Coexistence evaluation results for CPEs with 55 dBm EIRP, Samsung

- R4-1711147, Uncoordinated Urban Macro Simulation Results at 30GHz for 55dBm EIRP Transportable Stations, Nokia, Nokia Shanghai Bell

- R4-1711400, ACIR simulations results for 55dB EIRP transportable stations - Urban Macro deployment at 30GHz, Qualcomm Incorporated

- R4-1711401, ACIR simulations results for 55dBm EIRP transportable stations - Urban Macro deployment at 45GHz, Qualcomm Incorporated

- R4-1711483, Coexistence simulation results for for 55dBm CPE in mmWave FWA scenario, Ericsson

- R4-1711481, Inband receiver blocking for mmWave NR BS with 55dBm CPE FWA deployment, Ericsson

- R4-1712684, Coordinated Urban Macro Simulation Results with Total Fading Correlation at 30GHz for 55dBm EIRP Transportable Stations, Nokia, Nokia Shanghai Bell

Based on these contributions, we summarized the following simulation results.

## B.12.1 ACIR simulation results

### B.12.1.1 Urban macro (UMa) scenario

Following ACIR simulation results are available:

|  |  |  |
| --- | --- | --- |
| **Company** | **Collocated** | **Non-collocated** |
| Huawei |  | 21 |
| Samsung | 9 | 10 |
| Qualcomm | 10 | 15 |
| Ericsson | 10 | 15 |
| Nokia | 16 | 16 |

### B.12.1.2 Dense urban micro (UMi) scenario

Following ACIR simulation results are available:

|  |  |  |
| --- | --- | --- |
| **Company** | **30GHz** | **45GHz** |
| Huawei | 5dB | 5 |
| Samsung | 7 | 5 |
| Qualcomm | - | - |
| Ericsson | - | - |
| Nokia | 16 | 15 |

### B.12.1.3 Summary of ACIR simulations

The summary is listed below:

|  |  |
| --- | --- |
| Nokia | The simulation results have shown that 55dBm EIRP transportable stations can be used effectively to extend the coverage of coordinated and uncoordinated urban macro network at 30GHz, as well as dense urban network at 30GHz and 45GHz with minor impacts on the required BS dynamic range and in-band blocking performances, while applying the currently agreed UE ACLR and BS ACS will provide sufficient UL coexistence performance except in the coordinated urban macro network simulated with 0.5 shadowing correlation.  The simulation results (total fading) have shown that 55dBm EIRP transportable stations can be used effectively to extend the coverage of coordinated urban macro network at 30GHz, with minor impacts on the required BS dynamic range and in-band blocking performances, while applying the currently agreed UE ACLR and BS ACS will provide sufficient UL coexistence performance. |
| Huawei | Specify the ACLR/ACS requirements for 55dBm EIRP Transportable Stations based on 21dB ACIR value for 30GHz in urban macro scenario |
| Samsung | Considering CPEs, the simulated ACIR value (10 dB) for urban macro scenario is less than that (16.2 dB) calculated from the agreed ACLR and ACS for 30 GHz. The simulated ACIR value (7 dB) for dense urban scenario is less than the calculated 16.2 dB.  Considering CPEs, the simulated ACIR value (5 dB) for dense urban scenario is less than that (15.2 dB) calculated from the agreed ACLR and ACS for 45 GHz. |
| Qualcomm | The required ACIR for the worst-case scenario is ~15dB.  In case of co-located deployment, for UL scenarios the correlation between coupling losses of the adjacent operator wanted link and the coupling loss of cross operator interfering link is very close to 1.  In case of co-located deployment the assumption about the correlation between adjacent operator wanted link and cross operator interfering link should be specified. Baseline assumption should be 100% correlation, i.e. same coupling loss for the two links. |
| Ericsson | The ACIR levels in UL for non-collocated case are around 5dB higher than the collocated case and if we consider the 5% Average throughput loss, the ACIR levels in UL for both collocated and non-collocated case fall in the same range 10dB-15dB as agreed in TR 38.803 [10]. |

## B.12.2 Receiver dynamic range

|  |  |
| --- | --- |
| Nokia | Minor impact in receiver dynamic range when 55dBm CPE is considered. |

## B.12.3 Inband receiver blocking

Following conclusions are made:

|  |  |
| --- | --- |
| Nokia | Minor impact in receiver in-band blocking when 55dBm CPE is considered. |
| Ericsson | The “conducted” blocking levels are very similar when array gain is considered, with respect to 23dBm UE. |

## B.12.4 Conclusions

Based on the above simulation results, following has been agreed:

- Regarding the required AICR, the ACIR levels in UL for non-collocated case are around 5dB higher than the collocated case when different LSF is considered for victim and interfering network and if we consider the 5% Average throughput loss, the ACIR levels in UL for both collocated and non-collocated case fall in the same range 10dB-15dB as agreed in TR 38.803 [10].

- Regarding receiver dynamic range, minor impact in receiver dynamic range when 55dBm CPE is considered.

- Regarding inband receiver blocking, minor impact in receiver in-band blocking when 55dBm CPE is considered.

Annex C:  
Coexistence studies for 29 dBm UE power class for LTE Band 41 and NR Band n41

# C.1 Simulation assumptions

## C.1.1 Macro cell propagation model

### C.1.1.1 Macro cell propagation model - urban and suburban areas

The propagation model is a derived from TR 36.942 [9].

Considering a carrier frequency of 2.6 GHz and a base station antenna height of 15 m above average rooftop level, the propagation model is given by the following equation:



where:

R is the base station-UE separation in kilometres

### C.1.1.2 Macro cell propagation model - rural area

The propagation model is a derived from TR 36.942 [9].

For rural area, the Hata model is not applicable for a carrier frequency of 2.6 GHz, while the modified Hata model can be used:

*Case 1*: *d* ≤ 0.6 km



*Case 2*: *d*  0.6 km



where: d is the base station-UE separation in kilometres

## C.1.2 Power control simulation parameters

Table C.1.2-1: CLx-ile parameters for +23 dBm UE

(a) CLx-ile parameters for +23 dBm UE using 0.75 km inter-site distance and 2.6 GHz carrier frequency

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter set** | **Gamma** | **CLx-ile** | |
| **20 MHz bandwidth** | **10 MHz bandwidth** |
| Set 1 | 1 | 109 | 112 |
| Set 1' | 1 | 117 | 120 |
| Set 2 | 0,8 | 133 | 137 |

(b) CLx-ile parameters for +23 dBm UE using 2.8 km inter-site distance and 2.6 GHz carrier frequency

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter set** | **Gamma** | **CLx-ile** | |
| **20 MHz bandwidth** | **10 MHz bandwidth** |
| Set 1 | 1 | 133 | 136 |
| Set 2 | 0,8 | 149 | 153 |

(c) CLx-ile parameters for +23 dBm UE using 6 km inter-site distance and 2.6 GHz carrier frequency

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter set** | **Gamma** | **CLx-ile** | |
| **20 MHz bandwidth** | **10 MHz bandwidth** |
| Set 1 | 1 | 117 | 120 |
| Set 2 | 0,8 | 132 | 136 |

(d) CLx-ile parameters for +23 dBm UE using 8 km inter-site distance and 2.6 GHz carrier frequency

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter set** | **Gamma** | **CLx-ile** | |
| **20 MHz bandwidth** | **10 MHz bandwidth** |
| Set 1 | 1 | 122 | 124 |
| Set 2 | 0,8 | 136 | 140 |

Table C.1.2-2: CLx-ile power control algorithm parameters for +29 dBm UE

(a) CLx-ile power control algorithm parameters for +29 dBm UE using 0.75 km inter-site distance and 2.6 GHz carrier frequency

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter set** | **Gamma** | **CLx-ile** | |
| **20 MHz bandwidth** | **10 MHz bandwidth** |
| Set 1 | 1 | 115 | 118 |
| Set 1' | 1 | 123 | 126 |
| Set 2 | 0,8 | 141 | 145 |

(b) CLx-ile power control algorithm parameters for +29 dBm UE using 2.8 km inter-site distance and 2.6 GHz carrier frequency

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter set** | **Gamma** | **Modified CLx-ile** | |
| **20 MHz bandwidth** | **10 MHz bandwidth** |
| Set 1 | 1 | 139 | 142 |
| Set 2 | 0,8 | 157 | 161 |

(c) CLx-ile power control algorithm parameters for +29 dBm UE using 6 km inter-site distance and 2.6 GHz carrier frequency

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter set** | **Gamma** | **Modified CLx-ile** | |
| **20 MHz bandwidth** | **10 MHz bandwidth** |
| Set 1 | 1 | 123 | 126 |
| Set 2 | 0,8 | 140 | 144 |

(d) CLx-ile power control algorithm parameters for +29 dBm UE using 8 km inter-site distance and 2.6 GHz carrier frequency

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter set** | **Gamma** | **Modified CLx-ile** | |
| **20 MHz bandwidth** | **10 MHz bandwidth** |
| Set 1 | 1 | 128 | 130 |
| Set 2 | 0,8 | 144 | 148 |

## C.1.3 Cell layout

Base stations with 3 sectors per site are placed on a hexagonal grid with distance of 3\*R, where R is the cell radius (see Figure C.1.3-1), with wrap around. The number of sites shall be equal to or higher than 19. Uncoordinated macro cellular deployment is assumed, where interfering UE may be at cell edge of the serving base station but close to the victim base station (hence transmitting with highest power and causing highest interference).

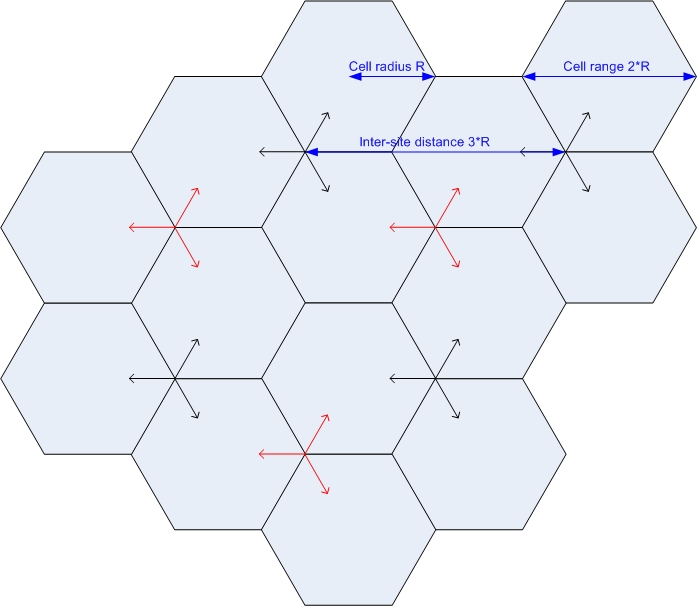


Figure C.1.3-1: Uncoordinated macro cellular deployment

The inter-site distances considered in the present document are provided in Table C.1.3-1 below.

Table C.1.3-1: Inter-site distances and Propagation model

|  |  |  |
| --- | --- | --- |
| **Environment** | **ISD (km)** | **ISD (miles)** |
| Urban | .75 | .47 |
| Suburban | 2.8 | 1.74 |
| Rural | 6 | 3.73 |
| Rural | 8 | 5 |

## C.1.4 Other simulation assumptions

Other simulation assumptions are summarized in Tables C.1.4-1 and C.1.4-2 below:

Table C.1.4-1: Simulation parameters for Band 41 system with 23 dBm UE

|  |  |  |
| --- | --- | --- |
|  | Base Station | UE |
| Carrier frequency | 2600 MHz | |
| Channel bandwidth | 20 MHz, 10 MHz | |
| Inter-site distance | Use Table C.1.3-1 | |
| Cell layout | Wrap-around 19 tri-sector cells, uncoordinated | |
| Frequency reuse | 1x3x1 | |
| Lognormal fading | 10 dB | |
| Shadowing correlation | Between cells: 0.5, between sites: 1.0 | |
| MCL (including antenna gain) | 70 dB (urban and suburban areas)  80 dB (rural area) | |
| Antenna gain and horizontal antenna pattern | 17 dBi, = 65 degrees,  *Am* = 20 dB | Omni-directional antenna with -3.5 dBi. |
| Noise figure | 5 dB | 9 dB |
| Transmit power | 46 dBm | 23 dBm |
| Antenna height | 45 m | 1.5 m |
| ACLR | 45 dB | Use Table 5.2 in TR 36.942  ACLR1: 30+X, ACLR2: 43+X  Where X is 1 dB |
| ACS | 45 dB | 27 dB |

Table C.1.4-2: Simulation parameters for Band 41 system with 29 dBm UE

|  |  |  |
| --- | --- | --- |
|  | Base Station | HPUE |
| Carrier frequency | 2600 MHz | |
| Channel bandwidth | 20 MHz, 10 MHz | |
| Inter-site distance | Use Table C.1.3-1 | |
| Cell layout | Wrap-around 19 tri-sector cells, uncoordinated | |
| Frequency reuse | 1x3x1 | |
| Lognormal fading | 10 dB | |
| Shadowing correlation | Between cells: 0.5, between sites: 1.0 | |
| MCL (including antenna gain) | 70 dB (urban and suburban areas)  80 dB (rural area) | |
| Antenna gain and horizontal antenna pattern | 17 dBi, = 65 degrees, *Am* = 20 dB | Omni-directional antenna with -3.5 dBi. |
| Noise figure | 5 dB | 9 dB |
| Transmit power | 46 dBm | 29 dBm |
| Antenna height | 45 m | 1.5 m |
| ACLR | 45 dB | Use Table 5.2 in TR 36.942  ACLR1: 30+X, ACLR2: 43+X  Where X is 1 dB |
| ACS | 45 dB | 27 dB |

Simulations should assume the worst case of 100 % HPUEs in the scenarios with HPUEs.

## C.1.5 Simulation procedure

For the co-existence study, the following procedure shall be performed:

1) Run the Band 41 UL to UL coexistence study, assuming parameters of both systems are according Table C.1.4-1. Power control parameters in Table C.1.2-1 are used. This corresponds to the coexistence of two commercial networks operating in adjacent channel and with similar deployment parameters. This is used as the reference. Band 41 victim system performance degradation results in this scenario are used as the baseline. Provide a CDF plot of UE transmit power.

2) Run the Band 41 UL to UL coexistence study, assuming +29 dBm power class UE is deployed in Band 41 interfering system only, and obtain the victim system performance degradation results. The simulation parameters in Tables C.1.4-1 and C.1.4-2 are used for the victim and interfering system, respectively. And the power control parameters in Tables C.1.2-1 and C.1.2-2 are used for the victim and interfering system, respectively. Provide a CDF plot of UE transmit power.

3) Compare the Band 41 victim system performance degradation obtaining in steps 1) and 2), choose the 29 dBm UE ACLR value so that the victim system performance degradation due to 29 dBm UE in 2) is the same as 1).

# C.2 Simulation results

## C.2.1 UE ACLR

The summary of the ACLR simulation results is shown in the Table C.2.1-1 below.

Table C.2.1-1: Summary of ACLR simulation results (additional ACLR needed)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | 20 MHz (R4-1901489, R4-1901490) | | 10 MHz (R4-1903115, R4-1903116) | | 10 MHz (R4-1904020, R4-1904021) | |
| ISD | Avg | 5th percentile | Avg | 5th percentile | Avg | 5th percentile |
| 0.75 km | 0.56 | 0.57 | 0.53 | 0.24 | 0.08 | 0.38 |
| 2.8 km | 0.23 | 0.31 | 0.08 | 0.11 |  |  |
| 6 km | 0.33 | 0.37 | 0.13 | 0.20 | 0.30 | 0.14 |
| 8 km | 0.29 | 0.18 | 0.07 | 0.07 | 0.20 | 0 |

The simulation results have shown that when the UL power control parameters are adjusted according to the UE maximum output power, the ACLR of the 29 dBm UE need to be improved (~1 dB) so that the victim system performance degradation due to 29 dBm interfering UE is the same as that due to 23 dBm interfering UE. Therefore, a value of 31 dB for ACLR is needed for 29 dBm UE.

## C.2.2 BS receiver blocking

The summary of the 99.99%-tile victim BS received signal power from 29 dBm UE for the simulated cases is shown in the Table C.2.2-1 below.

Table C.2.2-1: Summary of 99.99%-tile victim BS received signal power from 29 dBm UE

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Scenario | Power control parameters | 20 MHz (R4-1901489, R4-1901490) | 10 MHz (R4-1903115, R4-1903116) | 10 MHz (R4-1905987) |
| **29 dBm UE** | **Urban:**  **ISD = 0.75 km** | 1 | -42.3112 | -45.3109 | -44.7 |
| 1' | -50.3107 | -53.3107 | -52.7 |
| 2 | -62.8175 | -66.0175 | -63.5 |
| **Suburban:**  **ISD = 2.8 km** | 1 | -48.8596 | -51.8596 |  |
| 2 | -62.4909 | -65.6909 |  |
| **Rural:**  **ISD = 6 km** | 1 | -52.1831 | -55.0907 | -54.6 |
| 2 | -65.4718 | -68.6718 | -65.1 |
| **Rural:**  **ISD = 8 km** | 1 | -53.5211 | -55.5211 | -60.5 |
| 2 | -65.8158 | -69.0158 | -67.0 |

The simulation results have shown that the 99.99%-tile received signal power in all simulated cases, except with the more aggressive Set 1 for 0.75 km inter-site distance, are lower than the current -43 dBm in-band blocking requirements specified in RAN4 specifications for wide-area BS. Although the 99.99%-tile received signal power with the more aggressive Set 1 for 0.75 km inter-site distance with 20 MHz channel bandwidth is slightly (< 0.7 dB) higher than -43 dBm, this should not be an issue for typical BS implementation with reasonable margin over the standards requirements. Therefore, the current BS in-band blocking requirements can also be applied for the 29 dBm UE case, and there is no need to specify new BS in-band blocking requirements.

C.3 Conclusions

The simulation results have shown that when the UL power control parameters are adjusted according to the UE maximum output power, the ACLR of the 29 dBm UE need to be improved (~1 dB) so that the victim system performance degradation due to 29 dBm interfering UE is the same as that due to 23 dBm interfering UE. Therefore, a value of 31 dB for ACLR is needed for 29 dBm UE.

Moreover, the simulation results have shown that the current BS in-band blocking requirements can also be applied for the 29 dBm UE case when the UL power control parameters are adjusted according to the UE maximum output power, and there is no need to specify new BS in-band blocking requirements.

Annex D:  
Change history

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Change history** | | | | | | | |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2017-09 | RAN4-NR#3 | R4-1709767 |  |  |  | Report skeleton | 0.0.1 |
| 2017-10 | RAN4-#84bis | R4-1711049 |  |  |  | Approved TPs at RAN4 #84  R4-1708965, TP to TR 38.xxx (NR WI TR): NR band numbering  Approved at RAN4 NR#3  R4-1709871, TP for TR 38.xxx Update of NR bands  R4-1710078, TP to TR 38.xxx (UE TR): Subcarrier Spacing options for non SS channels  R4-1709941, TP for TR General aspects for UE RF for NR: Range 1 UE power class  R4-1709541, TP for UE RF TR 38.xxx: sub-6GHz minimum output power  R4-1709949, TP to TR General aspects for UE RF for NR: NR range 1 IQ Image and Carrier leakage  R4-1709485, TP for TR General aspects for UE RF for NR: Range 1 UE EVM  R4-1709477, TP for TR General aspects for UE RF for NR: Range 1 general SEM  R4-1709950, TP for TR General aspects for UE RF for NR: Range 1 ACLR | 0.1.0 |
| 2017-11 | RAN4-#85 | R4-1712893 |  |  |  | Approved TPs at RAN4 #84bis  R4-1711852 TP to TR 38.817-1 to add the subclause for UE general RF requirements for SUL and LTE-NR co-existence  R4-1711729 TP for TR 38.817-01: mixed numerology FDM requirements  R4-1711863 TP for TR 38.817-01 Further update of NR bands  R4-1711741 TP to TR 38.817-1: Basestation and UE bandwidth allocation  R4-1711555 TP to TR38.817-1 Environmental conditions for FR2  R4-1710960 TP to TR 38.817-01: Applicability of bandwithd combination sets to NR  R4-1711562 TP to TR General Aspects for UE RF for NR Sub-6 GHz - MPR table and inner allocation a  R4-1711621 TP to TR General Aspects for UE RF for NR Sub-6 GHz - NR Sub-6 GHz SU, SCS Allocation Alignment, TXBW and Guard-band  R4-1711604 TP to TR 38.817-02 v0.1.0: Transient time for NR UE  R4-1710959 TP to TR 38.817-01: In-band emissions  R4-1710957 TP to TR 38.817-01: Futher ACLR agreements  R4-1710556 TP for TR38.817-01:Conducted UE Tx spurious emission for FR1(section 5.5.4)  R4-1710555 TP for TR 38.817-01 on conducted UE transmitter intermodulation for FR1 (setion 5.6)  R4-1711967 UE RF requirements for UL sharing  R4-1711568 TP to TR 38.xxx - UE minimum transmit power for range 2 | 0.2.0 |
| 2018-01 | RAN4-AH-1801 | R4-1800782 |  |  |  | Approved TPs  R4-1712460 TP to TR 38.817-01: Furher discussion on bandwidth support for NR bands in LTE-NR DC Nokia, Nokia Shanghai Bell  R4-1712934 TP for UE RF TR 38.817-01: mmWave EIRP spherical coverage requirement Sumitomo Elec. Industries, Ltd  R4-1714002 TP for UE RF TR 38.817-01: mmWave power class Sumitomo Elec. Industries, Ltd  R4-1714099 TP for TR 38.817-01: UE RF requriements for SUL Huawei, HiSilicon  R4-1714168 TP for TS 38.817-01: NR CA bandwidth class Huawei, HiSilicon  R4-1714305 TP to 38.817-01 on ¡°Summary of simulation results on Coexistence Studies for 55dBm CPE¡± Ericsson, Nokia, Nokia Shanghai Bell  R4-1714370 TP for TR 38.817-01: UE Power Class for UL-MIMO Huawei, HiSilicon, CMCC  R4-1714452 TP to TR 38.817-01: UE REFSENS for NR bands below 6GHz Huawei, HiSilicon  R4-1714479 TP for TR 38.817-01 NR channel bandwidth Huawei, HiSilicon | 0.3.0 |
| 2018-02 | RAN4-#86 | R4-1802136 |  |  |  | Approved TPs  R4-1800440 TP for TR 38.817-01 NR channel bandwidth CMCC  R4-1800938 TP for TR 38.817-01v0.3.0 addition of n25 including refsens Sprint Corporation  R4-1800999 TP for TR 38.817-01 Further update of NR bands Huawei, HiSilicon  R4-1801009 pCR to UE TR 38.817-01: Spectrum utilization release 15 requirement Ericsson  R4-1801103 TP for TR 38.817-01 addition of 26 including refsens Sprint Corporation  R4-1801178 TP for TR 38.817-01v0.3.0 n41 refsens corrections Sprint Corporation  R4-1801324 pCR to TR 38.817-01: Spectrum utilization for multiple numerologies Ericsson | 0.4.0 |
| 2018-03 | RAN #79 | RP-180332 |  |  |  | Approved TPs  R4-1801431 TP for TR 38.817-01 NR UE power classes CMCC  R4-1801480 TP for TR38.817-01:Channel spacing for NR ZTE  R4-1801555 TP to TR 38.817-01 update of NR CBWs Huawei, HiSilicon  R4-1801556 TP to TR 38.817-01 update of NR REFSENS and UL configurations Huawei, HiSilicon  R4-1802144 TP to TR 38.817-01: NR channel and sync raster Ericsson  R4-1802145 TP to TR 38.817-01: Sync raster calculations Ericsson  R4-1802202 TP for TR 38.817-01: n41 correction Sprint Corporation  R4-1803526 TP to TR 38.817-01: Spectrum Utilization for multiple numerologies Ericsson | 1.0.0 |
| 2018-06 | RAN #80 | RP-180949 |  |  |  | Approved TPs  RAN4 #86bis  R4-1804224 TP for TR 37.817-01: n41 correction and addtion SPRINT Corporation  R4-1804225 TP for TR 38.817-01: n41 SEM and additional spurious emissions SPRINT Corporation  R4-1805452 TP for TR 38.817-01 on US 28 GHz band number Qualcomm Incorporated  R4-1805662 TP for TR 38.817-01 – Using BCS concept in NR ZTE Corporation  R4-1805781 TP for TR38.817-01:Power class and REFSENSE for Bands n34,n39 and n40 ZTE Corporation,CMCC  R4-1805901 TP for TS 38.817-01 Some corrections for SUL bands Huawei, HiSilicon  R4-1805984 TP to TR 38.817-01: Sync raster open issues (4.3.1) Ericsson  R4-1806006 UE RF requirements for EN-DC with UL sharing from UE perpective Huawei, HiSilicon  RAN4 #87  R4-1806804 TP for TR 38.817-01 Notations on NR CA, EN-DC & NR DC ZTE Corporation  R4-1806806 TP for TR 38.817-01 Introduction of BCS for intra-band EN-DC ZTE Corporation  R4-1807815 TP for TR 38.817-01 correction to DFT-S-OFDM table for n41 SEM Sprint Corporation  R4-1807823 TP for TR 37.817-01 Addition of intra-band EN-DC BCS text Sprint Corporation  R4-1808123 TP for TS 38-817-01 n41 -25 dBm/MHz spurious emissions with NS\_04 Sprint Corporation  R4-1808267 TP for TR 38.817-01 Corrections on sync raster description in section 4.3.1 ZTE Corporation  v2.0.0 submitted for plenary approval | 2.0.0 |
| 2018-06 | RAN#80 |  |  |  |  | Approved by plenary – Rel-15 spec under change control | 15.0.0 |
| 2018-09 | RAN#81 | RP-181896 | 0001 |  | F | CR on TRx RF test metrics for mmWave | 15.1.0 |
| 2018-09 | RAN#81 | RP-181896 | 0002 | 1 | D | CR for 38.817-01: Formulas for the GSCN calculation | 15.1.0 |
| 2018-12 | RAN#82 | RP-182359 | 0003 | 1 | F | CR to TR 38.817-01 on Correction of calculations of GSCN per operating band | 15.2.0 |
| 2018-12 | RAN#82 | RP-182359 | 0004 |  | F | CR for the definition of mmWave power class | 15.2.0 |
| 2019-03 | RAN#83 | RP-190401 | 0008 |  | F | CR to TS 38.817-01: Corrections on ACLR simulation result and annex heading | 15.3.0 |
| 2019-03 | RAN#83 | RP-190401 | 0010 | 2 | F | CR to TR 38.817-01 on GSCN raster ranges | 15.3.0 |
| 2019-03 | RAN#83 | RP-190402 | 0011 | 1 | F | CR to TR 38.817-01: FR1 upper frequency limit extension | 15.3.0 |
| 2019-06 | RAN#84 | RP-191237 | 0012 | 1 | F | CR to TR 38.817-01 on GSCN raster ranges | 15.4.0 |
| 2019-06 | RAN#84 | RP-191237 | 0013 | 2 | F | CR to 38.817-01: FR2 CA MPR explained | 15.4.0 |
| 2019-06 | RAN#84 | RP-191237 | 0015 |  | F | CR to 38.817-01 to align system level simulation assumptions with MPR definition | 15.4.0 |
| 2019-06 | RAN#84 | RP-191237 | 0016 | 1 | F | CR to 38.817-01 to capture outcome of beam correspondence | 15.4.0 |
| 2019-06 | RAN#84 | RP-191253 | 0014 | 1 | B | CR to TS 38.817-01: Coexistence study on 29dBm UE Power Class for LTE Band 41 and NR Band n41 | 16.0.0 |
| 2019-09 | RAN#85 | RP-192033 | 0017 |  | F | CR to TS 38.817-01: Correction on coexistence study on 29dBm UE Power Class for LTE Band 41 and NR Band n41 with 20MHz channel bandwidth | 16.1.0 |
| 2019-09 | RAN#85 | RP-192048 | 0019 |  | A | CR to TR 38.817-01 on FR1 inner RB allocation range | 16.1.0 |
| 2020-09 | RAN#89 | RP-201512 | 0021 |  | A | CR to capture WRC-19 impact on NR bands in TR38.817-01 Cat-A | 16.2.0 |
| 2021-09 | RAN#93 | RP-211921 | 0023 |  | A | CR for EESS protection for FR2 NR bands in TR 38.817-01 (Rel-16) | 16.3.0 |
| 2022-09 | RAN#97 | RP-222023 | 0025 |  | A | Big CR for 38.817-01 maintenance (Rel-16) | 16.4.0 |