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| 3GPP TR 38.880 V0.3.0 (2024-05) | |
| Technical Report | |
| 3rd Generation Partnership Project;  Technical Specification Group Radio Access Network;  UE requirements for 3Tx inter-band UL CA and EN-DC  (Release 18) | |
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# Foreword

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

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

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.

In the present document, modal verbs have the following meanings:

**shall** indicates a mandatory requirement to do something

**shall not** indicates an interdiction (prohibition) to do something

The constructions "shall" and "shall not" are confined to the context of normative provisions, and do not appear in Technical Reports.

The constructions "must" and "must not" are not used as substitutes for "shall" and "shall not". Their use is avoided insofar as possible, and they are not used in a normative context except in a direct citation from an external, referenced, non-3GPP document, or so as to maintain continuity of style when extending or modifying the provisions of such a referenced document.

**should** indicates a recommendation to do something

**should not** indicates a recommendation not to do something

**may** indicates permission to do something

**need not** indicates permission not to do something

The construction "may not" is ambiguous and is not used in normative elements. The unambiguous constructions "might not" or "shall not" are used instead, depending upon the meaning intended.

**can** indicates that something is possible

**cannot** indicates that something is impossible

The constructions "can" and "cannot" are not substitutes for "may" and "need not".

**will** indicates that something is certain or expected to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**will not** indicates that something is certain or expected not to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**might** indicates a likelihood that something will happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

**might not** indicates a likelihood that something will not happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

In addition:

**is** (or any other verb in the indicative mood) indicates a statement of fact

**is not** (or any other negative verb in the indicative mood) indicates a statement of fact

The constructions "is" and "is not" do not indicate requirements.

# 1 Scope

The present document is a technical report for UE requirements for 3Tx inter-band UL CA and EN-DC under Rel-18 time-frame. The purpose is to gather the relevant background information and studies of these 3Tx band combinations.

This TR contains the RF requirements of band combination specific part. The actual requirements are added to the corresponding technical specifications.

# 2 References

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

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

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

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

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

[2] 3GPP TS 38.101-1: "NR; User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone".

[3] 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".

[4] WI description, RP-231719: "WID revision for Core part 4Rx handheld UE for low NR bands (1GHz) and/or 3Tx for NR inter-band UL Carrier Aggregation (CA) and EN-DC"

[5] WI description, RP-232674: "New WID: Rel-18 new basket WI for 3Tx inter-band UL CA and EN-DC"

# 3 Definitions of terms, symbols and abbreviations

## 3.1 Terms

For the purposes of the present document, the terms given in 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 TR 21.905 [1].

**3Tx**: UE transmit with one Tx chain on one band and two Tx chains on the other band in CA or EN-DC band combinations.

**Carrier aggregation:** Aggregation of two or more component carriers in order to support wider transmission bandwidths.

**Inter-band carrier aggregation:** Carrier aggregation of component carriers in different operating bands.

## 3.2 Symbols

For the purposes of the present document, the following symbols apply:

ΔRIB,c Allowed reference sensitivity relaxation due to support for inter-band CA operation, for serving cell *c*

ΔTIB,c Allowed maximum configured output power relaxation due to support for inter-band CA operation, inter-band NR-DC operation and due to support for SUL operations, for serving cell *c*

## 3.3 Abbreviations

For the purposes of the present document, the abbreviations given in 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 TR 21.905 [1].

CA Carrier Aggregation

DC Dual Connectivity

IMD Inter-modulation

MSD Maximum Sensitivity Deduction

SCS Subcarrier spacing

# 4 Background

## 4.1 Introduction

General requirements for 3Tx feature was introduced in Rel-18 RAN4 specification 38.101-1 and 38.101-3 via WI [4]. After that, more band combinations are proposed and introduced via basket WI [5].

**The power capabilities considered in this technical report includes:**

CA power class or EN-DC power class is PC2

PC3 FDD band 1Tx + PC2 TDD band 2Tx (UL MIMO and TxD)

PC3 FDD band 1Tx + PC3 TDD band 2Tx (UL MIMO)

PC3 TDD band 1Tx + PC2 TDD band 2Tx (UL MIMO)

CA power class or EN-DC power class is PC1.5

PC3 FDD band 1Tx + PC1.5 TDD band 2Tx (UL MIMO and TxD)

The present document is a technical report for UE requirements for the newly introduced band combinations with 3Tx inter-band UL CA and EN-DC under Rel-18 time-frame. It covers the RF requirements for each band combination specific issues (i.e. one sub-clause defined per band combination) mainly MSD analysis caused by harmonic mixing, cross band leakage and IMD issue. It should be noticed that the MSD for harmonic interference is not considered here since in Rel-18 the band combinations considered mainly 1Tx in low frequency bands + 2Tx in high frequency bands as seen from the WI scope [5].

**The below agreements can be followed when introduce new 3Tx band combinations:**

For 3Tx PC2/PC1.5 harmonic mixing and cross-band leakage MSD:

Reuse the MSD of 2Tx band combination for 3Tx band combination as long as the aggressor TDD band has same power class

For 3Tx PC2 IMD MSD:

The IMD MSD specified based on 1Tx-1Tx UL configuration are applicable for 1Tx-2Tx UL configuration.

For 3Tx PC1.5 IMD MSD:

23+27.8 is used as the power configuration in the 3Tx PC1.5 IMD MSD calculation where band A is 23dBm and band B is 24.8dBm+24.8dBm with 2Tx

For the band combinations whose 2Tx MSD is not specified in the spec yet, 3Tx MSD needs to be evaluated. And it is encouraged to align the requirements between 2Tx and 3Tx band combinations.

## 4.2 TR Maintenance

A single company is responsible for introducing all approved TPs in the current TR, i.e. TR editor. However, it is the responsibility of the contact person of each band combination to ensure that the TPs related to the band combination have been implemented.

# 5 3Tx CA band combinations

## 5.x CA\_nX-nY (Example)

### 5.x.1 Operating bands for CA

Table 5.x.1-1: CA band combination of band nX+nY

|  |  |
| --- | --- |
| NR CA Band combination | NR Band |
| CA\_nX-nY | nX, nY |

### 5.x.2 Maximum output power for inter-band CA

Table 5.x.2-1: UE Power Class for 3Tx inter-band CA with UL MIMO

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **NR UL CA Configuration** | **Class 1.5 (dBm)** | **Tolerance (dB)** | **Class 2 (dBm)** | **Tolerance (dB)** | **Class 3 (dBm)** | **Tolerance (dB)** |
| CA\_nXA-nYA | 293 | +2/-3 | 262 | +2/-3 | 23 | +2/-3 |
| CA\_nXA-nYA |  |  | 264 | +2/-3 | 23 | +2/-3 |
| NOTE 1: (Void in this TR)  NOTE 2: The UE supports PC3 in FDD band and PC3 or PC2 with UL MIMO in TDD band.  NOTE 3: The UE supports PC3 in FDD band and PC1.5 with UL MIMO in TDD band.  NOTE 4: The UE supports PC2 with UL MIMO in either one of the TDD bands and PC2 in the other TDD band. | | | | | | |

Table 5.x.2-2: UE Power Class for 3Tx inter-band CA with TxD

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **NR UL CA Configuration** | **Class 1.5 (dBm)** | **Tolerance (dB)** | **Class 2 (dBm)** | **Tolerance (dB)** | **Class 3 (dBm)** | **Tolerance (dB)** |
| CA\_nXA-nYA | 293 | +2/-3 | 262 | +2/-3 | 23 | +2/-3 |
| NOTE 1: (Void in this TR)  NOTE 2: The UE supports PC3 in FDD band and PC2 with Tx Diversity in TDD band.  NOTE 3: The UE supports PC3 in FDD band and PC1.5 with Tx Diversity in TDD band. | | | | | | |

Editor's note: The targeted max Tx power configuration shall be within the scope of basket WI.

### 5.x.3 MSD scenario studies

Table 5.x.3-1 and 5.x.3-2 summarizes frequency ranges where harmonics mixing, cross band leakage, IMD interferences occur for CA\_ nX-nY.

Table 5.x.3-1: MSD scenarios for CA\_nX-nY with total power class 2

|  |  |  |  |
| --- | --- | --- | --- |
|  | Aggressor Tx | Victim Rx | Whether 2Tx requirements exists |
| **Harmonic mixing** | M order of nY UL | N order of nX DL | Yes or No? |
| … | … | … |
| **Cross band leakage** | nY UL | nX DL | Yes or No? |
| … | … | … |
| **IMD** | IMD order (M order of nX UL + N order of nY UL) | nX DL | Yes or No? |
| … | … | … |

Editor's note: only list the MSD scenario that exists for this band combination.

Table 5.x.3-2: MSD scenarios for CA\_nX-nY with total power class 1.5

|  |  |  |  |
| --- | --- | --- | --- |
|  | Aggressor Tx | Victim Rx | Whether 2Tx requirements exists |
| **Harmonic mixing** | M order of nY UL | N order of nX DL | Yes or No? |
| … | … | … |
| **Cross band leakage** | nY UL | nX DL | Yes or No? |
| … | … | … |
| **IMD** | IMD order (M order of nX UL + N order of nY UL) | nX DL | Yes or No? |
| … | … | … |

Editor's note: only list the MSD scenario that exists for this band combination.

### 5.x.4 REFSENS requirements

Editor's note1: Make it clear whether the existing 2Tx requirements are reused or newly analysed due to for example missing of the 2Tx requirements.

Editor's note2: If reused, just say to reuse the existing 2Tx MSD requirements for MSD type harmonic mixing, or cross band leakage or IMD.

Editor’s note3: If MSD is newly specified, it would be useful to give some key parameters as reference.

#### 5.x.4.1 REFSENS requirements for total power class 2

#### 5.x.4.2 REFSENS requirements for total power class 1.5

## 5.1 CA\_n2A-n77A

5.1.1 Operating bands for CA

Table 5.1.1-1: CA band combination of band nX+nY

|  |  |
| --- | --- |
| **NR CA Band combination** | **NR Band** |
| CA\_n2-n77 | n2, n77 |

5.1.2 Maximum output power for inter-band CA

Table 5.1.2-1: UE Power Class for 3Tx inter-band CA with UL MIMO

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **NR UL CA Configuration** | **Class 1.5 (dBm)** | **Tolerance (dB)** | **Class 2 (dBm)** | **Tolerance (dB)** | **Class 3 (dBm)** | **Tolerance (dB)** |
| CA\_n2A-n77A | 293 | +2/-3 | 262 | +2/-3 | 23 | +2/-3 |
| NOTE 1: (Void in this TR)  NOTE 2: The UE supports PC3 in FDD band and PC3 or PC2 with UL MIMO in TDD band.  NOTE 3: The UE supports PC3 in FDD band and PC1.5 with UL MIMO in TDD band.  NOTE 4: The UE supports PC2 with UL MIMO in either one of the TDD bands and PC2 in the other TDD band. | | | | | | |

Table 5.1.2-2: UE Power Class for 3Tx inter-band CA with TxD

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **NR UL CA Configuration** | **Class 1.5 (dBm)** | **Tolerance (dB)** | **Class 2 (dBm)** | **Tolerance (dB)** | **Class 3 (dBm)** | **Tolerance (dB)** |
| CA\_n2A-n77A | 293 | +2/-3 | 262 | +2/-3 | 23 | +2/-3 |
| NOTE 1: (Void in this TR)  NOTE 2: The UE supports PC3 in FDD band and PC2 with Tx Diversity in TDD band.  NOTE 3: The UE supports PC3 in FDD band and PC1.5 with Tx Diversity in TDD band. | | | | | | |

5.1.3 MSD scenario studies

Table 5.1.3-1 and 5.1.3-2 summarizes frequency ranges where harmonics mixing, cross band leakage, IMD interferences occur for CA\_ n2-n77.

Table 5.1.3-1: MSD scenarios for CA\_n2-n77 with total power class 2

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Aggressor Tx** | **Victim Rx** | **Whether 2Tx requirements exists** |
| **Harmonic mixing** | 1st order of n77 UL | 2nd order of n2 DL | Yes |
| **Cross band leakage** | n77 UL | n2 DL | Yes |
| **IMD** | IMD2 (1\*f\_n77-1\*f\_n2) | n2 DL | Yes |
| IMD4 (3\*f\_n2-1\*f\_n77) | n2 DL | Yes |
| IMD5 (2\*f\_n77-3\*f\_n2) | n2 DL | Yes, for PC3 only  (The PC2 MSD value is newly added in Table 5.1.4.1-2 below) |

Table 5.1.3-2: MSD scenarios for CA\_n2-n77 with total power class 1.5

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Aggressor Tx** | **Victim Rx** | **Whether 2Tx requirements exists** |
| **Harmonic mixing** | 1st order of n77 UL | 2nd order of n2 DL | Yes |
| **Cross band leakage** | n77 UL | n2 DL | Yes |
| **IMD** | IMD2 (1\*f\_n77-1\*f\_n2) | n2 DL | No |
| IMD4 (3\*f\_n2-1\*f\_n77) | n2 DL | No |
|  | IMD5 (2\*f\_n77-3\*f\_n2) | n2 DL | No |

### 5.1.4 REFSENS requirements

5.1.4.1 REFSENS requirements for total power class 2

In previous meeting, RAN4 agreed that the following rules will be as the baseline to define MSD requirement for PC2 inter-band CA or EN-DC:

Same MSD requirements can be applied for the band combination with either 1Tx or 2Tx in TDD aggressor band UL with same power class for harmonic mixing and cross band isolation, and

the requirements specified based on 1Tx-1Tx UL configuration are applicable for 1Tx-2Tx UL configuration

Based on the agreement, the analysis MSD results are summarized in Table 5.1.4.2-1. Mainly, they are the same as PC2 2Tx configuration for this 3Tx requirement to the current RAN4 specifications [2].

According to the current RAN4 specifications [2], CA\_n2-n77 is subject to IMD5 impact to n2 DL too. The value of PC2 IMD5 MSD is resulted in the Table 5.1.4.1-1, and it is derived based on linear extrapolation and referred the MSD for PC3 configuration.

Table 5.1.4.1-1: Derived MSD values for PC2 UL configurations

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **CA Combination** | **Power Class** | **NR Band** | **PUL (dBm)** | **IMD Source** | **IMD Order** | **MSD (dB)** |
| CA\_n2-n77 | 3 | n2 | 20 | IMD2 | 1 | 26.0 |
| n77 | 20 | 1 |
| 2 | n2 | 23 | 1 | 32.1 |
| n77 | 23 | 1 |
| 3 | n2 | 20 | IMD4 | 3 | 8.0 |
| n77 | 20 | 1 |
| 2 | n2 | 23 | 3 | 19.1 |
| n77 | 23 | 1 |
| 3 | n2 | 20 | IMD5 | 3 | 5.0 |
| n77 | 20 | 2 |
| 2 | n2 | 23 | 3 | 20.0 |
| n77 | 23 | 2 |

For the proposed MSD requirements, all required results are summarized in the following tables, except a new MSD value for IMD5 in the Table 5.1.4.1-3 as discussed above.

Table 5.1.4.1-2 (same as Table 7.3A.4-4a of 38.101-1): Reference sensitivity exceptions and uplink/downlink configurations due to harmonic mixing from a PC2 aggressor NR UL band for NR DL CA FR1

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **UL band** | **DL band** | **UL BW** | **SCS of UL band** | **UL RB Allocation** | **DL BW** | **MSD** | **UL/DL fc condition** | **UL/DL harmonic order** |
| **(MHz)** | **(kHz)** | **LCRB** | **(MHz)** | **(dB)** |
| n77 | n2 | 10 | 15 | 25 (RBstart=0) | 5 | 9.1 | NOTE 4 | UL1/DL2 |
| n77 | n2 | 20 | 15 | 100 (RBstart=0) | 20 | 6.7 | NOTE 4 | UL1/DL2 |

**Table 5.1.4.1-3: 2DL/2UL inter-band Reference sensitivity QPSK PREFSENS and uplink/downlink configurations for PC2 CA**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Band / Channel bandwidth / NRB / Duplex mode** | | | | | | | | **Source of IMD** |
| **NR CA**  **Configuration** | **NR band** | **UL Fc  (MHz)** | **UL/DL BW  (MHz)** | **UL  LCRB** | **DL Fc (MHz)** | **MSD  (dB)** | **Duplex mode** |  |
| CA\_n2-n77 | n2 | 1855 | 5 | 25 | 1935 | 32.1 | FDD | IMD2 |
|  | n77 | 3790 | 10 | 50 | 3790 | N/A | TDD | N/A |
|  | n2 | 1900 | 5 | 25 | 1980 | 19.1 | FDD | IMD4 |
|  | n77 | 3720 | 10 | 50 | 3720 | N/A | TDD | N/A |
|  | n2 | 1885 | 5 | 25 | 1965 | 20.0 | FDD | IMD5 |
|  | n77 | 3810 | 10 | 50 | 3810 | N/A | TDD | N/A |

Editor note: The MSD value for PC2 IMD5 is newly added for both 2Tx and 3Tx.

Table 5.1.4.1-4 (same as Table 7.3A.6-1a of 38.101-1): Reference sensitivity exceptions (MSD) and uplink/downlink configurations due to cross band isolation from a PC2 aggressor NR UL band for NR CA FR1

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **UL band** | **DL band** | **UL Fc** | **UL BW** | **SCS of UL band** | **UL RB Allocation** | **DL Fc** | **DL BW** | **MSD** | **Cross-band**  **Interference**  **source** |
| **(MHz)** | **(MHz)** | **(kHz)** | **LCRB** | **(MHz)** | **(MHz)** | **(dB)** |
| n77 | n2 | 3305 | 100 | 30 | 270 (RBstart=0) | 1987.5 | 5 | 1.0 | >ACLR2 |

5.1.4.2 REFSENS requirements for total power class 1.5

According to the current RAN4 specifications [2], CA\_n2-n77 is subject to IMD2, IMD4, and IMD5 impact to n2 DL. For IMD2, the IMD composition is 1st order in n2 UL and 1st order in n77 UL. For IMD4, the IMD composition is 3rd order in n2 UL and 1st order in n77 UL, and for IMD5, the IMD composition is 3rd order in n2 UL and 2nd order in n77 UL.

Table 5.1.4.2-1 summarizes the MSD analysis results where the MSD for PC3 and PC2 UL configurations are referenced to the current RAN4 specifications [2]. And, the MSD for PC1.5 UL configuration is derived based on linear extrapolation.

Table 5.1.4.2-1: Derived MSD values for PC2 UL configurations

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **CA Combination** | **Power Class** | **NR Band** | **PUL (dBm)** | **IMD Source** | **IMD Order** | **MSD (dB)** |
| CA\_n2-n77 | 3 | n2 | 20 | IMD2 | 1 | 26.0 |
| n77 | 20 | 1 |
| 2 | n2 | 23 | 1 | 32.1 |
| n77 | 23 | 1 |
| 1.5 | n2 | 23 | 1 | 35.2 |
| n77 | 27.8 | 1 |
| 3 | n2 | 20 | IMD4 | 3 | 8.0 |
| n77 | 20 | 1 |
| 2 | n2 | 23 | 3 | 19.1 |
| n77 | 23 | 1 |
| 1.5 | n2 | 23 | 3 | 26.4 |
| n77 | 27.8 | 1 |
| 3 | n2 | 20 | IMD5 | 3 | 5.0 |
| n77 | 20 | 2 |
| 2 | n2 | 23 | 3 | 20.0 |
| n77 | 23 | 2 |
| 1.5 | n2 | 23 | 3 | 28.0 |
| n77 | 27.8 | 2 |

Editor note: Except the MSD values for PC3, the MSD value for PC2 IMD5 and all of the MSD values for PC1.5 are newly proposed in this table.

Based on analysis above, for PC1.5 UL CA\_n2-n5 inter-band combination, the reference sensitivity values are summarized and proposed in Table 5.1.4.2-2

Table 5.1.4.2-2: 2DL/2UL inter-band Reference sensitivity QPSK PREFSENS and uplink/downlink configurations for PC1.5 CA

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Band / Channel bandwidth / NRB / Duplex mode** | | | | | | | | **Source of IMD** |
| **NR CA**  **Configuration** | **NR band** | **UL Fc  (MHz)** | **UL/DL BW  (MHz)** | **UL  LCRB** | **DL Fc (MHz)** | **MSD  (dB)** | **Duplex mode** |  |
| CA\_n2-n77 | n2 | 1855 | 5 | 25 | 1935 | 35.2 | FDD | IMD2 |
|  | n77 | 3790 | 10 | 50 | 3790 | N/A | TDD | N/A |
|  | n2 | 1900 | 5 | 25 | 1980 | 26.4 | FDD | IMD4 |
|  | n77 | 3720 | 10 | 50 | 3720 | N/A | TDD | N/A |
|  | n2 | 1885 | 5 | 25 | 1965 | 28.0 | FDD | IMD5 |
|  | n77 | 3810 | 10 | 50 | 3810 | N/A | TDD | N/A |

As both harmonic mixing and cross band isolation for this PC1.5 UL CA\_n2-n77 have been specified in 38.101-1, we copy/paste the same requirements into the Table 5.1.4.2-3 and Table 5.1.4.2-4

Table 5.1.4.2-3 (same as Table 7.3A.4-4b of 38.101-1): Reference sensitivity exceptions and uplink/downlink configurations due to harmonic mixing from a PC1.5 NR UL band for NR DL CA FR1

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **UL band** | **DL band** | **UL BW** | **SCS of UL band** | **UL RB Allocation** | **DL BW** | **MSD** | **UL/DL fc condition** | **UL/DL harmonic order** |
| **(MHz)** | **(kHz)** | **LCRB** | **(MHz)** | **(dB)** |
| n77 | n2 | 10 | 15 | 25 (RBstart=0) | 5 | 11.8 | NOTE 4 | UL1/DL2 |
| n77 | n2 | 20 | 15 | 100 (RBstart=0) | 20 | 9.2 | NOTE 4 | UL1/DL2 |

Table 5.1.4.2-4 (same as Table 7.3A.6-1b of 38.101-1): Reference sensitivity exceptions (MSD) and uplink/downlink configurations due to cross band isolation from a PC1.5 aggressor NR single UL band for DL NR CA FR1

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **UL band** | **DL band** | **UL Fc** | **UL BW** | **SCS of UL band** | **UL RB Allocation** | **DL Fc** | **DL BW** | **MSD** | **Cross-band**  **Interference**  **source** |
| **(MHz)** | **(MHz)** | **(kHz)** | **LCRB** | **(MHz)** | **(MHz)** | **(dB)** |
| n77 | n2 | 3305 | 100 | 30 | 270 (RBstart=0) | 1987.5 | 5 | 1.8 | >ACLR2 |

## 5.2 CA\_n25A-n41A

### 5.2.1 Operating bands for CA

Table 5.2.1-1: CA band combination of band n25+n41

|  |  |
| --- | --- |
| NR CA Band combination | NR Band |
| CA\_n25-n41 | n25, n41 |

### 5.2.2 Maximum output power for inter-band CA

Table 5.2.2-1: UE Power Class for 3Tx inter-band CA with UL MIMO

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **NR UL CA Configuration** | **Class 1.5 (dBm)** | **Tolerance (dB)** | **Class 2 (dBm)** | **Tolerance (dB)** | **Class 3 (dBm)** | **Tolerance (dB)** |
| CA\_n25A-n41A | 293 | +2/-3 | 262 | +2/-3 | 23 | +2/-3 |
| NOTE 1: (Void in this TR)  NOTE 2: The UE supports PC3 in FDD band and PC3 or PC2 with UL MIMO in TDD band.  NOTE 3: The UE supports PC3 in FDD band and PC1.5 with UL MIMO in TDD band.  NOTE 4: The UE supports PC2 with UL MIMO in either one of the TDD bands and PC2 in the other TDD band. | | | | | | |

Table 5.2.2-2: UE Power Class for 3Tx inter-band CA with TxD

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **NR UL CA Configuration** | **Class 1.5 (dBm)** | **Tolerance (dB)** | **Class 2 (dBm)** | **Tolerance (dB)** | **Class 3 (dBm)** | **Tolerance (dB)** |
| CA\_n25A-n41A | 293 | +2/-3 | 262 | +2/-3 | 23 | +2/-3 |
| NOTE 1: (Void in this TR)  NOTE 2: The UE supports PC3 in FDD band and PC2 with Tx Diversity in TDD band.  NOTE 3: The UE supports PC3 in FDD band and PC1.5 with Tx Diversity in TDD band. | | | | | | |

### 5.2.3 MSD scenario studies

Table 5.2.3-1 and 5.2.3-2 summarizes frequency ranges where harmonics mixing, cross band leakage, IMD interferences occur for CA\_ n25-n41.

Table 5.2.3-1: MSD scenarios for CA\_n25-n41 with total power class 2

|  |  |  |  |
| --- | --- | --- | --- |
|  | Aggressor Tx | Victim Rx | Whether 2Tx requirements exists |
| **Cross band leakage** | n41 UL | n25 DL | Yes |

Table 5.2.3-2: MSD scenarios for CA\_n25-n41 with total power class 1.5

|  |  |  |  |
| --- | --- | --- | --- |
|  | Aggressor Tx | Victim Rx | Whether 2Tx requirements exists |
| **Cross band leakage** | n41 UL | n25 DL | Yes |

### 5.2.4 REFSENS requirements

#### 5.2.4.1 REFSENS requirements for total power class 2

The PC2 MSD due to cross band isolation can be re-used from PC2 with 2Tx and therefore is not shown here.

#### 5.2.4.2 REFSENS requirements for total power class 1.5

The PC1.5 MSD due to cross band isolation can be re-used from PC1.5 with 2Tx and therefore is not shown here.

## 5.3 CA\_n41A-n66A

### 5.3.1 Operating bands for CA

Table 5.3.1-1: CA band combination of band n41+n66

|  |  |
| --- | --- |
| NR CA Band combination | NR Band |
| CA\_n41-n66 | n41, n66 |

### 5.3.2 Maximum output power for inter-band CA

Table 5.3.2-1: UE Power Class for 3Tx inter-band CA with UL MIMO

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **NR UL CA Configuration** | **Class 1.5 (dBm)** | **Tolerance (dB)** | **Class 2 (dBm)** | **Tolerance (dB)** | **Class 3 (dBm)** | **Tolerance (dB)** |
| CA\_n41A-n66A | 293 | +2/-3 | 262 | +2/-3 | 23 | +2/-3 |
| NOTE 1: (Void in this TR)  NOTE 2: The UE supports PC3 in FDD band and PC3 or PC2 with UL MIMO in TDD band.  NOTE 3: The UE supports PC3 in FDD band and PC1.5 with UL MIMO in TDD band.  NOTE 4: The UE supports PC2 with UL MIMO in either one of the TDD bands and PC2 in the other TDD band. | | | | | | |

Table 5.3.2-2: UE Power Class for 3Tx inter-band CA with TxD

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **NR UL CA Configuration** | **Class 1.5 (dBm)** | **Tolerance (dB)** | **Class 2 (dBm)** | **Tolerance (dB)** | **Class 3 (dBm)** | **Tolerance (dB)** |
| CA\_n41A-n66A | 293 | +2/-3 | 262 | +2/-3 | 23 | +2/-3 |
| NOTE 1: (Void in this TR)  NOTE 2: The UE supports PC3 in FDD band and PC2 with Tx Diversity in TDD band.  NOTE 3: The UE supports PC3 in FDD band and PC1.5 with Tx Diversity in TDD band. | | | | | | |

### 5.3.3 MSD scenario studies

Table 5.3.3-1 and 5.3.3-2 summarizes frequency ranges where harmonics mixing, cross band leakage, IMD interferences occur for CA\_ n41-n66.

Table 5.3.3-1: MSD scenarios for CA\_n41-n66 with total power class 2

|  |  |  |  |
| --- | --- | --- | --- |
|  | Aggressor Tx | Victim Rx | Whether 2Tx requirements exists |
| **Cross band leakage** | n41 UL | n66 DL | Yes |

Table 5.3.3-2: MSD scenarios for CA\_n41-n66 with total power class 1.5

|  |  |  |  |
| --- | --- | --- | --- |
|  | Aggressor Tx | Victim Rx | Whether 2Tx requirements exists |
| **Cross band leakage** | n41 UL | n66 DL | Yes |

### 5.3.4 REFSENS requirements

#### 5.3.4.1 REFSENS requirements for total power class 2

The PC2 MSD due to cross band isolation can be re-used from PC2 with 2Tx and is therefore not shown here.

#### 5.3.4.2 REFSENS requirements for total power class 1.5

The PC1.5 MSD due to cross band isolation can be re-used from PC1.5 with 2Tx and is therefore not shown here.

5.4 CA\_n7-n77

5.4.1 Operating bands for CA

**Table 5.4.1-1: CA band combination of band n7+n77**

|  |  |
| --- | --- |
| **NR CA Band combination** | **NR Band** |
| CA\_n7-n77 | n7, n77 |

5.4.2 Maximum output power for inter-band CA

**Table 5.4.2-1: UE Power Class for 3Tx inter-band CA with UL MIMO**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **NR UL CA Configuration** | **Class 1.5 (dBm)** | **Tolerance (dB)** | **Class 2 (dBm)** | **Tolerance (dB)** | **Class 3 (dBm)** | **Tolerance (dB)** |
| CA\_n7A-n77A | 293 | +2/-3 | 262 | +2/-3 | 23 | +2/-3 |
| NOTE 1: (Void in this TR)  NOTE 2: The UE supports PC3 in FDD band and PC3 or PC2 with UL MIMO in TDD band.  NOTE 3: The UE supports PC3 in FDD band and PC1.5 with UL MIMO in TDD band.  NOTE 4: The UE supports PC2 with UL MIMO in either one of the TDD bands and PC2 in the other TDD band. | | | | | | |

**Table 5.4.2-2: UE Power Class for 3Tx inter-band CA with TxD**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **NR UL CA Configuration** | **Class 1.5 (dBm)** | **Tolerance (dB)** | **Class 2 (dBm)** | **Tolerance (dB)** | **Class 3 (dBm)** | **Tolerance (dB)** |
| CA\_n7A-n77A | 293 | +2/-3 | 262 | +2/-3 | 23 | +2/-3 |
| NOTE 1: (Void in this TR)  NOTE 2: The UE supports PC3 in FDD band and PC2 with Tx Diversity in TDD band.  NOTE 3: The UE supports PC3 in FDD band and PC1.5 with Tx Diversity in TDD band. | | | | | | |

5.4.3 MSD scenario studies

Table 5.4.3-1 and 5.4.3-2 summarizes frequency ranges where harmonics mixing, cross band leakage, IMD interferences occur for CA\_ n7-n77.

**Table 5.4.3-1: MSD scenarios for CA\_n7-n77 with total power class 2**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Aggressor Tx** | **Victim Rx** | **Whether 2Tx requirements exists** |
| **Harmonic mixing** | n77(UL2/DL3) | n7 | Yes |
| **Cross band leakage** | n77 | n7 | Yes |
| **IMD** | IMD 4 (2nd order of n7 UL + 2nd order of n77 UL) | n7 | Yes |

**Table 5.4.3-2: MSD scenarios for CA\_n7-n77 with total power class 1.5**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Aggressor Tx** | **Victim Rx** | **Whether 2Tx requirements exists** |
| **Harmonic mixing** | n77(UL2/DL3) | n7 | Yes |
| **Cross band leakage** | n77 | n7 | Yes |
| **IMD** | IMD 4 (2nd order of n7 UL + 2nd order of n77 UL) | n7 | No |

5.4.4 REFSENS requirements

5.4.4.1 REFSENS requirements for total power class 2

- The 2Tx MSD due to harmonic mixing has already been specified, which is applicable for 3Tx.

- The 2Tx MSD due to cross band isolation has already been specified, which is applicable for 3Tx.

- The 2Tx MSD due to IMD has already been specified, which is applicable for 3Tx.

5.4.4.2 REFSENS requirements for total power class 1.5

- The 2Tx MSD due to harmonic mixing has already been specified, which is applicable for 3Tx.

- The 2Tx MSD due to cross band isolation has already been specified, which is applicable for 3Tx.

- The MSD due to IMD4 for PC1.5 3Tx is specified in the following table.

**Table 5.4.4.2-1: 2DL/2UL inter-band Reference sensitivity QPSK PREFSENS and uplink/downlink configurations for PC1.5 CA**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Band / Channel bandwidth / NRB / Duplex mode** | | | | | | | | **Source of IMD** |
| **NR CA**  **Configuration** | **NR band** | **UL Fc  (MHz)** | **UL/DL BW  (MHz)** | **UL  LCRB** | **DL Fc (MHz)** | **MSD  (dB)** | **Duplex mode** |  |
| CA\_n7-n77 | n7 | 2540 | 5 | 25 | 2660 | 29.7 | FDD | IMD4 |
|  | n77 | 3870 | 10 | 50 | 3870 | N/A | TDD | N/A |

5.5 CA\_n25-n77

5.5.1 Operating bands for CA

**Table 5.5.1-1: CA band combination of band n25+n77**

|  |  |
| --- | --- |
| **NR CA Band combination** | **NR Band** |
| CA\_n25-n77 | n25, n77 |

5.5.2 Maximum output power for inter-band CA

**Table 5.5.2-1: UE Power Class for 3Tx inter-band CA with UL MIMO**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **NR UL CA Configuration** | **Class 1.5 (dBm)** | **Tolerance (dB)** | **Class 2 (dBm)** | **Tolerance (dB)** | **Class 3 (dBm)** | **Tolerance (dB)** |
| CA\_n25A-n77A |  |  | 262 | +2/-3 | 23 | +2/-3 |
| NOTE 1: (Void in this TR)  NOTE 2: The UE supports PC3 in FDD band and PC3 or PC2 with UL MIMO in TDD band.  NOTE 3: The UE supports PC3 in FDD band and PC1.5 with UL MIMO in TDD band.  NOTE 4: The UE supports PC2 with UL MIMO in either one of the TDD bands and PC2 in the other TDD band. | | | | | | |

**Table 5.5.2-2: UE Power Class for 3Tx inter-band CA with TxD**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **NR UL CA Configuration** | **Class 1.5 (dBm)** | **Tolerance (dB)** | **Class 2 (dBm)** | **Tolerance (dB)** | **Class 3 (dBm)** | **Tolerance (dB)** |
| CA\_n25A-n77A |  |  | 262 | +2/-3 | 23 | +2/-3 |
| NOTE 1: (Void in this TR)  NOTE 2: The UE supports PC3 in FDD band and PC2 with Tx Diversity in TDD band.  NOTE 3: The UE supports PC3 in FDD band and PC1.5 with Tx Diversity in TDD band. | | | | | | |

5.5.3 MSD scenario studies

Table 5.5.3-1 and 5.5.3-2 summarizes frequency ranges where harmonics mixing, cross band leakage, IMD interferences occur for CA\_ n25-n77.

**Table 5.5.3-1: MSD scenarios for CA\_n25-n77 with total power class 2**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Aggressor Tx** | **Victim Rx** | **Whether 2Tx requirements exists** |
| **Harmonics mixing** | n77 (UL1/DL2) | n25 | Yes |
| **IMD** | IMD 2 (1st order of n25 UL + 1st order of n77 UL) | n25 | Yes |
| IMD 4 (3rd order of n25 UL + 1st order of n77 UL) | n25 | Yes |
| IMD 5 (3rd order of n25 UL + 2nd order of n77 UL) | n25 | Yes |

**Table 5.5.3-2: MSD scenarios for CA\_n25-n77 with total power class 1.5**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Aggressor Tx** | **Victim Rx** | **Whether 2Tx requirements exists** |
| **Harmonics mixing** | n77 (UL1/DL2) | n25 | Yes |
| **IMD** | IMD 2 (1st order of n25 UL + 1st order of n77 UL) | n25 | Yes |
| IMD 4 (3rd order of n25 UL + 1st order of n77 UL) | n25 | Yes |
| IMD 5 (3rd order of n25 UL + 2nd order of n77 UL) | n25 | Yes |

5.5.4 REFSENS requirements

5.5.4.1 REFSENS requirements for total power class 2

- The existing 2Tx MSD value due to harmonic mixing has already been specified, which is also applicable for 3Tx.

- The existing 2Tx MSD value due to IMD has already been specified, which is also applicable for 3Tx.

5.5.4.2 REFSENS requirements for total power class 1.5

- The existing 2Tx MSD value due to harmonic mixing has already been specified, which is also applicable for 3Tx.

- The existing 2Tx MSD value due to IMD has already been specified, which is also applicable for 3Tx.

5.6 CA\_n66A-n77A

### 5.6.1 Operating bands for CA

Table 5.6.1-1: CA band combination of band n66+n77

|  |  |
| --- | --- |
| NR CA Band combination | NR Band |
| CA\_n66-n77 | n66, n77 |

### 5.6.2 Maximum output power for inter-band CA

Table 5.6.2-1: UE Power Class for 3Tx inter-band CA with UL MIMO

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **NR UL CA Configuration** | **Class 1.5 (dBm)** | **Tolerance (dB)** | **Class 2 (dBm)** | **Tolerance (dB)** | **Class 3 (dBm)** | **Tolerance (dB)** |
| CA\_n66A-n77A | 293 | +2/-3 | 262 | +2/-3 | 23 | +2/-3 |
| NOTE 1: (Void in this TR)  NOTE 2: The UE supports PC3 in FDD band and PC3 or PC2 with UL MIMO in TDD band.  NOTE 3: The UE supports PC3 in FDD band and PC1.5 with UL MIMO in TDD band.  NOTE 4: The UE supports PC2 with UL MIMO in either one of the TDD bands and PC2 in the other TDD band. | | | | | | |

Table 5.6.2-2: UE Power Class for 3Tx inter-band CA with TxD

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **NR UL CA Configuration** | **Class 1.5 (dBm)** | **Tolerance (dB)** | **Class 2 (dBm)** | **Tolerance (dB)** | **Class 3 (dBm)** | **Tolerance (dB)** |
| CA\_n66A-n77A | 293 | +2/-3 | 262 | +2/-3 | 23 | +2/-3 |
| NOTE 1: (Void in this TR)  NOTE 2: The UE supports PC3 in FDD band and PC2 with Tx Diversity in TDD band.  NOTE 3: The UE supports PC3 in FDD band and PC1.5 with Tx Diversity in TDD band. | | | | | | |

### 5.6.3 MSD scenario studies

Table 5.6.3-1 and 5.6.3-2 summarizes frequency ranges where harmonics mixing, cross band leakage, IMD interferences occur for CA\_n66-n77.

Table 5.6.3-1: MSD scenarios for CA\_n66-n77 with total power class 2

|  |  |  |  |
| --- | --- | --- | --- |
|  | Aggressor Tx | Victim Rx | Whether 2Tx requirements exists |
| **Harmonic mixing** | N/A | N/A | N/A |
| **Cross band leakage** | n77 UL | n66 DL | Yes |
| **IMD** | IMD2 (1\*f\_n77-1\*f\_n66) | n66 DL | Yes |
|  | IMD5 (2\*f\_n77-3\*f\_n66) | n66 DL | Yes |

Table 5.6.3-2: MSD scenarios for CA\_n66-n77 with total power class 1.5

|  |  |  |  |
| --- | --- | --- | --- |
|  | Aggressor Tx | Victim Rx | Whether 2Tx requirements exists |
| **Harmonic mixing** | N/A | N/A | N/A |
| **Cross band leakage** | n77 UL | n66 DL | Yes |
| **IMD** | IMD2 (1\*f\_n77-1\*f\_n66) | n66 DL | No |
|  | IMD5 (2\*f\_n77-3\*f\_n66) | n66 DL | No |

### 5.6.4 REFSENS requirements

5.6.4.1 REFSENS requirements for total power class 2

In previous discussion, RAN4 agreed that the following rules will be as the baseline to define MSD requirement for PC2 inter-band CA or EN-DC:

Same MSD requirements can be applied for the band combination with either 1Tx or 2Tx in TDD aggressor band UL with same power class for harmonic mixing and cross band isolation, and

the requirements specified based on 1Tx-1Tx UL configuration are applicable for 1Tx-2Tx UL configuration

Based on the agreement, the PC2 MSD results are referred in both Table 5.6.4.1-1 andTable 5.6.4.2-1. Mainly, they are the same as the PC2 2Tx configuration for this 3Tx requirement to the RAN4 specifications [2].

According to the RAN4 specifications [2], both IMD2 and IMD5 are the subjects to n66DL in CA\_n66-n77. The value of PC2 IMD2 and IMD5 are the summarized in Table 5.6.4.1-1.

**Table 5.6.4.1-1: Derived MSD values for PC2 UL configurations**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **CA Combination** | **Power Class** | **NR Band** | **PUL (dBm)** | **IMD Source** | **IMD Order** | **MSD (dB)** |
| CA\_n66-n77 | 3 | n66 | 20 | IMD2 | 1 | 31 |
| n77 | 20 | 1 |
| 2 | n66 | 23 | 1 | 34.3 |
| n77 | 23 | 1 |
| 3 | n66 | 20 | IMD5 | 3 | 5.0 |
| n77 | 20 | 2 |
| 2 | n66 | 23 | 3 | 11.3 |
| n77 | 23 | 2 |

For the proposed MSD requirements, the required values are summarized in the Table 5.6.4.1-2, and the MSD value are based on discussed above.

Table 5.6.4.1-2: 2DL/2UL inter-band Reference sensitivity QPSK PREFSENS and uplink/downlink configurations for PC2 CA

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Band / Channel bandwidth / NRB / Duplex mode | | | | | | | | Source of IMD |
| NR CA  Configuration | NR band | UL Fc  (MHz) | UL/DL BW  (MHz) | UL  LCRB | DL Fc (MHz) | MSD  (dB) | Duplex mode |  |
| CA\_n66-n77 | n66 | 1775 | 5 | 25 | 2175 | 34.3 | FDD | IMD2 |
|  | n77 | 3950 | 10 | 50 | 3950 | N/A | TDD | N/A |
|  | n66 | 1760 | 5 | 25 | 2160 | 11.3 | FDD | IMD5 |
|  | n77 | 3720 | 10 | 50 | 3720 | N/A | TDD | N/A |

For CA\_n66-n77 band combination, RAN4 has concluded that the harmonic mixing is not a subject to this combo. Thus, the same conclusion is held in this TP.

For the cross-band isolation to this PC2 UL CA, the same requirement from Table 7.3A.6-1a of 38.101-1 is maintained in this proposal, and it is summarized in the Table 5.6.4.1-3

Table 5.6.4.1-3 (same as Table 7.3A.6-1a of 38.101-1): Reference sensitivity exceptions (MSD) and uplink/downlink configurations due to cross band isolation from a PC2 aggressor NR UL band for NR CA FR1

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| UL band | DL band | UL Fc | UL BW | SCS of UL band | UL RB Allocation | DL Fc | DL BW | MSD | Cross-band  Interference  source |
| (MHz) | (MHz) | (kHz) | LCRB | (MHz) | (MHz) | (dB) |
| n77 | n66 | 3350 | 100 | 30 | 270 (RBstart=0) | 2197.5 | 5 | 1.0 | >ACLR2 |

#### 5.6.4.2 REFSENS requirements for total power class 1.5

According to the RAN4 specification [2], both IMD2 and IMD5 are the subjects to n66DL in CA\_n66-n77. For IMD2, the IMD composition is 1st order in n66 UL and 1st order in n77 UL. And, the IMD composition is 3rd order in n66 UL and 2nd order in n77 UL for IMD5.

Table 5.6.4.2-1 summarizes the MSD analysis results where the MSD for PC3 and PC2 UL configurations are referenced to the RAN4 specification [2]. And, the MSD for PC1.5 UL configuration is derived based on linear extrapolation.

**Table 5.6.4.2-1: Derived MSD values for PC1.5 UL configurations**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **CA Combination** | **Power Class** | **NR Band** | **PUL (dBm)** | **IMD Source** | **IMD Order** | **MSD (dB)** |
| CA\_n66-n77 | 3 | n66 | 20 | IMD2 | 1 | 31 |
| n77 | 20 | 1 |
| 2 | n66 | 23 | 1 | 34.3 |
| n77 | 23 | 1 |
| 1.5 | n66 | 23 | 1 | 40.0 |
| n77 | 27.8 | 1 |
| 3 | n66 | 20 | IMD5 | 3 | 5.0 |
| n77 | 20 | 2 |
| 2 | n66 | 23 | 3 | 11.3 |
| n77 | 23 | 2 |
| 1.5 | n66 | 23 | 3 | 26.0 |
| n77 | 27.8 | 2 |

For the proposed MSD requirement, the required values are summarized in Table 5.6.4.2-2, and the MSD value are based on discussed above.

Table 5.6.4.2-2: 2DL/2UL inter-band Reference sensitivity QPSK PREFSENS and uplink/downlink configurations for PC1.5 CA

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Band / Channel bandwidth / NRB / Duplex mode | | | | | | | | Source of IMD |
| NR CA  Configuration | NR band | UL Fc  (MHz) | UL/DL BW  (MHz) | UL  LCRB | DL Fc (MHz) | MSD  (dB) | Duplex mode |  |
| CA\_n66-n77 | n66 | 1775 | 5 | 25 | 2175 | 40.0 | FDD | IMD2 |
|  | n77 | 3950 | 10 | 50 | 3950 | N/A | TDD | N/A |
|  | n66 | 1760 | 5 | 25 | 2160 | 26.0 | FDD | IMD5 |
|  | n77 | 3720 | 10 | 50 | 3720 | N/A | TDD | N/A |

For CA\_n66-n77 band combination, RAN4 has concluded that the harmonic mixing is not a subject to this combo. Thus, the same conclusion is held in this TP.

For the cross-band isolation to this PC1.5 UL CA, the same requirement from Table 7.3A.6-1b of 38.101-1 is maintained in this proposal, and it is summarized in Table 5.6.4.2-3.

Table 5.6.4.2-3 (same as Table 7.3A.6-1b of 38.101-1): Reference sensitivity exceptions (MSD) and uplink/downlink configurations due to cross band isolation from a PC1.5 aggressor NR single UL band for DL NR CA FR1

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| UL band | DL band | UL Fc | UL BW | SCS of UL band | UL RB Allocation | DL Fc | DL BW | MSD | Cross-band  Interference  source |
| (MHz) | (MHz) | (kHz) | LCRB | (MHz) | (MHz) | (dB) |
| n77 | n66 | 3350 | 100 | 30 | 270 (RBstart=0) | 2197.5 | 5 | 1.8 | >ACLR2 |

5.7 CA\_n5A-n77A

### 5.7.1 Operating bands for CA

Table 5.7.1-1: CA band combination of band n5+n77

|  |  |
| --- | --- |
| NR CA Band combination | NR Band |
| CA\_n5-n77 | n5, n77 |

### 5.7.2 Maximum output power for inter-band CA

Table 5.7.2-1: UE Power Class for 3Tx inter-band CA with UL MIMO

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **NR UL CA Configuration** | **Class 1.5 (dBm)** | **Tolerance (dB)** | **Class 2 (dBm)** | **Tolerance (dB)** | **Class 3 (dBm)** | **Tolerance (dB)** |
| CA\_n5A-n77A |  |  | 262 | +2/-3 | 23 | +2/-3 |
| NOTE 1: (Void in this TR)  NOTE 2: The UE supports PC3 in FDD band and PC3 or PC2 with UL MIMO in TDD band.  NOTE 3: The UE supports PC3 in FDD band and PC1.5 with UL MIMO in TDD band.  NOTE 4: The UE supports PC2 with UL MIMO in either one of the TDD bands and PC2 in the other TDD band. | | | | | | |

Table 5.7.2-2: UE Power Class for 3Tx inter-band CA with TxD

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **NR UL CA Configuration** | **Class 1.5 (dBm)** | **Tolerance (dB)** | **Class 2 (dBm)** | **Tolerance (dB)** | **Class 3 (dBm)** | **Tolerance (dB)** |
| CA\_n5A-n77A |  |  | 262 | +2/-3 | 23 | +2/-3 |
| NOTE 1: (Void in this TR)  NOTE 2: The UE supports PC3 in FDD band and PC2 with Tx Diversity in TDD band.  NOTE 3: The UE supports PC3 in FDD band and PC1.5 with Tx Diversity in TDD band. | | | | | | |

### 5.7.3 MSD scenario studies

Table 5.7.3-1 and 5.7.3-2 summarizes frequency ranges where harmonics mixing, cross band leakage, IMD interferences occur for CA\_ n5-n77.

Table 5.7.3-1: MSD scenarios for CA\_n5-n77 with total power class 2

|  |  |  |  |
| --- | --- | --- | --- |
|  | Aggressor Tx | Victim Rx | Whether 2Tx requirements exists |
| **Harmonic mixing** | 1st order of n77 UL | 4nd order of n5 DL | Yes |
| **Cross band leakage** | N/A | N/A | N/A |
| **IMD** | IMD4 (1\*f\_n77-3\*f\_n5) | n5 DL | Yes |
|  | IMD5 (1\*f\_n77-4\*f\_n5) | n5 DL | Yes |

### 5.7.4 REFSENS requirements

#### 5.7.4.1 REFSENS requirements for total power class 2

In previous meeting, RAN4 agreed that the following rules will be as the baseline to define MSD requirement for PC2 inter-band CA or EN-DC:

Same MSD requirements can be applied for the band combination with either 1Tx or 2Tx in TDD aggressor band UL with same power class for harmonic mixing and cross band isolation, and

the requirements specified based on 1Tx-1Tx UL configuration are applicable for 1Tx-2Tx UL configuration

Based on the agreement, the analysis MSD results are summarized in both Table 5.7.4.1-1. Actually, the same MSD PC2 2Tx configuration from the specification [2] is applied for this 3Tx requirement based on the rule above.

According to the RAN4 specification [2], both PC2 IMD4 and IMD5 are the subjects to DL n5 in CA\_n5-n77, and IMD values are derived in Table 5.7.4.1-1 based on linear extrapolation and referred the MSD for PC3 configuration.

**Table 5.7.4.1-1: Derived MSD values for PC2 UL configurations**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **CA Combination** | **Power Class** | **NR Band** | **PUL (dBm)** | **IMD Source** | **IMD Order** | **MSD (dB)** |
| CA\_n5-n77 | 3 | n5 | 20 | IMD4 | 3 | 8.3 |
| n77 | 20 | 1 |
| 2 | n5 | 23 | 3 | 18.6 |
| n77 | 23 | 1 |
| 3 | n5 | 20 | IMD5 | 4 | 5.5 |
| n77 | 20 | 1 |
| 2 | n5 | 23 | 4 | 20.0 |
| n77 | 23 | 1 |

For the MSD requirements, the required values are summarized in the Table 5.7.4.1-2 based on discussion above.

Table 5.7.4.1-2: 2DL/2UL inter-band Reference sensitivity QPSK PREFSENS and uplink/downlink configurations for PC2 CA

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Band / Channel bandwidth / NRB / Duplex mode | | | | | | | | | Source of IMD |
| NR CA  Configuration | NR band | | UL Fc  (MHz) | UL/DL BW  (MHz) | UL  LCRB | DL Fc (MHz) | MSD  (dB) | Duplex mode |  |
| CA\_n5-n77 | 5 | | 844 | 5 | 25 | 889 | 18.6 | FDD | IMD4 |
|  | n77 | | 3421 | 10 | 50 | 3421 | N/A | TDD | N/A |
|  | n5 | 829 | | 5 | 25 | 874 | 20.0 | FDD | IMD5 |
|  | n77 | 4190 | | 10 | 50 | 4190 | N/A | TDD | N/A |

For the harmonic mixing requirement to this PC2 UL CA\_n5-n77 combo, the requirements are reused from [2] into Table 5.7.4.1-2.

Table 5.7.4.1-2 (same as Table 7.3A.4-4a of 38.101-1): Reference sensitivity exceptions and uplink/downlink configurations due to harmonic mixing from a PC2 aggressor NR UL band for NR DL CA FR1

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| UL band | DL band | UL BW | SCS of UL band | UL RB Allocation | DL BW | MSD | UL/DL fc condition | UL/DL harmonic order |
| (MHz) | (kHz) | LCRB | (MHz) | (dB) |
| n77 | n5 | 10 | 15 | 25 (RBstart=0) | 5 | 8.1 | NOTE 5 | UL1/DL4 |
| n77 | n5 | 20 | 15 | 20 (RBstart=0) | 20 | 4.3 | NOTE 5 | UL1/DL4 |

RAN4 has concluded that there is no cross-band isolation issue to this combo. Thus, the same conclusion is held in this proposal.

## 5.8 CA\_n71A-n77A

### 5.8.1 Operating bands for CA

Table 5.8.1-1: CA band combination of band n71+n77

|  |  |
| --- | --- |
| NR CA Band combination | NR Band |
| CA\_n71-n77 | n71, n77 |

### 5.8.2 Maximum output power for inter-band CA

Table 5.8.2-1: UE Power Class for 3Tx inter-band CA with UL MIMO

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **NR UL CA Configuration** | **Class 1.5 (dBm)** | **Tolerance (dB)** | **Class 2 (dBm)** | **Tolerance (dB)** | **Class 3 (dBm)** | **Tolerance (dB)** |
| CA\_n71A-n77A | 293 | +2/-3 | 262 | +2/-3 | 23 | +2/-3 |
| NOTE 1: (Void in this TR)  NOTE 2: The UE supports PC3 in FDD band and PC3 or PC2 with UL MIMO in TDD band.  NOTE 3: The UE supports PC3 in FDD band and PC1.5 with UL MIMO in TDD band. | | | | | | |

Table 5.8.2-2: UE Power Class for 3Tx inter-band CA with TxD

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **NR UL CA Configuration** | **Class 1.5 (dBm)** | **Tolerance (dB)** | **Class 2 (dBm)** | **Tolerance (dB)** | **Class 3 (dBm)** | **Tolerance (dB)** |
| CA\_n71A-n77A | 293 | +2/-3 | 262 | +2/-3 | 23 | +2/-3 |
| NOTE 1: (Void in this TR)  NOTE 2: The UE supports PC3 in FDD band and PC2 with Tx Diversity in TDD band.  NOTE 3: The UE supports PC3 in FDD band and PC1.5 with Tx Diversity in TDD band. | | | | | | |

### 5.8.3 MSD scenario studies

Table 5.5.3-1 and 5.5.3-2 summarizes frequency ranges where harmonics mixing, cross band leakage, IMD interferences occur for CA\_ n71-n77.

Table 5.5.3-1: MSD scenarios for CA\_n71-n77 with total power class 2

|  |  |  |  |
| --- | --- | --- | --- |
|  | Aggressor Tx | Victim Rx | Whether 2Tx requirements exists |
| **Harmonic Mixing** |  |  | No |
| **IMD** | n71+n77 | n71 | Yes |
| **Cross band leakage** | n77 UL | n71 DL | Yes |

Table 5.5.3-2: MSD scenarios for CA\_n71-n77 with total power class 1.5

|  |  |  |  |
| --- | --- | --- | --- |
|  | Aggressor Tx | Victim Rx | Whether 2Tx requirements exists |
| **Harmonic Mixing** |  |  | No |
| **IMD** | n71+n77 | n71 | No |
| **Cross band leakage** | n77 UL | n71 DL | Yes |

### 5.8.4 REFSENS requirements

#### 5.8.4.1 REFSENS requirements for total power class 2

The PC2 IMD MSD can be re-used from 2Tx.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| CA\_n71-n77 | n71 | 681.5 | 5 | 25 | 635.5 | 11.4 | FDD | IMD57 |
|  | n77 | 3361.5 | 10 | 50 | 3361.5 | N/A | TDD | N/A |

For 2 Tx the power is 23 dBm for n71 + 23 dBm for n77 = 26 dBm total.

For 3Tx the power is 23 dBm for n71 + 20 dBm + 20 dBm for n77, 23 dBm on n77 and 26 dBm total.

The PC2 MSD due to cross band isolation can be re-used from PC2 with 2Tx and therefore is not shown here.

#### 5.8.4.2 REFSENS requirements for total power class 1.5

There is no PC1.5 MSD requirement for CA\_n71-n77A because PC1.5 requires 2Tx in the TDD band currently.

For 3Tx the power is 23 dBm for n71 + 24.8 dBm + 24.8 dBm for n77 for 27.8 dBm TDD, 29 dBm total.

Therefore, the n77 power is increased by 4.8 for PC1.5 compared to PC2 since the n71 power is unchanged.

And for the IMD combination, it is -4\*n71\_Tx + 1\*n77\_Tx = n71\_Rx

So, we can expect 4.8dB IMD power increase because the order for n77 is one.

MSD due to interference power *I* is given by:



where *N* is the noise spectral density and BW is the bandwidth of the carrier. If the initial MSD is known,

then we have:

Text

Description automatically generated

If *I* is increased by *X* dB, then *MSD(X)* is given by

A picture containing logo

Description automatically generated

A picture containing control panel

Description automatically generated



Based on the 4.8 dB dB increase intermod power, the resulting MSD is 16.0.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| CA\_n71-n77 | n71 | 681.5 | 5 | 25 | 635.5 | 16.0 | FDD | IMD57 |
|  | n77 | 3361.5 | 10 | 50 | 3361.5 | N/A | TDD | N/A |

The PC1.5 MSD due to cross band isolation can be re-used from PC1.5 with 2Tx and therefore is not shown here.

5.9 CA\_n70A-n77A

5.9.1 Operating bands for CA

**Table 5.9.1-1: CA band combination of band n70+n77**

|  |  |
| --- | --- |
| **NR CA Band combination** | **NR Band** |
| CA\_n70-n77 | n70, n77 |

5.9.2 Maximum output power for inter-band CA

**Table 5.9.2-1: UE Power Class for 3Tx inter-band CA with UL MIMO**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **NR UL CA Configuration** | **Class 1.5 (dBm)** | **Tolerance (dB)** | **Class 2 (dBm)** | **Tolerance (dB)** | **Class 3 (dBm)** | **Tolerance (dB)** |
| CA\_n70A-n77A | 293 | +2/-3 | 262 | +2/-3 | 23 | +2/-3 |
| NOTE 1: (Void in this TR)  NOTE 2: The UE supports PC3 in FDD band and PC3 or PC2 with UL MIMO in TDD band.  NOTE 3: The UE supports PC3 in FDD band and PC1.5 with UL MIMO in TDD band.  NOTE 4: The UE supports PC2 with UL MIMO in either one of the TDD bands and PC2 in the other TDD band. | | | | | | |

**Table 5.9.2-2: UE Power Class for 3Tx inter-band CA with TxD**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **NR UL CA Configuration** | **Class 1.5 (dBm)** | **Tolerance (dB)** | **Class 2 (dBm)** | **Tolerance (dB)** | **Class 3 (dBm)** | **Tolerance (dB)** |
| CA\_n70A-n77A | 293 | +2/-3 | 262 | +2/-3 | 23 | +2/-3 |
| NOTE 1: (Void in this TR)  NOTE 2: The UE supports PC3 in FDD band and PC2 with Tx Diversity in TDD band.  NOTE 3: The UE supports PC3 in FDD band and PC1.5 with Tx Diversity in TDD band. | | | | | | |

5.9.3 MSD scenario studies

Table 5.9.3-1 and 5.9.3-2 summarizes frequency ranges where harmonics mixing, cross band leakage, IMD interferences occur for CA\_ n70-n77.

**Table 5.9.3-1: MSD scenarios for CA\_n70-n77 with total power class 2**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Aggressor Tx** | **Victim Rx** | **Whether 2Tx requirements exists** |
| **Harmonic mixing** | n77(UL1/DL2) | n70 | No |
| **IMD** | IMD 2 (1st order of n77 UL – 1st order of n70 UL) | n70 | No |
| IMD5 (2nd order of n77UL- 3rd order of n70) | n70 | No |

**Table 5.9.3-2: MSD scenarios for CA\_n70-n77 with total power class 1.5**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Aggressor Tx** | **Victim Rx** | **Whether 2Tx requirements exists** |
| **Harmonic mixing** | n77(UL1/DL2) | n70 | No |
| **IMD** | IMD 2 (1st order of n77 UL – 1st order of n70 UL) | n70 | No |
| IMD5 (2nd order of n77UL- 3rd order of n70) | n70 | No |

5.9.4 REFSENS requirements

5.9.4.1 REFSENS requirements for total power class 2

- 2nd harmonic mixing could be waived, according to Note 6 of Table 7.3A.4-4 of TS 38.101-1.

- IMD2/5 of dual UL are defined as follows:

The IMD MSD values specified for 2TX are applicable for this 3TX case as well. Hence, the following PC3 IMD2/IMD5 are used as a starting point:

* IMD2 interference for PC3 is -68dBm
* IMD5 interference for PC3 is -95.7dBm

The interference levels for PC2 case (IMD2/IMD5) are derived by increasing the interference levels which result the MSDs for PC3 (31dB IMD2 and 5.0dB IMD5) according to the following:

* IMD2 PC2 interference level is derived by increasing the IMD2 PC3 interference by 6dB (1,1)
* IMD5 PC2 interference level is derived by increasing the IMD5 PC3 interference by 15dB (3,2)

The scaling is logical as the TX power for each CC increases by 3dB when going from PC3 to PC2 UE power class (20+20 to 23+23).

The resulting interference levels and respective MSDs are as follows:

* Interference level for PC2 IMD2 is -62dBm, with IMD2 MSD of 37dB
* Interference level for PC2 IMD5 is -80.7dBm, with IMD5 MSD of 18.4dB

Table 5.9.4.1-1: Reference sensitivity exceptions and uplink/downlink configurations due to harmonic mixing from a PC2 aggressor NR UL band for NR DL CA FR1

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| UL band | DL band | UL BW | SCS of UL band | UL RB Allocation | DL BW | MSD | UL/DL fc condition | UL/DL harmonic order |
| (MHz) | (kHz) | LCRB | (MHz) | (dB) |
| n772 | n70 | N/A | N/A | N/A | N/A | N/A | NOTE 4 | UL1/DL2 |
| NOTE 2: For a UE which supports this band combination only when the Band n77 frequency range restriction defined in NOTE 12 of Table 5.2-1 applies, the MSD test point(s) cannot be verified for the band combination and the test point(s) can be skipped. | | | | | | | | |

**Table 5.9.4.1-2: 2DL/2UL inter-band Reference sensitivity QPSK PREFSENS and uplink/downlink configurations for PC2 CA**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Band / Channel bandwidth / NRB / Duplex mode** | | | | | | | | **Source of IMD** |
| **NR CA**  **Configuration** | **NR band** | **UL Fc  (MHz)** | **UL/DL BW  (MHz)** | **UL  LCRB** | **DL Fc (MHz)** | **MSD  (dB)** | **Duplex mode** |  |
| CA\_n70-n77 | n70 | 1702.5 | 5 | 25 | 2002.5 | 37 | FDD | IMD2 |
|  | n77 | 3705 | 10 | 50 | 3705 | N/A | TDD | N/A |
|  | n70 | 1697.5 | 5 | 25 | 1997.5 | 18.4 | FDD | IMD5 |
|  | n77 | 3545 | 10 | 50 | 3545 | N/A | TDD | N/A |

5.9.4.2 REFSENS requirements for total power class 1.5

- 2nd harmonic mixing could be waived, according to Note 6 of Table 7.3A.4-4 of TS 381.101-1.

- IMD2/5 of dual UL are defined as follows:

The IMD MSD values specified for 2TX are applicable for this 3TX case as well. Hence, the following PC3 IMD2/IMD5 are used as a starting point:

* IMD2 interference for PC3 is -68dBm
* IMD5 interference for PC3 is -95.7dBm

The interference levels for PC1.5 case (IMD2/IMD5) are derived by increasing the interference levels which result the MSDs for PC3 (31dB IMD2 and 5.0dB IMD5) according to the following:

* Interference for PC1.5 IMD2 is derived by increasing the IMD2 PC3 interference by 10.8dB (1,1)
* Interference for PC 1.5 IMD5 is derived by increasing the IMD5 PC3 interference by 24.6dB (3,2)

This scaling fully accounts the TX power test conditions for each band in PC1.5 FDD+TDD (23+27.8dBm).

The resulting interference level and respective MSDs are as follows:

* Interference level for PC1.5 IMD2 is -57.2dBm, with IMD2 MSD of 41.8dB
* Interference level for PC1.5 IMD5 is -71.1dBm, with IMD5 MSD of 27.9dB

Table 5.9.4.2-1: Reference sensitivity exceptions and uplink/downlink configurations due to harmonic mixing from a PC1.5 aggressor NR UL band for NR DL CA FR1

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| UL band | DL band | UL BW | SCS of UL band | UL RB Allocation | DL BW | MSD | UL/DL fc condition | UL/DL harmonic order |
| (MHz) | (kHz) | LCRB | (MHz) | (dB) |
| n772 | n70 | N/A | N/A | N/A | N/A | N/A | NOTE 4 | UL1/DL2 |
| NOTE 2: For a UE which supports this band combination only when the Band n77 frequency range restriction defined in NOTE 12 of Table 5.2-1 applies, the MSD test point(s) cannot be verified for the band combination and the test point(s) can be skipped. | | | | | | | | |

**Table 5.9.4.2-2: 2DL/2UL inter-band Reference sensitivity QPSK PREFSENS and uplink/downlink configurations for PC1.5 CA**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Band / Channel bandwidth / NRB / Duplex mode** | | | | | | | | **Source of IMD** |
| **NR CA**  **Configuration** | **NR band** | **UL Fc  (MHz)** | **UL/DL BW  (MHz)** | **UL  LCRB** | **DL Fc (MHz)** | **MSD  (dB)** | **Duplex mode** |  |
| CA\_n70-n77 | n70 | 1702.5 | 5 | 25 | 2002.5 | 41.8 | FDD | IMD2 |
|  | n77 | 3705 | 10 | 50 | 3705 | N/A | TDD | N/A |
|  | n70 | 1697.5 | 5 | 25 | 1997.5 | 27.9 | FDD | IMD5 |
|  | n77 | 3545 | 10 | 50 | 3545 | N/A | TDD | N/A |

# 6 3Tx EN-DC band combinations

## 6.x DC\_bx\_nY (Example)

### 6.x.1 Operating bands for EN-DC

Table 6.x.1-1: EN-DC band combination of band bX+nY

|  |  |
| --- | --- |
| NR CA Band combination | Bands |
| DC\_bX\_nY | bX, nY |

### 6.x.2 Maximum output power for inter-band EN-DC

Table 6.x.2-1: UE Power Class for 3Tx inter-band EN-DC

| EN-DC configuration | Power class 2  (dBm) | Tolerance  (dB) | Power class 3  (dBm) | Tolerance  (dB) |
| --- | --- | --- | --- | --- |
| DC\_3A\_n78A5 | 26 | +2/-3 | 23 | +2/-3 |
| DC\_40A\_n78A5,6 | 26 | +2/-3 | 23 | +2/-3 |
| NOTE 1: (Void in this TR)  NOTE 2: (Void in this TR)  NOTE 3: (Void in this TR)  NOTE 4: (Void in this TR)  NOTE 5: The UE supports PC3 in E-UTRA band, and supports PC2 with UL MIMO in NR band  NOTE 6: The UE supports PC3 in E-UTRA band, and supports PC3 with UL MIMO in NR band | | | | |

Editor's note1: The targeted max Tx power configuration shall be within the scope of basket WI.

Editor's note2: For inter band EN-DC with 3Tx, total power class 1.5 is not considered here due to no general requirements introduced for total power class 1.5 in general WI “4Rx\_low\_NR\_band\_handheld\_3Tx\_NR\_CA\_ENDC”.

### 6.x.3 MSD scenario studies

Table 6.x.3-1 summarizes frequency ranges where harmonics mixing, cross band leakage, IMD interferences occur for DC\_bX-nY.

Table 6.x.3-1: MSD scenarios for DC\_bX-nY with total power class 2

|  |  |  |  |
| --- | --- | --- | --- |
|  | Aggressor Tx band | Victim Rx band | Whether 2Tx requirements exists |
| **Harmonic mixing** | M order of nY UL | N order of bX DL | Yes or No? |
| … | … | … |
| **Cross band leakage** | nY UL | bX DL | Yes or No? |
| … | … | … |
| **IMD** | IMD order (M order of bX UL + N order of nY UL) | bX DL | Yes or No? |
| … | … | … |

Editor's note: only list the MSD scenario that exists for this band combination.

### 6.x.4 REFSENS requirements

Editor's note1: Make it clear whether the existing 2Tx requirements are reused or newly analysed due to for example missing of the 2Tx requirements.

Editor's note2: If reused, just say to reuse the existing 2Tx MSD requirements for MSD type harmonic mixing, or cross band leakage or IMD.

Editor’s note3: If MSD is newly specified, it would be useful to give some key parameters as reference.

#### 6.x.4.1 REFSENS requirements for total power class 2

## 6.1 DC\_7A\_n78A

6.1.1 Operating bands for EN-DC

**Table 6.1.1-1: EN-DC band combination of band 7+n78**

|  |  |
| --- | --- |
| **EN-DC Band combination** | **Bands** |
| DC\_7A\_n78A | 7, n78 |

6.1.2 Maximum output power for inter-band EN-DC

**Table 6.1.2-1: UE Power Class for 3Tx inter-band EN-DC**

| **EN-DC configuration** | **Power class 2**  **(dBm)** | **Tolerance**  **(dB)** | **Power class 3**  **(dBm)** | **Tolerance**  **(dB)** |
| --- | --- | --- | --- | --- |
| DC\_7A\_n78A5,6 | 26 | +2/-3 | 23 | +2/-3 |
| NOTE 1: (Void in this TR)  NOTE 2: (Void in this TR)  NOTE 3: (Void in this TR)  NOTE 4: (Void in this TR)  NOTE 5: The UE supports PC3 in E-UTRA band, and supports PC2 with UL MIMO in NR band  NOTE 6: The UE supports PC3 in E-UTRA band, and supports PC3 with UL MIMO in NR band | | | | |

6.1.3 MSD scenario studies

Table 6.3.3-1 summarizes frequency ranges where harmonics mixing occur for DC\_7\_n78

**Table 6.3.3-1: MSD scenarios for DC\_7\_n78 with total power class 2**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Aggressor Tx band** | **Victim Rx band** | **Whether 2Tx requirements exists** |
| **cross band leakage** | n78 UL | 7 DL | yes |

6.1.4 REFSENS requirements

The MSD is already available in Table 7.3B.2.3.4-1a of TS 38.101-3.

## 6.2 DC\_8A\_n78A

6.2.1 Operating bands for EN-DC

**Table 6.2.1-1: EN-DC band combination of band 8+n78**

|  |  |
| --- | --- |
| **EN-DC Band combination** | **Bands** |
| DC\_8A\_n78A | 8, n78 |

6.2.2 Maximum output power for inter-band EN-DC

**Table 6.2.2-1: UE Power Class for 3Tx inter-band EN-DC**

| **EN-DC configuration** | **Power class 2**  **(dBm)** | **Tolerance**  **(dB)** | **Power class 3**  **(dBm)** | **Tolerance**  **(dB)** |
| --- | --- | --- | --- | --- |
| DC\_8A\_n78A5,6 | 26 | +2/-3 | 23 | +2/-3 |
| NOTE 1: (Void in this TR)  NOTE 2: (Void in this TR)  NOTE 3: (Void in this TR)  NOTE 4: (Void in this TR)  NOTE 5: The UE supports PC3 in E-UTRA band, and supports PC2 with UL MIMO in NR band  NOTE 6: The UE supports PC3 in E-UTRA band, and supports PC3 with UL MIMO in NR band | | | | |

6.2.3 MSD scenario studies

Table 6.2.3-1 summarizes frequency ranges where MSD could occur for DC\_8\_n78

**Table 6.2.3-1: MSD scenarios for DC\_8\_n78 with total power class 2**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Aggressor Tx band** | **Victim Rx band** | **Whether 2Tx requirements exists** |
| **Harmonic mixing** | Fundamental of n78 | 4th harmonic of band 8 DL | No, but it can be taken from CA\_n8-n78 for PC2 |
| **IMD** | IMD4 (3rd order of band 8 UL - fundamental of n78 UL ) | Band 8 Rx | yes |

6.2.4 REFSENS requirements

**Table 6.2.4-1: Reference sensitivity exceptions (MSD) due to receiver harmonic mixing for PC2 EN-DC in NR FR1**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **UL band** | **DL band** | **UL BW** | **SCS of UL band** | **UL RB Allocation** | **DL BW** | **MSD** | **UL/DL fc condition** | **UL/DL harmonic order** |
| **(MHz)** | **(kHz)** | **LCRB** | **(MHz)** | **(dB)** |
| n78 | 8 | 10 | 15 | 25 (RBstart=0) | 5 | 8.1 | NOTE 5 | UL1/DL4 |
| n78 | 8 | 20 | 15 | 20 (RBstart=0) | 20 | 4.3 | NOTE 5 | UL1/DL4 |
| NOTE 5: The requirements should be verified for UL NR-ARFCN of the aggressor (higher) band (superscript HB) such that  in MHz and  with  the carrier frequency in the victim (lower) band and  the channel bandwidth configured in the higher band | | | | | | | | |

For IMD4, Reuse the existing 2Tx MSD requirements.

## 6.3 DC\_20A\_n78A

6.3.1 Operating bands for EN-DC

**Table 6.3.1-1: EN-DC band combination of band 20+n78**

|  |  |
| --- | --- |
| **EN-DC Band combination** | **Bands** |
| DC\_20A\_n78A | 20, n78 |

6.3.2 Maximum output power for inter-band EN-DC

**Table 6.3.2-1: UE Power Class for 3Tx inter-band EN-DC**

| **EN-DC configuration** | **Power class 2**  **(dBm)** | **Tolerance**  **(dB)** | **Power class 3**  **(dBm)** | **Tolerance**  **(dB)** |
| --- | --- | --- | --- | --- |
| DC\_20A\_n78A5,6 | 26 | +2/-3 | 23 | +2/-3 |
| NOTE 1: (Void in this TR)  NOTE 2: (Void in this TR)  NOTE 3: (Void in this TR)  NOTE 4: (Void in this TR)  NOTE 5: The UE supports PC3 in E-UTRA band, and supports PC2 with UL MIMO in NR band  NOTE 6: The UE supports PC3 in E-UTRA band, and supports PC3 with UL MIMO in NR band | | | | |

6.3.3 MSD scenario studies

Table 6.3.3-1 summarizes frequency ranges where harmonics mixing occur for DC\_20\_n78

**Table 6.3.3-1: MSD scenarios for DC\_20\_n78 with total power class 2**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Aggressor Tx band** | **Victim Rx band** | **Whether 2Tx requirements exists** |
| **IMD** | IMD4 (3rd order of b20 UL+ fundamental n78 UL) | 20 DL | No |

6.3.4 REFSENS requirements

As the MSD for PC2, with 2Tx, on this band combination is not yet specified, we propose the following MSD values based on the following analysis.

|  |  |  |
| --- | --- | --- |
| **DC\_20-n78 parameters** | | |
| Antenna ISO | 10 | dB |
| PCB isolation Paout-Pain | 60 | dB |
| PCB isolation Paout Div-Pain main | 65 | dB |
| Diplexer ISO | 15 | dB |
| 20 TX SAW/duplexer rejection at n78 Tx | 30 | dB |
| 20 RX duplexer rejection at n78 Tx | 50 | dB |
| 20 SAW/Duplexer TX rejection at 20 RX band | 60 | dB |
| filter n78 TX rejection at 20 RX band | 47 | dB |
| n78 Tx attenuation at 20 RX | 47 | dB |
| n78 Tx attenuation at 20 TX | 47 | dB |
| Diplexer IL | 0.5 | dB |
| Antenna switch IL | 1 | dB |
| TX/RX switch IL | 0.5 | dB |
| 20 Dup IL | 4 | dB |
| n78 RX SAW filter IL | 3 | dB |
| Pout 20 | 23 | dBm |
| Pout n78 | 24.8 | dBm |
| Pout n78 Div | 24.8 | dBm |
| REFSENS 20 | -97 | dBm |

|  |  |
| --- | --- |
| **Main Path** | **received interference, IMD4 (dBm) on 20 Rx** |
| Antenna switch | -74.7 |
| Diplexer (H-H or L-L) | -68.8 |
| 20 SAW/Duplexer | -82.5 |
| 20 PA Forward mixing | -80.3 |
| n78 PA Forward mixing | -176.8 |
| 20 PA Reverse mixing | -111.9 |
| n78 PA Reverse mixing | -260.8 |
| Total | -67.4 |
| n78 LNA via filters | -121.1 |
| n78 LNA via PCB coupling | -118.3 |
| Total main IMD | -67.4 |

|  |  |
| --- | --- |
| **Diversity Path** | **received interference, IMD4 (dBm) on 20 Rx** |
| From main path | -77.4 |
| Diplexer | -105.6 |
| Antenna switch | -107.6 |
| 20 SAW Filter | -103.3 |
| n78 PA div Forward mixing | -193.3 |
| 20 LNA via antenna ISO | -154.1 |
| 20 LNA via PCB coupling | -126.3 |
| Total div IMD | -77.4 |

|  |  |
| --- | --- |
| **MSD calculation parameters** | **received interference, IMD4 (dB) on 20 Rx** |
| MSD | 23.7 |
| SNR | -19.8 |
| MSD at SNR=-1 | 18.8 |

**Table 6.3.4-1: Reference sensitivity exceptions (MSD) due to receiver harmonic mixing for EN-DC in NR FR1**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Band / Channel bandwidth / NRB / Duplex mode** | | | | | | | |
| **EN-DC Configuration** | **EUTRA or NR band** | **UL Fc  (MHz)** | **UL/DL BW  (MHz)** | **UL  LCRB** | **DL Fc (MHz)** | **MSD  (dB)** | **IMD order** |
| DC\_20\_n78 | 20 | 850 | 5 | 25 | 809 | 18.8 | IMD4 |
|  | n78 | 3359 | 10 | 50 | 3359 | N/A | N/A |

## 6.4 DC\_28A\_n78A

6.4.1 Operating bands for EN-DC

**Table 6.4.1-1: EN-DC band combination of band 28+n78**

|  |  |
| --- | --- |
| **EN-DC Band combination** | **Bands** |
| DC\_28A\_n78A | 28, n78 |

6.4.2 Maximum output power for inter-band EN-DC

**Table 6.4.2-1: UE Power Class for 3Tx inter-band EN-DC**

| **EN-DC configuration** | **Power class 2**  **(dBm)** | **Tolerance**  **(dB)** | **Power class 3**  **(dBm)** | **Tolerance**  **(dB)** |
| --- | --- | --- | --- | --- |
| DC\_28A\_n78A5,6 | 26 | +2/-3 | 23 | +2/-3 |
| NOTE 1: (Void in this TR)  NOTE 2: (Void in this TR)  NOTE 3: (Void in this TR)  NOTE 4: (Void in this TR)  NOTE 5: The UE supports PC3 in E-UTRA band, and supports PC2 with UL MIMO in NR band  NOTE 6: The UE supports PC3 in E-UTRA band, and supports PC3 with UL MIMO in NR band | | | | |

6.4.3 MSD scenario studies

Table 6.4.3-1 summarizes frequency ranges where harmonics mixing occur for DC\_28\_n78

**Table 6.4.3-1: MSD scenarios for DC\_28\_n78 with total power class 2**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Aggressor Tx band** | **Victim Rx band** | **Whether 2Tx requirements exists** |
| **Harmonics** | fundamental of n78 UL | 5th harmonic of n28 DL | yes |
| **IMD** | IMD5 (fundamental of n78 UL - 4th order of band 28 UL ) | 28 Rx | yes |

6.4.4 REFSENS requirements

Reuse the existing 2Tx MSD requirements.

## 6.5 DC\_41A\_n78A

6.5.1 Operating bands for EN-DC

**Table 6.5.1-1: EN-DC band combination of band 41+n78**

|  |  |
| --- | --- |
| **EN-DC Band combination** | **Bands** |
| DC\_41A\_n78A | 41, n78 |

6.5.2 Maximum output power for inter-band EN-DC

**Table 6.5.2-1: UE Power Class for 3Tx inter-band EN-DC**

| **EN-DC configuration** | **Power class 2**  **(dBm)** | **Tolerance**  **(dB)** | **Power class 3**  **(dBm)** | **Tolerance**  **(dB)** |
| --- | --- | --- | --- | --- |
| DC\_41A\_n78A5,6 | 26 | +2/-3 | 23 | +2/-3 |
| NOTE 1: (Void in this TR)  NOTE 2: (Void in this TR)  NOTE 3: (Void in this TR)  NOTE 4: (Void in this TR)  NOTE 5: The UE supports PC3 in E-UTRA band, and supports PC2 with UL MIMO in NR band  NOTE 6: The UE supports PC3 in E-UTRA band, and supports PC3 with UL MIMO in NR band | | | | |

6.5.3 MSD scenario studies

Table 6.5.3-1 summarizes frequency ranges where harmonics mixing occur for DC\_41\_n78

**Table 6.5.3-1: MSD scenarios for DC\_41\_n78 with total power class 2**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Aggressor Tx band** | **Victim Rx band** | **Whether 2Tx requirements exists** |
| **Harmonic mixing** | 2nd harmonic of n78 | 3rd harmonic of 41 Rx | No, but can reuse from DC\_41\_n77 |
| **Cross band leakage** | n78 UL | 41 DL | No, but can reuse from DC\_41\_n77 |

6.5.4 REFSENS requirements

The MSD due to harmonic mixing and the cross band isolation can be taken from a similar band combination such DC\_41A\_n77A for PC2 with 2Tx, as given below.

**Table 6.5.4-1: Reference sensitivity exceptions (MSD) due to receiver harmonic mixing for EN-DC in NR FR1**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **UL band** | **DL band** | **UL BW** | **SCS of UL band** | **UL RB Allocation** | **DL BW** | **MSD** | **UL/DL fc condition** | **UL/DL harmonic order** |
| **(MHz)** | **(kHz)** | **LCRB** | **(MHz)** | **(dB)** |
| n78 | 41 | 10 | 15 | 12 (RBstart=0) | 5 | 19.4 | NOTE 4 | UL2/DL3 |
| n78 | 41 | 20 | 15 | 50 (RBstart=0) | 20 | 19.4 | NOTE 4 | UL2/DL3 |
| NOTE 4: The requirements should be verified for DL EARFCN of the victim (lower) band (superscript LB) such that with the DL carrier frequency in the lower band and the UL carrier frequency in the higher band, both in MHz. | | | | | | | | |

**Table 6.5.4-2: Reference sensitivity exceptions (MSD) due to cross band isolation and uplink/downlink configurations for PC2 EN-DC in NR FR1**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **UL band** | **DL band** | **UL Fc**  **(MHz)** | **UL BW**  **(MHz)** | **SCS of UL band**  **(kHz)** | **UL RB Allocation**  **LCRB** | **DL Fc**  **(MHz)** | **DL BW**  **(MHz)** | **MSD**  **(dB)** | **Cross-band**  **Interference**  **source** |
| n78 | 411 | 3350 | 100 | 30 | 270 (RBstart=0) | 2687.5 | 5 | 6.5 | >ACLR2 |
| NOTE 1: Applicable only when harmonic mixing MSD for this combination is not applied. | | | | | | | | | |

# Annex A (informative): Change history

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Change history | | | | | | | |
| Date | Meeting | TDoc | CR | Rev | Cat | Subject/Comment | New version |
| 2023-11 | RAN4 #109 | R4-2320017 |  |  |  | TR skeleton and first version of TR | 0.1.0 |
| 2023-11 | RAN4 #109 | R4-2321757 |  |  |  | TP for TR 38.880 DC\_7A\_n78A with 3Tx | 0.1.0 |
| 2023-11 | RAN4 #109 | R4-2321758 |  |  |  | TP for TR 38.880 DC\_8A\_n78A | 0.1.0 |
| 2023-11 | RAN4 #109 | R4-2321759 |  |  |  | TP for TR 38.880 DC\_20A\_n78A | 0.1.0 |
| 2023-11 | RAN4 #109 | R4-2321760 |  |  |  | TP for TR 38.880 DC\_28A\_n78A | 0.1.0 |
| 2023-11 | RAN4 #109 | R4-2318724 |  |  |  | TP for TR 38.880 DC\_41A\_n78A | 0.1.0 |
| 2023-11 | RAN4 #109 | R4-2321753 |  |  |  | TP for TR 38.880: 3Tx inter-band CA\_n2-n77 | 0.1.0 |
| 2023-11 | RAN4 #109 | R4-2321761 |  |  |  | TP for TR 38.880: Input for CA\_n25A-n41A | 0.1.0 |
| 2023-11 | RAN4 #109 | R4-2321762 |  |  |  | TP for TR 38.880: Input for CA\_n41A-n66A | 0.1.0 |
| 2024-03 | RAN4 #110 |  |  |  |  | TR updates | 0.2.0 |