**3GPP TSG-RAN WG4 Meeting # 111 R4-2410652**

**Fukuako, Japan, May. 20th – 24th, 2024**

Source: ZTE Corporation, Skyworks, Nokia, Huawei, HiSilicon

Title: WF on two band DL band combination template

Agenda Item: 6.1.2

Document for: Approval

# **Introduction/background**

The templates for harmonic/harmonic mixing/cross band isolation were approved in [1] [2] in the last meeting. In this meeting, some contributions [3][4][5] on improvements on the MSD/TR template are provided.

This WF aims to capture the MSD/TR table template for Rel-19 2DL bands with xUL(x=1,2) bands inter-band NR CA ].

The (sub-) clauses numbers used in this WF is based on the existing Rel-18 TR38718-02-01.

# **Way forward**

## 5.x CA\_nX-nY

### 5.x.1 Common for 1 band UL and 2 bands UL CA

#### 5.x.1.1 Operating bands for CA

Table 5.x.1.1-1: CA band combination of band nX+nY

|  |  |  |  |
| --- | --- | --- | --- |
| **NR Band** | **Uplink (UL) band** | **Downlink (DL) band** | **Duplex**  **mode** |
| **BS receive / UE transmit** | **BS transmit / UE receive** |
| **FUL\_low – FUL\_high** | **FDL\_low – FDL\_high** |
| nX | xxxx MHz – xxxx MHz | xxxx MHz – xxxx MHz | XXX |
| nY | xxxx MHz – xxxx MHz | xxxx MHz – xxxx MHz | XXX |
| NOTE X:  *Editor's note: Whether or not supporting simultaneous Rx/Tx capability should be identified for TDD-TDD or FDD-TDD band combination* | | | |

If the band combination is TDD/TDD, is SimRx/Tx supported (YES/NO/N-A)?

*Editor's note: If yes, please add the NOTE in the above table.*

#### 5.x.1.2 Channel bandwidths per operating band for CA

Table 5.x.1.2-1: Supported bandwidths per CA band combination of band nX+nY

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **NR CA configuration** | **Uplink CA configuration or single uplink carrier** | **NR Band** | **Channel bandwidth (MHz)** | **Bandwidth combination set** |
| CA\_nXA-nYA | - \*  or  CA\_nXA-nYA | nX | Channel BWs | X |
|  |  | nY | Channel BWs |  |
| CA\_nX(A/B/C(2A)-nY(A/B/C(2A) | CA\_nX(A/B/C(2A)-nY(A/B/C(2A) | nX | Channel BW or CA BCS | X |
|  |  | nY | Channel BW or CA BCS |  |

*Editor's note\*: ‘-’ is for 1UL*

*Editor's note: The table format shall be the same with Table 5.5A.3.1-1 in the latest TS 38.101-1. The table format above is from the latest Rel.18 38.101-1, note that the table format might be changed in Rel.19.*

#### 5.x.1.3 UE co-existence studies for 1 band UL

*Editor’s Note: The tables in this section are provided to identify potential issues to be analysed based on interference frequency range calculations, whether to specify the MSD related to collisions with the victim receiver frequency range should be based on the detailed REFSENS analysis.*

Table 5.x.1.3-1 summarizes frequency ranges where harmonics and/or harmonics mixing occur for CA\_ nX-nY.

**Table 5.x.1.3-1 UL/DL harmonics/haromic mixing analysis**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **UL/DL harmonics** | | **nX** | **UL12** | **UL2** | **UL33** | **UL4** | **UL5** | **MSD type** |
| **fLow** |  |  |  |  |  |
| **nY** | **fLow** | **fHigh** |  |  |  |  |  |
| **DL1** |  |  | N/A |  |  |  |  | **UL harmonic** |
| **DL23** |  |  |  | N/A |  | N/A | N/A | **Harmonic mixing** |
| **DL34** |  |  |  |  | N/A |  | N/A |
| **DL4** |  |  |  | N/A | N/A | N/A | N/A |
| **DL54** |  |  |  |  | N/A | N/A | N/A |
| **Analysis** | | | text | | | | | |
| **UL/DL harmonics** | | **nY** | **UL14** | **UL2** | **UL33** | **UL4** | **UL5** | **MSD type** |
| **fLow** |  |  |  |  |  |
| **nX** | **fLow** | **fHigh** |  |  |  |  |  |
| **DL1** |  |  | N/A |  |  |  |  | **UL harmonic** |
| **DL23** |  |  |  | N/A |  | N/A | N/A | **Harmonic mixing** |
| **DL34** |  |  |  |  | N/A |  | N/A |
| **DL4** |  |  |  | N/A | N/A | N/A | N/A |
| **DL54** |  |  |  |  | N/A | N/A | N/A |
| **Analysis** | | | text | | | | | |
| Note 1: ULx means UL xth harmonic frequency, and DLy means DL yth harmonic frequency range  Note 2: When a collision is detected with an overlap >0Hz between the ULx with DLy frequency ranges, the ULx/DLy cell is marked “D” for direct hit.  When the gap between ULx and DLy frequency range is from 0Hz to n\*MinULCBW, the ULx/DLy cell is marked “N” for Near miss.  Note 3: UL3/DL2 harmonic mixing direct hit case for PC3/5 only apply for DL>3GHz  Note 4: For harmonic mixing, near-miss cases only apply for UL1 and odd DLy orders. | | | | | | | | |

Table 5.x.1.3-2 summarizes frequency ranges where cross band isolation may occur for CA\_ nX-nY.

Table 5.x.1.3-2: Cross-band isolation analysis

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Bands3** | **nX** | | **nY** | |
| **Frequency limit** | **flow** | **fhigh** | **flow** | **fhigh** |
| **fUL (MHz)** |  |  |  |  |
| **fDL (MHz)** |  |  |  |  |
| **UL CBW (MHz)2** | Minimum CBW | Maximum CBW | Minimum CBW | Maximum CBW |
|  |  |  |  |
| **ACLR1 range** | fxULlow-maxULCBWx | fxULhigh+maxULCBWx | fyULlow-maxULCBWy | fyULhigh+maxULCBWy |
| **ACLR1 (MHz)** |  |  |  |  |
| **ACLR2 range** | fxULlow-2\*maxULCBWx | fxULhigh+2\*maxULCBWx | fyULlow-2\*maxULCBWy | fyULhigh+2\*maxULCBWy |
| **ACLR2 (MHz)** |  |  |  |  |
| **ACLR3 range** | fxULlow-3\*maxULCBWx | fxULhigh+3\*maxULCBWx | fyULlow-3\*maxULCBWy | fyULhigh+3\*maxULCBWy |
| **ACLR3 (MHz)** |  |  |  |  |
| **ACLR4 range** | fxULlow-4\*maxULCBWx | fxULhigh+4\*maxULCBWx | fyULlow-4\*maxULCBWy | fyULhigh+4\*maxULCBWy |
| **ACLR4 (MHz)** |  |  |  |  |
| **ACLR5 range1** | fxULlow-5\*maxULCBWx | fxULhigh+5\*maxULCBWx | fyULlow-5\*maxULCBWy | fyULhigh+5\*maxULCBWy |
| **ACLR5 (MHz)** |  |  |  |  |
| **Analysis** |  | |  | |
| Note 1: Even if there is no overlap up to ACLR5, MSD beyond the ACLR5 range should be evaluated further if:   * The UL aggressor band and DL aggressor band are part of the same or adjacent band group as described in table A.1. * If the DL band is above the UL band, it’s lower frequency edge must be below the UL lowest 2nd harmonic frequency * As an indicative threshold, if >45dB UL rejection at the DL band frequency can be guaranteed, assuming a -130dBm/Hz TX noise floor level, the transmitter noise floor related MSD should be negligible   Note 2: The maximum UL channel bandwidth of the BCS (noted maxULCBW) is used to calculate the band ACLR ranges  while the minimum DL channel bandwidth of the BCS (noted minDLCBW) is used for the DL band victim channel bandwidth. | | | | |

Table 5.X.1.3-3 summarizes frequency ranges where IMD products caused by one UL band with 2CC intra-band UL CA may occur for CA\_ nX-nY

**Table 5.x.1.3-3: Intra-band ULCA IMD overlap with the other DL band analysis.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| All in MHz | flow | fhigh | BB IMD range3 | | |
| nX fUL |  |  | Order | flow | fhigh |
| nY fDL |  |  |
| 2CCBW1 | Minimum | Maximum | IMD2 (1-1) | Min2CCBW | Max2CCBW |
|  |  |  |  |
| Close to UL IMD range2 | | | IMD4 (2-2) | 2\*Min2CCBW | 2\*Max2CCBW |
| Order | flow | fhigh |  |  |
| IMD3 (2-1) | fULlow-Max2CCBW | fULhigh+Max2CCBW | IMD6 (3-3) | 3\*Min2CCBW | 3\*Max2CCBW |
|  |  |  |  |
| IMD5 (3-2) | fULlow-2\*Max2CCLBW | fULhigh+2\*Max2CCBW | Close to H2 IMD range4 | | |
|  |  | Order | flow | fhigh |
| IMD7 (4-3) | fULlow-3\*Max2CCBW | fULhigh+3\*Max2CCBW | IMD4 (3-1) | 2\*fULlow-Max2CCBW | 2\*fULhigh+Max2CCBW |
|  |  |  |  |
| IMD9 (5-4) | fULlow-4\*Max2CCBW | fULhigh+4\*Max2CCBW | IMD6 (4-2) | 2\*fULlow-2\*Max2CCBW | 2\*fULhigh+2\*Max2CCBW |
|  |  |  |  |
| IMD11 (6-5) | fULlow-5\*Max2CCBW | fULhigh+5\*Max2CCBW | Close to H3 IMD range4 | | |
|  |  | Order | flow | fhigh |
| IMD13 (7-6) | fULlow-6\*Max2CCBW | fULhigh+6\*Max2CCBW | IMD5 (4-1) | 3\*fULlow-Max2CCBW | 3\*fULhigh+Max2CCBW |
|  |  |  |  |
| **Analysis** |  | | | | |
| Note 1: 2CCBW is the instantaneous transmit bandwidth of the two intra-band UL CCs: - The minimum 2CCBW for contiguous / non-contiguous intra-band ULCA is 0 / minimum UL channel bandwidth - The maximum 2CCBW for contiguous / non-contiguous ULCA is Min(maximum aggregated bandwidth / maximum separation bandwidth(600MHz),fULhigh-fULlow)  Note 2: The close to UL IMD range is the most critical when the victim DL band in proximity to the UL band: - For contiguous/non-contiguous intra-band ULCA within a TDD band, IMD order up to 9/7 should be considered and MPR assumed - For intra-band ULCA within a FDD band, IMD order up to 13 should be considered for bands in the same band group and MPR is not assumed. If justified by poor filtering performance, higher order IMD may need to be specified.  Note 3: The BB IMD range should only be considered if the DL band is below the UL band and for non-contiguous ULCA within a TDD band >3GHz (assuming CA with 450MHz bands is not considered) -IMD2 is not considered assuming CA with 450MHz bands is not considered -IMD4 is considered for FDD or SimRx/Tx TDD bands <1GHz -IMD6 is considered for FDD or SimRx/Tx TDD bands <1.68GHz  Note 4: The harmonic 2 and 3 IMD ranges should only be considered if the DL band is above the UL band | | | | | |

#### 5.x.1.4 ∆TIB,c and ∆RIB,c values

*Editor’s note: for the table of ∆TIB,c and ∆RIB,c values, please use the same table format as in the latest TS 38.101-1, the table below is from the latest Rel.18 38.101-1, note that the table format might be changed in Rel.19.*

For CA\_nX-nY, the ΔTIB,c and ΔRIB,c values are given in the tables below.

Table 5.x.1.4-1: ΔTIB,c

|  |  |  |
| --- | --- | --- |
| Inter-band CA combination | ΔTIB,c for NR bands (dB)\* | |
| Component band in order of bands in configuration\*\* | |
| CA\_nX-nY |  |  |
| NOTE \*: “-” denotes ΔTIB,c = 0.  NOTE \*\*: The component band order in the configuration should be listed by the order of NR bands, such as for CA\_n1-n3 the band order from left to right is n1 and n3. | | |

Table 5.x.1.4-2: ΔRIB,c

|  |  |  |
| --- | --- | --- |
| Inter-band CA combination | ΔRIB,c for NR bands (dB)\* | |
| Component band in order of bands in configuration\*\* | |
| CA\_nX-nY |  |  |
| NOTE \*: “-” denotes ΔRIB,c = 0.  NOTE \*\*: The component band order in the configuration should be listed by the order of NR bands, such as for CA\_n1-n77 the band order from left to right is n1 and n77. | | |

#### 5.x.1.5 REFSEN requirements

*Editor's note 1: Text may be added if harmonics/harmonic mixing/cross band isolation/Intra-band ULCA IMD issues are identified in subclause 5.x.1.3.*

*Editor's note 2: It is encouraged proponent to provide the detailed technical analysis of the MSD requirements. For example: RF architecrtue, RFcomponents parameter, and etc.*

*Editor's note 3: The table format shall be the same with the corresponding tables in TS38.101-1, i.e.: Table 7.3A.4-1, Table 7.3A.4-4, Table 7.3A.6-1 for harmonics, harmonic mixing and cross band isolation, respectively.*

#### 5.x.1.6 OOB blocking exception requirements

Table 5.x.1.6-1: CA band combination with exceptions allowed

|  |
| --- |
| CA band combination |
|  |

### 5.x.2 Specific for 2 bands UL CA

*Editor's note: Text will be added if 2 bands UL CA are supported, otherwise all the clauses shall be void.*

#### 5.x.2.1 Maximum output power for inter-band CA

**Table 5.x.2.1-1: UE Power Class for uplink inter-band CA**

|  |  |  |
| --- | --- | --- |
| Uplink CA Configuration | Power Class 3 (dBm) | Tolerance (dB) |
| CA\_nXA-nYA | 23 | +x/-y |
| CA\_nX/YA/B/C/(2A) | 23 | +x/-y |
| CA\_nXA/B/C-nXA/B/C | 23 | +x/-y |

#### 5.x.2.2 UE co-existence studies for 2 bands UL

*Editor’s note: The tables in this section are provided to identify potential issues to be analysed based on interference frequency range calculations, whether to specify the MSD related to collisions with the victim receiver frequency range should be based on the detailed REFSENS analysis.*

Table 5.x.2.2-1 lists Band nX + Band nY 2 bands UL CA(2CC) 2nd, 3rd, 4th and 5th order IMD for the UE-to-UE coexistence analysis.

**Table 5.x.2.2-1:** **Band nX and Band nY for 2CC UL IMD products**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| UE UL carriers | fx\_low | fx\_high | fy\_low | fy\_high |
| 2nd order IMD products | |fy\_low – fx\_high| | |fy\_high – fx\_low| | |fy\_low + fx\_low| | |fy\_high + fx\_high| |
| IMD frequency limits (MHz) | – | | – | |
| Two-tone 3rd order IMD products | |2\*fx\_low – fy\_high| | |2\*fx\_high – fy\_low| | |2\*fy\_low – fx\_high| | |2\*fy\_high – fx\_low| |
| IMD frequency limits (MHz) | – | | – | |
| Two-tone 3rd order IMD products | |2\*fx\_low + fy\_low| | |2\*fx\_high + fy\_high| | |2\*fy\_low + fx\_low| | |2\*fy\_high + fx\_high| |
| IMD frequency limits (MHz) | – | | – | |
| Two-tone 4th order IMD products | |3\*fx\_low –1\* fy\_high| | |3\*fx\_high – 1\*fy\_low| | |3\*fy\_low – 1\*fx\_high| | |3\*fy\_high – 1\*fx\_low| |
| IMD frequency limits (MHz) | – | | – | |
| Two-tone 4th order IMD products | |2\*fx\_low –2\* fy\_high| | |2\*fx\_high –2\* fy\_low| |  |  |
| IMD frequency limits (MHz) | – | |  | |
| Two-tone 4th order IMD products | |3\*fx\_low +1\* fy\_low| | |3\*fx\_high + 1\*fy\_high| | |3\*fy\_low + 1\*fx\_low| | |3\*fy\_high + 1\*fx\_high| |
| IMD frequency limits (MHz) | – | | – | |
| Two-tone 4th order IMD products | |2\*fx\_low +2\* fy\_low| | |2\*fx\_high +2\* fy\_high| |  |  |
| IMD frequency limits (MHz) | – | |  | |
| Two-tone 5th order IMD products | |fx\_low – 4\*fy\_high| | |fx\_high – 4\*fy\_low| | |fy\_low – 4\*fx\_high| | |fy\_high – 4\*fx\_low| |
| IMD frequency limits (MHz) | – | | – | |
| Two-tone 5th order IMD products | |2\*fx\_low - 3\*fy\_high| | |2\*fx\_high - 3\*fy\_low| | |2\*fy\_low - 3\*fx\_high| | |2\*fy\_high -3\*fx\_low| |
| IMD frequency limits (MHz) | – | | – | |
| Two-tone 5th order IMD products | |fx\_low + 4\*fy\_low| | |fx\_high + 4\*fy\_high| | |fy\_low + 4\*fx\_low| | |fy\_high + 4\*fx\_high| |
| IMD frequency limits (MHz) | – | | – | |
| Two-tone 5th order IMD products | |2\*fx\_low + 3\*fy\_low| | |2\*fx\_high + 3\*fy\_high| | |2\*fy\_low + 3\*fx\_low| | |2\*fy\_high + 3\*fx\_high| |
| IMD frequency limits (MHz) | – | | – | |
| NOTE : For each IMD item, when two bound values before taking absolute have different signs, the relevant IMD range shall be set such that (1) the lower bound is 0 and (2) the upper bound is the bigger value of the two after taking absolute. The lowest even order and lowest odd order IMD MSDs shall be considered. | | | | |

Based on Table 5.x.2.2-1, nth order IMD may also fall into Rx frequencies of bands nX or band nY.

Table 5.x.2.2-2 lists Band nX + Band nY 2 bands UL CA(3CC) triple beat IMD analysis for Band nX- Band nY

**Table 5.x.2.2-2: Band nX and Band nY for 3CC UL IMD products**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Band / CA1** | **nX** | | **CA\_nYB/C** | |
| **Frequency limit (all MHz)** | **fx\_low** | **fx\_high** | **fy\_low** | **fy\_high** |
| **fUL** |  |  |  |  |
| **fDL** |  |  |  |  |
| **2CCBW2** | N/A | N/A | Minimum | Maximum |
|  |  |
| **IMD3 products** | fxUL\_low-max2CCBW | fxUL\_low | fxUL\_high | fxUL\_high+max2CCBW |
| **IMD3 (MHz)** |  |  |  |  |
| **Analysis** |  | | | |
| Note 1: If the two bands are not part of the same or adjacent band groups as defined in table A.1, the analysis can be ignored.  Note 2: For contiguous intra-band ULCA, the minimum and maximum separation BW are 0MHz and Min(fy\_high-fy\_low, maximum aggregated BW) respectively. | | | | |
|  | | | | |

Table 5.x.2.2-3 lists the protected bands required for the 2UL bands CA configuration.

**Table 5.x.2.2-2: Protected bands for the 2UL bands CA configuration**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **NR CA Configuration** | **Spurious emission** | | | | | | |
| **Protected band** | **Frequency range (MHz)** | | | **Maximum Level (dBm)** | **MBW (MHz)** | **NOTE** |
| CA\_nX-nY | E-UTRA Band ..... | FDL\_low | - | FDL\_high |  |  | x |
| Frequency range |  | - |  |  |  |  |
| NOTE x: .....  *Editor's note: The NOTE order must keep consistent with the Table 6.5A.3.2.3-1 in TS38.101-1.* | | | | | | | |

#### 5.x.2.3 REFSENS requirements

*Editor's note: Text will be added if IMD due to 2 bands UL with 2 UL carriers or triple beat due to 2 bands UL with 3 UL carriers issues are identified in table 5.x.2.2-1 and table 5.x.2.2-2, respectively.*

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*Other section for NR DC are omitted in this version of the example \*\*\*\*\*\*\*\*\*

Annex A: Band group definition

For the following MSD issues detection, a criterion applies in terms of band group as defined in Table A.1:

* For 2DL 1UL/1CC cross-band isolation, and for the Tx noise floor MSD to be considered, the two bands should be part of the same or adjacent band group.
* For 2DL 2UL/3CC triple beat MSD to be considered, the two bands should be part of the same or adjacent band group.

**Table A.1: Band group definition for same or adjacent band-group criterion**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| FR1 band group range | | | | | |
| Name | **FR1-a** | **FR1-b** | **FR1-c** | **FR1-d** | **FR1-e** |
| Range (MHz) | 600-1000 | 1400-2200 | 2300-2700 | 3300-5000 | 5150-7125 |
| Duplex mode | Mostly FDD | Mostly FDD | FDD and TDD | TDD only | TDD only |

Annex B: Valid UL configurations

For CA\_nX-nY two band DL inter band combinations, the following UL configurations are applicable:

* One band UL with one CC: nXA, nYA
* One band UL with two CC: CA\_nXB, CA\_nXC, CA\_nX(2A), CA\_nYB, CA\_nYC, CA\_nY(2A)
* two band UL with one CC per band: CA\_nXA-nYA
* two band UL with two CC in one band: CA\_nXB-nYA, CA\_nXC-nYA, CA\_nXA-nYB, CA\_nXA-nYC

The following three UL cluster cases are not supported: CA\_nX(2A)-nYA, CA\_nXA-nY(2A)

Combinations with four UL CCs are not supported.

# **Reference**

[1] R4-2404250, On cross-band isolation MSD analysis, Skyworks Solutions Inc., Nokia, Murata

[2] R4-2405935, Improved harmonic related MSDs template, Skyworks Solutions Inc.

[3] R4-2408359 Improved R19 TR templates for PC3 xUL/2DL inter-band NR CA/DC, ZTE Corporation, Sanechips

[4] R4-2407231 Template for 2 band DL 1or2 band UL inter-band combination TR and TP Skyworks Solutions Inc., Nokia

[5] R4-2409318 Discussion on TR template for band combination basket WI Huawei, HiSilicon

[6] R4-2410650, Ad hoc minutes on [111][105] NR\_Baskets\_Part\_1, Skyworks