**3GPP TSG-RAN WG4 Meeting #104-bis-e R4-2215376**

**10th October – 19th October 2022**

**Source: Qualcomm Incorporated**

**Title: TP for V2X\_n34A-n47A, V2X\_34A\_n47A and V2X\_n34A\_47A for TR37.878**

**Agenda item: 5.14.2**

**Work Item: NR\_LTE\_V2X\_PC5\_combos-Core**

**Document for: Approval**

--Start of changes

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# 1 Scope

The present document is the Technical Report on TR on band combinations for con-current operation of NR/LTE Uu bands/band combinations and one NR/LTE V2X band in Release 18.

The purpose of the present document is to study the extension of the band combinations for V2X service to grow the NR V2X ecosystem. Operators propose new band combinations for con-current operation of NR/LTE Uu bands/band combinations and one NR/LTE V2X band. Whether to specify con-current operation of LTE/NR CA/DC band combinations and V2X band depends on requests in Rel-18. Specifically, the self-desensitization problem of con-current operation band combinations will be analysed including harmonics, IMD problem, etc.. Also the candidate solutions will be studied to solve the self-desensitization problem.

Table 1-1: Release 18 NR V2X band combinations

|  |  |
| --- | --- |
| **V2X Band combination** | **REL independent from** |
| V2X\_n1-n47 | Rel-16 |
| V2X\_n5-n47 | Rel-16 |
| V2X\_n8-n47 | Rel-16 |
| V2X\_n34-n47 | Rel-16 |
| V2X\_n39-n47 | Rel-16 |
| V2X\_n40-n47 | Rel-16 |
| V2X\_n41-n47 | Rel-16 |
| V2X\_n78-n47 | Rel-16 |
| V2X\_n79-n47 | Rel-16 |
| V2X\_n1\_47 | Rel-16 |
| V2X\_n5\_47 | Rel-16 |
| V2X\_n8\_47 | Rel-16 |
| V2X\_n34\_47 | Rel-16 |
| V2X\_n39\_47 | Rel-16 |
| V2X\_n40\_47 | Rel-16 |
| V2X\_n41\_47 | Rel-16 |
| V2X\_n78\_47 | Rel-16 |
| V2X\_n79\_47 | Rel-16 |
| V2X\_1\_n47 | Rel-16 |
| V2X\_3\_n47 | Rel-16 |
| V2X\_5\_n47 | Rel-16 |
| V2X\_8\_n47 | Rel-16 |
| V2X\_34\_n47 | Rel-16 |
| V2X\_39\_n47 | Rel-16 |
| V2X\_40\_n47 | Rel-16 |
| V2X\_41\_n47 | Rel-16 |

Note: All band combinations in table 1-1 that are release independent from Rel-16 are optional

6 Con-current operation with one Uu band and one PC5 band

6.1 Con-current operation between one LTE Uu band and one NR PC5 band

**<<Unchanged section omitted>>**

6.1.1 V2X\_34A\_n47A

6.1.1.1 Operating bands for V2X\_34A\_n47A

The operating bands for V2X\_34A\_n47A are specified in table 6.1.1.1-1.

**Table 6.1.1.1-1: Inter-band con-current V2X operating bands for V2X\_34A\_n47A**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **V2X con-current configuration** | **E-UTRA / NR Operating Band** | **Interface** | **Uplink (UL) band** | **Downlink (DL) band** | **Duplex Mode** |
| **BS receive / UE transmit** | **BS transmit / UE receive** |
| **FUL\_low – FUL\_high** | **FDL\_low – FDL\_high** |
| V2X\_34A\_n47A | 34 | Uu | 2010 MHz | – | 2025 MHz | 2010 MHz | – | 2025 MHz | TDD |
| n47 | PC5 | 5855 MHz | – | 5925 MHz | 5855 MHz | – | 5925 MHz | HD |

6.1.1.2 Channel bandwidths per operating band for V2X\_34A\_n47A

The channel bandwidths per operating band for V2X\_34A\_n47A are specified in table 6.1.1.2-1.

**Table 6.1.1.2-1: V2X inter-band con-current configurations and bandwidth combination sets for V2X\_34A\_n47A**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **V2X inter-band Configuration** | **E-UTRA / NR operating Band** | **SCS kHz** | **Channel bandwidth (MHz)** | **Maximum aggregated bandwidth [MHz]** | **Bandwidth combination set** |
| V2X\_34A\_n47A | 34 | 15 | 5, 10, 15, | 55 | 0 |
| n47 | 15 | 10, 20, 30, 40 |
| 30 | 10, 20, 30, 40 |
| 60 | 10, 20, 30, 40 |

6.1.1.3 UE co-existence studies

The UE co-existence studies specified for V2X\_n34A-n47A in clause 6.2.1.3 are applicable to V2X\_34A\_n47A since band 34 and band n34 have the same frequency range.

6.1.1.4 MSD, ∆TIB and ∆RIB values

Table 6.1.1.4-1: ΔTIB,c for inter-band con-current V2X operation (two bands)

|  |  |  |
| --- | --- | --- |
| V2X con-current band Combination | E-UTRA or V2XOperating Band | ΔTIB,c [dB] |
| V2X\_34A\_n47A | 34 | 0.0 |

Table 6.1.1.4-2: ΔRIB,c for inter-band con-current V2X operation (two bands)

|  |  |  |
| --- | --- | --- |
| V2X inter-band con-current band Combination | E-UTRA Band | ΔRIB,c [dB] |
| V2X\_34A-n47A | 34 | 0.0 |

6.1.1.5 REFSENS requirements

6.2 Con-current operation between one NR Uu band and one NR PC5 band

**<<Unchanged section omitted>>**

6.2.1 V2X\_n34A-n47A

6.2.1.1 Operating bands for V2X\_n34A-n47A

The operating bands for V2X\_n34A-n47A are specified in table 6.2.1.1-1.

**Table 6.2.1.1-1: Inter-band con-current V2X operating bands for V2X\_n34A-n47A**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **V2X con-current configuration** | **E-UTRA / NR Operating Band** | **Interface** | **Uplink (UL) band** | **Downlink (DL) band** | **Duplex Mode** |
| **BS receive / UE transmit** | **BS transmit / UE receive** |
| **FUL\_low – FUL\_high** | **FDL\_low – FDL\_high** |
| V2X\_n34A-n47A | n34 | Uu | 2010 MHz | – | 2025 MHz | 2010 MHz | – | 2025 MHz | TDD |
| n47 | PC5 | 5855 MHz | – | 5925 MHz | 5855 MHz | – | 5925 MHz | HD |

6.2.1.2 Channel bandwidths per operating band for V2X\_n34A-n47A

The channel bandwidths per operating band for V2X\_n34A-n47A are specified in table 6.2.1.2-1.

**Table 6.2.1.2-1: V2X inter-band con-current configurations and bandwidth combination sets for V2X\_n34A-n47A**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **V2X inter-band Configuration** | **E-UTRA / NR operating Band** | **SCS kHz** | **Channel bandwidth (MHz)** | **Maximum aggregated bandwidth [MHz]** | **Bandwidth combination set** |
| V2X\_n34A\_n47A | n34 | 15 | 5, 10, 15 | 55 | 0 |
| 30 | 10, 15 |
| 60 | 10, 15 |
| n47 | 15 | 10, 20, 30, 40 |
| 30 | 10, 20, 30, 40 |
| 60 | 10, 20, 30, 40 |

6.2.1.3 Coexistence studies

The harmonics analysis for V2X\_n34A-n47A is specified in table 6.2.1.3-1. Up to 4th harmonics of band n34 are provided since the frequency range of the 5th harmonics is much higher than 5.9GHz. The harmonics of band n47 are not listed as the harmonics distributed in the frequency range much higher than 5.9GHz have no impact on GNSS and ISM bands.

**Table 6.2.1.3-1: Harmonics analysis for V2X\_n34A-n47A**

|  |  |  |
| --- | --- | --- |
| **Operating Band** | **Band n34** | **Band n47** |
| **UE UL carriers** | **fx\_low** | **fx\_high** | **fy\_low** | **fy\_high** |
| **UL frequency (MHz)** | 2010 | 2025 | 5855 | 5925 |
| **2nd harmonics frequency limits** | 2\*fx\_low | 2\*fx\_high | No effect |
| **2nd harmonics frequency limits (MHz)**  | 4020 | 4050 |
| **3rd harmonics frequency limits** | 3\*fx\_low | 3\*fx\_high | No effect |
| **3rd harmonics frequency limits (MHz)**  | 6030 | 6075 |
| **4th harmonics frequency limits** | 4\*fx\_low | 4\*fx\_high | No effect |
| **4th harmonics frequency limits (MHz)**  | 8040 | 8100 |

The IMD analysis for V2X\_n34A-n47A is specified in table 6.2.1.3-2. Up to the 5th order IMDs of band n34 and band n47 are provided. Based on the IMD analysis, it is observed that no IMD products fall into the associated bands.

| **Operating Band** | **Band 34** | **Band n47** |
| --- | --- | --- |
| **UE UL carriers** | **fx\_low** | **fx\_high** | **fy\_low** | **fy\_high** |
| UL frequency (MHz) | **2010** | **2025** | **5855** | **5925** |
| 2nd harmonics frequency limits | **2\*fx\_low** | **2\*fx\_high** | **2\* fy\_low** | **2\* fy\_high** |
| 2nd harmonics frequency limits (MHz)  | **4020** | **4050** | **11710** | **11850** |
| 3rd harmonics frequency limits | **3\*fx\_low** | **3\*fx\_high** | **3\* fy\_low** | **3\* fy\_high** |
| 3rd harmonics frequency limits (MHz) | **6030** | **6075** | **17565** | **17775** |
| Two tone 2nd order IMD products | **|fy\_low – fx\_high|** | **|fy\_high – fx\_low|** | **|fy\_low + fx\_low|** | **|fy\_high + fx\_high|** |
| IMD frequency limits (MHz) | **3830** | **3915** | **7865** | **7950** |
| 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) | **1905** | **1805** | **9685** | **9840** |
| 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) | **9875** | **9975** | **13720** | **13875** |
| Two-tone 4th order IMD products | **|3\*fx\_low – fy\_high|** | **|3\*fx\_high – fy\_low|** | **|3\*fy\_low – fx\_high|** | **|3\*fy\_high – fx\_low|** |
| IMD frequency limits (MHz) | **105** | **220** | **15540** | **15765** |
| Two-tone 4th order IMD products | **|3\*fx\_low + fy\_low|** | **|3\*fx\_high + fy\_high|** | **|3\*fy\_low + fx\_low|** | **|3\*fy\_high + fx\_high|** |
| IMD frequency limits (MHz) | **11885** | **12000** | **19575** | **19800** |
| Two-tone 4th order IMD products | **|2\*fx\_low – 2\*fy\_high|** | **|2\*fx\_high – 2\*fy\_low|** | **|2\*fx\_low + 2\*fy\_low|** | **|2\*fx\_high + 2\*fy\_high|** |
| IMD frequency limits (MHz) | **7830** | **7660** | **15730** | **15900** |
| 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) | **21690** | **21395** | **2245** | **2115** |
| 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) | **25430** | **25725** | **13895** | **14025** |
| 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) | **13755** | **13515** | **5635** | **5820** |
| 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) | **21585** | **21825** | **17740** | **17925** |

**Table 6.2.1.3-2: IMD analysis for V2X\_n34A-n47A**

The harmonics and intermodulation products should be evaluated when V2X inter-band con-current operating UE coexists with other systems such as GNSS and ISM. The harmonics and IMD analysis of V2X\_n34A-n47A for GNSS and ISM bands is shown in table 6.2.7.3-3. Based on the analysis for GNSS and ISM bands, band n47 has an impact on the ISM band (5GHz).

**Table 6.2.7.3-3: Harmonic and IMDs analysis of V2X\_n34A-n47A UE for GNSS and ISM bands**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Victim Systems** | **Frequency range [MHz]** | **Impact** | **Regions** | **Comments** |
| COMPASS(Beidou) | 1559 | - | 1591 | No |  |  |
| Galileo | 1559 | - | 1591 | No |  |  |
| GLONASS | 1591 | - | 1610 | No |  |  |
| GPS | 1563 | - | 1587 | No |  |  |
| ISM band (2.4GHz) | 2400 | - | 2483.5 | No | US/Europe |  |
| 2400 | - | 2494 | No | Asia |  |
| ISM band (5GHz) | 5150 | - | 5925 | Yes | US | 5th IMD, Band n47 |
| 5150 | - | 5350 | Yes | Europe |  |
| 5470 | - | 5725 | Yes | 5th IMD |
| 5150 | - | 5825 | Yes | Asia | 5th IMD |

6.2.7.4 MSD, ∆TIB and ∆RIB values

Table 6.2.7.4-1: ΔTIB,c for inter-band con-current V2X operation (two bands)

|  |  |  |
| --- | --- | --- |
| V2X con-current band Combination | NROperating Band | ΔTIB,c [dB] |
| V2X\_n34A-n47A | 34 | 0.0 |

Table 6.2.7.4-2: ΔRIB,c for inter-band con-current V2X operation (two bands)

|  |  |  |
| --- | --- | --- |
| V2X inter-band con-current band Combination | NR Operating Band | ΔRIB,c [dB] |
| V2X\_n34A-n47A | 34 | 0.0 |

6.2.7.5 REFSENS requirements

6.3 Con-current operation between one NR Uu band and one LTE PC5 band

**<<Unchanged section omitted>>**

6.3.1 V2X\_n34A\_47A

6.3.1.1 Operating bands for V2X\_n34A\_47A

The operating bands for V2X\_n34A\_47A are specified in table 6.3.1.1-1.

**Table 6.3.1.1-1: Inter-band con-current V2X operating bands for V2X\_n34A\_47A**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **V2X con-current configuration** | **E-UTRA / NR Operating Band** | **Interface** | **Uplink (UL) band** | **Downlink (DL) band** | **Duplex Mode** |
| **BS receive / UE transmit** | **BS transmit / UE receive** |
| **FUL\_low – FUL\_high** | **FDL\_low – FDL\_high** |
| V2X\_n34A\_47A | n34 | Uu | 2010 MHz | – | 2025 MHz | 2010 MHz | – | 2025 MHz | TDD |
| 47 | PC5 | 5855 MHz | – | 5925 MHz | 5855 MHz | – | 5925 MHz | HD |

6.3.7.2 Channel bandwidths per operating band for V2X\_n34A\_47A

The channel bandwidths per operating band for V2X\_n34A\_47A are specified in table 6.3.1.2-1.

**Table 6.3.1.2-1: V2X inter-band con-current configurations and bandwidth combination sets for V2X\_n34A\_47A**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **V2X inter-band Configuration** | **E-UTRA / NR operating Band** | **SCS kHz** | **Channel bandwidth (MHz)** | **Maximum aggregated bandwidth [MHz]** | **Bandwidth combination set** |
| V2X\_n34A\_47A | n34 | 15 | 5, 10, 15 | 35 | 0 |
| 30 | 10, 15 |
| 60 | 10, 15 |
| 47 | 15 | 10, 20 |

6.3.7.3 UE co-existence studies

The UE co-existence studies specified for V2X\_n34A-n47A in clause 6.2.1.3 are applicable to V2X\_n34A\_47A since band 47 and band n47 have the same frequency range.

6.3.7.4 MSD, ∆TIB and ∆RIB values

Table 6.3.7.4-1: ΔTIB,c for inter-band con-current V2X operation (two bands)

|  |  |  |
| --- | --- | --- |
| V2X con-current band Combination | NROperating Band | ΔTIB,c [dB] |
| V2X\_n34A\_47A | 34 | 0.0 |

Table 6.3.7.4-2: ΔRIB,c for inter-band con-current V2X operation (two bands)

|  |  |  |
| --- | --- | --- |
| V2X inter-band con-current band Combination | NR Operating Band | ΔRIB,c [dB] |
| V2X\_n34A\_47A | 34 | 0.0 |

6.3.7.5 REFSENS requirements

--End of changes