3GPP TSG-RAN WG4 Meeting #108-bis R4-23xxxx

Xiamen, China, 9th Oct. – 13th Oct. 2023

**Agenda Item: 4.1.1.2**

**Source: Charter Communications, Inc.**

**Title: WF on NR-U ULCA in Band\_n96**

**Document for: Approval**

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In RAN4#108bis meeting, a draft CR for introducing Carrier aggregation to Power class 5 (PC5) in NR-unlicensed spectrum was presented [1]. The draft CR was based on previous simulation results from paper [2] and [3] from August meeting. Another contribution was submitted with measurement results in the October meeting [4]. Based on the draft CR, the comments during the meeting, as well as newly submitted measurement results, this WF is taking all of this into consideration for companies to address their views for the next meeting.

#  Way Forward

First of all, all requirements in the draft CR have not received any comments or feedback, so it is copy and pasted in here to ensure everyone are fine with them.

**Issue 2-1: Adding the additional requirements for transmit power density for intra-band contiguous CA**

6.2F.1A.2 UE maximum output power for intra-band contiguous CA

For uplink intra-band contiguous carrier aggregation, the maximum output power is specified in Table 6.2F.1A.2-1. For downlink intra-band contiguous carrier aggregation with a single uplink component carrier configured in the NR-U band, the maximum output power is specified in Table 6.2F.1-1 for power class 5.

**Table 6.2F.1A.2-1: UE Power Class for intra-band contiguous CA**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **NR CA Configuration** | **Class 1 (dBm)** | **Tolerance (dB)** | **Class 2 (dBm)** | **Tolerance (dB)** | **Class 3 (dBm)** | **Tolerance (dB)** | **Class 5 (dBm)** | **Tolerance (dB)** |
| CA\_n96B |  |  |  |  |  |  | 20 | +2/-3 |
| CA\_n96C |  |  |  |  |  |  | 20 | +2/-3 |
| NOTE 1: PPowerClass is the maximum UE power specified without taking into account the tolerance.NOTE 2: Power class 5 is default power class unless otherwise stated.  |

The UE operating shall meet the following additional requirements for maximum mean transmission power density specified in Table 6.2F.1A.2-2 when CA\_NS is signalled and when transmission overlaps with any portion of the specified frequency range. In case transmission overlaps multiple frequency ranges, the lowest power density requirement applies.

**Table 6.2F.1A.2-2: Additional requirements for transmit power density for intra-band contiguous CA**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **NR CA Band** | **NS value** | **Aggregated channel bandwidth (MHz)** | **Frequency range (MHz)** | **Maximum mean power density (dBm/MHz)** |
| CA\_n96 | CA\_NS\_53 | 20, 40, 60, 80, 100, 120, 140, 160 | 5925 – 7125 | -1 |
| CA\_NS\_54 | 20, 40, 60, 80, 100, 120, 140, 160 | 5925 – 6425 | 17 |
| 6525 – 6875 |

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| Companies | Comments |
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**Issue 2-2: Adding section of UE additional maximum output power reduction for Intra-band contiguous CA**

6.2F.3A.2 UE additional maximum output power reduction for Intra-band CA

6.2F.3A.2.1 UE additional maximum output power reduction for Intra-band contiguous CA

Additional emission requirements can be signalled by the network. Each additional emission requirement is associated with a unique network signalling (NS) value indicated in RRC signalling by an NR frequency band number of the applicable operating band and an associated value in the field *additionalSpectrumEmission.* Throughout this specification, the notion of indication or signalling of an NS value refers to the corresponding indication of an NR frequency band number of the applicable operating band, the IE field *freqBandIndicatorNR* and an associated value of *additionalSpectrumEmission* in the relevant RRC information elements [7]*.* Relation between NR CA band and NR frequency band is specified in Table 5.2A.1-1.

To meet the additional requirements, additional maximum power reduction (A-MPR) is allowed for the maximum output power as specified in Table 6.2F.1A.2-1. Unless stated otherwise, the total reduction to UE maximum output power is max(MPR, A-MPR) where MPR is defined in clause 6.2F.2A.2. In absence of modulation and waveform types the A-MPR applies to all modulation and waveform types.

Table 6.2F.3A.2.1-1 specifies the additional requirements with their associated network signalling values and the allowed A-MPR and applicable CA band(s) for each CA\_NS value. The CA\_NS\_xy value indicates the additional unwanted emissions requirements that apply for intra-band contiguous CA bands with NS\_xy indicated or configured in multiple uplinks serving cells, except CA\_NS\_01 that indicates the general emission requirements for intra-band contiguous CA bands. The mapping of NR CA band numbers and values of the *additionalSpectrumEmission* to network signalling labels is specified in Table 6.2F.3A.2.1-2. For any NR CA band not listed in Table 6.2F.3A.2.1-2 the network signalling label CA\_NS\_01 applies.

Table 6.2F.3A.2.1-1: Additional maximum power reduction (A-MPR)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Network signalling label | Requirements (clause) | NR CA Band | Aggregated channel bandwidth (MHz) | Resources blocks (*N*RB) | A-MPR (dB) |
| CA\_NS\_01 | 6.5F.2A.1.2 | CA\_n96 | 20, 40, 60, 80, 100, 120, 140, 160 |  | N/A |
| CA\_NS\_53 | 6.5F.3A.3.1 | CA\_n96 | 20, 40, 60, 80, 100, 120, 140, 160 |  | 6.2F.3A.2.2 |
| CA\_NS\_54 | 6.5F.3A.3.1 | CA\_n96 | 20, 40, 60, 80, 100, 120, 140, 160 |  | 6.2F.3A.2.3 |
| NOTE 1: The A-MPR shall apply to all active 20 MHz sub-bands contiguously allocated in the channel. |

Table 6.2F.3A.2.1-2: Mapping of network signalling label

|  |  |
| --- | --- |
| NR CA band | Value of additionalSpectrumEmission |
|  | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** |
| CA\_n96 | CA\_NS\_01 | CA\_NS\_53 | CA\_NS\_54 |  |  |  |  |  |
| NOTE: *additionalSpectrumEmission* corresponds to an information element of the same name defined in clause 6.3.2 of TS 38.331 [7]. |

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| Companies | Comments |
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**Issue 2-3: A-MPR table for NS\_53**

Proposal 1

|  |  |  |
| --- | --- | --- |
| Pre-coding | Modulation | Bandwidth of transmitted sub-bands / RB Allocation |
|  |  | 20 MHz | 40 MHz | 60 MHz | 80 MHz | 100MHz | 120MHz, 140MHz, 160MHz |
|  |  | Full (dB) | Partial (dB) | Full (dB) | Partial (dB) | Full (dB) | Partial (dB) | Full (dB) | Partial (dB) | Full (dB) | Partial (dB) | Full (dB) | Partial (dB) |
| DFT-s-OFDM | PI/2 BPSK2 | ≤ [9.0] | ≤ [12.0] | ≤ [6.5 | ≤ [9.0] | ≤ [4.5] | ≤ [7.0] | ≤ [4.5] | ≤ [5.5] | ≤ [4.0] | ≤ [4.0] | ≤ [4.0] | ≤ [4.0] |
| QPSK | ≤ [9.0] | ≤ [12.0] | ≤ [6.5 | ≤ [9.0] | ≤ [4.5] | ≤ [7.0] | ≤ [4.5] | ≤ [5.5] | ≤ [4.0] | ≤ [4.5] | ≤ [4.0] | ≤ [4.0] |
|  | 16 QAM | ≤ [9.0] | ≤ [12.0] | ≤ [6.5 | ≤ [9.0] | ≤ [4.5] | ≤ [7.0] | ≤ [4.5] | ≤ [5.5] | ≤ [4.5] | ≤ [4.5] | ≤ [4.5] | ≤ [4.5] |
|  | 64 QAM | ≤ [9.0] | ≤ [12.0] | ≤ [6.5 | ≤ [9.0] | ≤ [4.5] | ≤ [7.0] | ≤ [5.5] | ≤ [6.0] | ≤ [5.0] | ≤ [5.0] | ≤ [5.0] | ≤ [5.0] |
|  | 256 QAM | ≤ [9.0] | ≤ [12.0] | ≤ [6.5 | ≤ [9.0] | ≤ [6.0] | ≤ [7.0] | ≤ [6.0] | ≤ [6.0] | ≤ [6.0] | ≤ [6.0] | ≤ [6.0] | ≤ [6.0] |
| CP-OFDM | QPSK | ≤ [9.0] | ≤ [12.0] | ≤ [6.5 | ≤ [9.0] | ≤ [5.0] | ≤ [7.0] | ≤ [5.0] | ≤ [6.0] | ≤ [5.5] | ≤ [6.5] | ≤ [5.5] | ≤ [6.5] |
|  | 16 QAM | ≤ [9.0] | ≤ [12.0] | ≤ [6.5 | ≤ [9.0] | ≤ [6.0] | ≤ [7.0] | ≤ [5.5] | ≤ [6.0] | ≤ [6.0] | ≤ [6.5] | ≤ [6.0] | ≤ [6.5] |
|  | 64 QAM | ≤ [9.0] | ≤ [12.0] | ≤ [6.5 | ≤ [9.0] | ≤ [6.0] | ≤ [7.0] | ≤ [6.5] | ≤ [6.5] | ≤ [6.5] | ≤ [6.5] | ≤ [6.5] | ≤ [6.5] |
|  | 256 QAM | ≤ [9.0] | ≤ [12.0] | ≤ [7.0 | ≤ [9.0] | ≤ [7.0] | ≤ [7.0] | ≤ [7.0] | ≤ [7.0] | ≤ [7.0] | ≤ [7.0] | ≤ [7.0] | ≤ [7.0] |
| NOTE 1: Full allocation A-MPR applies when all RB’s in a 20 MHz channel or all RB’s in all sub-bands for wideband operation are fully allocated and all sub-bands are transmitted. Partial allocation A-MPR applies when one or more RB’s in one or more sub-bands are not allocated but when all sub-bands within the channel are transmitted. When not all sub-bands within the channel are transmitted, the A-MPR associated with the channel bandwidth according to the bandwidth of the contiguously transmitted sub-bands and according to the allocation type applies.NOTE 2: Applicable to Pi/2-BPSK modulation when IE powerBoostPi2BPSK is set to 0. |

Proposal 2

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| --- | --- | --- |
| Pre-coding | Modulation | Bandwidth of transmitted sub-bands / RB Allocation |
| 20 MHz | 40 MHz | 60 MHz | 80 MHz | 100MHz | 120MHz | 140MHz | 160MHz |
| Full (dB) | Partial (dB) | Full (dB) | Partial (dB) | Full (dB) | Partial (dB) | Full (dB) | Partial (dB) | Full (dB) | Partial (dB) | Full (dB) | Partial (dB) | Full (dB) | Partial (dB) | Full (dB) | Partial (dB) |
| DFT-s-OFDM | PI/2 BPSK2 | ≤ [9.0] | ≤ [11.5] | ≤ [6.0] | ≤ [8.5] | ≤ [4.0] | ≤ [7.0] | ≤ [3.0] | ≤ [5.5] | ≤ [3.0] | ≤ [4.5] | ≤ [3.0] | ≤ [4.0] | ≤ [3.0] | ≤ [3.5] | ≤ [3.0] | ≤ [3.0] |
| QPSK | ≤ [9.0] | ≤ [11.5] | ≤ [6.0] | ≤ [8.5] | ≤ [4.0] | ≤ [7.0] | ≤ [3.0] | ≤ [5.5] | ≤ [3.0] | ≤ [4.5] | ≤ [3.0] | ≤ [4.0] | ≤ [3.0] | ≤ [3.5] | ≤ [3.0] | ≤ [3.0] |
| 16 QAM | ≤ [9.0] | ≤ [11.5] | ≤ [6.0] | ≤ [8.5] | ≤ [4.0] | ≤ [7.0] | ≤ [3.5] | ≤ [5.5] | ≤ [3.5] | ≤ [4.5] | ≤ [3.5] | ≤ [4.0] | ≤ [3.5] | ≤ [3.5] | ≤ [3.5] | ≤ [3.5] |
| 64 QAM | ≤ [9.0] | ≤ [11.5] | ≤ [6.0] | ≤ [8.5] | ≤ [4.5] | ≤ [7.0] | ≤ [4.5] | ≤ [5.5] | ≤ [4.5] | ≤ [4.5] | ≤ [4.5] | ≤ [4.5] | ≤ [4.5] | ≤ [4.5] | ≤ [4.5] | ≤ [4.5] |
| 256 QAM | ≤ [9.0] | ≤ [11.5] | ≤ [6.0] | ≤ [8.5] | ≤ [6.0] | ≤ [7.0] | ≤ [6.0] | ≤ [6.0] | ≤ [6.0] | ≤ [6.0] | ≤ [6.0] | ≤ [6.0] | ≤ [6.0] | ≤ [6.0] | ≤ [6.0] | ≤ [6.0] |
| CP-OFDM | QPSK | ≤ [9.0] | ≤ [11.0] | ≤ [5.5] | ≤ [8.5] | ≤ [5.0] | ≤ [6.5] | ≤ [5.0] | ≤ [5.5] | ≤ [4.5] | ≤ [6.5] | ≤ [4.0] | ≤ [4.5] | ≤ [4.5] | ≤ [4.5] | ≤ [4.0] | ≤ [4.0] |
| 16 QAM | ≤ [9.0] | ≤ [11.0] | ≤ [5.5] | ≤ [8.5] | ≤ [5.0] | ≤ [6.5] | ≤ [5.0] | ≤ [5.5] | ≤ [4.5] | ≤ [5.0] | ≤ [4.5] | ≤ [4.5] | ≤ [4.5] | ≤ [4.5] | ≤ [4.5] | ≤ [4.5] |
| 64 QAM | ≤ [9.0] | ≤ [11.0] | ≤ [6.0] | ≤ [8.5] | ≤ [6.0] | ≤ [6.5] | ≤ [6.0] | ≤ [6.0] | ≤ [6.0] | ≤ [6.0] | ≤ [6.0] | ≤ [6.0] | ≤ [6.0] | ≤ [6.0] | ≤ [6.0] | ≤ [6.0] |
| 256 QAM | ≤ [9.0] | ≤ [11.0] | ≤ [7.0] | ≤ [8.5] | ≤ [7.0] | ≤ [7.0] | ≤ [7.0] | ≤ [7.0] | ≤ [7.0] | ≤ [7.0] | ≤ [7.0] | ≤ [7.0] | ≤ [7.0] | ≤ [7.0] | ≤ [7.0] | ≤ [7.0] |
| NOTE 1: Full allocation A-MPR applies when all RB’s in a 20 MHz channel or all RB’s in all sub-bands for wideband operation are fully allocated and all sub-bands are transmitted. Partial allocation A-MPR applies when one or more RB’s in one or more sub-bands are not allocated but when all sub-bands within the channel are transmitted. When not all sub-bands within the channel are transmitted, the A-MPR associated with the channel bandwidth according to the bandwidth of the contiguously transmitted sub-bands and according to the allocation type applies.NOTE 2: Applicable to Pi/2-BPSK modulation when IE powerBoostPi2BPSK is set to 0. |

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**Issue 2-4: A-MPR table for NS\_54**

Proposal 1:

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| --- | --- | --- | --- |
| Pre-coding | Modulation | RB Allocation (Note 2) | RB Allocation (Note 3) |
|  |  | Full/Partial | Full (dB) | Partial (dB) |
| DFT-s-OFDM | PI/2 BPSK4 | See Table 6.2F.2A.2-1 | ≤ [3.5] | ≤ [5.0] |
| QPSK | ≤ [3.5] | ≤ [5.0] |
|  | 16 QAM |  | ≤ [3.5] | ≤ [5.0] |
|  | 64 QAM |  | ≤ [4.5] | ≤ [5.0] |
|  | 256 QAM |  | ≤ [6.0] | ≤ [6.0] |
| CP-OFDM | QPSK |  | ≤ [4.5] | ≤ [6.0] |
|  | 16 QAM |  | ≤ [4.5] | ≤ [6.0] |
|  | 64 QAM |  | ≤ [6.0] | ≤ [6.5] |
|  | 256 QAM |  | ≤ [7.0] | ≤ [7.0] |
| NOTE 1: Full allocation A-MPR applies when all RB’s in a 20 MHz channel or all RB’s in all sub-bands for wideband operation are fully allocated and all sub-bands are transmitted. Partial allocation A-MPR applies when one or more RB’s in one or more sub-bands are not allocated or when not all transmitted sub-bands for wideband operation are transmitted.NOTE 2: Applicable for all valid channels and bandwidth of contiguously transmitted sub-bands other than those valid in NOTE 3.NOTE 3: Applicable for bandwidths of contiguously transmitted sub-bands with an aggregated channel’s lower edge at 5945MHz. NOTE 4: Applicable to Pi/2-BPSK modulation when IE powerBoostPi2BPSK is set to 0. |

Proposal 2:

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| --- | --- | --- |
| Pre-coding | Modulation | Bandwidth of transmitted sub-bands / RB Allocation |
| RB Allocation (Note 4) | 40MHz – 100MHz (Note 5) | 120MHz – 160MHz (Note 6) |
|  |  | Full (dB)2 | Partial (dB)3 | Full (dB) | Partial (dB) | Full (dB) | Partial (dB) |
| DFT-s-OFDM | PI/2 BPSK7 | ≤ [3.0] | ≤ [3.5] | ≤ [5.0] | ≤ [3.0] | ≤ [4.0] |
| QPSK | ≤ [3.0] | ≤ [3.5] | ≤ [5.0] | ≤ [3.0] | ≤ [4.0] |
|  | 16 QAM | ≤ [3.5] | ≤ [4.0] | ≤ [5.0] | ≤ [3.5] | ≤ [4.0] |
|  | 64 QAM | ≤ [4.5] | ≤ [4.5] | ≤ [5.0] | ≤ [4.5] | ≤ [4.5] |
|  | 256 QAM | ≤ [6.0] | ≤ [6.0] | ≤ [6.0] | ≤ [6.0] | ≤ [6.0] |
| CP-OFDM | QPSK | ≤ [4.0] | ≤ [4.5] | ≤ [6.0] | ≤ [4.0] | ≤ [4.5] |
|  | 16 QAM | ≤ [4.5] | ≤ [4.5] | ≤ [6.0] | ≤ [4.5] | ≤ [4.5] |
|  | 64 QAM | ≤ [6.0] | ≤ [5.5] | ≤ [6.0] | ≤ [6.0] | ≤ [6.0] |
|  | 256 QAM | ≤ [7.0] | ≤ [7.0] | ≤ [7.0] | ≤ [7.0] | ≤ [7.0] |
| NOTE 1: Full allocation A-MPR applies when all RB’s in a 20 MHz channel or all RB’s in all sub-bands for wideband operation are fully allocated and all sub-bands are transmitted. Partial allocation A-MPR applies when one or more RB’s in one or more sub-bands are not allocated.NOTE 2: The A-MPR for Full allocation applies to all RBs in all contiguously transmitted sub-bands for operation that are fully allocated.NOTE 3: The A-MPR for Partial RB allocation applies to all contiguously transmitted sub-bands with interlaced allocations with uplink resource allocation type 2 as specified in TS38.214 [10]. NOTE 4: Applicable for all valid channels and bandwidth of contiguously transmitted sub-bands other than those enumerated in NOTE 5 and NOTE 6.NOTE 5: Applicable for bandwidths of 40MHz - 100MHz of contiguously transmitted sub-bands with an aggregated channel’s lower edge at 5945MHz.NOTE 6: Applicable for bandwidths of 120MHz - 160MHz of contiguously transmitted sub-bands with an aggregated channel’s lower edge at 5945MHz. NOTE 7: Applicable to Pi/2-BPSK modulation when IE powerBoostPi2BPSK is set to 0. |

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**Issue 2-5: Alternative writing of Note 3 in proposal 1 in Issue 2-4 and Note 5 and Note 6 in proposal 2 in Issue 2-4.**

Proposal 1:

NOTE 3: Applicable for bandwidths of contiguously transmitted sub-bands with an aggregated channel’s lower edge at 5945MHz.

NOTE 5: Applicable for bandwidths of 40MHz - 100MHz of contiguously transmitted sub-bands with an aggregated channel’s lower edge at 5945MHz.

NOTE 6: Applicable for bandwidths of 120MHz - 160MHz of contiguously transmitted sub-bands with an aggregated channel’s lower edge at 5945MHz.

Proposal 2:

Applicable for bandwidths of contiguously transmitted sub-bands with the first carrier’s centre frequency at 5925 + 20 + X/2, where X is the first carrier’s bandwidth. The second carrier is adjacent to the first carrier. The bandwidths above account only for the bandwidth of the contiguous transmitted sub-bands.

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| Companies | Comments |
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**Issue 2-6: Adding spurious emissions, general and additional emissions.**

### 6.5F.3A Spurious emissions for CA

#### 6.5F.3A.0 General

To improve measurement accuracy, sensitivity and efficiency, the resolution bandwidth may be smaller than the measurement bandwidth. When the resolution bandwidth is smaller than the measurement bandwidth, the result should be integrated over the measurement bandwidth in order to obtain the equivalent noise bandwidth of the measurement bandwidth.

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

#### 6.5F.3A.1 General spurious emissions

For intra-band contiguous carrier aggregation, the spurious emission limits apply for the frequency ranges that are more than FOOB (MHz) in Table 6.5F.3A.1-1 from the edge of the aggregated channel bandwidth. For frequencies ΔfOOB greater than FOOB as specified in Table 6.5F.3A.1-1 the spurious emission requirements in Table 6.5.3.1-2 are applicable.

Table 6.5F.3A.1-1: Boundary between out of band and spurious emission domain for intra-band contiguous carrier aggregation

|  |  |
| --- | --- |
| Aggregated channel bandwidth | OOB boundary FOOB (MHz)  |
| BWChannel\_CA | BWChannel\_CA + 5 |

#### 6.5F.3A.2 Spurious emissions for UE co-existence

Spurious emissions requirements for UE coexistence are not applicable to bands restricted to stand-alone operation with shared spectrum channel access as identified in Table 5.2-1.

#### 6.5F.3A.3 Additional spurious emissions

##### 6.5F.3A.3.0 General

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

##### 6.5F.3A.3.1 Requirements for network signalling value "CA\_NS\_53" or "CA\_NS\_54"

When "CA\_NS\_53" or "CA\_NS\_54" is indicated in the cell, the power of any UE emission shall not exceed the levels specified in Table 6.5F.3A.3.1-1. These requirements also apply for the frequency ranges that are less than FOOB (MHz) in Table 6.5.3.1-1 from the edge of the aggregated channel bandwidth.

Table 6.5F.3A.3.1-1: Additional requirements

|  |  |  |
| --- | --- | --- |
| Frequency band(MHz) | Spectrum emission limit(dBm) | Measurement bandwidth |
| f ≤ 5925 | -27 | 1 MHz |
| f ≥ 7125 | -27 |

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# Reference

[1] R4-2316808, Draft CR for introducing NR-U uplink CA for NS\_53 and NS\_54, Charter Communications Inc

[2] R4-2313823, Simulation results on UE RF NR-U UL CA A-MPR for PC5, Charter Communications Inc

[3] R4-2311250, On NR-U ULCA A-MPR for NS\_53 and NS\_54, Apple Inc

[4] R4-2316777, PC5 NR-U CA\_n96B A-MPR for NS\_53 NS\_54, Skyworks Solutions Inc,