**3GPP TSG-RAN WG4 Meeting # 100eR4-2114899**

**Electronic Meeting, Aug. 16-27, 2021**

**Source:** Skyworks Solutions, Inc. […..]

**Title:** WF on NRU ULCA cases and evaluation assumptions

**Agenda Item:** 8.7.2 UE RF requirements for FR1 [NR\_CA\_R17\_intra-Core]

**Document for:** Approval

# Valid configurations for NR-U contiguous UL CA

In round one, a first discussion on contiguous NR-U UL CA CC configurations was done based on proposals in [1]

The scope of the way forward is to agree on a reduced set of cases to use for the MPR/A-MPR studies to manage the workload and reduce the complexity of the specification. It is not intended to limit the system design and implementation.

## Wideband operation configuration in each CC

Each CC must respect current single CC restriction of only contiguous sub-bands are transmitted, there is also consensus that sub-bands should be contiguous across both CCs. Like for single CC UL, if there is an LBT failure in one scheduled sub-band, the whole Cc is not transmitted.

Way-Forward:

* Only contiguous sub-bands across the two CCs can be scheduled in NR-U UL CA
* In case of LBT failure in one scheduled sub-band, the corresponding CC is not transmitted.

## Waveform type and modulation order in each CC

Having the same modulation in each CC (ie CP-OFDM+CP-OFDM or DFT-s-OFDM+DFT-s-OFDM) was proposed, and questions were raised if this kind of restriction were agreed in NR UL CA. If one looks at the NR UL CA MPR in Table 6.2A.2.1-1 in 38.101-1, the MPR table is organized by waveform type and modulation type showing that indeed same waveform type and modulation order is used in each CC.

Way-Forward: Same waveform type (CP-OFDM or DFT-s-OFDM) and modulation order is used in each CC.

## Channel configuration priorities

Current understanding from one company is that there are no restrictions on DL CA related to channel bonding rules and thus this should not apply to UL.

Given this we can at least agree on priorities for evaluation of the more critical case for NR-U competitiveness, provided that the MPR can apply to any 2CC channel configurations.

Way forward:

* 20+20 and 80+80MHz 2CC channel configurations are evaluated in priority provided that MPR can apply to all cases up to 160MHz aggregated bandwidth
* Aggregation with 60MHz must consider channelization constraints
* Aggregation with 100MHz must wait for 100MHz channel channelization agreement

## Full and interlace allocation in each CC

No agreement was reached on the valid configurations for full and interlace waveforms in each CC and especially if the same RB allocation is used in each CC. Also constraints on RB position in each CC for interlaces could not be agreed. Since it may be difficult to agree on such restrictions, it is better to agree a limited number of scenarios for evaluation and then further check if other configurations can be covered with the derived MPR and A-MPR.

Way forward:

* For MPR and A-MPR evaluation, the following scenarios are prioritized:
	+ Lowest valid SCS is used
	+ Full allocation in CC1 and CC2
	+ 1RB0 interlace in CC1 and 1BB interlace in CC2 positioned such that the interlaces in CC1 and CC2 are aligned (distance between highest allocated RB in CC1 and lowest allocated in CC2 should be as close as possible to a multiple of the interlace repetition)
	+ This is evaluated for fully allocated channel and wideband operation cases
* FFS if derived back-off for MPR and A-MPR can be used for any allocation configuration
* Evaluation of Full in CC1 + interlace in CC2 is not precluded
* Evaluation of unaligned interlaces in CC1 and CC2 are not precluded

# Requirements and evaluation for contiguous NR-U UL CA

## MPR and A-MPR cases priority

There was consensus that covering MPR and A-MPR for n46 NS\_28/29/30/31 and n96 NS\_53/54 should be the priority.

Way Forward: Priority is given to contiguous UL CA evaluation of MPR and A-MPR for n46 NS\_28/29/30/31 and n96 NS\_53/54 for normal (entire CC) and wideband operation.

## Background: agreed emissions requirements

A number of emission requirements are already agreed in [2] and the relevant part for n46 and n96 is copied here:

**Table [1]: General requirements for intra-band contiguous NR-U CA ACLR**

|  |  |
| --- | --- |
|  | **ACLR / Measurement bandwidth** |
| **CA ACLR** | 27 dB |
| **CA Measurement bandwidth (NOTE 1)** | Nominal channel space+MBWACLR,low/2+ MBWACLR,high/2 |
| **Adjacent channel centre frequency offset (in MHz)** | + BWChannel\_CA / - BWChannel\_CA |
| **Difference between ACLR MBW center and Fc,low** | MBWshift= (MBWACLR\_CA-MBWACLR,low)/2 |
| **NOTE 1: MBWACLR,low and MBWACLR,high are the single-channel ACLR measurement bandwidths specified for channel bandwidths BWchannel(low) and BWchannel(high) in 6.5.2.4.1-1(see Appendix), respectively.** |

**Table [3]: 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 |

For spurious emissions the generic NR spurious emission Table is valid with the yellow highlighted rows corresponding to n46 and n96 bands.

**Table [4]: Requirement for general spurious emissions limits for NR-U CA**

|  |  |  |  |
| --- | --- | --- | --- |
| **Frequency Range** | **Maximum Level** | **Measurement bandwidth** | **NOTE** |
| **9 kHz ≤ f < 150 kHz** | -36 dBm | 1 kHz |  |
| **150 kHz ≤ f < 30 MHz** | -36 dBm | 10 kHz |  |
| **30 MHz ≤ f < 1000 MHz** | -36 dBm | 100 kHz |  |
| **1 GHz ≤ f < 12.75 GHz** | -30 dBm | 1 MHz | 4 |
| -25 dBm | 1 MHz | 3 |
| **12.75 GHz ≤ f < 5th harmonic of the upper frequency edge of the UL operating band in GHz** | -30 dBm | 1 MHz | 1 |
| **12.75 GHz < f < 26 GHz** | -30 dBm | 1 MHz | 2 |
| **NOTE 1: Applies for Band that the upper frequency edge of the UL Band more than 2.69 GHz****NOTE 2: Applies for Band that the upper frequency edge of the UL Band more than 5.2 GHz****NOTE 3: Applies for Band n41, CA configurations including Band n41, and EN-DC configurations that include n41 specified in clause 5.2B of TS 38.101-3 [3] when NS\_04 is signalled.****NOTE 4: Does not apply for Band n41, CA configurations including Band n41, and EN-DC configurations that include n41 specified in clause 5.2B of TS 38.101-3 [3] when NS\_04 is signalled.** |

Furthermore, SEM requirement for normal operation (full CC) is also agreed in [2] but SEM for wideband operation is lacking.

|  |  |  |
| --- | --- | --- |
| **ΔfOOB****(MHz)** | **Spectrum emission limit (dBr)** | **Measurement bandwidth** |
| **± 0 - 1** | $$-20 \left|∆f\_{OOB}\right|$$ | [100kHz]3 |
| **± 1 - 5** | NOTE 1 | 1 MHz |
| **± 5 - BWChannel\_CA** | NOTE 2 | 1 MHz |
| **± BWChannel\_CA – (BWChannel\_CA +5)** | -40 | 1 MHz |
| **NOTE 1: C****NOTE 2: Given as:** $-16-\left(^{12}/\_{B}\right) \left|∆f\_{OOB}\right|$ **where** $B= \left(^{BWChannel\\_CA}/\_{2}\right)$**NOTE 3: The measured value shall be scaled by a factor equal to the ratio of the reference bandwidth (1 MHz) to the measurement bandwidth before the emission limit (dBr) is applied.** |

## SEM for wideband operation

Since the transmitted sub-bands are contiguous across the CCs, the UL wideband operation SEM can be based on the aggregated transmitted sub-band BW and as for the single CC case have an in-band floor of -28dBr to accommodate the image leakage and a 1MHz exception for carrier leakage.

Let’s define: BWSub-band\_CA as the aggregated bandwidth across the two CCs of the transmitted Sub-bands. While as already defined, BWChannel\_CA is the aggregated channel BW

Way forward on Wideband operation contiguous UL CA SEM:

* SEM is defined only for cases where transmitted sub-bands are contiguous across the two CCs
* A single SEM mask can be defined using rules as defined in 38.101-1 section 6.5F.2.2.1 “Spectrum emission mask for non-transmitted channels”
	+ OOB part of the mask is based on the aggregated channel bandwidth BWChannel\_CA as per Table 6.5F.2.2-1 where Channel Bandwidth is replaced by BWChannel\_CA
	+ In-band 0dBr part is based on the aggregated contiguous scheduled sub-bands bandwidth BWSub-band\_CA with same specification as in 6.5F.2.2.1:

In the case of non-transmitted 20 MHz channel(s) on the edges of an assigned channel bandwidth the spectrum emission mask for operation with shared spectrum channel access, specified in Table 6.5F.2.2-1, is applied by using the total bandwidth of the remaining transmitted channels. The spectrum emission mask for non-transmitted channels is floored at -28dBr.

The relative power of any UE emission shall not exceed the most stringent levels given by the spectrum emission mask for operation with shared spectrum channel access with full channel bandwidth and the spectrum emission mask for non-transmitted channels with the channel bandwidth of the transmitted channels in the case of non-transmitted channels at the edge of an assigned channel bandwidth.

An exception to the spectrum emission mask for non-transmitted channels allows a single [2] MHz bandwidth to extend to [-28] dBc relative to total transmit power, or [-20] dBm, whichever is the greatest. to account for image leakage like for wideband operation single CC case

## Architecture and PA calibration assumptions

As proposed in [1], since only PC5 is finalized for NR-U single CC, UL CA is also based on PC5; and as for NR contiguous UL CA, architecture is based on single PA.

Way forward:

* Single PC5 transmit chain with 1LO is the baseline architecture used to derive MPR tables, one LO leakage exception is specified
* FFS if two transmit chains, two LO architecture is accommodated for > 100MHz aggregated BW.
* If accommodated, it shall use the same MPR table than baseline architecture
* FFS if two LO leakage exceptions are specified

Evaluation assumptions:

* Post PA losses: 4dB
* PA is calibrated for 19dBm at the antenna with 20MHz 100RB3 DFT-s-OFDM QPSK waveform

# References

[1] R4-2112304 NRU ULCA including wideband operation, Skyworks Solutions Inc., RAN4#100e

[2] R4-2107807 WF on introduction of NR-U ULCA requirements, Qualcomm, RAN4#99e