**3GPP TSG-RAN WG4 Meeting #112-bis R4-2417111**

**Hefei, China, 14th -18th Oct, 2024**

**Title:** WF on power domain enhancements

**Agenda Item:** 6.1.3

**Source: Huawei, HiSilicon**

**Document for:** Approval

# Topic #1: Power domain enhancements for single carrier

#### **Issue 1-1-1: Approaches for scenario 1**

* WF
	+ Strive to the unified solution which can accommodate both scenario 1 and scenario 2 under the framework with converting outer RB allocation to inner RB allocation.
		- It does not preclude separate solutions for each applicable scenario
		- No relaxation of ACLR/SEM/SE values

**Issue 1-2-1: Clarification of BS CBW**

* WF
	+ The approach of converting outer RB allocation to inner RB allocation should consider multi-carrier spectrum scenario from NW perspective while limit MPR reduction for single CC of the UE side.

**Issue 1-2-2: Approaches of converting outer RB allocation to inner RB allocation**

* WF
	+ The approach should consider the following aspects
		- General solution could be applicable for both scenario 1 and scenario 2
		- General solution considering the spectrum allocation status of operators, e.g multi-CC case from NW perspective, to better leverage the feature of MPR reduction
		- Solution could benefit RedCap and non-RedCap with UE CBW less or even identical to BS CBW
		- Solution could include both symmetric and asymmetric CBW extension
		- Whether the extended UE CBW could exceed the BS CBW for different scenarios
		- Signalling overhead is considered for the proposed approach(s)

#### **Issue 1-2-3: Where to use IBE in the larger BS CBW**

* WF
	+ IBE should be used between edges of UE CBW and extended UE CBW
		- FFS whether IBE could be used in the guard band of UE CBW
		- FFS the full RB allocation scenario
		- FFS the impact to testability

#### **Issue 1-2-4: Boundary to apply ACLR and SEM**

* Proposals
	+ Proposal 1: ACLR and SEM should be applicable from the edge of extended UE CBW instead of the BS CBW. (OPPO, China Telecom, Sony, Qualcomm, vivo, ZTE, Huawei)
	+ Proposal 2: ACLR, SEM and spurious emissions would be defined based on BS channel bandwidth. (Nokia, Ericsson, CATT, Murata)
* WF
	+ FFS in next meeting
		- ITU regulation of 250% necessary bandwidth should be considered in further analysis

#### **Issue 1-2-5: Boundary to apply SE**

* Proposals
	+ Proposal 1: The application range of SE should be altered with the shifting of the edge of the UE CBW. (OPPO, China Telecom, Murata, vivo, MTK, Huawei)
	+ Proposal 2: SE is applied at BS channel bandwidth. (Nokia, Ericsson)
* WF
	+ FFS in next meeting
		- ITU regulation of 250% necessary bandwidth should be considered in further analysis

#### **Issue 1-2-6: Which CBW is utilized as the basis for the integral region of OOBE**

* Proposals
	+ Proposal 1: The integral region and the boundary of OOBE should be based on UE CBW. (OPPO, China Telecom, vivo, ZTE, MTK, Sony, Huawei, LGE)
	+ Proposal 2: The integral region and boundary of OOBE is based on BS CBW. (Ericsson, Nokia)
* WF
	+ FFS in next meeting

#### **Issue 1-2-7: Ratio size of extended CBW between UE CBW and larger BS channel BW**

* WF
	+ To discuss the following aspects for the extended UE CBW:
		- Whether the extended CBW with new boundary of FOOB should comply with the recommendation by ITU-R on necessary bandwidth in terms of SE for the original UE BW
		- Whether default or fixed extension, e.g. 1/2 UE CBW could be stipulated in the spec or the extension ratio could be a UE capability to fulfil the conversion of outer to inner
		- Whether the extended UE CBW could belong to the regular defined channel bandwidth
		- Whether some premise should be established for the extension size, e.g.
			* minimum extended CBW compared to original UE CBW
			* minimum BS CBW compared to UE CBW
			* frequency separation of the RB allocation to the BS edge
		- Other identified issues are not precluded

#### **Issue 1-2-8: Asymmetrical extended CBW approach**

* WF
	+ Asymmetrical extension is considered, FFS the solution.

#### **Issue 1-2-10: Signaling aspects**

* Proposals
	+ Proposal 1: on advertised BS transmission BW signalling: (Skyworks)
		- To enable more use cases to be covered in the future, the BS advertised transmission BW may be smaller than, equal to or larger than the BS CBW, depending on where the ACLR/SEM and spurious emission limits need to be met.
		- It is advertised via:
			* BS\_NRB parameter that can be up to 566 as it is limited to twice the largest UE CBW.
			* RB0shift parameter to signal where the UE RBs are placed within the BS RBs, this parameter should be able to place any UE CBW within twice the largest UE CBW.
			* Where 10bit seems sufficient to code both parameters.
	+ Proposal 2: no changes of signalling are specified for the feature ‘narrower UE channel BW within wider BS bandwidth’ except specification of a capability bit to indicate support of the feature. (Ericsson)
	+ Proposal 3: If any reduction of MPR would be specified in the end, it should be an optional feature for UE with per band capability. (Sony)
	+ Proposal 4: The frequency interval for UE (or RB allocation) and BS edge should be judged by the NW. When the interval is wide enough, the NW could indicate which side of the UE CBW should be extended. (vivo)
		- The UE would refer to the inner MPR requirement instead.
		- At the same time, the corresponding emission requirements could be tested based on the agreed virtual extended UE CBW, which is proportional to the UE CBW
	+ Proposal 5: BS indication should be designed to allow selection of which ACLR/SEM/spurious emission can be relaxed to fully enable this feature. (NTT DOCOMO)
	+ Proposal 6: The information exchange between NW and UE should contain the required offset for UE to convert outer to inner. It also should have a UE capability that indicates whether adjacent channel has enough space to extend which is for NW to make configuration. (China Telecom)
* WF
	+ To further discuss the signalling aspects with consideration of above proposals in conjunction with the solution to be adopted for MPR reduction.
		- Companies are encouraged to provide thinking on signalling impact together with the proposed solution

# Topic #2: MPR applicability for FR1 intra-band UL CA

### Sub-topic 2-1: Intra-band contiguous UL CA

#### **Issue 2-1-1: Applicable MPR for intra-band contiguous CA with single activated cell**

Tentative agreement in main session:

* For PC3/PC2 intra-band contiguous carrier aggregation with single CC with activated cell, the following MPR requirements are applied
	+ MPR defined in Table 6.2.2-1 applies for UE power class 3 CA bandwidth classes B and C;
		- The Rel-18 power boosting feature can be supported depending on UE capability
			* FFS on whether the Rel-18 or new signalling is needed
			* ~~FFS if the further requirements need be changed for the power boosting feature~~
	+ MPR defined in Table 6.2D.2-1 applies for power class 2 CA bandwidth classes B and C when TxD and/or UL-MIMO capability are indicated
	+ MPR defined in Table 6.2.2-2 applies for power class 2 CA bandwidth classes B and C when TxD and/or UL-MIMO capability are absent.
* FFS PC1.5 MPR enhancement as intra-band CA MPR requirements for PC1.5 are not available yet

#### **Issue 2-1-2: Single CC CBW or aggregated CBW for applying requirements of ACLR/SEM/SE**

* Proposals
	+ Proposal 1: activated CC CBW or aggregated CBW adopted for integral region and boundary of spurious emissions/ACLR/SEM depending on *dualPA-Architecture* IE indication. (vivo, Skyworks)
		- For PC3/PC2 intra-band contiguous carrier aggregation with single CC activated, when *dualPA-Architecture* IE is indicated, the single CC MPR could apply. And the integral region and boundary of SE/ACLR/SEM should be based on the activated CBW.
		- For PC3/PC2 intra-band contiguous CA with single CC with activated cell, when *dualPA-Architecture* IE is not indicated, the MPR of the single carrier could apply. And the integral region and boundary of SE/ACLR/SEM should be based on the aggregated CBW.
	+ Proposal 2: Emission requirements are based on aggregated channel bandwidth also in case that only one CC is activated. (Nokia, CATT, Qualcomm, ZTE, Huawei)
* WF
	+ FFS in next meeting

#### **Issue 2-1-3: Single CC or CA requirements of ACLR/SEM/SE applied for single activated cell**

* Proposals
	+ Proposal 1: CA requirements of ACLR/SEM/SE should be applied for intra-band contiguous CA with single activated cell. (OPPO, Nokia, Qualcomm, ZTE, Huawei)
	+ Proposal 2: (Skyworks, vivo)
		- For UE supporting contiguous ULCA with the dualPA IE:
			* The applicable SEM, ACLR and spurious emissions are the **single CC emissions** defined in Table 6.5.2.2-1, Table 6.5.2.4.1-1 and Table 6.5.3.1-2 respectively.
		- For UE supporting contiguous ULCA without signalling the dualPA IE or signalling PC1.5 or TxD or UL MIMO support:
			* The applicable SEM, ACLR and spurious emissions are the **configured contiguous ULCA CC emissions** defined in Table 6.5A.2.2.1-1, Table 6.5.2.4.1-1 and Table 6.5.3.1-2 respectively.
	+ Proposal 1: After the initial configuration of contiguous ULCA, upon SCELL deactivation with only 1CC active, the applied SEM mask should be the aggregated CA BW SEM as stated in sub-clause 6.5A.2.2.1 in TS38.101-1. **Further discuss SEM mask for single CC fall back only if dualPA-architecture is supported** (Murata)
		- Observation: If there are unallocated PRBs in contiguous ULCA, as there are in a deactivated carrier, the In-band Emissions (IBE) mask applies to the unallocated RBs in that deactivated carrier as stated clearly in TS38.101-1. Logically, the SEM mask must apply outside of the IBE mask (Murata)
	+ Proposal 3: Apply single carrier spurious emission/ACLR/SEM requirements for contiguous UL CA with only 1 CC transmitted. (CATT)
* WF
	+ FFS in next meeting

#### **Issue 2-1-4: Whether UL interruption is allowed for intra-band contiguous CA with single activated cell**

* Proposals
	+ Proposal 1: No interruptions are allowed for enabling single carrier MPR for the case when only one CC is activated in intra-band contiguous UL CA.
* Agreement in AH
	+ Proposal 1

### Sub-topic 2-2: Intra-band non-contiguous CA

#### **Issue 2-2-1: Applicable MPR for FR1 intra-band non-contiguous UL CA**

* Proposals

**Option 1**: No spec impact or minimum spec impact with some clarification but no changes of requirements

* + Proposal 1: for PC3 and PC2 intra-band non-contiguous CA as the standard already accounts for the use of the single CC MPR tables when only 1 CC is scheduled **no further changes to the standard are required**. (Qualcomm, OPPO, Huawei)
	+ Proposal 2: adding 1CC activation as a supplementary scenario in the spec but no changes of the requirements (vivo)
		- For PC3 and PC2 intra-band non-contiguous CA with single CC with activated cell, when dualPA-Architecture IE is indicated, the MPR of single carrier applies and no spec changes are needed except for adding 1CC activation as a supplementary scenario.
		- For PC3 and PC2 intra-band non-contiguous CA with single CC with activated cell, when dualPA-Architecture IE is not indicated,
			* Activating 1CC could be added as a supplementary scenario after configuring 1CC
			* No need to specify all intra-band NC CA with single CC activated to follow single carrier’s MPR.
			* If 5.5dB and 6.5dB could not guarantee the output performance of narrow RB allocation cases then it should be re-evaluated in other items so that the worst scenario could be covered.
	+ Proposal 3: **single CC MPR applied with single CC emission requirements**: (Skyworks)
		- The MPR in tables Table 6.2.2-1, 6.2.2-2, 6.2D.2-1 and 6.2D.2-2 apply for PC3, PC2 1Tx, PC2 2Tx and PC1.5 respectively.
		- The applicable SEM, ACLR and spurious emissions are the single CC emissions defined in Table 6.5.2.2-1, Table 6.5.2.4.1-1 and Table 6.5.3.1-2 respectively.
		- For band specific emissions, the NS requirement applies when RBs are active in only one CC.
		- UL interruption for LO retuning is allowed for UE supporting non-contiguous ULCA without signalling the dualPA IE or UE signalling PC1.5, TxD or UL MIMO support.

**Option 2**: Single CC MPR/SEM applied on indication of dualPA IE

* + Proposal 4: To apply **non-CA (single CC) MPR based on indication of dualPA IE** (Ericsson)
		- specify in 38.101-1 that for non-contiguous UL CA configurations with sub-blocks consisting of one cell and supported by dual PA architecture, the non-CA (single CC) MPR applies for one cell active among the configured uplink serving cells, the other cell deactivated.
		- specify in 38.101-1 that for non-contiguous UL CA configurations with sub-blocks consisting of one cell not supported by a dual PA architecture, applicability of the non-CA (single CC) MPR for one active cell among the configured uplink serving cells, the other cell deactivated, is subject to UE capability, e.g. indication of [mpr-singleCC-activated-FR1] for the band combination.
		- consider specification of non-CA MPR for UL intra-band non-contiguous CA configurations with 2Tx and non-concurrent UE transmissions in a new or updated WI, this enhancement subject to UE capability and based on improved requirements based on state-of-the-art performance.
	+ Proposal 5: After the initial configuration of non-contiguous ULCA, upon SCELL deactivation with only 1CC active, **the applied SEM mask should be the composite SEM** of the 2CCs as stated in sub-clause 6.5A.2.2.2 in TS38.101-1. Further discuss to support the single CC SEM only if dualPA-architecture is supported. (Murata)
		- Further discuss the added requirement for LO settling time per UE capability to support single CC MPR fallback for single PA architecture without minimum RB allocation condition this meeting.
		- If the LO-retuning capability is not scope of the power domain enhancement for ULCA work item, then apply single CC fall-back MPR as defined in sub-clause 6.2A.2.2.0 upon SCELL deactivation when dual PA architecture is not supported.

**Option 3**: Possible spec impact on LO retuning

* + Proposal 6: (Apple)
		- Discuss impact on requirements if LO needs to be re-configured to support single CC MPR. This discussion would be required for intra-band contiguous and non-contiguous carrier aggregation.
* WF (to be discussed in main session)
	+ For PC2 and PC3, no MPR requirements to be changed.
	+ FFS PC1.5 when NC CA requirements are available
	+ FFS clarification for the applicable emission requirements whether they are single CC based or composite based
	+ Further check whether LO retuning is out of WI scope, if not included, drop the corresponding discussion in Rel-19

# Topic #3: MPR applicability for FR2

#### **Issue 3-1-2: Applicable MPR for FR2 UL CA with DL intra band CA**

Agreement in main session:

* + In general, with UE indication of new capability [FR2 MPR enhancements-R19] for MPR improvement, MPR based on UL BWchannel\_CA applies instead that based on cumulative aggregated channel BW (CABW).
		- If only 1 UL CC is activated, the MPR requirements of single carrier could be reused.
		- A note should be added to the MPR table, e.g.



* + For FR2-1, for 200MHz BW granularity, RAN4 to change the MPR calculation for DFT-s-BPSK or DFT-s-QPSK from “MPRC\_CA = MAX(MPR1, MPR2)” to “MPRC\_CA = MPR2”, for UE with UE indication of new capability for MPR improvement.

#### **Issue 3-2-1: Optional UE capability**

Agreement in main session:

* + An optional per UE capability for FR2 is introduced
		- The capability is implementation agnostic
		- Supporting FR2 MPR enhancement is not release independent