**3GPP TSG-RAN WG4 Meeting #110 R4-2401102**

**Athens, Greece, 26 Feb - 01 Mar, 2024**

**Agenda item:** 12.4

**Source:** Moderator (Samsung)

**Title:** Topic summary for [110][143] NR\_power\_class

**Document for:** Information

# Introduction

This email thread is focused on the Power class related topics under AI 12.2.1.

# Topic #1: Title

*Main technical topic overview. The structure can be done based on sub-agenda basis.*

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2400201 | Samsung | 1. *ue-PowerClassPerBandPerBC-r17* is applicable to only NR inter-band UL CA, i.e. when there is uplink configured in two different operating bands. Each uplink band contains only single UL CC or intra-band contiguous UL CA. *ue-PowerClassPerBandPerBC-r17* is not applicable to MR-DC BCs.
2. *ue-PowerClassPerBandPerBC-r17* indicates the power class over the carrier(s) for each individual band within a given band combination that a UE supports, while *powerClass*/*powerClass-v1610* indicates the power class for the NR inter-band ULCA.
3. *ue-PowerClassPerBandPerBC-r17* if indicated for a band shall determine the power class over the carrier(s) for this constituent band of a band combination, otherwise *ue-PowerClass*/*ue-PowerClass-v1610*/*ue-PowerClass-v1700* applies.
4. *ue-PowerClassPerBandPerBC-r17* does not modify *powerClass/powerClass-v1610* for a band combination and conversely. The capability definition of *powerClass/powerClass-v1610* requires update to include *ue-PowerClassPerBandPerBC-r17,* i.e., if the power class indicated by *powerClass/powerClass-v1610* is higher than the power class that the UE supports on the individual bands of this band combination (*ue-PowerClassPerBandPerBC-r17* if indicated or *ue-PowerClass* in *BandNR otherwise*), the latter determines maximum TX power available in each band.
 |
| R4-2400202 | Samsung | ***Observation 1: There is no doubt that the applicable power for a band within a BC should be capped by the value indicated by IE PowerClass for this band combination, in terms of intra-band ULCA, inter-band ULCA(2CC), and inter+intra ULCA(3CC).*** ***Observation 2: Regarding the applicable power class for a band within a BC, both alternatives (Alt 1 is ue-PowerClass; Alt2 is Min (ue-PowerClass, PowerClass)) are workable with pros and cons for each.******Observation 3: It appears the group have concern on changing the power class for the constituent band within the BC.******Observation 4: For DLCA only(either inter- or intra- or inter+intra), inter-band ULCA(2CC), inter+intra ULCA(3CC), it is suggested to adopt ue-PowerClass as default applicable power class, if PowerClassPerBandPerBC-r17 is absent .******Observation 5: For intra-band ULCA, maintain the agreement of RAN4#108 to adopt PowerClass as default applicable power class for this band.******Observation 6: Do not extend the applicability of PowerClassPerBandPerBC-r17 to DLCA only case nor intra-band ULCA case.******Proposal 1:***

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Scenario** | **Whether *ue-PowerClassPerBandPerBC-r17* is applicable for this scenario** | **The default applicable power class for the constituent band within the BC if *ue-PowerClassPerBandPerBC-r17* is absent or not applicable** |
| ***#1*** | ***Intra-band ULCA*** | ***No*** | ***PowerClass*** |
| ***#2*** | ***Inter-band 2CC ULCA*** | ***Yes*** | ***ue-PowerClass*** |
| ***#3*** | ***Inter+intra 3CC ULCA*** | ***Yes*** | ***ue-PowerClass*** |
| ***#4*** | ***Intra-band DLCA only*** | ***No*** | ***ue-PowerClass*** |
| ***#5*** | ***Inter-band DLCA only*** | ***No*** | ***ue-PowerClass*** |
| ***#6*** | ***Inter+intra DLCA only*** | ***No*** | ***ue-PowerClass*** |
| Note: In scenario #4/#5/#6, UL is single CC. |

***Proposal 2: In terms of DLCA only case, it is ok to allow UE to exceed PowerClass when ue-PowerClass is higher than PowerClass, with the assumption there is no MSD allowed(i.e., MSD=0) until this higher power class (the same value as indicated by ue-PowerClass) for this DLCA combo is introduced in spec.******Proposal 3: It is strongly recommended to send the clarified LS [10] to RAN2 in this meeting.*** |
| R4-2400345 | Nokia, Nokia Shanghai Bell | **Observation 1**: Process to determine the highest attainable power for a band in NR inter-band UL CA is as follows.A blue rectangular sign with white text  Description automatically generatedFigure 1: Process to determine the highest attainable power for a band in NR inter-band UL CA without intra band contiguous UL CA part**Observation 2**: RAN4#109 agreed to use *ue-PowerClass* to refer to the highest attainable power for UL intra band contiguous CA part within UL inter band CA in CRs of [R4-2318030, R4-2318031].**Observation 3**: Observation 2 means that even if a UE supporting e.g., UL CA\_n1A-n41C, indicates *powerClass* for intra band contiguous UL CA, e.g., CA\_n41C, the highest attainable power for n41C part in CA\_n1A-n41C is not determined by *powerClass* for CA\_n41C, but rather *ue-PowerClass* for n41, if *ue-PowerClassPerBandPerBC-r17* in n41 is not indicated.**Observation 4**: Observation 3 means that *powerClass* for intra band contiguous UL CA like CA\_n41C is irrelevant to the determination of the power for intra band contiguous UL CA part in NR inter-band UL CA.**Observation 5:** From Observation 2 - 4, the same process in Figure 1 applies to inter-band UL CA with intra band contiguous UL CA.With the consideration of the observations 1-5, we propose the content of the LS as follows.**Proposal 2**: Possible answer for the 2nd question* If *ue-PowerClassPerBandPerBC-r17* is indicated for a band(s) in an NR inter-band UL CA and
	1. if the power class in *ue-PowerClassPerBandPerBC-r17* is less than or equal to *powerClass* for the NR inter-band UL CA, the power class in *ue-PowerClassPerBandPerBC-r17* determines the highest power over the carrier(s) of the band(s) in the NR inter-band UL CA,
	2. otherwise, the *powerClass* determins the highest power in the band(s)
* In other words, the above corresponds to taking min {power class in *ue-PowerClassPerBandPerBC-r17*, *powerClass* for the NR inter-band UL CA} for a band(s), in case *ue-PowerClassPerBandPerBC-r17* for the band(s) is indicated.
* It is noted that, in a), the term carrier”s” corresponds to the case where the NR inter-band UL CA includes intra-band contiguous UL CA in it.
 |
| R4-2400346 | Nokia, Nokia Shanghai Bell | RAN4 further discussed two questions in the LS of R2-2211023 and would like to share following answers for the respective questions.Q1. Whether R4 16-8 is applicable to only inter-band CA?A1. *ue-PowerClassPerBandPerBC-r17* is applicable to only NR inter-band UL CA with two different operating bands where each uplink band contains single CC or multiple CCs (intra-band contiguous UL CA). It’s also noted that *ue-PowerClassPerBandPerBC-r17* is not applicable to MR-DC.Q2. What is the interaction between R4 16-8 and the existing power class capabilities (i.e. ue-PowerClass/ue-PowerClass-v1610/ue-PowerClass-1700, powerClassNRPart-r16 (if R4 16-8 is also applicable to the cases other than inter-band CA) and powerClass/powerClass-v1610) ?A2: If *ue-PowerClassPerBandPerBC-r17* is indicated for a band(s) in an NR inter-band UL CA and 1. if the power class in *ue-PowerClassPerBandPerBC-r17* is less than or equal to *powerClass* for the NR inter-band UL CA, the power class in *ue-PowerClassPerBandPerBC-r17* determines the highest power over the carrier(s) of the band(s) in the NR inter-band UL CA,
2. otherwise, the *powerClass* determines the highest power in the band(s)

In other words, the above corresponds to taking min {power class in *ue-PowerClassPerBandPerBC-r17*, *powerClass* for the NR inter-band UL CA} for a band(s), in case *ue-PowerClassPerBandPerBC-r17* for the band(s) is indicated. It is noted that, in a), the term carrier”s” corresponds to the case where the NR inter-band UL CA includes intra-band contiguous UL CA in it.. |
| R4-2401278 | ZTE Corporation | **Proposal: To consider the further clarification in the response to the LS from RAN2:****The new *ue-PowerClassPerBandPerBC-r17* is applicable to each band in the NR inter-band UL CA configurations, where single carrier or intra-band CA can be configured for each band as specified in TS 38.101-1.****If *ue-PowerClassPerBandPerBC-r17* is absent, the interaction between *ue-PowerClass/ue-PowerClass-v1610/ue-PowerClass-1700* and *powerClass/powerClass-v1610* have already been described in TS38.306 spec.****If *ue-PowerClassPerBandPerBC-r17* is present, and if the power class of the band combination indicated by *powerClass/powerClass-v1610* is higher than the power class that the UE supports on the individual bands of this band combination (*ue-PowerClassPerBandPerBC-r17*), the latter determines maximum TX power available in each**  |
| R4-2401279 | ZTE Corporation | ***Observation 1: There have been no descriptions or restrictions for the scenario of ‘If this power class is lower than the power class that the UE supports on the individual bands of this band combination (ue-PowerClass in BandNR)’ in TS38.306 from the beginning.******Observation 2: For non-CA UL, the power class is not included in the UE CA power class tables, instead, it refers to single band power class table, i.e. Table 6.2.1-1 in TS38.101-1.*****Proposal 1: In the case of DL only CA with single carrier in UL(i.e. non-CA UL), the power class for the UL single carrier is indicated by *ue-PowerClass/ue-PowerClass-v1610/ue-PowerClass-1700,* and it is not subject to the band combination power class indicated by *powerClass/powerClass-v1610.*****Proposal 2: To add the following additional corrections for combinations of intra-band and inter-band carrier aggregation in section 6.2A.4.1.3 in TS38.101-1:**

|  |
| --- |
| For combinations of intra-band and inter-band carrier aggregation with UE configured for transmission on three serving cells (up to two contiguously aggregated carriers per operating band), the following apply:The UE power class for the serving cell(s) on the operating band *Bi* including intra-band carrier aggregation shall be determined by the *ue-PowerClassPerBandPerBC-r17* IE [7] as indicated for the band combination if signalled, *ue-PowerClass/ue-PowerClass-v1610/ue-PowerClass-1700* otherwise.For the case when the UE indicates *higherPowerLimit-r17*, PPowerClass,CA is replaced by 10 log10 (pPowerClass,A + pPowerClass,CA,B). |

 |
| R4-2401520 | vivo | **Proposal 1:** Reliability, simplification and minimised impact are more important than optimized performance in choosing the way forward. Adding per-band limitation can be baseline if no NBC issue found.**Proposal 2:** Not considering the BC power class limitation for a single band can be preferred in case of DL CA only. |
| R4-2401795 | OPPO | **Whether the band within BC is capped by powerClass of the BC****Proposal 1: The MOP of a band within BC shall be capped by *powerClass* of the BC.****Proposal 2: Consider the case that UE Tx power in a band exceeds the total power class of band combination in future release if necessary.****Applicable power capability for band in inter-band UL CA****Observation 1: From UE Tx power point of view, UE Tx power of band in a BC will be limited by both *ue-PowerClass* and *powerClass* of the BC, i.e. actual max Tx power is Min {*ue-PowerClass*, *powerClass*}.****Observation 2: When *ue-PowerClassPerBandPerBC-r17* is absent, there seems no difference in adopting either *ue-PowerClass* of the band or Min{*ue-PowerClass*, *powerClass*} in determining UE Tx power since even the default power class is *ue-PowerClass*, in the end its Tx power still be limited by *powerClass* which is same as Min{*ue-PowerClass*, *powerClass*}.****Observation 3: From requirements test perspective, UE shall be tested according to its real max Tx power. In other words, when *ue-PowerClass* is higher than *powerClass*, then it shall be tested according to the lower power capability which caps the max Tx power.****Observation 4: If use *ue-PowerClass* as the default power class, then it means UE has to report *ue-PowerClassPerBandPerBC-r17* when *ue-PowerClass* of band A is higher than *powerClass* of A+B. This probably is doable for Rel-17 and onwards, but apparently is not for Rel-15/16.****Proposal 3: The MPR/RF requirements to be tested for a band in BC shall be according to its real max Tx power which is capped by both *ue-PowerClass* of the band and *powerClass* of the BC when *ue-PowerClassPerBandPerBC-r17* is absent.** **Proposal 4: Apply Min{*ue-PowerClass, powerClass*} as the default power class when *ue-PowerClassPerBandPerBC-r17* is absent with considerations of*** **UE Tx power and requirements will be capped by the lower power capability of *ue-PowerClass* of the band and *powerClass* of the BC;**
* **And to make it applicable also for Rel-15/16 instead of only for Rel-17 onwards.**

**Applicable power capability and MPR for DL-only CA****Observation 5: From PA ability perspective, there is no difficulty to keep same Tx power as the single band power class as long as the MSD if any has been introduced in the spec.****Observation 6: From signalling perspective, if *powerClass* IE is applicable to DL-only CA case, then it can be different from *ue-powerClass* IE, and MOP of *powerClass* is no higher than MOP of *ue-powerClass* in DL-only CA.****Proposal 5: Clarify *powerClass* IE is applicable to DL-only CA scenario.****Proposal 6: For DL-only CA scenario, UE indicate its Tx power capability via *powerClass* IE, if not the default power class is applied.****Applicable power capability for intra-band UL CA in intra +inter band combination****Observation 7: If apply the *ue-powerClass* IE to determine the power class of intra UL CA in inter+intra UL CA, the UE power capabilities might be overestimated. One example is as below according to current spec:**

|  |  |
| --- | --- |
| Band / band combination | Power capability |
| UL CA\_n3A-n41C | *powerClass =* PC3 |
| UL CA\_n41C | *powerClass =* PC2 |
| UL n41 | *ue-powerClass* = PC1.5 |

**Observation 8: Pcmax,L of intra+inter UL CA is also bounded by the SUM of Pcmax,L of each band, and for Pcmax,L of intra-band UL CA the CA power class takes effect.****Observation 9: It is more nature to apply the power class of intra-band UL CA to determine the power capability of intra+inter band combination and this is also what specified in current spec.****Observation 10: For the intra-band UL CA, as long as the DL CA configuration is fixed, the applicable power capability is clear no matter it is reported via *powerClass* IE or inherited from parent BC power class.****Observation 11: For the same intra-band UL CA, if UE report different power classes when the DL CA configurations are different, then there will be some ambiguity in which power class should be applied for this intra-band UL CA.****Observation 12: Neither *ue-powerClass* IE nor *powerClass* IE is perfect in determining the power class of intra-band CA in inter+intra UL CA.****Observation 13: If use *ue-powerClass* IE as default, and UE real Tx power of intra-band UL CA in inter+intra UL CA, then UE can** **use the *ue-PowerClassPerBandPerBC-r17* IE to report the exact power capability.****Proposal 7: Apply *ue-powerClass* as default to determine the power capability of intra-band UL CA part in intra+inter UL CA from Rel-17 onwards, and if UE implementation is different from this it shall report the *ue-PowerClassPerBandPerBC-r17* IE to clearly indicate its power capability.** |
| R4-2401847 | Ericsson | Which capability applies? **Observation 1: the power capability for a NR non-CA band combination (BC) used by the network to request FS for bands can now be indicated by three (3) parameters, *ue-PowerClass, ue-PowerClassPerBandPerBC-r17* and *powerClass*.**Rather than trying to modify the applicability of the above parameters in 38.306, we propose that**Proposal 1: for NR non-CA band combinations, the UE shall meet the requirements according to the power class as indicated by the *Band NR* capability *ue-PowerClass* (hence the per-BC *powerClass* for these BCs should indicate support of the same power class).**We observe that**Observation 2: even if not intended originally, the *ue-PowerClassPerBandPerBC-r17* is now also reported for intra-band CA and NR non-CA band combinations in the field.**and that **Observation 3: given that *ue-PowerClassPerBandPerBC-r17* is already used for CA configurations other than UL inter-band as originally intended, it can also be used for an intra-band part of an UL inter-band combination no matter if 2Tx is used for meeting the per-band power class.**No matter the power-class indication**Proposal 2: for DL-only CA configurations, the UE shall meet the requirements according to the power class as indicated by the Band NR capability ue-PowerClass.**  |
| R4-2402210 | Huawei, HiSilicon | RAN4 would like to provide the following responses in replacement of the previous reply LS in R4-2303630.***Response to 1):*** *ue-PowerClassPerBandPerBC-r17* is applicable to NR inter-band UL CA, i.e. when there is uplink configured in two different operating bands. Each uplink band contains only single UL CC or intra-band contiguous UL CA. Additionally, it is also applicable to the fallback band combinations including single-carrier UL or intra-band CA UL with inter-band CA DL. It is not applicable to MR-DC, hence has no interaction with *powerClassNRPart-r16*.***Response to 2):*** It is RAN4’s common understanding that:* *ue-PowerClass* and its extensions are used to indicate the power class capability for single-carrier operations on a given band. It represents the upper bound of the maximum output power that a UE can support on this band;
* *powerClass* and its extension are used to indicate the power class capability for CA/DC operations on a given band combination. It sets the limit on the total maximum output power measured as the sum of all UL bands;
* *ue-PowerClassPerBandPerBC-r17* is used to indicate the power class capability per band for CA operations on a given NR band combination. Due to the limitation of the number of transmitters and/or other implementation factors, the UE power class capability for a band in a band combination may be lower than that indicated by *ue-PowerClass*. Additionally, the UE power class capability for a band in a fallback band combination resulting from the release of SCell UL may be higher than that indicated by *powerClass* for the parent band combination.

Based on the above clarification, it’s recommended to update the description for *powerClass* in TS 38.306 as highlighted below:

| ***powerClass, powerClass-v1610***Indicates power class the UE supports when operating according to this band combination. If the field is absent, the UE supports the default power class. If this power class is higher than the power class that the UE supports on the individual bands of this band combination (*ue-PowerClassPerBandPerBC-r17* if indicated or *ue-PowerClass* in *BandNR* otherwise), the latter determines maximum TX power available in each band. The UE sets the power class parameter only in band combinations that are applicable as specified in TS 38.101-1 [2] and TS 38.101-3 [4]. This capability is not applicable to IAB-MT. | BC | No | N/A | FR1 only |
| --- | --- | --- | --- | --- |

 |
| R4-2402211 | Huawei, HiSilicon | **Observation 1: As per RAN2 signalling for band combinations, the component band numbers are indicated in the *bandList* parameter and the DL/UL configurations are conveyed in the *featureSetCombination* parameter, both within the *BandCombination* IE.****Observation 2: RAN2 adopts the principle of capability inheritance. A fallback band combination shall not be reported if it has the same or lower capabilities as a parent band combination.****Observation 3: The UE may report fallback BCs having additional functionality, either by adding entries in FeatureSetCombination of the same *BandCombination* IE, or by separate *BandCombination* entries.****Proposal 1: Differentiate power class and power class capability. And “power class fallback” means that the RF requirements corresponding to a lower power class apply.****Proposal 2: Use "indicated power class" when referring to the power class capability reported by the UE and "applied power class" when referring to the effective power class requirements, especially when power class fallback occurs.****Observation 4: Due to RAN2’s rule for reporting fallbacks, a UE shall not report the power class capability for the single-carrier UL (with DL CA) unless it’s higher than the parent BC(s).****Proposal 3: The power class capability of a single-carrier UL with DL CA shall be determined from its parent band combination unless it’s explicitly reported.****Observation 5: From the network perspective, there might be ambiguity in deriving the power class capability for single-carrier UL with DL CA when there’re multiple parent band-combinations being reported.****Proposal 4: A UE shall be able to maintain the same per-band per-BC power class capability for the fallback compared with its parent BC(s), while the fallback BC power class can be lower if the SCell UL is released.****Proposal 5: Allow *ue-PowerClassPerBandPerBC-r17* to report the power class capability for single-carrier UL with DL CA.****Proposal 6: Allow *ue-PowerClassPerBandPerBC-r17* to report the power class capability for intra-band CA UL with DL inter-band CA.****Proposal 7: To be aligned with RAN2’s specification, do not change the UE Tx power requirements based on activation or deactivation of serving cell(s).****Proposal 8: The *ue-PowerClassPerBandPerBC-r17* capability can be used for 3Tx band combinations.** |
| R4-2402739 | Qualcomm Inc. | **Proposal 1: Allow UE to exceed PowerClass for non-CA UL transmissions when ue-Powerclass is higher than PowerClass****Proposal 2: Allow ue-PowerClassPerBandPerBC-r17 to indicate higher power class than *powerClass* for a band, as it can remove ambiguity on single band maximum power capabilities.****Proposal 3: Adopt the new general clause to TS 38.101-1 as shown below**6.2A.0 GeneralNon-CA UL transmissions are not bounded by the power class for the band combination indicated by *powerClass* and *powerClass* may be ignored in setting the configured maximum output power for CA with single CC UL transmission.The non-CA and CA configurations for which minimum requirements have been evaluated for Power Class 2 or Power Class 1.5 operation are indicated in clause 5.5A.**Proposal 4: If necessary, for power headroom reporting purposes Pcmax\_H can be always based on powerclass of the band.** |

## Open issues summary

*Before Meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions.*

### Sub-topic 1-1

*Sub-topic description:*

*In current RAN4 specs, there is ambiguity on the applicable power (PCMAX, f,c), the applicable power class and the applicable requirements for a band in a band combination in terms of 7 different cases. In particular, when a band has a higher power class when operating in a single band than that in a band combination.*

*CR and LS can be updated according to the consensus on the following issues.*

*Note that the following discussion is for Rel-17 and onwards.*

*Open issues and candidate options before meeting:*

**Issue 1-1: It is suggested to differentiate power class and power class capability. And “power class fallback” means that the RF requirements corresponding to a lower power class apply. (Huawei)**

*(For more explanation could refer to R4-2402211)*

* Proposals：
	+ Option 1: Agree
	+ Option 2: Disagree
* Recommended WF
	+ TBD

Nokia: OK to try to clarify the definition. But on the way to discussion not only power class discussions but also p\_power class and lower MSD discussions. UE power class state. Current requirements say that when delta-P power is 3, the lower power class requirement applies. It is better to redefine the behavior. Power class is only the maximum power cap.

OPPO: Power class does not fallback. Only the transmission power is falls back.

Mediatek: Power class concept is static and does not change. We used to avoid power class fallback. We just use the transmission power. We agree that this should be clarified in RAN4 spec.

Apple: Similar view as Mediatek. Based on particular issue, power class should be differentiated from transmit power. Power class won’t change due to duty cycle. The change is Pcmax.

Samsung: Agree comments above. Power class won’t change. There is paragraph for single CC under MOP table. The current text may lead to misunderstanding. Apple proposed to remove the confusing paragraph, which is good approach.

Ericsson: We also agree with the comments from Mediatek and apple. We should distinguish the power class per band and Pcmax output power for certain band. We disagree with Huawei proposal.

Vivo: We also share the companies’ view. Support to find some refinement. But removing the whole paragraph may cause some problem. Some refinement is needed.

Huawei: We agree that power class capability is semi-static. The power class requirement can be changed.

Ericsson: indicated capability means that UE can meet some requirements. We should differentiate it from Pcmax.

Qualcomm: indeed that the spec says the lower power class requirement apply. What is the corresponding requirement?

NTT DOCOMO: not only for MOP but also ACLR.

Nokia: normally the higher power class is more stringent.

**Tentative agreement:**

* The power class indicated by UE capability is static or semi-static, and UE is expected to meet the corresponding requirements no matter what Delta\_P\_powerclass value indicates.
* Differentiate the indicated power class capability and Pcmax for UE.

**Issue 1-2: A UE shall be able to maintain the same per-band per-BC power class capability for the fallback compared with its parent BC(s), while the fallback BC power class can be lower if the SCell UL is released. (Huawei)**

* Proposals：
	+ Option 1: Agree
	+ Option 2: Disagree
* Recommended WF
	+ TBD

**Issue 1-3: The power class capability of a single-carrier UL with DL CA shall be determined from its parent band combination unless it’s explicitly reported. (Huawei)**

* Proposals：
	+ Option 1: Yes
	+ Option 2: No, need further modification
* Recommended WF
	+ TBD

Ericsson: in our view, it should 1.3-3. Nothing prevents UE indicating the different power class capability for DL only configuration. UE does not reduce the power class when adding the SCell in the field. It will take gNB a long time to configure power class when SCell added in the field.

Samsung: According to current RAN2 spec, the statement is true. However, we also see that more companies want to have chance to make UE exceed the reported power class for DL only case. We hope the exception is option

Nokia: the text must be corrected. We are fine to find a way allowing UE to transmit higher power.

OPPO: Can we have agreements? In RAN4 we choose the different behavior from RAN2. Allowing UE transmit more power would be a new feature.

Apple: Agree with Ericsson that current RAN2 spec allow UE to report different power class for the same band combination. The feature requires the per-feature set indication. The question is how we interpret the power class when UE falls back to single carrier case.

Mediatek: In general, this issue is general principle. We think it is more specific to RAN4 spec to clarify what the real power class capability. From signalling perspective, we can report three sets of power class, single carrier, per feature set…

Qualcomm: Huawei proposal does not solve the problem where PC2 requirements is defined for single carrier but not defined for BC.

**Issue 1-4: For NR non-CA band combinations, the UE shall meet the requirements according to the power class as indicated by the Band NR capability *ue-PowerClass* (hence the per-BC *powerClass* for these BCs should indicate support of the same power class). (Ericsson)**

*(To moderator’s understanding, this proposal corresponds to the following description of Ericsson CR R4-2401850, while it might be good if proponent could help to elaborate more on “hence the per-BC powerClass for these BCs should indicate support of the same power class”)*

(Ericsson clarification: for each of the NR non-CA band combinations requested by the NW as port of capability enquiry (the frequency band filtering), the UE should report a power class for the band combination consistent with the *ue-PowerClass* in the *BandNR* for the NR band.Hence the UE shall meet the following:)

****

* Proposals：
	+ Option 1: Agree
	+ Option 2: Disagree
* Recommended WF
	+ TBD

Ericsson: the proposal is related to Mediatek explanation. The capability can be indicated by three different capabilities. There is no restriction. UE should meet the requirements according to power class per band combination.

Huawei: alternative way is to say the single carrier operation is determined by UE power class in the NR band in RAN4 spec.

Nokia: our understanding is UE power class for individual band is determined by UE power class in band NR.

Mediatek: from infra perspective, if UE reports three values, what will be used. It is better for RAN4 to clarify which value is used.

Moderator: can we agree with Ericsson clarification?

Agreement:

* For UE that is configured in the single carrier mode (1 DL + 1 UL on this band), the power class is determined by ue-PowerClass for this NR band.

**Issue 1-5: To be aligned with RAN2’s specification, do not change the UE Tx power requirements based on activation or deactivation of serving cell(s). (Huawei)**

*(Note that the agreements of this issue has impact on Issue 1-6)*

* Proposals：
	+ Option 1: Agree
	+ Option 2: Disagree, and the reason
* Recommended WF
	+ TBD

Huawei: UE needs follow the reported capability.

Mediatek: we agree with Huawei. If UE is configured with CA, even if SCell is de-activated, UE should follow the CA capability.

Qualcomm: RAN4 rules do not reflect the capability changes. We can apply the same power class when the DL CA is configured. We can say the same capability as indicated can be used to RAN2.

Huawei: to Qualcomm, for Tx switching, if uplink is switched to other band with 2Tx, UE can transmit higher power. So it depends on the additional capability.

Qualcomm: we are just talking about the regular CA.

OPPO: if UE can do PC2 in the single band, why do you indicate PC2?

Nokia: from our perspective, we would like to increase the power. We would like to make sure that UE behavior can be differentiated by network.

Mediatek: to us the deactivated SCell is like network scheduling. We cannot agree that the power class can be changed according to the scheduling.

Apple: Agree with Mediatek. We should not mix configuration and activated/deactivated.

Qualcomm: The current spec is not clear. It is talking about the assignment.

**Issue 1-6: For the following different cases, whether the applicable power (PCMAX, f,c) for a band within a band combination should be capped by the value indicated via *PowerClass* of this band combination?**

*(Moderator identify 7 cases based on experts’ input, the following table is adopted to facilitate the discussion)*

**In addition, please clarify if companies’ answers are based on which following CC status, before diving into the detailed discussion of Issue 1-6 and Issue 1-7,**

 **- Alt 1: All the UL CCs are configured**

 **- Alt 2: All the UL CCs are activated**

 **- Alt 3: Some CC(s) are activated while some not**

* Proposals：

|  |  |  |
| --- | --- | --- |
|  | **Scenario** | **Options** |
| ***#1*** | **Intra-band DLCA with intra-band ULCA** | **Alt1: Yes** (Samsung, Ericsson, OPPO, vivo, ZTE, Huawei, Nokia)**Alt2: No** |
| ***#2*** | **Inter-band 2CC ULCA** | **Alt1: Yes** (Samsung, Ericsson, OPPO, vivo, ZTE, Nokia, Huawei)**Alt2: No, and if necessary for power headroom reporting purposes PCMAX\_H,f,c can be always based on *powerclass* of the band.**(Qualcomm) |
| ***#3*** | **Inter+intra 3CC ULCA** | **Alt1: Yes** (Samsung, Ericsson, OPPO, vivo, ZTE, Nokia, Huawei)**Alt2: No, and if necessary for power headroom reporting purposes** **PCMAX\_H,f,c can be always based on *powerclass* of the band**. (Qualcomm) |
| ***#4*** | **Intra-band DLCA only** | **Alt1: Yes** (OPPO)**Alt2: No, which means allow UE to exceed *powerClass* when *ue-PowerClass* is higher than *PowerClass*** (Samsung, Qualcomm, Ericsson, ZTE, vivo)**Alt3: Yes if such a BC is explicitly reported, otherwise the power class capability inherited from its parent BC applies** (Huawei)**Alt4: For TDD, Alt2. For FDD, if MSD requirements are ready, Alt 2, if not Alt 1. (While it would be good to find a way to allow Alt2)** (Nokia) |
| ***#5*** | **Inter-band DLCA only** | **Alt1: Yes** (OPPO)**Alt2: No, which means allow UE to exceed *powerClass* when *ue-PowerClass* is higher than *PowerClass*** (Samsung, Qualcomm, Ericsson, ZTE, vivo)**Alt3: Yes if such a BC is explicitly reported, otherwise the power class capability inherited from its parent BC applies** (Huawei)**Alt4: With the current spec, Alt 1 is the choice, but it would be good to find a way to allow Alt2** (Nokia) |
| ***#6*** | **Inter+intra DLCA only** | **Alt1: Yes** (OPPO)**Alt2: No, which means allow UE to exceed *powerClass* when *ue-PowerClass* is higher than *PowerClass*** (Samsung, Qualcomm, Ericsson, ZTE, vivo)**Alt3: Yes if such a BC is explicitly reported, otherwise the power class capability inherited from its parent BC applies** (Huawei)**Alt4: With the current spec, Alt 1 is the choice, but it would be good to find a way to allow Alt2** (Nokia) |
| ***#7*** | **Inter+intra DLCA with intra-band ULCA** | **Alt1: Yes** (Samsung, OPPO, vivo, ZTE, Nokia)**Alt2: No** **Alt3: Yes if such a BC is explicitly reported, otherwise the power class capability inherited from its parent BC applies** (Huawei) |
| Note 1: In scenario #4/#5/#6, UL is single CC. |

* Recommended WF
	+ TBD

**Issue 1-7: For the following scenarios, whether *ue-PowerClassPerBandPerBC-r17* is applicable? Which power class applies for the constituent band within the BC if ue-*PowerClassPerBandPerBC-r17* is absent or not applicable?**

* Proposals：

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Scenario** | **Whether *ue-PowerClassPerBandPerBC-r17* is applicable for this scenario** | **Which power class applies for the constituent band within the BC if *ue-PowerClassPerBandPerBC-r17* is absent or not applicable** |
| ***#1*** | **Intra-band DLCA with intra-band ULCA** | **Alt1: No** (Samsung)**Alt2: Yes** (Ericsson) | **Alt1:** ***PowerClass*** (Note this is agreed in RAN4#108)(Samsung)**Alt2: *ue-PowerClass*** (Ericsson) |
| ***#2*** | **Inter-band 2CC ULCA** | **Yes** | **Alt1:*ue-PowerClass*** (Samsung, ZTE, Ericsson, Nokia)**Alt2: Min{*ue-PowerClass*, *powerClass*}** (Huawei, OPPO) |
| ***#3*** | **Inter+intra 3CC ULCA** | **Yes** | **For the single CC band:****Alt1:*ue-PowerClass*** (Samsung, ZTE, Nokia, Ericsson)**Alt2: Min{*ue-PowerClass*, *powerClass*}** (OPPO, Huawei)**For the intra band:****Alt1:*ue-PowerClass*** (Samsung, ZTE, Nokia, Ericsson, OPPO)**Alt2: the default power class i.e. PC3 or PC5** (Huawei)**Alt3: Min{*ue-PowerClass*, *powerClass*}**  |
| ***#4*** | **Intra-band DLCA only** | **Alt1: No** (Samsung)**Alt2: Yes** (Huawei) | **Alt1: *ue-PowerClass*** (Samsung, ZTE, Ericsson)**Alt2: *powerClass*** (OPPO)**Alt3: the power class capability inherited from its parent BC applies**(Huawei) |
| ***#5*** | **Inter-band DLCA only** | **Alt1: No** (Samsung)**Alt2: Yes** (Qualcomm, Huawei) | **Alt1:*ue-PowerClass*** (Samsung, ZTE, Ericsson)**Alt2: *powerClass***(OPPO)**Alt3: the power class capability inherited from its parent BC applies**(Huawei) |
| ***#6*** | **Inter+intra DLCA only** | **Alt1: No** (Samsung)**Alt2: Yes** (Qualcomm, Huawei) | **Alt1:*ue-PowerClass*** (Samsung, ZTE, Ericsson)**Alt2: *powerClass*** (OPPO)**Alt3: the power class capability inherited from its parent BC applies**(Huawei) |
| ***#7*** | **Inter+intra DLCA with intra-band ULCA** | **Alt1: No****Alt2: Yes** (Huawei, Ericsson) | **Alt1:*ue-PowerClass*** (ZTE, Samsung, Nokia? Ericsson)**Alt2: the power class capability inherited from its parent BC applies**(Huawei)**Alt3: Min{*ue-PowerClass*, *powerClass*}** **Alt4: *powerClass***  |
| Note: In scenario #4/#5/#6, UL is single CC. |

* Recommended WF
	+ TBD

*OPPO: this is Rel-17 IE. Can we extend it?*

*Apple: I wonder which companies propose it to intra-band. What is the motivation.*

*Huawei: we support to extension to other case. It can allow UE to report higher power class. RAN2 specifies two ways to do it.*

*Mediatek: in our understanding, no signaling prevents UE to report such IE. But RAN4 needs to clarify the functionality when the different values are reported.*

*Ericsson: It is only specified for inter-band UL CA. It is for TxD. In RAN2 spec, there is no restrict for field. It can be used widely.*

**Issue 1-8: For DL-only CA configurations, if it is agreed to allow UE to exceed *PowerClass* when *ue-PowerClass* is higher than *PowerClass* in Issue 1-7, how to treat the MSD requirements missing issue?**

* Proposals：
	+ Option 1: With the assumption there is no MSD allowed (i.e., MSD=0) until this higher power class (the same value as indicated by ue-PowerClass) for this DLCA combo is introduced in spec. (Samsung)
	+ Option 2: Refer to CR R4-2401852(Ericsson)
* Recommended WF
	+ TBD

*OPPO: what does it mean by missing issue? (Samsung: not defined) In such case, UE should assume no MSD defined.*

*Mediatek: If UE intends to use higher power, we do not need additional agreement on that.*

*Qualcomm: As Ericssion, if the basket WI approach the higher power class introduction is delayed for the case where the higher power class is defined to single carrier.*

*Apple: This issue is related to the issue that we discussed yesterday. UE is allowed to report higher power class. There is no MSD allowed. It should be PC3 MSD rather than MSD=0.*

*Huawei: it opens the door that all the high power UE will bypass the basket WI.*

*Nokia: the direction we would like to support. The procedure must be clarified. If it is allowed, should we define the requirements later.*

*Samsung: we are also OK to option 2. We agree with Huawei in term of bypassing the rule.*

**Issue 1-9: For DL-only CA configurations, the UE shall meet the requirements according to the power class as indicated by the Band NR capability *ue-PowerClass*. (Ericsson)**

* Proposals：
	+ Option 1: Agree
	+ Option 2: Disagree, and the reason
* Recommended WF
	+ TBD

*Samsung: we are not OK with “shall”.*

*Huawei: we have similar as Samsung. Flexilbility should be allowed. We think it “can”.*

*OPPO: Share the similar understanding. There is already IE can be used.*

*Ericsson: Power reduction in the field should be avoided. We recognize the hard work to complete MSD in the basket WI. It is related to performance in the field.*

*Apple: from the uplink coverage perspective, we agree with the proposal. The current signaling allows UE to report DL only capability. No need to bind them together.*

*Qualcomm: Prefer to have flexibility.*

**Issue 1-10: Which MPRc and A-MPRc applies per serving cell c of a configured band combination?**

* Proposals：
	+ Option 1: MIN { PPowerClass,c – ΔPPowerClass,c, PPowerClass,CA – ΔPPowerClass,CA }
	+ Option 2: MIN { PPowerClass,c, PPowerClass,CA}
	+ Option 2: Other
* Recommended WF
	+ TBD

**Issue 1-11: The *ue-PowerClassPerBandPerBC-r17* capability can be used for 3Tx band combinations such as UL CA+TxD and UL CA+UL MIMO. (Huawei)**

* Proposals：
	+ Option 1: Agree
	+ Option 2: Disagree
* Recommended WF
	+ TBD

OPPO: the UE power class per band per BC does not distinguished 2Tx and 3Tx UE.

Mediatek: same understanding.

Samsung: share the similar view.

Agreement:

* The RAN4 common understanding is the ue-PowerClassPerBandPerBC-r17 capability can be used for 3Tx band combinations such as UL CA+TxD and UL CA+UL MIMO