**3GPP TSG-RAN WG4 Meeting #102-e R4-220xxxx**

**e-Meeting, Feb.- Mar. 2022**

**Title: WF on FR2 inter-band UL CA**

**Source: Qualcomm Incorporated**

# 1. WF – Band Combinations

1. GTW Agreement: RAN4 recommends that UL CA\_n260-n261 is included in this WI in addition to CA\_n257-n259.

*Moderator-note: Discussion will be transferred to email discussion document at the end of 2nd round, any agreements from discussion will be retained here*

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| Company | Comments |
| MediaTek | Okay, it’s operator’s demand |
| ZTE | Ok. Revised this WI to include UL CA n260-n261 in March RAN plenary meeting is needed. Then UL CA n260-n261 can be discussed in this WI. |
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# WF – Power Classes applicable for inter-band ULCA

1. **GTW Agreements:** 
   1. Focus on the common requirements (i.e., MPR and power control) of PC1/2/3/4/5 and Delta\_TIB values of PC1/2/4/5
   2. Discuss PC3-specific requirements after step 1a (i.e., Delta\_TIB values and total power issue).
   3. A power class cannot be supported without finalizing requirements including Delta\_TIB.
2. **GTW Agreements:** 
   1. The total power concept is not applied for power classes such as PC1/2/5
   2. FFS include new power class
   3. Further check the MPE regulation for FWA/CPE.
3. **PC4 is removed from WF2.1 to make consistent with GTW agreement in WF2.2 (y/n)**

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| Company | Agree/Disagree, include justification |
| MediaTek | Agree. Not only for consistence, PC4 device size could be not large, may suffer similar issues as PC3 handheld device. |
| OPPO | After checking the regulations, currently both CE/FCC/ICNIRP have the restriction of total Tx power for FWA/CPE also. It seems MPE impacts would be similar as handheld UE. |
| Xiaomi | Support bullet 3 |
| Qualcomm | OK to remove PC4.  To Oppo : Would you clarify how MPE impact would change the requirement structure? P-MPR would already capture MPE impact in the configured power requirement, so not sure if any further consideration is required. MPE already impacts single band requirements and it is captured in configured power for that configuration. |
| vivo | OK with bullet 3 |
| Nokia | Support. |
| Ericsson | It is difficult to progress without an agreement on the power control. OK to specify PC3 at a later stage. |
| Sony | From the practical aspect, it might be even better to only focus on PC1/5 for Rel-17, which has more clear demand on UL CA feature. However, we are fine with the current agreement.  For MPE issue, again, it can be addressed by PMPR and uplink duty cycle, we don’t think the CA operation is anything special comparing to the single CC case. Therefore, there is no need to compromise the minimum requirement due to the MPE limitation. |
| OPPO2 | To clarify the MPE issue and reply QC question:  Currently the MPE requirements for FR2 are free space based power density requirements which means UE has to meet the max power limitation w/ or w/o human body. Assume this limitation power is X dBm, then in single CC or CA this is the max total power that UE can transmit.  It is correct that PMPR is used for UE to meet the SAR/MPE regulations and no PMPR is used in conformance testing, however, the MPE requirement is free space based there is no chance for UE to transmit higher than this limitation and UE cannot distinguish this is in conformance testing or in the field. This is different from SAR testing where is phantom based requirement and UE can transmit higher power when no phantom is nearby in the conformance testing.  That’s why we are saying there is no difference in MPE for handheld UE and FWA/CPE. If RAN4 ignore this and defined requirements, then in the end UE has to deactivate the PMPR manually in the conformance testing then activate it when goes to market, the actual UE total Tx power still is limited by MPE. In our understanding this is not the intention of this discussion.  We are open to hear more views. |
| Huawei | Support to remove PC4.  (Copied by DCM to de-fork.) |

1. **RAN4 to complete inter-DLCA requirements for power classes that are enabled for inter-band ULCA**
   1. **Companies are encouraged to bring proposals for delta(RIB) for:**
      1. **PC1/2/5**
      2. **IBM inter-band DLCA for agreed band combinations (WF1)**

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| Company | Agree/Disagree, include justification |
| MediaTek | We are open for this; however, it would be better to have operator’s clarification on the demand firstly, compared to do all the possible combination directly. For example, there is even no PC2 n260 or n259 single band requirement so far, it would be not made sense to define PC2 DL/UL CA with n259 or n260.   |  |  |  |  | | --- | --- | --- | --- | |  | CA | CA\_n257-n259 | CA\_n260-n261 | | PC1 | DL |  |  | | UL |  |  | | PC2 | DL |  |  | | UL |  |  | | PC5 | DL |  |  | | UL |  |  |   **(Added in v8)**  **Response to Qualcomm:** Thanks for the discussion. Because FR2 power class are related to UE type (assumption), our intention is to clarify market’s interest firstly, instead of discussing all possibilities. |
| OPPO | Need more time to study the PC1/2/5 since previous analysis is only based on handheld UE types. |
| Xiaomi | We are open for this issue, as Media Tek comments, whether single CC operation need support the related power class firstly, i.e., n260 just supports PC1/3/4 and n259 supports PC3/5 currently. If needed, just need define   |  |  |  |  | | --- | --- | --- | --- | |  | CA | CA\_n257-n259 | CA\_n260-n261 | | PC1 | DL |  | N/A | | UL |  | N/A | | PC2 | DL | N/A | N/A | | UL | N/A | N/A | | PC5 | DL | N/A |  | | UL | N/A |  | |
| Qualcomm | We support  To MTK: We are not sure an operator would care which power class is enabled for the feature, it is up to UE vendors to provide solutions. The network can choose to configure each PC individually for inter-ULCA.  We do see that PC1 can only be defined currently for n260+n261 and PC5 for n257+n259, due to insufficient single band coverage |
| LG Electronics | For PC2, We prefer not to leave PC2 out based on GTW agreement. To cover PC2, we're going to submit contribution which includes single band(39GHz, i.e, n259) and CA bands in next meeting. We believe that PC2 can be covered in next meeting not lately given that WI is extended with 1Q. |
| vivo | Generally OK. We also support only define n260-n261 for PC1 and n257-n259 for PC5 due to lack of single band requirements. |
| ZTE | We also think the PC should be supported for the constituent band first for FR2 inter-band CA. |
| Samsung, | Agree with PC1 for n260+n261 and PC5 for n257+n259 for now. For PC2, if one quarter is extended and 39GHz band is added, also okay for PC2. |
| Nokia | PC1 is originally requested for US market and PC5 for Japanese market. Furthermore, UL CA\_n260-n261 and CA\_n257-n259 are requested by operators from these regions.  PC1 for CA\_n260-n261 and PC5 for CA\_n257-n259 should be in a higher priority than others. |
| Sony | As we commented in the previous issue, it might be more practical to focus on only PC1/5 for Rel-17. However, we are fine with the proposal. |
| Huawei | In general ok with the proposal.  (Copied by DCM to de-fork.) |
| DOCOMO | Based on the lack of single band requirements, we support defining requirements for n260-n261 for PC1 and for n257-n259 for PC5 before defining the UL CA requirements for PC3 (Handheld UE).  We show our understanding of relaxation factors to advance the discussion. Of course, additional factors and discussions are welcome. In our understanding, PC1 and PC5 have the following differences compared to PC3.  1. MBR may be smaller because they are not restricted by device size.  2. Based on the difference in requirement values between minimum peak EIPR and EIRP spherical coverage, PSD imbalance will be smaller.  3. Common coverage impact may be smaller because the guaranteed coverage is narrow.   |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | | **Factors** | **CA for PC3** | | **CA for PC1** | | **CA for PC5** | | **CA for New PC** | | | **DL** | **UL** | **DL** | **UL** | **DL** | **UL** | **DL** | **UL** | | Total power concept | - | FFS | - | - | - | - | - | - | | PSD imbalance | 1.0 | - | < 1.0 | - | < 1.0 | - | 1.0 | - | | MBR | 0.5 | 0.5 | ≤ 0.5 | ≤ 0.5 | ≤ 0.5 | ≤ 0.5 | 0.5 | 0.5 | | Common coverage | 2.0 | 2.0 | ≤ 2.0 | ≤ 2.0 | ≤ 2.0 | ≤ 2.0 | 2.0 | 2.0 | | Freq. separation impact | | Other margins | | Relaxation value (dB) | **3.5** | **FFS** | **[< 3.5]** | **[< 2.5]** | **[< 3.5]** | **[< 2.5]** | **[3.5]** | **[2.5]** | |

1. **A new power class is defined to enable inter-band ULCA for non-handheld devices like laptop PCs and table-top UEs (y/n)**
   1. New power class is assumed to be an industrial-packaged UE that would normally declare itself to be PC3 to the network
   2. New power class would carry over all existing requirements from PC3 without changes
   3. Total power concept is not applied for the new power class

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| Company | Agree/Disagree, include justification |
| MediaTek | We are open for this; however, it would be better to have operator’s clarification on the demand firstly.   |  |  |  |  | | --- | --- | --- | --- | |  | CA | CA\_n257-n259 | CA\_n260-n261 | | New power class (# handheld is precluded.) (UE type assumption is laptop.) | DL |  |  | | UL |  |  |   (Added in v8)  **Response to Qualcomm:** As commented above. |
| OPPO | For clarification, is the a/b/c all need to be met by UE? Why this UE will declare itself to be PC3 rather than PC1/2/5? |
| Qualcomm | To Oppo: a/b/c is proposed to be the characteristics of the new power class. A laptop or desktop UE would be able to declare itself to be PC\_<new powerclass> if it wants to support inter-ULCA and its original design was to meet PC3 like requirements.  To MTK: see comment to #4 above |
| Samsung | We are open to define new power class for UEs like laptop and table-top, but we are not sure to carry over all existing PC3 requirements. For example the use scenario for the new power class is placed on table and lower half hemisphere may have no radiation, so the spherical coverage percentile may be different from PC3’s.  Moreover, as we have commented in 1st round, we need to exclude the dongle type and embedded type UE etc. which are also industrial-packaged UE that would normally declare itself to be PC3 to the network  Besides, it seems necessary to revise WID to include this objective. |
| Nokia | We are open for further discussion.  We assume this new power class (if introduced) would be based on the similar chipset and RF/antenna modules as existing PC3 but with sufficient power supply and heat sink like a modem card/module form factor so that that it can avoid power and thermal issues. Thus all existing RF requirement are the same as PC3. So it makes sense to us. |
| Huawei | Disagree. If all requirements are inherited from existing requirements from PC3 without changes but not total power concept, we think it just changes a name for PC3, then why not continue the discussion of PC3 and trying to address the remaining issues. As mentioned by Samsung, the usage scenario could be different from the one we discussed for PC3, which means requirements affiliated to the scenario still need further discussion.  What’s the new power class number? PC7? Shouldn’t we need to have a new WI for the new power class?  (Copied by DCM to de-fork.) |
| DOCOMO | We support defining the requirements for new PC before defining the UL CA requirements for PC3 (Handheld UE). The provided a/b/c are OK for us. Please see our comments on other PCs above. |
| Qualcomm | We don’t think a new WI is required if the need for a new PC is identified during an existing WI. In terms of characteristics, there are many UE types that call themselves PC3 today, and this new power class would be a home for them, without having to go through the hoops set up for handheld UEs (PC3). We are open to further development of the new power class concept. UEs that want to be excluded can continue calling themselves PC3 where is it is not clear if meaningful inter-ULCA requirements are possible to establish. |

# 3. WF – Power Control for IBM and bands from different band groups

1. **GTW Agreement:** Focus on inter-band IBM UL CA for agreed band combinations (WF1)
2. **Options (***moderator-note: options below are compliant with 38.213***):**
   1. The UE configures a PCMAX in an implementation-specific manner like for the intra-band case and relative power limits are used for controlling the power on the serving cells. PCMAX ≥ PCMAX,f,c for each configured serving cell *c* with PCMAX,f,c as specified in clause 6.2.4 with parameters MPR and A-MPR as specified per serving cell or modified as needed for the band combination (CA MPR)
   2. **From [R4-22006057]:**

A UE can configure its maximum output power for each uplink band when it is configured for inter-band UL carrier aggregation with two NR bands each with a single UL CC. For each uplink band *n*, the configured UE maximum output power PCMAX,f,c,n for carrier *f* of a serving cell *c* is defined as that available to the reference point of a given transmitter branch that corresponds to the reference point of the higher-layer filtered RSRP measurement as specified in TS 38.215 [11].

The configured UE maximum output power PCMAX,f,c,n for carrier *f* of a serving cell *c* in band *n* shall be set such that the corresponding measured peak EIRP PUMAX,f,c,n is within the following bounds

PPowerclass + PIBE – MAX(MAX(MPRf,c,n, A- MPRf,c,n) + ΔTIBP,n, P-MPRf,c,n) – MAX{T(MAX(MPRf,c,n, A- MPRf,c,n,)), T(P-MPRf,c,n)} ≤ PUMAX,f,c,n ≤ EIRPmax

while the corresponding measured total radiated power PTMAX,f,c,n is bounded by

PTMAX,f,c,n ≤ TRPmax

with PPowerclass the UE power class as specified in sub-clause 6.2.1, EIRPmax the applicable maximum EIRP as specified in sub-clause 6.2A.1, MPRf,c,n as specified in sub-clause 6.2A.2 , A-MPRf,c,n as specified in sub-clause 6.2A.3, ΔTIBP,n the peak EIRP relaxation as specified in clause 6.2A.1 and TRPmax the maximum TRP for the UE power class as specified in sub-clause 6.2.1. The requirement is verified in beam peak direction.

PIBE, *mpr-PowerBoost-FR2-r16* and *maxUplinkDutyCycle-FR2* are described in clause 6.2.4.

P-MPRf,c,n is the power management maximum output power reduction P-MPRf,c in band *n.* P-MPRf,c is defined in clause 6.2.4.

The tolerance T(∆P) for applicable values of ∆P (values in dB) in each band is specified in Table 6.2.4-1.

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| Company | Comments |
| Qualcomm | ‘independently’ needs to be removed from alt2 |
| vivo | We do not support option a for now. option b with ‘independently’ is ok to us. |
| Samsung | For alt2, it is better not to refer to the reference point of RSRP. refer to details in https://www.3gpp.org/ftp/tsg\_ran/WG4\_Radio/TSGR4\_102-e/Inbox/Drafts/%5B102-e%5D%5B125%5D%20NR\_RF\_FR2\_enh2\_Part\_1/UL%20CA%20draft%20CR/revisedR4-2206057\_dCRB\_FR2ULCA\_v02\_QC\_Samsung.docx |
| Ericsson | We support alt a. as proponents. The power control is specified in 38.213 and this includes a total PCMAX. There would be a limit to the total power, if not due to the TER. This does not necessarily mean that the EIRP for the two uplink beams need be significantly degraded.  We assume that the regulators apply the total exposure ratio TER that can include MPE in different FR2 bands (ignoring SAR for the moment by assuming EN-DC is not considered). Hence there will be a dependence between the power levels on the uplink bands. However, this does not necessarily mean that the peak EIRP on the two uplinks must be reduced significantly, would depend on the implementation since the MPE is measured on all surfaces of the device to our understanding and P-MPR is already allowed. |
| Huawei | We don't think we can have a conclusion without answering the following questions:  1. Whether we need to consider Pcmax,ca  if needed, we need to consider whether and how to define Ptmax,total and Pumax,total that is similar to intra-band CA  2. If we introduce MPRpa-pa for inter-band CA, even Pcmax,ca is not defined for inter-band CA, whether the power control for each cell can be independent. If not, whether we need to introduce MPRpa-pa  (Copied by DCM to de-fork.) |
| Apple | In general, we need further discussion on this issue. We would also like to share our comment which was provided to the similar discussion topic in the LS response thread:  From the IBM UL CA reference architecture discussion (and we are also assuming different frequency groups, since the example band combinations for inter-band UL CA work have been from different grouops only so far), we have the outcome that a multi-chain Tx architecture is used to derive the requirements. This implies that it is feasible for the UE to set the output power level per carrier independently.  MPR\_PAPA (although not yet agreed) is intended to capture the impact of rIMD, which is an effect from band A to band B when simultaneously transmitting. Although RAN4 will take these cross-band impacts into account when defining MPR\_PAPA, it is still up to UE implementation how much of the allowed MPR\_PAPA to apply per carrier. P-MPR, which is the power back-off the UE uses to comply with MPE regulation, is also totally up to UE implementation.  Combining both observations, we have the outcome that PCmax,f,c can be set independently per carrier for IBM UL CA, and RAN4 will set requirements on MPR\_PAPA such that they take rIMD effects into account. |
| Qualcomm | This discussion is not about whether the UE can perform independent power control (we had mistakenly used this expression earlier). This debate is whether we can write the configured power inequality in a per band format. There may continue to be cross-band linkage through terms in the inequality, and we realize that (MPR, delta(TIB), PMPR). The option ‘b’ formulation does not prevent that.  Recall that RAN4 has already agreed that TRPmax and EIRPmax are independent per band quantities (see WFs from RAN4#98 and later).  Option 2.a proposes a ‘relative power limit’ per band, but this is not even agreed for intra-band CA. |

# 4. Extension of WI for completion of CA MPR

1. **Rel-17 WI to be extended one quarter to allow companies time to finalize MPR proposals**

*Moderator-note: Discussion will be transferred to email discussion document at the end of 2nd round, any agreements from discussion will be retained here:*

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| Company | Comments |
| MediaTek | Just for clarification, is the extension is only for CA MPR? |
| Qualcomm | The extension is by WI objective, and we think it would apply to all of FR2 ULCA |
| LG Electronics | If 1Q is extended, all PC1/2/5 and new Power Class UL CA would be applied. |
| Apple | We prefer not to extend the work item but instead to transfer the work scope to Rel-18. The entier power control issue is actually an open issue, and just defining CA MPR is but one possible solution. So we would prefer to finalize this work in Rel-18 with properly scoped TU allocation. |