**3GPP TSG RAN#90e RP-20xxxx**

**e-Meeting, December 7th – 11th, 2020**

**Agenda item:** 9.1.4

**Source:** Moderator(Qualcomm Incorporated)

**Title:** Email Summary on Introduction of high-power devices operation use cases over Band n77

**Document for:** Discussion/Decision

# Introduction

In this document, the summary of the e-mail discussion on the proposal to introduce power classes with higher output power (PC1 and PC1.5) for band n77. The proposal is in the following contribution:

* RP-202280 New WID on high-power devices operation use cases over Band n77 Verizon

# Proposals

RP-202280 is a new work item proposal with the following objectives:

### 4.1 Objective of SI or Core part WI or Testing part WI

The objective of this work is to develop RF requirements that are applicable for HPUE and FWA operations over the NR band n77, including

1. Define new feature to enable single component carrier UL operation and dual-PA equipped devices
   1. enable NR band n77 Power Class 1.5 (29dBm) for both high power mobile and FWA devices, and
   2. enable NR band n77 Power Class 1 (31dBm) for FWA devices

to be utilized for standalone NR 2x2 UL MIMO and antenna diversity

1. Define requirements, including Tx power tolerance, MPR, A-MPR, IBE and ACLR for both Power Class 1.5 an Power Class 1. Improve A-MPR/MPR for both 29dBm and 31dBm band n77 in scope.
2. Ensue Tx duty cycle requirements sufficient to meet FCC SAR limit for UE and FWA devices and meet all of the regulatory requirements
   1. Solve the issues related to HPUE and FWA in use of 29dBm and 31dBm power classes if there are impacts
3. Assess the impact on eNB requirements required to support a 29dBm and 31dBm UE power class
4. Enhance the hardware requirements for high power devices
   1. improve the antenna isolation for FWA devices, and
   2. allow the PC2 UE device to deliver 28dBm power based on already present in the UE in carry 23 dBm and 26 dBm capable transmitters that can operate concurrently (R4-2016439)

### 4.2 Objective of Performance part WI

NOTE: Leave empty if the WI proposal does not contain a RAN performance part.

## Initial Email Discussion

### Companies comments

Questions to be handled in the initial phase of the e-mail discussion:

1. Do you agree with the approval of the WID on adding PC1 and PC1.5 support for band n77? If no, elaborate why. If yes but with changes in the objective, please also included comments on the next questions.

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| **Company** | **Views** |
| Bell Mobility | Yes and also for n78 as per the revised RP-202808 |
| Ericsson | Support |
| Huawei, HiSilicon | Since the WI proposal is spectrum related, we think the WI should be focused on PC1.5 for band n77. General requirements for PC1 are not defined yet, which should be included in the Rel-17 non-spectrum related UE RF FR1 WI if needed. PC1 should be removed from this WI. Our following comments for Q2 are for PC1.5 related objectives. |
| Verizon | To Bell Mobility: yes the n78 is in scope!  To Hauwei: Either PC1.5 or PC1 is the spectrum related. The objective of item is to initialize and define the related requirement for both n77 and n78. |
| OPPO | For clarification, the n77 here means the whole band or the parts that specific for US only, i.e. 3700 – 3980 MHz? And whether PC1 related requirements will be defined in this WI or Rel-17 FR1 enhancement WI? |
| Intel | We are ok with the general WID. Please see comments on the individual objectives below. |
| vivo | It seems that general requirements for a new higher power class is usually introduced in a separate power class than combined with introducing new bands for an existing one. |

1. Do you have any comments on the proposed objectives?

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| **Company** | **Views** |
| Bell Mobility | Please capture objectives as in the revised tdoc RP-202808 |
| Ericsson | Regardnig the objective:   * Assess the impact on eNB requirements required to support a 29dBm and 31dBm UE power class   Our understanding is that the new UE power class should not necessitate any network upgrades by any involved operators and thus it would help to clarify the objective as follows:  Assess any impact at the gNB of a 29dBm and 31dBm UE power class. The existing gNB requirements shall be applied |
| Qualcomm Incorporated | For objective 2,  Define requirements, including Tx power tolerance, MPR, A-MPR, IBE and ACLR for both Power Class 1.5 an Power Class 1. Improve A-MPR/MPR for both 29dBm and 31dBm band n77 in scope.  If there is improvement found for MPR, it would not be restricted to Band n77 but could apply generally.  For objective 5,  Enhance the hardware requirements for high power devices   * 1. improve the antenna isolation for FWA devices, and   the improvement should not be limited to FWA device but also to mobile devices that are capable. Suggest to include an objective   * 1. introduce new signaling or existing signaling to enable the UE to indicate to the network whether it supports improved A-MPR and MPR |
| Huawei, HiSilicon | 1. The term of HPUE used in the objectives are not consistent. What’s the meaning of high power mobile? Does it include other type of mobile UE devices besides the hand held UE? It would be better to make it clear of the UE types considered in the WI.  2. General UE RF requirements for PC1.5 are already defined in the specification. Only additional requirements, e.g. A-MPR should be specified for PC1.5 for n77. Any improvement for general requirements should be considered in non-spectrum UE RF FR1 WI.  3. Band n77 is a global used band, we prefer that the additional requirements for other applicable regions should be considered as well, not just based on FCC limits. And it’s not clear what’s the meaning of “Ensure Tx duty cycle requirements”, is it based on duty cycle capability or fixed duty cycle? Similar to other HPUE WIs, we would like to have some options for SAR solutions in the WID.  4. Not clear what’s the impact for BS requirements with introduction of new power class for n77. Some clarification is needed.  5. For the enhancement of the hardware requirements for high power devices, which was discussed in last RAN4 meeting, but no consensus was reached. Improving antenna isolation should be a feasibility study rather than a dedicated objective in the WID. Allowing the PC2 UE device to deliver 28dBm exceeding the power class reported by the UE may have SAR issue and possibly violate the regulatory requirements, which should not be considered in the WI. |
| Verizon | To Ericsson: yes, the comment will be reflected in revised item!  To Qualcomm: yes, the comments will be reflected in revised item!  To Huawei:   * For 1, Ok we will remove ‘HPUE’ and replace it to “new power UE device”. * For 2, Not quite follow the logic, but the scope of this work is for both n77 and n78. * For 3, It is clearly stated the FCC rule is for North American operations. This is based on all of the supporting companies’ requests. Of course, we welcome other inputs for operators are interested in this work! * For 4, The objective is modified. Thanks Ericsson! * For 5, As indicated few lines above, the FCC SAR limit is an objective. |
| Apple | We have the following questions for clarifications:   1. Is the intended HPUE to support UL MIMO only or including single layer transmission? The latter would depend on the outcome of pending Tx diversity requirements if the implementation is expected to be from dual-PA. 2. We already have PC1 defined for n14 which is based on single-PA implementation. How do we differentiate the output power capability and the associated requirements (such as MPR) between FWA PC1 for n77/n78 and PC1 for n14 where the former is expected to be based on dual-PA implementation? 3. What does the objective 5b mean?   “allow the PC2 UE device to deliver 28dBm power based on already present in the UE in carry 23 dBm and 26 dBm capable transmitters that can operate concurrently (R4-2016439)” Does it mean the power sum of 23 dBm and 26 dBm is 28 dBm? If so, can we still call this device as PC2 UE? Or should this be considered a new feature to be listed in objective 1? |
| LGE | For Objective 2, we propose as follow since the MPR/A-MPR were defined in Rel-16. It is not clear what is the enhanced factors for MPR/A-MPR improvements.  Define Tx requirements, including UE maximum output power with power tolerance, MPR, A-MPR, IBE and ACLR for both Power Class 1.5 an Power Class 1. ~~Improve A-MPR/MPR for both 29dBm and 31dBm band n77 in scope.~~  For Objective 5, we propose as follow  Enhance the hardware requirements for high power devices   * 1. improve the antenna isolation for FWA devices only, and   2. allow the PC2 UE device to deliver up to 26dBm total maximum output power per UE as same in Rel-16. ~~based on already present in the UE in carry 23 dBm and 26 dBm capable transmitters that can operate concurrently (R4-2016439)~~   To QC, RAN4 already agreed to use 10dB antenna isolation for 29dBm handheld device in Rel-16. The improvement of antenna isolation is only for FWA device only. Also LGE agree the Apple comment for objective 5b. The 28dBm power UE is not PC2 UE. |
| OPPO | 1. For clarification, is only dual-PA be considered for FWA n77 PC1.5 and PC1?  2. If these HPUEs in n77 is targeting US spectrum only, better to be clarified in the WID.  3. The following item should be studied and discussed in normal FR1 enhancment WIs as has been done in last meeting. The max power should include both 28dBm and 29dBm.   1. allow the PC2 UE device to deliver 28dBm power based on already present in the UE in carry 23 dBm and 26 dBm capable transmitters that can operate concurrently (R4-2016439)   4. The improvement of A-MPR/MPR should be clearly targeted if included comparing to existing requirements. |
| Intel | 1) In objective 1 “Antenna diversity” is not clear. Is it “transparent TxD”? If so, we suggest to clarify this. We also prefer to wait for conclusions of Rel-16 work for this before the Rel-17 on this topic starts.  2) For UL MIMO 29dBm HPUE, we suggest to consider assumption of 26dBm+26dBm PAs. For 31dBm HPUE, consider assumption of 28dBm+28dBm PAs.  3) Since WID is for NR HPUE, in objective 4 need to change eNB to gNB.  4) For “improve the antenna isolation for FWA devices” – we are overall fine. Is it intended for MPR evaluations? If so, we suggest to clarify this in the objectives.  5) The objectives include FWA and high power mobile devices, meantime FR1 specs typically do not differentiate different device types and requirements are agnostic of device type. One suggestion is to make the objectives agnostic to device types and add a note that the requirements are aimed for FWA and high power mobile devices use cases. |
| Skyworks | On objective 5b, this can only be applicable to inter-band case since for intra-band the MPR wouldnot apply properly (which reference?, how does it works for intra-band non-contiguous CA with 1 PA per CC? wich CC get 23dBm?). the objective if agreed should be restricted to inter-band case.  For PC1.5 our assumption is that this is for single CC only as for non-contiguous intra-band CA with equal PSD/equal backoff 29dBm can only be achieved for equal BW allocation. |
| vivo | We also have concerns on objective 5b that this is still hotly debating in last RAN4 meeting. This kind of implantation is not consistent with current PC2 definition and is actually setting up new reporting for different archrictures. It is difficult to be listed as an objective since the views are still quite divergent at current stage. |
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1. Any other comments?

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| **Company** | **Views** |
| T\_Mobile | This would be an NR WID. Shouldn’t the impacted specification be TS 38.101-1 and not TS 36.101? Also, RAN#93 is not June 2021. |
| Verizon | To T\_Mobile: Thanks! Typos will be corrected. |

### Summary of the initial email discussion

Multiple companies expressed their views on the work item and the proposed objectives.

There are no objections to this work item, however, many of the objectives would need to be clarified or modified.

Regarding the 1st question, on support for the work item in general:

1. It is proposed to add also n78 as one of the bands targeted by this work, this is a subset of n77. This proposal was submitted quite late so it should be further discussed in the intermediate round. There were no negative comments to including n78 so far.
2. No company objected to having PC 1.5 handled in this WI. Ther are some comments regarding handling of PC1, this needs further discussion.
3. There were multiple comments that the WID includes PC1 for which the general requirements are not yet defined. The proponents should clarify whether general requirements for PC1 are defined or not and what is the relation to PC1 defined for band n14.
4. One company questioned whether the work is intended to apply to the entire n77 or just the part that is US specific? Further clarification from the proponent is welcome

Regarding the 2nd question on the proposed WID objectives:

1. Multiple companies commented that since MPR applicability is general, any improvement on this work should not be discussed under this WI. Moderator suggests to clarify the handling of this issue further. There was also a suggestion that if improvements for MPR/A-MPR are introduced, there should be corresponding signaling defined.
2. The term HPUE is not consistent, should be further discussed how to refine this. One proposal is to use “new power UE device”
3. N77(and also n78 if agreed) is globablly used, clarifications are needed whether this work would apply only to the US or to other regions as well. If it would apply to other regions, the handling of other requirements should be clarified.
4. One company commented that different solutions for handling SAR should be considered, not just limiting Tx duty cycle to meet FCC limits. Further discussion on how to proceed is needed.
5. One company commented that objective 4 should be clarified and provided a suggestion, moderator recommends to check on whether the proposed update is agreeable or not or more edits are needed during the intermediate round.
6. It is proposed in the objectives to allow transmit power higher than the upper limit set currently by the power class. Multiple compaies commented that this was discussed in the last RAN4 meeting(RAN4#97e) but not agreed. Moderator suggests to check whether this objective can be kept in some form or should be removed from this WID (this should not impact the generic RAN4 discussion on this topic).
7. “Antenna diversity” should be clarified. Transparent Tx Diversity is likely what was meant.
8. It is suggested to assume 28dBm+28dBm for 31dBm PC1 UE. This should be further discussed.
9. Antenna isolation improvement is assumed only for FWA? This should be clarified
10. FR1 UE RF requirements do not differentiate different UE types, one company commented that device types should not be used in the objectives, rather a note with the target device should be chosen.
11. One company asked to clarify if the work is targeting only dual Tx UEs. Moderator’s understanding is yes, however, the proponents should confirm.

## Intermediate Email Discussions

### Companies comments

Based on the initial round of e-mail discussions, the companies are invited to express their views on the following issues:

Is the addition of n78 agreeable? Are there any specific changes needed with this addition?

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| **Company** | **Views** |
| Qualcomm Incorporated | Inclusion of Band n78 is agreeable. |
| Apple | Agreeable |
| Huawei, HiSilicon | Adding n78 is agreeable. Both n77 and n78 should be considered as global bands in the WI, not for a specific region. |
| Intel | Agreeable |
| LGE | Agreeable |

How should the generic requirements for PC1 be handled and what is the relationship with PC1 defined for n14? Should this work wait for the TX diversity discussion to coclude or not?

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| **Company** | **Views** |
| Qualcomm Incorporated | There are many open questions related to PC1. We also note that the FCC rules for 3700 – 3980 MHz only allow a maximum transmit power of 30 dBm EIRP for mobile and portable devices but higher power for fixed or basestation. It is not fully clear whether FWA would be regarded as a portable or as a fixed in the context of FCC rules. Separating out PC1.5 from PC1 therefore seems reasonable. It is recommended to restrict the scope of this work item to PC1.5 and follow-up with PC1 in a separate WI/SI. |
| Apple | It is unclear whether the intended FWA UE would assume using the PA designed for mobile devices. To achieve 31dBm output power, it may require three 26dBm PAs running simultaneously which could be even more complicated than Tx diversity requirements as currently being dicussed with dual-PA implementation. Therefore, we also recommend to confine the scope of this WI to PC1.5 only. |
| Huawei, HiSilicon | The WI is spectrum related, but no general requirements defined for PC1, even we have PC1 n14 in the spec. As usual, general requirements shall be specified in the UE RF FR1 WI if needed. We recommend that this spectrum related WI is focused on PC1.5. |
| Intel | The proposal from companies above to focus on PC1.5 is fine for us.  PC1 general requirements can be considered in a separate SI/WI. |
| LGE | Agree with Quaclcomm. Based on the current FCC regulation, RAN4 can decouple the PC1.5 and PC1. So RAN focus on PC1.5 for handheld UE in this WID. |

Will this work apply to the entire n77 or be limited to the US? If yes, is there a need to have any special handling for other requirements, especially SAR or will a generic solution be enough?

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| **Company** | **Views** |
| Qualcomm Incorporated | So far, the power class has been defined to be applicable for the entire band. Furthermore, Band n77/n78 is not limited to deployment in the US. Therefore, we should assume that the work item relates to the entirety of Band n77/n78 for any country in which it might be deployed. In some countries, regulatory restrictions may impose limits on the maximum UE transmit power of 23 dBm, but the P-max signaling is available for this purpose. What probably does need discussion is what the default maximum output power of the UE should be in the absence of P-max signaling. |
| Apple | Our assumption is that the requirement is applicable to the entire band. |
| Huawei, HiSilicon | It is recommended that the WI covers generic case for n77/n78, which is not limited to a certain region or certain frequency range inside of the whole band. |
| Intel | Covering the entire n77 is our first preference to have a generic solution. |
| LGE | Generally need to study the regulatory requirements in each countries. In some regions, it is not possible the PC1.5 HPUE operation in n77/n78. So RAN4 define the general RF requirements firstly. And additional regional requirements will be discussed and specified in rel-17 timeline. |

Can MPR improvements be handled in this WI or should they be handled in another WI?

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| **Company** | **Views** |
| Qualcomm Incorporated | We see no reason why MPR improvements cannot be handled in this work item. There are no NS’s defined for n77 and n78 so it is only MPR that applies. An alternative is to define NS for n77 and n78 and associate and improved MPR with it (as A-MPR), so that the improvement would not be general. But this doesn’t seem like a very good approach. |
| T-Mobile USA | We support handling MPR improvements in this WID. However, for PC1.5 since dual Tx is required MPR measurements will be needed since simulations aren’t available. |
| Apple | PC1.5 has been defined based on n41. Is the improvement intended for generic PC1.5 or specific for n77/n78 relative to current PC1.5? |
| Huawei, HiSilicon | MPR is a general requirement. For spectrum related WI, our understanding is that only band specific requirements should be considered. If MPR improvement for PC1.5 is agreeable for Rel-17, it should be include in the UE RF FR1 WI rather than a band specific WI. |
| Intel | MPR improvement is ok. Same questions as Apple – is it proposed to define generic or band specific MPR improvements? |
| LGE | In Rel-16, RAN4 specified MPR/A-MPR for PC1.5 UE in n41 UL-MIMO. So what is reason to improve the MPR/A-MPR in rel-17? RAN4 already agreed the antenna isolation as 10dB and dual PA/2Tx RF architecture. So RAN4 carefully check which factors are enhanced or improved in Rel-17. |

If MPR/A-MPR improvements are introduced, should the proposed objective regarding signaling be added(introduce new signaling or existing signaling to enable the UE to indicate to the network whether it supports improved A-MPR and MPR)?

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| **Company** | **Views** |
| Qualcomm Incorporated | New signaling is needed to indicate for example that the device is FWA and/or capable of a different MPR than the existing one. |
| T-Mobile USA | We don’t’ think that new signalling is needed. We think that modifiedMPRbehavior signalling can be used. |
| Huawei, HiSilicon | New signalling is not needed if MPR improvement is agreeable. |
| LGE | Need further discuss whether reuse or define new MPR/A-MPR with NS\_xx. |

Should the removal of the upper limit on the UE output power(e.g. allow 28dBm for a UE with 23dBm and 26dBm capabilities) be kept in this WID or not?

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| **Company** | **Views** |
| Qualcomm Incorporated | It should be kept. During the last RAN4 meeting, all companies expressed interest in further studying but some concerns were raised. It was also questioned whether there was operator interest. In this WI, the scope is limited to a specific work item for which the operator is interested. |
| T-Mobile USA | We think it should be kept. |
| Apple | It should be a new feature instead of PC2 without upper limit of UE output power. |
| Huawei, HiSilicon | The idea was just proposed in last RAN4 meeting and no consensus was reached. Concerns were raised in RAN4 that output power exceeding the reported power class may cause SAR, measurement uncertainty issues, and it may also violate the regulatory requirements. And also it is not band specific issue to be discussed in the spectrum related WI. |
| Intel | We noted that there is a similar discussion in thread [45] on these objectives. We should aim to avoid duplicated objectives in different items. Can the proponents clarify the intention? |
| LGE | Don’t consider the upper limit for PC2 UE to allow 28dBm power with 26dBm PA + 23dBm PA |

Should different target devices(e.g. FWA) be used in the objectives or a generic approach should be taken? If a generic approach is taken, how should the objectives be reformulated?

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| **Company** | **Views** |
| Qualcomm Incorporated | FWA can be used descriptively in the WID, but it should be recognized that the 3GPP specifications do not differentiate different device types. |
| T-Mobile USA | If the UE is a handheld, SAR requirements shall be met. FWA doesn’t have the same constraints. |
| Huawei, HiSilicon | We would like to see clear target devices described in the WID, as some requirements are different for handheld UE and FWA UE in the specification. |
| Intel | FWA description can be kept in WID. However, from the 3GPP spec persective no differentiation is needed for different device types. |
| LGE | In FR1, there was no different device types between FWA and handheld UE. The FWA UE with PC1.5 and PC1 will be studied in seprate WI. |

Should it be already assumed 2x28dBm PAs for 31dBm output power?

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| **Company** | **Views** |
| Apple | Is 28dBm PA available? |
| LGE | Based on FCC regulatory requirements, PC1 FWA can be deprioritized. |

Antenna isolation improvement is assumed only for FWA?

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| **Company** | **Views** |
| T-Mobile USA | We believe that antenna isulation improvement should be considered, but not necessarily limited to FWA. |
| Apple | Improvement on handheld devices could be quite challenging due to limited form factor. |
| Huawei, HiSilicon | We don't think antenna isolation assumption should be changed as lots of requirements in the existing spec are related to the common acceptable assumtions. |
| LGE | Just follow same antenna isolation assumption in rel-16 for PC1.5 UE. FWA can be deprioritized. |

Regarding objective 4, is the change proposed by Ericsson agreeable (Assess any impact at the gNB of a 29dBm and 31dBm UE power class. The existing gNB requirements shall be applied)? If not, please provide suggested wording.

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| **Company** | **Views** |
| Huawei, HiSilicon | As commented above, we think 31dBm power class should not be considered in a spectrum related WI before the general RF requirements are specified. |

Proponents should further clarify what is meant by “ antenna diversity”, transparent Tx Div?

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| **Company** | **Views** |
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What term should be used throughout the WID? Will “new power UE device” be fine?

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| **Company** | **Views** |
| Qualcomm Incorporated | I don’t see the problem with calling it HPUE in the WID. In the specification, it will be called PC1.5 or PC1 since there is no such term as HPUE in the specifications. |
| T-Mobile USA | We agree with Qualcomm. HPUE is fine in the WID. |
| Huawei, HiSilicon | We want to use consistent term in the WID objectives, but for the HPUE, it should be clear what UE types included. |

Is this WID intended just for dual Tx UEs?

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| **Company** | **Views** |
| Qualcomm Incorporated | PC1.5 is for dual Tx UE’s only. |
| T-Mobile USA | We agree, PC1.5 is only defined for dual Tx. However, PC1 is defined for single Tx for other bands so we don’t think that PC1 should be limited to dual Tx. |
| Apple | Dual-PA for PC1.5 is our assumption. PC1 is subjected to further studies. |
| Huawei, HiSilicon | Similar to n41, only dual Tx is considered for PC1.5. |
| Intel | Dual Tx for PC1.5 |
| LGE | Agree |

Any other comments?

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| **Company** | **Views** |
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### Summary of the Intermediate Email Discussion

# Conclusion

# References

RP-202280 New WID on high-power devices operation use cases over Band n77 Verizon