3GPP TSG-RAN WG2 #103 Tdoc R2-18xxxxx

Gothenburg, Sweden, August 20th – 24th 2018

Agenda Item: x.x.x.x

Source: Ericsson

Title: Email discussion report: Power Class and P-max

Document for: Discussion, Decision

# 1 Introduction

In this email discussion RAN2 is supposed to “*reach a common understand of the power class related signalling as required by RAN1 and RAN4 agreements, and to progress the CR*”. The intended outcome is a report and a set of CRs to the next meeting.

The deadline for the discussion is Thursday 2018-08-02.

# 2 Discussion

## 2.1 Background

At the AH1807 meeting, the discussion was based on the following paper:

* [R2-1810384](ftp://ftp.3gpp.org/tsg_ran/WG2_RL2/TSGR2_AHs/2018_07_NR/Docs//R2-1810384.zip) E234/E235 Power Class and P-max Ericsson discussion Rel-15

Several agreements have been reached:

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| => The per-UE power is clarified to be just for FR1 (call it per-UE-FR1)  => Make the change backward compatible. (Changes to INMs may be non-backwards compatible)  => The change to the NR side should go into the SA CR, and the LTE side should go into the EN-DC CR.  => UE capability and INM aspects can be progressed offline |

During the AH meeting we provided corresponding CRs for LTE and NR RRC that reflect the agreements:

* [R2-1810858](ftp://ftp.3gpp.org/tsg_ran/WG2_RL2/TSGR2_AHs/2018_07_NR/Docs/R2-1810858.zip) Power class and P-max, CR to 38.331 Ericsson, RAN2-102-AH Montreal
* [R2-1810934](ftp://ftp.3gpp.org/tsg_ran/WG2_RL2/TSGR2_AHs/2018_07_NR/Docs/R2-1810934.zip) Power class and P-max, CR to 36.331 Ericsson, RAN2-102-AH Montreal

As seen above, RAN2 agreed (based on RAN4’s input) that the per-UE power class should be applicable to serving cells on FR1 only. Furthermore, the existing inter-node signalling for conveying the per-cell-group values p-NR and p-LTE stated also explicitly that it is applicable only for serving cells in FR1. We therefore adjusted also the corresponding Uu signalling by renaming p-NR to p-NR-FR1 and p-LTE to p-LTE-FR1 (change “2” in the 38.331 CR).

## 2.2 Discussion

At the presentation of the above-mentioned CRs questions were raised whether it is really intended by RAN4 to apply the power restrictions only to FR1 or whether they should also apply to FR2. And if the latter, the question was whether separate signalling parameters would be required for FR2 or whether one parameter would apply to all serving cells (irrespective whether FR1 or FR2). To resolve these open issues and to finalize the CRs we would hence appreciate companies views... **preferably after consulting their RAN4 colleagues**.

### 2.2.1 Configuring maximum power in DL signalling

**Q1.1) Do the p-Max fields in dedicated signalling (p-NR, p-LTE, p-UE) and in inter-node signalling apply only to serving cells operating on FR1 or also to serving cells operating on FR2?**

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| Company | Comment |
| Sprint | RAN4 only requested p-Max for FR1. From R2-1806639:  P-Max for EN-DC and NR CA is also necessary to limit the total transmission power for some potential use cases such as 10 dBm in a hospital.   * *P-Max for EN-DC and NR CA in FR1 is introduced for some power limited use cases.*   PEMAX (which is what RAN4 calls p-Max) appears in 38.101-1:  PCMAX\_L,f,c ≤ PCMAX,f,c ≤ PCMAX\_H,f,c with  PCMAX\_L,f,c = MIN {PEMAX,c– ∆TC,c, (PPowerClass – ΔPPowerClass) – MAX(MPRc + A-MPRc+ ΔTIB,c + ∆TC,c +∆TRxSRS, P-MPRc) }  PCMAX\_H,f,c = MIN {PEMAX,c, PPowerClass – ΔPPowerClass }  But not in 38.101-2 (FR2 spec):  The configured UE maximum output power PCMAX,f,c for carrier *f* of a serving cell *c* shall be set such that the corresponding measured peak EIRP PUMAX,f,c is within the following bounds  PPowerclass – MPRf,c – P-MPRf,c – T(MPRf,c + P-MPRf,c) ≤ PUMAX,f,c ≤ EIRPmax  while the corresponding measured total radiated power PTMAX,f,c is bounded by  PTMAX,f,c ≤ TRPmax |
| Huawei | In our understanding at least in current RAN4 agreements, Pmax is only applied to EN-DC and NR CA for FR1, we suggest currently we only apply this parameter to FR1. if later RAN4 introduces similar thing to FR2, we can introduce another parameter for FR2 as even this applies to both FR1 and FR2, the specific value might be different for FR1 and FR2. |
| T-Mobile USA | These apply to both FR1 and FR2 |
| NTT DOCOMO | RAN4 LS (R2-1806639) stated that *P-Max for EN-DC and NR CA in FR1 is introduced for some power limited use cases*. As the serving cell level power limitation is already supported regardless of FR1/FR2 as in LTE (called P-Max), we understand the RAN4 intention such that “P-Max for EN-DC and NR CA in FR1” is the power limitation per UE in FR1. RAN4 has agreed this per-UE power limitation for FR1 only. RAN4 has not discussed whether the per-UE power limitation is needed for FR2 as well. |
| Apple | We think for now Pmax is only applicable to EN-DC and NR CA for FR1. For FR2 case, in section 6.2.4 of TS38.101-2, the upper limit of configured UE maximum output power PCMAX,f,c is EIRPmax, which is actually the regulatory requirement limit, rather than a base station configured limitation.  The signaling part to support limitation configured by base station for FR2 could be discussed again in RAN2 only after RAN4 decides to support this feature in FR2. |
| LG | Currently, p-Max restriction is applicable for FR1 in RAN4. For FR2, configured transmitted power is based on EIRP and p-Max is not considered so far. RAN2 need to wait RAN4 decision or agreements how to define the limitation of the TX power at FR2 for similar usage on it |
| Ericsson | As DCM says, the value provided anyway per cell (in FrequencyInfoUL) could be used for FR1 and FR2. Based on companies input, the other values seem to be applicable only for FR1. |

1. Except for p-Max in FrequencyInfoUL, all other p-values (p-NR-FR1, p-UE-FR1) apply only to FR1 (additional p-values could be added later if RAN4 decides whether and how to support restrictions for FR2 and/or for combinations of FR1 and FR2) (CR tags corresponding fields as “FR1”)

**Q1.2) If they apply only to FR1, do we need additional parameters for FR2?**

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| Company | Comment |
| Sprint | Maybe, but that shouldn’t hold up the addition of p-Max for FR1 as requested by RAN4. |
| Huawei | As explained above, we are not sure whether same value can be applied to FR1 and FR2 and in this case we prefer to introduce another parameter, however this seems not essential to be introduced right now. As long as we allow future extensions with backward compatible changes, this can be added later until RAN4 has further agreements. |
| NTT DOCOMO | It is better to wait for further input from RAN4. |
| Apple | It’s not quite appropriate for RAN2 to introduce additional parameters for FR2 since RAN4 hasn’t concluded anything yet. |
| LG | If RAN4 define the similar thing for p-Max at FR2, additional equation would be needed.  Total powerclass should be only defined in FR1 +FR1 DC band combos. Individual power class was specified for FR1+ FR2 or FR2+FR2. |

1. Do not introduce additional p-values for FR2 unless RAN4 tells us that/how to do that.

**Q1.3) Impact on dynamic power sharing?**

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| Company | Comment |
| Huawei | In previous discussion RAN1 made agreement that the dynamic power sharing is justified by the condition whether P\_lte + P\_nr > X\_total, and RAN4 defined X\_total as UE’s power class. Now if we introduce Pmax for EN-DC and NR CA case (also requested by RAN4), I am not sure whether the previous justification for dynamic power sharing is still valid anymore. It seems the more appropriate way is to define the X\_total as the Pmax used for EN-DC case? We need to check with RAN4 on this point. In addition we need to think about whether this would further affect LTE power control in RAN1 as in my current understanding LTE power control has not taken this into account. |
| NTT DOCOMO | X\_total could be P\_CMAX as in LTE, i.e. min {p-UE, power class}. |
| Apple | Not sure we understand the question. We think the X\_total should be exactly the Pmax. |
| LG | There is no impact for dynamic power sharing for FR1+FR2 or FR2+ FR2 band combinations. Dynamic power sharing will be applied only FR1 + FR1. In case, RAN4 can follow the RAN1 dynamic power sharing agreements as baseline. Some specific band combos will be treated the MPR/A-MPR by RAN4 decision. |
| Ericsson | We agree with Huawei’s observation that the UE (which supports dynamic power sharing) has to perform dynamic power sharing if the sum of the configured per-cell-group power limit exceeds the configured per-UE power limit.  However, this formula is currently not shown in 38.331 anyway. Hence, we believe that we just need to inform RAN1 and RAN4 of our understanding. |

1. Inform RAN1 and RAN4 of RAN2’s understanding that “the UE uses dynamic power sharing if P-LTE + P-NR-FR1 > min {p-UE-FR1, power class}”

### 2.2.2 Power-Class signalling in UE capabilities

**Q2.1) Do we need an additional powerClass parameter for FR2 in the UE capability?**

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| Company | Comment |
| Ericsson | **No** - It was concluded in the RAN2 AH meeting that the additional power class value in the band combination works anyway only for 2 UL and that hence a single “powerClass” value per band combination is sufficient. The network derives the allowed split among the Uls from the per-band power class.  Hence, from signalling point of view, it does not matter whether the two ULs are for FR1 and/or FR2. In other words, the one powerClass parameter introduced in the CR should be sufficient for FR2, too. |
| Sprint | **Not at this time, but maybe Yes in the future – I**t is important to note that powerClass for FR1 and for FR2 are completely independent. Power class for FR1 is in dBm (conducted power), while PowerClass for FR2 is in EIRP (radiated power). From 38.101-3:  6.2B.1.5 Inter-band EN-DC including both FR1 and FR2  *< OTA requirements >*  <Editor’s notes: chapter numbers to be updated.>  For inter-band EN-DC of LTE and NR in both FR1 and FR2, the UE shall meet each transmitter power requirement for inter-band EN-DC of LTE and NR in FR1specified in clause 6.2B.1.3 of TS 38.101-3 and for NR in FR2 clause 6.2.1 of TS 38.101-2 independently.  For now, there are no CA or EN-DC band combinations with more than one FR2 band. So, per-band Power Class should be sufficient for FR2 bands. If and when CA or EN-DC combinations are added with more than one FR2 band in the uplink, then a UE capability for FR2 power class per band combination might be needed. |
| Huawei | We think it is fine to have one single powerClass, however it is worth clarifying that this does not mean this powerClass also applies to the band combination for FR1+FR2. As far as we understand from RAN4’s agreement, currently the powerClass only applies for the EN-DC case with FR1 band combination, even there is a combination including both FR1 and FR2, such Pmax is only restricted to FR1 part. For example, if there is a band combination FR1 A + FR1 B + FR2 C, this parameter only considers A+B and Band C is not taken into account. Maybe we need to think about more on the fallback case as well. |
| T-Mobile USA | We agree with Ericsson’s comment. In addition P\_NR applies to both FR1 and FR2 and therefor there is no need for a new FR2 parameter |
| NTT DOCOMO | No. For FR2, we understand that per-band power class (outside band combination) is applied even for NR CA in FR2, as in LTE. This is due to the fact that PA is different for FR1 and FR2. If a UE supports a band combination including FR1 and FR2, UE has two PAs which are isolated each other. |
| Apple | No signaling is needed since power class is now specified per band thus it could already be used for FR2. But the values in power class should be extended to cover power class 1 and 4.  Besides, we agree with Huawei that according to RAN4 spec, the power class for FR1 and FR2 should be independent with each other. |
| LG | No. Total powerclass should be only defined in FR1 +FR1 DC band combos. Individual power class was specified for FR1+ FR2 or FR2+FR2. So No need to define additional powerclass parameters in these cases. |
| Ericsson | If we understand other companies’ input correctly, there is no need to signal a total uplink power for an FR1+FR2 band combination since it is **always** so that the UE offers the sum of the (two) per band values. In an FR1+FR1 band combination, the UE will usually just support a total of 23 dBm. And hence it has to indicate explicitly if/whether it supports actually more than that.  If this is the understanding and if there is no risk that future FR1+FR2 UEs will **not** support the sum of the FR1 and FR2 power class values, we could clarify in the field description that the UE sets this capability only in band combinations with two FR1 uplink serving cells (as discussed, with more than two FR1 serving cells this single value would not provide the required functionality either) |

1. Clarify that the UE sets the new power class parameter only in band combinations with two FR1 uplink serving cells. (added in CR)

**Q2.2) Power class for FR2 per band and value range?**

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| Company | Comment |
| Huawei | Currently in ASN.1 the ue-powerclass only addressed PC2 and PC3, however this is only for FR1 case. For FR2 case, at least 4 power classes have been defined in 38.101-2 and in R2-1809442 it is clearly stated that “*necessary number (bit) of power classes for FR2 would be 4 bits since it is expected that there would be several use cases and UE types in FR2. However, the number of bits should be considered also from signalling overhead perspective in RAN2, so the number of bits can be modified appropriately in RAN2 if necessary.*” So I don’t think current RAN2 signaling correctly capture the latest RAN4 agreements and we should define another power class for FR2 per band. |
| NTT DOCOMO | We agree that the RAN4 spec defines 4 power classes in FR2. Since power class 2 and 3 can be reported as shown below, it is enough to add another two power classes as shown below.  BandNR ::= SEQUENCE {  bandNR FreqBandIndicatorNR,  ue-PowerClass ENUMERATED {pc2, pc3} OPTIONAL,  ...,  [[ ue-PowerClass2 ENUMERATED {pc3, pc4} OPTIONAL  ]]  } |
| Apple | Agree with NTT DOCOMO. |
| LG | It is reasonable to define Powerclass for FR2 per band. RAN4 defined at least 4 power classes in FR2. It should be applied in RAN2. |
| Ericsson | We basically agree but wonder why we need the pc3 twice (once in the ue-PowerClass and once in the ue-PowerClass2? We assume this was not intentional.  We think we should consider a NBC change and just add the pc4 to the ue-PowerClass field since it saves 3 byte overhead per Band entry and since in particular initial UEs (with two separate modems) are likely to make use of it. |

1. Add the power class value “pc4” in BandNR. Discuss whether to do this as NBC change or in a backwards compatible manner. (CR shows all but inter-node as BC)

### 2.2.3 Inter-Node Message

**Q3.1) Impact on inter-node message?**

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| Company | Comment |
| Huawei | Currently in CG-ConfigInfo there is an IE as below:  powerCoordination-FR1 SEQUENCE {  p-maxNR P-Max OPTIONAL,  p-maxEUTRA P-Max OPTIONAL  }  These two parameters only addressed the maximum transmission power for EUTRA and NR, but for the new Pmax used across multiple CG for FR1, there is no information exchanged. In this case it would be difficult for the SCG to understand what power is really allowed from the UE side and in our understanding, the new added ***p-UE-FR1*** should also be added in the inter-node message. |
| NTT DOCOMO | In the power limited scenario, we assume that the limited power is the same for serving cell level and per-UE level. In that sense, NW can set p-maxNR and p-maxEUTRA accordingly. In that sense, p-UE-FR1 is not needed in INM. On the other hand, if there is another case that serving cell level power limitation and per-UE level power limitation is different, p-UE-FR1 might be needed in INM. |
| Apple | We don’t have strong view on this. Since the limitation on UE transmission power is a static configuration, the MeNB could simply update the p-maxNR to SgNB when such limitation is required or updated. |
| LG | RAN4 agreed to specify the total max power for EN-DC at FR1. So RAN2 need to define the new parameter related to the total max power of UE. |
| Ericsson | We had proposed such addition in our original discussion document for the Ad-Hoc meeting in Montreal. However, as Huawei shows above, the MN indicates already two p-values... one for the EUTRA cell group and one for the NR cell group. The only reason to introduce also a value for the total sum could be to prevent the SN from requesting a higher share when it sees e.g. that the sum of the p-NR and the p-LTE allowed by the MN is smaller than the maximum supported by the UE. This could happen when the MN knows that certain total levels have to be enforced (based on OAM) but the EN-DC SN does not. We did not see a strong need for such additional signalling and hence omitted it in the draft CR. But maybe it is safer to add it?! |

1. Consider adding p-UE-FR1 in inter-node signalling from MN to SN (added in CR)

### 2.2.4 Other

**Q4.1) Backwards compatibility**

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| Company | Comment |
| T-Mobile USA | Backward compatibility - Given the aggressive deployment timeline for SA and NSA it is important that the changes be backward compatible. |
| NTT DOCOMO | Backward compatible change is preferred, except for INM. |
| Apple | Backward compatible change is preferred. |
| LG | Agree with DOCOMO |
| Ericsson | Generally, we agree. But as can be seen from the 38.331 CR, the backwards compatible addition in UE capabilities requires quite many changes and causes quite a bit of overhead. Therefore, we tend to prefer an NBC change also for the additions to UE capabilities. |

## 2.3 Draft CRs

The above-mentioned CRs that were briefly discussed at the RAN2-AH meeting are also in the Email discussion folder on the FTP server. We will update them based on input provided here. But other companies are also invited to provide their suggestion there directly by adding RIL-comments (like in the ASN.1 review). Please increment the version number of the file.

We provided an updated version of the 38.331 CR (version 01) on the FTP server wherein recent additions are marked in green.

# Conclusion

Based on the discussion in the previous sections we propose the following:

[Proposal 1 Except for p-Max in FrequencyInfoUL, all other p-values (p-NR-FR1, p-UE-FR1) apply only to FR1 (additional p-values could be added later if RAN4 decides whether and how to support restrictions for FR2 and/or for combinations of FR1 and FR2) (CR tags corresponding fields as “FR1”)](#_Toc521063211)

[Proposal 2 Do not introduce additional p-values for FR2 unless RAN4 tells us that/how to do that.](#_Toc521063212)

[Proposal 3 Inform RAN1 and RAN4 of RAN2’s understanding that “the UE uses dynamic power sharing if P-LTE + P-NR-FR1 > min {p-UE-FR1, power class}”](#_Toc521063213)

[Proposal 4 Clarify that the UE sets the new power class parameter only in band combinations with two FR1 uplink serving cells. (added in CR)](#_Toc521063214)

[Proposal 5 Add the power class value “pc4” in BandNR. Discuss whether to do this as NBC change or in a backwards compatible manner. (CR shows all but inter-node as BC)](#_Toc521063215)

[Proposal 6 Consider adding p-UE-FR1 in inter-node signalling from MN to SN (added in CR)](#_Toc521063216)