**3GPP TSG-RAN WG4 Meeting # 98-bis-e R4-210XXXX**

**Electronic Meeting, 12th – 20th April, 2021**

**Agenda item:** 9.4

**Source:** Moderator (China Unicom)

**Title:** Email discussion summary for [98-bis-e][143] FS\_NR\_PC2\_UE\_FDD

**Document for:** Information

# Introduction

*Briefly introduce background, the scope of this email discussion (e.g. list of treated agenda items) and provide some guidelines for email discussion if necessary.*

*List of candidate target of email discussion for 1st round and 2nd round*

* 1st round: TBA
* 2nd round: TBA

# Topic #1: PC2 for NR FDD band

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

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2106550 | Xiaomi | **Observation 1: the evaluation period when deriving the UL dutycycle shall be carefully defined.**  **Observation 2: to weight the sensitivity degradation compared to PC3 case, the MSD approach can be used. The detail value shall be derived until RF components feasibility and performance can be assessed properly.**  **Observation 3: only one set of MSD value by considering the worst case between two different RF architectures is specified.**  **Observation 5: UE implementation based solution, i.e. P-MPR shall be allowed for PC2 FDD high power UE.** |
| R4-2104509 | Softbank | **[Question to the group]**  **Assuming that the power down problem is likely to happen in duty cycle solution,**   1. **in P-MPR scheme where backoff logic is implementation dependent, should we also assume that the problem happens?** 2. **if such problems are unavoidable, should we assume to create a new set of test suite for FDD-PC2 and solicit a regulator to adopt?** |
| R4-2106560 | OPPO | **Observation 1: FDD duty cycle can be calculated by UE itself and it is unlikely for the NW to align the calculation window with UE under current capability framework.**  **Observation 2: It is unknown whether this FDD UL duty cycle concept can be accepted by regulations, if not then FDD HPUE has to apply PMPR.**  **Proposal 1: It is proposed to conclude that the FDD duty cycle concept can be applied by UE itself.** |
| R4-2106362 | ZTE | **Proposal 1. Same duty cycle capability for HPUE FR1TDD bands can be reused for HPUE FDD bands.**  **Observation 1. Taking more aggressive duplexer assumption into account, no additional REFSEN degradation might need to be considered for PC2 band n1.**  **Observation 2. REFSEN degradation will become more severer for PC2 band n3, especially for 40/50MHz.** |
| R4-2104997 | LGE | **Observation 1: In n3 FDD band, the 0.9 dB MSD is needed when Duplexer isolation charateristic is decreased 2dB compare to current filter characteristics.**  **Observation 2: In n1 FDD band, the 0.4dB MSD is needed when Duplexer isolation charateristic is decreased 2dB compare to current filter characteristics.**  **Observation 3: Eventhough duplexer isolation level keep or enhance the Tx/Rx isolation level, the raised leakage problem in Rx band by RFIC/PA operation in FDD band will be impacted to the sensitivity degradation in FDD band.**  **Observation 4: In n3 FDD band, the 0.7 dB MSD is needed when assume noise level might be increased about 1.5dB in Rx band by RFIC/PA operation.**  **Observation 5: In n1 FDD band, the 0.3dB MSD is needed when assume noise level might be increased about 1.5dB in Rx band by RFIC/PA operation.**  **Observation 6: In n3 FDD band, the 1.7 dB MSD is needed when both Duplexer isolation charateristic (2dB relaxation) and increased noise level (1.5dB) in Rx band by RFIC/PA operation for PC2 FDD UE.**  **Observation 7: In n1 FDD band, the 0.8dB MSD is needed when both duplexer isolation charateristic (2dB relaxation) and increased noise level (1.5dB) in Rx band by RFFIC/PA operation for PC2 FDD UE.**  **Proposal 1: To reduce the sensitivity degradation in n3/n1 band, filter vendor shall keep or enhance the duplexer Tx/Rx isolation level.**  **Proposal 2: RAN4 need to hear of RF component vendor’s opinions when they can support the enhanced RF component performance such as RFIC, duplexer and PAs to support PC2 UE in FDD band.**  **Proposal 3: RAN4 can further study for sensitivity degradation requirements when RF component vendor provide these commercial Duplexer, PAs and RFICs for PC2 UE in FDD band. The above MSD results can be considered as baseline to derive MSD requirements in WI phase.** |
| R4-2107298 | Huawei, HiSilicon | **Observation: For 2Tx PC2 UE, noise floor for Band n3 and n1 in the Rx band is negligible.**  **Proposal 1: For specific band n3 and n1, it can be concluded that there is no obvious REFSENS degradation for PC2 FDD HPUE.** |
| R4-2107299 | Huawei, HiSilicon | **Observation 1: Whether the components targeted to PC3 UE can be reused for PC2 UE depends on the maximum rating capability, some of them may need to be redesigned.**  **Observation 2: FDD HPUE with 2Tx can reuse existing RF components targeted for PC3, while 1Tx may need to use newly designed components to enhance the maximum rating ability to address the reliability issue.**  **Proposal: It is proposed to focus on 2Tx UE architecture for FDD HPUE to fully utilize the existing RF components and take advantage of the economies of scale.** |
| R4-2107354 | Qualcomm | **Proposal: FDD ON/OFF duty cycle control needs to be managed. A mechanism where the maximum uplink duty cycle UE capability is reported and counted based on transmitted symbols should be defined. The details are FFS.**  **Proposal: Companies to evaluate a guideline for the uplink configuration for PC2 FDD reference sensitivity.** |
| R4-2107300 | Huawei, HiSilicon | **Observation 1: From the simulation results, performance gain can be observed for both cell average and cell edge cases. And extremely obvious performance gain on cell average throughput is observed.**  **Proposal 1: It is proposed not to spend more time to justify the obvious system performance gain for FDD HUPE and focus on other remaining issues.** |
| R4-2107119 | Qualcomm | **Observation 1: The system performance is sensitive to the power control set parameters. PC2 UE brings system gain when realistic assumptions are considered. A degradation can be seen if we assume that throughput will be reduced by half due to the duty cycle constraints. In realistic situation, where several UEs are multiplexed in the same cell, non-negligible gain in UL performance can be observed in both mean and 5%-tile throughput.**  **Observation 2: The potential DL degradation due to Tx/Rx de-sense does not lead to substantial performance degradation in typical interference limited scenarios. The performance degradation for noise limited scenarios might be seen which depends on operator’s deployment.** |
| R4-2104922 | ZTE | **Observation: From the simulation results, obvious performance gains on cell average throughput and cell edge throughput can be observed.** |
| R4-2104541 | vivo | **Observation 1:**   * The overall gain is much smaller compared to [3] and there exist some negative gain case. * Alpha values have significant impact on the gain.   + Though Alpha = 0.8 generally have larger gain for cell average, the absolute value is smaller than alpha=0.6. It maybe because higher interference. * Under 50% (per-subframe) restriction, generally there is some performance penalty, particularly for cell edge.   **Observation 2**: Alpha = 0.8 means more UE would be in the state of power saturation. |

## Open issues summary

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

### Sub-topic 1-1 SAR Scheme

*Sub-topic description:*

*Open issues and candidate options before e-meeting:*

**Issue 1-1-1: How to apply duty cycle in FDD band**

* Proposals
  + Option 1: Same duty cycle capability for HPUE FR1 TDD bands can be reused for HPUE FDD bands.
  + Option 2: FDD duty cycle concept can be applied by UE itself, it is unlikely for the NW to align the calculation window with UE under current capability framework.
* Recommended WF
  + TBA

**Issue 1-1-2: Whether power down problem is likely to happen in P-MPR solution?**

* Proposals
  + Option 1: Yes
  + Option 2: No
* Recommended WF
  + TBA

### Sub-topic 1-2 Interference

*Sub-topic description*

*Open issues and candidate options before e-meeting:*

**Issue 1-2-1: How to handle REFSENS degradation**

* Proposals
  + Option 1: Reduce the Tx power for reference sensitivity back to PC3 power levels
  + Option 2: Reduce the uplink configuration (number of RB’s) for reference sensitivity
  + Option 3: Introduce an MSD term
* Recommended WF
  + TBA

**Issue 1-2-2: Evaluation of receiver sensitivity degradation**

* Proposals
* Option 1: MSD evaluation as well as uplink configuration for FDD PC2 is calculated based on PC3 assumptions
* Option 2: MSD evaluation as well as uplink configuration for FDD PC2 is calculated based on new assumptions
* Recommended WF
  + TBA

### Sub-topic 1-3 System Performance evaluation

***Sub-topic description: Target to conclude on system performance evaluation for NR FDD HUPE based on simulation results submitted in this meeting.***

*Open issues and candidate options before e-meeting:*

**Issue 1-3: Simulation results**

* Proposals
  + Option 1: There are performance gain observed based on simulation results, no further evaluation is needed.
  + Option 2: The performance gain needs to be further evaluated.
* Recommended WF
  + TBA

## Companies views’ collection for 1st round

### Open issues

Sub topic 1-1 SAR Scheme

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| --- | --- |
| **Company** | **Comments** |
| LGE | Issues 1-1-1: **: How to apply duty cycle in FDD band**  Prefer option1. Duty Cycle approach can be applied for FDD band if there are not any big problem to apply the dutycycle capability.  Issue 1-1-2: **Whether power down problem is likely to happen in P-MPR solution?**  Option 2: P-MPR solution is one of alternative solution by UE implementation to meet SAR regulation. NW should be known the P-MPR level after apply P-MPR to meet SAR regulation. |
| ZTE | **Issue 1-1-1: Option 1**  The duty cycle as HPUE TDD band can be feasible for HPUE FDD band, and also when the duty cycle condition is not met, the same fall back behaviour as HPUE TDD band, i.e, fall back to PC3, is applied.  We agree more studies are needed for HPUE FDD duty cycle considering the Tx control and duty cycle calculation are different with HPUE TDD.  **Issue 1-1-2:**  Option 2. P-MPR is used to compliance to the SAR limits by reducing the Tx max.out power. |
| Qualcomm | Issue 1-1-1: Recognizing that the FDD duty cycle reporting is crude and subject to ambiguity, it may still be beneficial to report it. If the network is not able to interpret the duty cycle from the UE, then anyways, the UE reverts to autonomous behavior, so the option 1 and option 2 converge.  Issue 1-1-2: Power down via P-MPR is likely if the Tx is run at full power continuously. If some Tx duty cycle can be applied, then power down can be avoided. |
| OPPO | **Issue 1-1-1: How to apply duty cycle in FDD band**  Both option 1 and 2 are ok. The capability is reported and it is up to NW and UE how to use it.  **Issue 1-1-2: Whether power down problem is likely to happen in P-MPR solution?**  In conformance testing, the PMRP will not be triggered, since it is tested without human body nearby. However, due to long time transmitting max power, it might reduce power to overcome e.g. heating issues. |
| Huawei | **Issue 1-1-1: How to apply duty cycle in FDD band**  For a standardized solution, duty cycle capability similar to TDD band can be utilized, i.e. option 1. As a UE implementation solution, option 2 could be used as well.  **Issue 1-1-2: Whether power down problem is likely to happen in P-MPR solution?**  Power down is possible for P-MPR solution in real application scenario. |
| Xiaomi | Issue 1-1-1: Dutycycle approach, more study is needed on how to guarantee BS and UE having the same evaluation period.  Issue 1-1-2: We don’t quite understand what the intention for this issue. We think P-MPR is already used in current PC3 FDD bands**.** |
| Ericsson | Issue 1-1-1: duty-cycle reporting solution as specified for EN-DC and discussed for UL CA PC2 should not be used for FDD PC2. The evaluation period is ambiguous for duty-cycle schemes. TDM-like patterns or any other fixed schemes would have an impact on latency. Can anything other than P-MPR be used for SAR compliance? What is the difference between Option 2 and the P-MPR method in practice?  Issue 1-1-2: power fall-back would occur for the P-MPR method (to reduce the long-term output power average for high duty-cycle transmissions). |
| Apple | Issue 1-1-1: We are leaning to Option 1. But not sure if there would be impact to RAN1 specifications.  Issue 1-1-2: If UL cycle exceeds the limit, then P-MPR would have to be applied. |
| Vivo | Issue 1-1-1: We slightly prefer option 1.  Issue 1-1-2: Power down is highly to happen. The duty cycle solution may help to avoid it. |

Sub topic 1-2 Interference

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| --- | --- |
| **Company** | **Comments** |
| LGE | **Issue 1-2-1: How to handle REFSENS degradation**  Prefer option 3 to define MSD for PC2 UE  **Issue 1-2-2: Evaluation of receiver sensitivity degradation**  Prefer option 1 to define MSD & UL configuration based PC3 assumptions |
| Skyworks | **Issue 1-2-1: How to handle REFSENS degradation**  Given that PC2 is meant for cell edge where REFSENS is relevant and increased MSD will happen whatever the architecture => option 3 is preferred  **Issue 1-2-2: Evaluation of receiver sensitivity degradation**  REFSENS or MSD is assessed with the same UL configuration than for PC3 |
| ZTE | **Issue 1-2-1: How to handle REFSENS degradation**  Either option 2 or option 3, or both option 2 and option 3 are feasible.  For option 1, it excludes the HPUE influence, and seems it is new fallback behaviour.  For option 2, indeed, reducing the UL configuration can reduce the overlapping between interfering and own DL frequency range, which can potential reduce the REFSEN degradation. However, we are not sure whether it is enough. If it is not enough to avoid the large REFSEN degradation, then MSD values are still needed (Option 3).  For option 3, it is straightforward, and it depends on the architecture (1Tx or 2Tx), maybe we can focus on 1Tx with 26dBm PA, and some new assumptions maybe needed.  **Issue 1-2-2: Issue 1-2-2: Evaluation of receiver sensitivity degradation**  Both, it depends on the architecture (1Tx or 2Tx). For 2Tx with 2\*23dBm PA, we think the current PC3 assumptions can be reused. For 1Tx with 26dBm PA, and some new assumptions maybe needed. |
| Qualcomm | Issue 1-2-1: Option 2 is preferred, but we can also consider Option 3. The problem with Option 3 however is that the evaulation is likely to be more time consuming on a case-by-case basis, and RAN4 tends to define very large MSD values. In any case, our expectation is that the UE implementation should be able to mitigate some of the effects by improved filtering and other design improvements so that not all of the degradation will be covered by spec relaxation.  Issue 1-2-2: Option 2. It is expected that new designs should be used to support this more advanced feature. Even for 2Tx PC3-based solutions, we should not overly degrade the performance of PC2 by blindly using PC3 assumptions. |
| OPPO | **Issue 1-2-1: How to handle REFSENS degradation**  Option 2 or 3.  **Issue 1-2-2: Evaluation of receiver sensitivity degradation**  Option 2. |
| Huawei | **Issue 1-2-1: How to handle REFSENS degradation**  Prefer option 3. At least for n1 and n3, the REFSENS degradation is not that large. For some other FDD cases, option 2 could be considered as well.  **Issue 1-2-2: Evaluation of receiver sensitivity degradation**  Prefer option 1. For existing RF components, e.g. duplexer, the maximum rating capability may not support 1Tx FDD HPUE, but for 2Tx, at least the implementation feasibility can be guaranteed. Otherwise, new design may need to be considered. |
| Xiaomi | Issue 1-2-1: prefer option 3, but also can accept option 2. Option 1 cannot reflect the impact on reference sensitivity for PC2.  Issue 1-2-2: Option 2. The MSD requirements shall be derived based on assumptions on RF component used for high power and we need more views from RF component vendors. |
| Ericsson | Issue 1-2-1: REFSENS is a noise factor test. Option 3 to verify linearity and relation to PC3 performance (and REFSENS used for all RX tests).  Issue 1-2-2: Option 1. |
| Apple | Issue 1-2-1: Option 2 and Option 3 have already been used in PC3 REFSENS  Issue 1-2-2: If this is only for UL configuration, either option is fine. |
| Vivo | Issue 1-2-1: Prefer to option 2. Reducing the uplink configuration reduce the impact on reference sensitivity and could increase PSD, which align with the WI objective to increase the cell coverage.  Issue 1-2-2: Option 1. |

Sub topic 1-3 System performance evaluation

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| --- | --- |
| **Company** | **Comments** |
| LGE | **Issue 1-3: Simulation results**  Prefer option 2. Need further evaluation to align the system simulation results. |
| ZTE | Option 1. We also provide the performance evaluation in R4-2104922, and we observe obvious performance gains on cell average throughput and cell edge throughput. We think it should be better to focus on the other issues. |
| Qualcomm | Issue 1-3: Simulation results  Option 2. We observe different trends for the simulation results provided by companies. For example, even with the same simulation approach and assumptions, some results show performance gains at the cell edge, while some show the gain at the cell center. We’re wondering the rationale behind the different trends. In addition, we see a big gap among the simulation results from companies. RAN4 should align the simulation results as much as possible. |
| OPPO | **Issue 1-3: Simulation results**  Option 2, different observations were given in the papers this meeting, it is better to align the understanding on the performance gains in different scenarios. |
| Samsung | We prefer Option 2. Although some companies use the same assumption and method, the results and its interpretations vary by company. In order for a better understanding of the study result, RAN4 should continue the performance evaluation discussion for convergence. |
| Huawei | **Issue 1-3: Simulation results**  Prefer option 1. We see obvious perf gain from the simulation results. More effort should be focused on other remaining issues. |
| T-Mobile USA | **Issue 1-3: Simulation results**  We are interested in a theoretical explanation behind the gains. If a UE has sufficient throughput with 1 PRB scheduled 50% of the time, then it can get better coverage with PC2. On the other hand, if a UE needs 2 RBs with 50% duty cycle, the performance should be the same with 2 PRBs with 50% duty cycle at PC2 as it is with 1 PRB and 100% duty cycle at PC3, because the PSD would be the same. Is this an accurate assessment? |
| Apple | **Issue 1-3 Simulation results**  Option 2. We also share the same view as T-Mobile USA on the assessment. |
| Vivo | **Issue 1-3: Simulation results**  Option 2. Further evaluation is needed, e.g. Further check results, how to align 50% duty cycle, CDF meaning, etc. We also think that full buffer is also a meaningful scenario, which can be used to evaluate higher interference impact of PC2 UE. |

### CRs/TPs comments collection

*For close-to-finalize WIs and maintenance work, comments collections can be arranged for TPs and CRs. For ongoing WIs, suggest to focus on open issues discussion on 1st round.*

|  |  |
| --- | --- |
| **CR/TP number** | **Comments collection** |
| XXX | Company A |
| Company B |
|  |
| YYY | Company A |
| Company B |
|  |

## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

|  |  |
| --- | --- |
|  | **Status summary** |
| **Sub-topic #1** | *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:* |

### CRs/TPs

*Moderator tries to summarize discussion status for 1st round and provides recommendation on CRs/TPs Status update*

*Note: The tdoc decisions shall be provided in Section 3 and this table is optional in case moderators would like to provide additional information.*

|  |  |
| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation** |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

## Discussion on 2nd round (if applicable)

# Topic #2: TR Skeleton

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

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2106912 | China Unicom | TR skeleton for Study on high power UE (power class 2) for one NR FDD band |

## Open issues summary

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

### Sub-topic 2-1

*Sub-topic description:*

*Open issues and candidate options before e-meeting:*

**Issue 2-1: TR skeleton**

* Recommended WF
  + It is recommended to agree on the TR skeleton.

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| XXX | Sub topic 2-1: |

### CRs/TPs comments collection

*Major close to finalize WIs and Rel-15 maintenance, comments collections can be arranged for TPs and CRs. For Rel-16 on-going WIs, suggest to focus on open issues discussion on 1st round.*

|  |  |
| --- | --- |
| **CR/TP number** | **Comments collection** |
| XXX | Company A |
| Company B |
|  |
| YYY | Company A |
| Company B |
|  |

## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

|  |  |
| --- | --- |
|  | **Status summary** |
| **Sub-topic#1** | *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:* |

### CRs/TPs

*Moderator tries to summarize discussion status for 1st round and provided recommendation on CRs/TPs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation** |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

## Discussion on 2nd round (if applicable)

*Moderator can provide summary of 2nd round here. Note that recommended decisions on tdocs should be provided in the section titled ”Recommendations for Tdocs”.*

# Recommendations for Tdocs

## 1st round

**New tdocs**

|  |  |  |
| --- | --- | --- |
| **Title** | **Source** | **Comments** |
| WF on … | YYY |  |
| LS on … | ZZZ | To: RAN\_X; Cc: RAN\_Y |
|  |  |  |

**Existing tdocs**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Tdoc number** | **Title** | **Source** | **Recommendation** | **Comments** |
| R4-210xxxx | CR on … | XXX | Agreeable, Revised, Merged, Postponed, Not Pursued |  |
|  |  |  |  |  |
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|  |  |  |  |  |

Notes:

1. Please include the summary of recommendations for all tdocs across all sub-topics incl. existing and new tdocs.
2. For the Recommendation column please include one of the following:
   1. CRs/TPs: Agreeable, Revised, Merged, Postponed, Not Pursued
   2. Other documents: Agreeable, Revised, Noted
3. For new LS documents, please include information on To/Cc WGs in the comments column
4. Do not include hyper-links in the documents

## 2nd round

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Tdoc number** | **Title** | **Source** | **Recommendation** | **Comments** |
| R4-210xxxx | CR on … | XXX | Agreeable, Revised, Merged, Postponed, Not Pursued |  |
| R4-210xxxx | WF on … | YYY | Agreeable, Revised, Noted |  |
| R4-210xxxx | LS on … | ZZZ | Agreeable, Revised, Noted |  |
|  |  |  |  |  |

Notes:

1. Please include the summary of recommendations for all tdocs across all sub-topics.
2. For the Recommendation column please include one of the following:
   1. CRs/TPs: Agreeable, Revised, Merged, Postponed, Not Pursued
   2. Other documents: Agreeable, Revised, Noted
3. Do not include hyper-links in the documents