**3GPP TSG-RAN WG4 Meeting # 99-e R4-210XXXX**

**Electronic Meeting, 19th – 27th May, 2021**

**Agenda item:** 10.5.1

**Source:** Moderator (China Unicom)

**Title:** Email discussion summary for [99-e][153] 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

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| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2110163 | Apple | **Observation 1**: In FDD bands, there is no concept of duty cycle and contiguous UL transmission has always been assumed during SAR characterization.  **Observation 2**: To support HPUE in FDD bands, 3GPP may need to accept the duty-cycled UL transmission for FDD bands.  **Observation 3**: To support HPUE for FDD bands, duplexer power handling capability needs to be evaluated.  **Observation 4**: For FDD bands with narrow duplex distance, further UL RB allocation restriction may be needed under HPUE operation to prevent REFSENS degradation which could render a countereffect on having HPUE to improve UL throughput near the cell edge as motivated by this study item.  **Observation 5**: Half-duplex operation in FDD bands by nature is duty-cycled which has inherently resolved the SAR issue under HPUE scenario.  **Observation 6**: Half-duplex operation allows bypassing the high insertion loss duplexer and avoids REFSENS impact from transmit leakages which can save UL from RB allocation restriction for FDD bands with narrow duplex distance.  **Proposal**: Introduce half-duplex operation for NR FDD bands under HPUE scenario to enable a quick adoption for PC2 in NR FDD bands. |
| R4-2110197 | Xiaomi | **Observation 1**: The evaluation period when deriving the UL dutycycle shall be carefully defined.  **Observation 2**: To guarantee BS and UE has the same knowledge of UL dutycycle, defining a unified evaluation period between BS and UE is necessary.  **Observation 3**: Only one set of MSD value by considering the worst case between two different RF architectures is specified. |
| R4-2110829 | OPPO | **Observation 1**: To make sure UE capability can be guaranteed, NW need to calculate the duty cycle capability based on per frame window length with 1 symbol moving step.  **Observation 2**: It is not meaningful to continue discussing how to align the understanding of calculation window between UE and NW since the duty cycle capability probably will never be considered in scheduling.  **Proposal 1**: It is proposed to conclude that the FDD duty cycle capability is only required to be applied by UE itself and complete the discussion of duty cycle based SAR solution. |
| R4-2109700 | vivo | **Proposal**: After the connection setup, the last MSG1/MSGA of RACH before connection setup is proposed as the starting point of evaluation period.  **Observation**: Before the connection setup, the SAR impact of MSG1/MSGA is negligible. And UE can use P-MPR to meet SAR limits. |
| R4-2110433 | ZTE | **Observation 1:** With the existing assumptions, no MSD degradation for band n1 and band n3 for separate PA architecture.  **Observation 2:** There were no agreements on the new assumptions.  **Observation 3:** Taking more aggressive duplexer assumption into account, no additional REFSEN degradation might need to be considered for PC2 band n1.  **Observation 4:** REFSEN degradation will become more severer for PC2 band n3, especially for 40/50MHz.  Nevertheless, new assumptions should be discussed and agreed first. |
| R4-2111446 | 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 to make a conclusion on system performance gain for FDD HUPE and focus on other remaining issues for the SI. |
| R4-2109699 | vivo | **Observation 1:** The performance gain of FDD HPUE has been observed for both cell average and cell edge, but it does not match the actual situation in which only part of UE can perform high power.  **Observation 2:** The data density of the current traffic model is too low to reflect the interference of HPUE.  **Proposal 1:** It should be more reasonable to limit the proportion of HPUE in the simulation.  **Proposal 2:** The higher data density traffic model is also needed for the performance evaluation. |
| R4-2109763 | ZTE | **Observation:** From the simulation results, obvious performance gains on cell average throughput and cell edge throughput can be observed for the case of 10 kB packet size. |
| R4-2109998 | LG Electronics | TP on UE implementation for PC2 FDD band |
| R4-2110798 | Qualcomm | TP to TR38.861: Simulation results for FDD HPUE |

## 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(s)

*Sub-topic description:*

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

**Issue 1-1-1: How to handle evaluation period for duty cycle solution**

* Proposals
  + Option 1: Using UE implementation based method to handle duty cycle capability. (i.e. FDD duty cycle capability is only required to be applied by UE)
  + Option 2: UE and network using unified evaluation period, with the last MSG1/MSGA of RACH before connection setup is proposed as the starting point of evaluation period.
  + Option 3: Reuse the existing duty cycle capability as other HPUEs since R15 and R16.
* Recommended WF
  + TBA

**Issue 1-1-2: Half-duplex operation**

* Proposal: Introduce half-duplex operation for NR FDD bands under HPUE scenario to enable a quick adoption for PC2 in NR FDD bands.
  + Option 1: Not to introduce half-duplex operation for FDD PC2, as there are significant performance loss for DL operation.
  + Option 2: Introduce half-duplex operation for FDD PC2.
* Recommended WF
  + TBA

### Sub-topic 1-2 Interference

*Sub-topic description*

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

**Issue 1-2: MSD evaluation**

* Moderator observation: MSD values provided by companies based on existing assumptions for n1 and n3 is not a limiting factor for FDD HPUE.
* Proposals:
  + Option 1: To evaluate MSD values based on available RF components and existing assumptions, the specific values can be discussed based on available inputs.
  + Option 2: New assumptions (based on new RF component capability), if proposed and agreed in the group, can be used for MSD evaluation.
* Recommended WF
  + TBA

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

*Sub-topic description*

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

**Issue 1-2: Simulation results**

* Proposal 1: There are performance gain observed based on simulation results from agreed assumptions.
* Recommended WF
  + To conclude that there is performance gain observed based on simulation results.

## Companies views’ collection for 1st round

### Open issues

Sub topic 1-1 SAR Scheme(s)

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| **Company** | **Comments** |
| Qualcomm | Issue 1-1-1: For option 1, how would this be any different from P-MPR? Option 2 is an interesting idea but needs further investigation. Option 3 doesn’t appear to work.  Issue 1-1-2: The proposal for half duplex is to enable quick adoption, but we fear it might have the opposite effect. In order to enable half duplex, the networks have to support it and we think that may take more time than solving the UE problems related to full duplex PC2. But we would be interested to hear the perspectives from other companies. |
| Huawei | Issue 1-1-1: Option 3. We think the solution based on UL dutycycle is the same as those for other HPUE WI.  Essentially option 1 is UE implementation, which is similar to P-MPR solution. For option 2, we don’t think that the UE capability should have impact on BS behavior.  Issue 1-1-2: Option 1. The proposal of half duplexer solution is aiming to solve the SAR issue, however, the performance loss introduced by the solution could too high than the purpose of introducing FDD HPUE. |
| Skyworks | Issue 1-1-1: As discussed in previous meeting duty cycle alone might not be sufficient, a max 100% duty cycle duration is needed for RF front end components to have a known thermal and reliability behavior. The UE shall at least be able to use PMPR when the 100% duty cyle duration is too long.  Issue 1-1-2: Question for clarification: is this HD-FDD proposed as an option on top of FD-FDD or the only operation mode for PC2 FDD? From the diagram it seems that FD-FDD is supported too up to 23dBm and then HD-FDD is used only above 23dBm. Is this the right understanding? |
| Xiaomi | Issue 1-1-1: Needs to better understanding how option 3 work in FDD operation. For option 1, does it means only P-MPR solution is considered?  Issue 1-1-2: The proposed half duplexer solution is beneficial to avoid desense. If the desense is very severe for specific FDD band, this proposal can be considered. Thus, we are open to discuss this proposal of half duplexer solution. |
| Vivo | Issue 1-1-1: option 2  Issue 1-1-2: it seems difficult to sync between NW and UE about when to use half-duplex. |
| ZTE | Issue 1-1-1: Option 1 is UE implementation, like P-MPR method, and it seems the fallback behoviour (i.e. fallback to PC3) might not feasible. Option 3, The Tx control and duty cycle calculation might be different with HPUE TDD.  Issue 1-1-2: Half duplex can solve some issue such as SAR and interfering from Tx to Rx. However, it might need switching time between Tx<->Rx or guard band to protect the UL or DL symbols, like GP in TDD, otherwise the performance loss would be seen. |
| Ericsson: | Issue 1-1-1: this is essentially the same as a proprietary P-MPR method. But the P-MPR method is preferred to a duty-cycle reporting method with a PC3 (?) fallback that may not be necessary, the actual output power not considered. The P-MPR method can be tested: use an RMC with a specific duty cycle e.g. 50%. Then the average output power should be 23 dBm.  Issue 1-1-2: HD will be covered by other device types with reduced capability. |
| Apple | Issue 1-1-1: Option 1 and Option 3 does not seem to relate to “how to handle evaluation period for duty cycle solution”.  Issue 1-1-2: The half-duplex operation not only mitigates the SAR issue, it also completely avoids the REFSENS impact to DL. Another advantage is that duplexer can be bypassed to reduce the UL insertion loss which is a further boost for UL power. The overall throughput impact can be further analyzed. In half-duplex operation, UL can take the advantage of full RB allocations and achieve the same UL throughput with a shorter UL burst (as compared to full-duplex operation with UL RB restriction and duty cycle). With a shorter UL burst, more time can be allocated to DL. |
| LGE | Issue 1-1-1: Option 1 and Option 3 is feasible for PC2 FDD UE. For Option 3, the Tx control and duty cycle calculation might be different with HPUE TDD.  Issue 1-1-2: Option 1. Half-duplexer can be avoid the Rx/Tx interference and satisfy the SAR requirmeents. But, it was not analyzed in SLS evaluation so, if to introduce the half-duplexer mode, then T-put gain significantly degraded. The REFSENS problem can be solved by RB position & size restriction with small UL/DL Gap. |
| OPPO | **Issue 1-1-1: How to handle evaluation period for duty cycle solution**  Option 1. In our view this is the most practical outcome of the FDD duty cycle discussion since there is no practical way to align NW/UE on the evaluation period, but of course this is common issue as other HPUE not just FDD HPUE.  **Issue 1-1-2: Half-duplex operation**  Option 1. |
| China Unicom | Issue 1-1-1: Option 3. The TDM patterns for FDD band used for FDD+TDD EN-DC and ongoing UL CA PC2 can be aligned. We can further investigate the Tx control and duty cycle calculation issues for FDD PC2.  Issue 1-1-2: HD operation might be beneficial to solve DESENS issues, but we have concerns on performance loss for NR FDD. |

Sub topic 1-2 Interference

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| **Company** | **Comments** |
| Qualcomm | Option 2 |
| Huawei | Option 1. Based on the analysis in these two meetings, we already see that the MSD for n1 and n3 due to HPUE is not very large. The requirements can be determined in WI stage. |
| Skyworks | We do not agree with the analysis for n3 and thus the moderator and huawei observation that the MSD is not very different:  In R4-2109998 there is only 3dB increase in PA noise between n1 and n3, this is totally ignoring the fact that at 40-45MHz CBW, the DL is subject to IMD5 of wanted and image (duplex distance is 95MHz and BW up to 45MHz). In fact the interference level can be as high as -30dBm/MHz based on MPR. With 50dB isolation, the worst case MSD is >10dB. As ZTE mentions in their paper the n3 REFSENS degradation is large while for n1 with the large duplex distance it is negligible.  Since this PC2 FDD discussion is guided by the use of wider CBW to be supported vs LTE. It is very important that the worst case MSD is understood. At least as a first step the normal assumptions shall be used with the allocation in the worst position, carrier, image, CIM3,CIM5 TRX impairments as per current 3GPP assumptions. It should be noticed that the TRX impairments actually dominates this issue as the PA only generates the unwanted IMDs in the DL because of the presence and level of the TRX impairments. We are not against looking at options that would make PC2 FDD REFSENS similar to PC3 but we should start from the baseline PC3 test points. These options should include improvements of TRX impairments |
| Xiaomi | It may depend on case by case |
| ZTE | There are two different RF architecture, one 26dBm PA and 2\*23dBm PA. So we think for 2\*23dBm RF architecture, the existing assumptions would be reused (Option 1), while for one 26dBm PA, New assumptions would be needed (Option 2.). |
| Apple | We share the same views with Skyworks. For FDD bands with narrow duplex distance, substantial UL RB restriction may be needed to avoid REFSENS impact. For n3 under PC3, even with UL RB restriction down to 50 RBs, we can still see significant REFSENS degradation for 45MHz DL BW. |
| LGE | Option 2 is more generic to determine the simulation assumptions and change the RX position and RB size restriction, it shall be considered the enhanced RF component feasibility such as duplexer and PA linearity enhancement. |

Sub topic 1-3 System Performance Evaluation

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| **Company** | **Comments** |
| Huawei | Based on the simulations in these two meetings, we already see the performance gain by FDD HPUE. Thus we think that the conclusion on system performance evaluation can be made in this meeting. |
| vivo | The interference of high power is not analyzed in the FTP traffic mode, because of the low resource usage, the uplink transmission of multi-UE happens at the same time are very rare. In the other traffic mode, such full buffer traffic mode, the defect of the high power can be observed. |
| ZTE | Agree with the recommended WF. |
| OPPO | Share similar view as vivo, the interference should be modeled in a more practical way to see how much interference would happen in high load, middle load, low load situations. And the vivo simulation shows that the performance gain would be small or even degraded. |
| China Unicom | Agree with the WF. From the simulation results submitted by companies in the current and previous meeting based on agreed assumptions, performance gain in both cell average and cell edge can be observed.  Regarding the simulation based on full buffer model, the full buffer traffic is very unlikely to be seen in the commercial network, especially for UL operation, so practically full buffer is not a good representation for UL data traffic. And there is no need to include it in the study. |

### 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** |
| R4-2109998 (TP on UE implementation for PC2 FDD band) - LGE | Skyworks: we do no agree on the MSD analysis for n3 which does not account for the critical IMD cases for large CBW which is the main argument for PC2 FDD.  🡪 LGE: We think that RAN4 just evaluate the MSD degradation impact in SI phase. If RAN4 agree to necessity the MSD analysis for wider CBW in SI phase, then we can provide expected MSD degradation in the wider CBW in next meeting. So, TP can be approved in this meeting and updated with wider CBW in next RAN4 meeting. |
| ZTE: It seems only 10MHz CBW is evaluated. However, for other CBW, espcially for big CBW, CIM issues needs to be considered. such as for 40/50MHz for band n3.  🡪 LGE: We think that RAN4 just evaluate the MSD degradation impact in SI phase. If RAN4 agree to necessity the MSD analysis for wider CBW in SI phase, then we can provide expected MSD degradation in the wider CBW in next meeting. So, TP can be approved in this meeting and updated with wider CBW in next RAN4 meeting. |
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| R4-2110798 (TP to TR38.861: Simulation results for FDD HPUE) - Qualcomm | Company A |
| Company B |
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## 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.*

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| --- | --- |
|  | **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)

# 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