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

**Electronic Meeting, 25 Jan. – 05 Feb., 2021**

**Agenda item:** 12.5

**Source:** Moderator (China Unicom)

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

**Document for:** Information

# Introduction

In the RAN#90e meeting, the new SI of RP-202870 for FS\_NR\_PC2\_UE\_FDD was approved. This RAN4 #98e meeting is the first meeting to work on this topic with the SI objectives. This email discussion thread will focus on the following aspects:

* Work plan
* PC2 for NR FDD band

# Topic #1: Work Plan

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

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2100081 | China Unicom | Work plan 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 1-1

**Issue 1-1: Work Plan**

* Recommended WF
  + It is recommended to approve the work plan in R4-2100081.

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Qualcomm | Sub topic 1-1:  Issue 1-1: Work Plan  For system gain evaluation, companies need to calibrate the simulation platform before discussing the simulation results. Otherwise, we could not guarantee the simulation results provided by companies are valid. We prefer to add one step to calibrate the simulation platform. |

### 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:* |

*Recommendations on WF/LS assignment*

|  |  |  |
| --- | --- | --- |
|  | **WF/LS t-doc Title** | **Assigned Company,**  **WF or LS lead** |
| #1 |  |  |

### CRs/TPs

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

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

## Summary on 2nd round (if applicable)

*Moderator tries to summarize discussion status for 2nd round and provided recommendation on CRs/TPs/WFs/LSs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP/LS/WF number** | **T-doc Status update recommendation** |
| XXX | *Based on 2nd round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

# Topic #2: 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** |
| R4-2101110 | Xiaomi | Observation 1: the difference coverage between UL and DL is the main justification when high power UE is introduced for TDD bands.  Observation 2: the better understanding the system performance gains to introduce FDD high power UE is necessary.  Observation 3: it is a bit premature to support high power UE in n1 and n3 with one Tx architecture from the implementation point of view.  Observation 4: Besides the requirements ACLR, MPR and A-MPR should be reevaluated, impact on the Rx reference sensitivity also needs to be considered.  Observation 5: UE implementation based solution, i.e. P-MPR shall be allowed for PC2 FDD high power UE. |
| R4-2102391 | Huawei, Hisilicon | Observation 1: P-MPR is the baseline SAR solution for the HPUE feature.  Observation 2: RF component feasibility is not a limiting issue for FDD PC2 HPUE according to current implementation capability.  Observation 3: Self-interference or Tx noise impact on REFSENS could be different for different FDD bands.  Observation 4: The co-existence study conclusion based on simulation for TDD HPUE can be used for FDD HPUE as well.  Observation 5: Obvious performance gain on cell average throughput can be found in system level simulation evaluation.  Proposal 1: P-MPR is the baseline SAR solution for FDD HPUE.  Proposal 2: Existing duty cycle capability for FR1 TDD bands can be reused for FDD bands.  Proposal 3: Both UE architectures of 1Tx 26dBm and 2Tx 23dBm should be considered for FDD PC2 HPUE.  Proposal 4: RF component feasibility is not a limiting issue for FDD PC2 HPUE  Proposal 5: Self-interference or Tx noise impact on REFSENS should be studied case by case.  Proposal 6: No need to perform the co-existence simulation for FDD HPUE and previous conclusion for TDD HPUE can used for FDD as well. |
| R4-2102610 | Apple | Observation 1: In FDD bands, there is no concept of duty cycle and contiguous transmission has always been assumed during SAR characterization.  Observation 2: To support HPUE in FDD bands, 3GPP may not only alter the FDD band physical layer design, but also convince the regulatory body to accept the duty-cycled UL transmission for FDD bands in SAR characterization.  Observation 3: To support HPUE for FDD bands, duplexer power handling capability needs to be evaluated.  Observation 4: REFSENS impact can be caused by increased Tx output power alone, and further aggravated due to Tx/Rx isolation degradation by thermal effect.  Observation 5: Under SAR regulation, the UL performance is virtually a “par” between PC2 and PC3 UEs.  Observation 6: If taking into account the potential REFSENS degradation caused by increased UL maximum outpower for PC2 UE, the PC2 UE system performance could be even worse than PC3 UE.  Observation 7: Many FDD bands are already subjected to UL RB restriction to avoid further REFSENS degradation which has essentially helped boost the UL PSD.  Observation 8: Increasing UL maximum output power does not really aid to improve UL resource utilization for most of FDD bands. |
| R4-2102708 | vivo | Proposal 1: The system performance of multi-cell and multi-UE scenario is proposed to be evaluated.  Proposal 2: The system performance of PC3 UE with 100% uplink duty cycle and PC2 UE with less uplink duty cycle is proposed to analysis.  Proposal 3: The typical power control parameters: P0 (-76dBm) and alpha (0.6), fully buffer traffic model and mandatory modulation 64QAM are proposed. Detailed assumptions also attached in the Annex.  Proposal 4: P-MPR and duty cycle-based solution should be the baseline SAR solution. To reduce unexpected UE output power fallback and help gNB scheduling, reporting UE capability for the duty cycle is preferred.  Observation: ACLR and out-of-band emission may be an issue for HPUE in FDD band. |
| R4-2100110 | CMCC | Proposal: It is possible that the FDD duty cycle scheme may be suitable for the PC2 FDD scheme, but RAN4 needs to further discuss details such as how to define the uplink duty cycle for the FDD bands. From the perspective of China Mobile, we do not rule out other implementation schemes, such as P-MPR is also a UE implementation scheme to support the release independent manner. |
| R4-2102186 | ZTE | Proposal 1.Current P-MPR can be used as baseline for HPUE FDD band SAR solution.  Proposal 2. Besides P-MPR scheme, TDM operation for FDD could be alternative for SAR solution. |
| R4-2100290 | LG Electronics | Observation 1: In FDD band, the PA/Duplexer charateristic is not support PC2 maximum output power since PA linearity and Duplexer allowed maximum power rating shall improve the performance at least 3dB higher than current component charateristics.  Proposal 1: RAN4 need to hear of RF component vendor’s opinions when they can support the enhanced RF component performance to support PC2 UE in FDD band.  Proposal 2: RAN4 can study on high power UE (power class 2) for one NR FDD band when RF component vendor are ready to support the RF component performance to support PC2 UE in FDD band. |
| R4-2100543 | Skyworks | Proposal on PC2 Power amplifier:   * Only single antenna / power amplifier architecture is considered for FDD PC2 * Long term average power should be close to 23dBm for both SAR and thermal / power consumption aspects * Default 26dBm duty-cycle and duration shall be bounded accordingly and account for DTX * 31 dB ACLR is assumed   Proposal on duplexer:   * To assess reliability and thermal behavior of duplexers and ultimately the TX-RX and TX antenna performance assumptions for PC2 REFSENS and band protection:   + Peak and average power and thermal reliability and variability aspect should be studied with band 3 as example band   + Long term average power should be close to 23dBm for both SAR and thermal/power consumption aspects   + Default 26dBm duty-cycle and duration shall be bounded accordingly and account for DTX * Legacy PC3 assumptions on Tx-Rx isolation and TX-Ant can be re-used for PC2 as a starting point * FFS if duplexer assumptions can be improved by 3dB to account for state-of-the-art performance depending on reliability and thermal aspects. This can be discussed per band   Proposal on UE RX and coexistence: revision of REFSENS and coexistence specification for PC2 should wait for duplexer performance and reliability assessment based on well-defined peak and average power profile. |
| R4-2102392 | Huawei, Hisilicon | Observation 1: From the simulation results, obvious performance gain on cell average throughput is observed.  Proposal 1: It is proposed to agree on the above simulation assumptions. |
| R4-2102503 | Qualcomm | Proposal 1: Option 2 is selected as the baseline approach for the system gains evaluation and further investigate how to emulate the difference for UL duty cycle. Other aspects can be considered if identified.  Proposal 2: N (N depends on UL duty cycle) sub-snapshots within one snapshot could be considered to emulate the difference for UL duty cycle in FDD HPUE simulation.  Proposal 3: The power control simulation parameters form TR36.886 i.e., power control Set 1, 2, 4A and 4B shall be the basis and can be further updated if needed.  Proposal 4: The inter-site discusses and propagation model in Table 2 should be adopted.  Proposal 5: RAN4 to agree other simulation assumptions listed in Table 3 for FDD HPUE performance gain evaluations. |

## 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 SAR scheme(s)

*Sub-topic description*

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

**Issue 2-1: SAR Scheme(s)**

* Proposals: P-MPR is the baseline SAR solution, existing duty cycle capability for FR1 TDD bands can be reused for FDD bands. Clarification of “duty cycle” in FDD band is needed.
* Other solutions are not precluded.
* Recommended WF
  + TBA

### Sub-topic 2-2 Interference & Co-existence issues

*Sub-topic description*

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

**Issue 2-2-1: Interference issues**

* Proposals: Impact on Rx REFSENS should be studied case by case.
* Recommended WF
  + TBA

**Issue 2-2-2: Co-existence issues**

* Proposals: No need to perform the co-existence simulation for FDD HPUE and previous conclusion for TDD HPUE can used for FDD as well.
* Recommended WF
  + TBA

### Sub-topic 2-3 UE implementation issues

*Sub-topic description*

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

**Issue 2-3-1: UE architecture**

* Proposals
  + Option 1: Both UE architectures of 1Tx 26dBm and 2Tx 23dBm should be considered for FDD PC2 HPUE.
  + Option 2: Only 2Tx 23dBm is considered, because it is a bit premature to support high power UE in n1 and n3 with one Tx architecture.
  + Option 3: Only single antenna / power amplifier architecture is considered for FDD PC2.
* Recommended WF
  + TBA

**Issue 2-3: RF component feasibility**

* Proposals
  + Option 1: RF component feasibility is not a limiting issue for FDD PC2 HPUE.
  + Option 2: To support HPUE for FDD bands, duplexer power handling capability needs to be evaluated, e.g. duplexer performance and reliability assessment based on well-defined peak and average power profile.
* Recommended WF
  + TBA

### Sub-topic 2-4 System performance evaluations

*Sub-topic description:*

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

**Issue 2-4: Simulations Assumptions**

* Proposals
  + Huawei’s Assumption (Dynamic system level simulation)

|  |  |
| --- | --- |
| **Configuration parameters** | **Values** |
| **Scenario** | Urban macro |
| **ISD** | 500 m |
| **Duplexing** | FDD |
| **Carrier frequency** | 1.8 GHz, 2.1GHz |
| **Modulation** | Up to 256QAM |
| **Numerology** | 15 kHz |
| **Simulation bandwidth** | 20 MHz |
| **Transmission scheme** | SU-MIMO |
| **Codebook** | For 2Tx, codebook [1 1]T is used for transmit diversity |
| **SU dimension** | 1 layer |
| **Antenna configuration at TRxP** | 4Rx, (M,N,P,Mg, Ng) = (1,2,10,1,1; 1,2)  32Rx, (M,N,P,Mg, Ng) = (8,8,2,1,1; 2,8) |
| **Antenna configuration at UE** | 1Tx, (M,N,P,Mg, Ng) = (1,1,1,1,1; 1,1),  2Tx, (M,N,P,Mg, Ng) = (1,1,2,1,1; 1,1), |
| **UE maximal transmit power** | For 1Tx, 23 dBm for each TXRU  For 1Tx, 26 dBm for each TXRU (High power UE)  For 2Tx, 23 dBm for each TXRU (High power UE) |
| **Scheduling** | PF |
| **Receiver** | MMSE-IRC |
| **Channel estimation** | Ideal |
| **Power control parameter** | P0=-60, alpha = 0.6 |
| **TRxP number per site** | 3 |
| **TRxP number** | 21 |
| **Channel model** | UMa following TR 38.901 |
| **Electronic tilt** | 102° |
| **Traffic model** | FTP3, packet size: 100k / 10k Byte, arrival rate: 1 packet / s. |

* + vivo’s Assumption (Dynamic system level simulation)

|  |  |
| --- | --- |
| **Configuration parameters** | **Values** |
| **Scenario** | Urban macro |
| **ISD** | 500m |
| **Duplexing** | FDD |
| **Carrier frequency** | 2.1 GHz |
| **Modulation** | Up to [**64QAM]** |
| **Numerology** | 15 kHz |
| **Simulation bandwidth** | 40 MHz |
| **Antenna configuration at TRxP** | 4Rx, (M, N, P, Mg, Ng) = (**1, 4, 2, 1, 2**) |
| **Antenna configuration at UE** | 1Tx, (M, N, P, Mg, Ng) = (1, 1, 1, 1, 1) |
| **UE maximal transmit power** | For 1Tx, 23dBm for each TXRU (baseline)  For 1Tx, 26dBm for each TXRU (HPUE) |
| **Scheduling** | PF |
| **Receiver** | MMSE-IRC |
| **Channel estimation** | Ideal |
| **Power control parameter** | **[P0 = -76**, alpha = 0.6] |
| **TRxP per site** | 3 |
| **TRxp number** | 21 |
| **Channel model** | 38.901 |
| **Electronic tilt** | 102° |
| **Traffic model** | FTP3, package size: 100 kbyte  arrival rate: 1 package/200ms  **[Full buffer]** |
| **Uplink duty cycle** | **50%, 100%** |

* + Qualcomm’s Assumption (Monto Carlo simulation)

|  |  |  |
| --- | --- | --- |
| **Environment** | **ISD (KM)** | **ISD (miles)** |
| Urban | .75 | .47 |
| Suburban | 2.8 | 1.74 |
| Rural | 6 | 3.73 |
| Rural | 8 | 5 |

**(a) With 23 dBm UE**

|  |  |  |
| --- | --- | --- |
|  | **Base Station** | **UE** |
| Carrier frequency | 2GHz | |
| Channel bandwidth | 40MHz, 20 MHz, 10 MHz | |
| UL duty cycle | 100% | |
| Active UE number in UL | 3 | |
| Inter-site distance | Use Table 2 | |
| Cell layout | Wrap-around 19 tri-sector cells | |
| Frequency reuse | 1x3x1 | |
| Lognormal fading | 10 dB | |
| Shadowing correlation | Between cells: 0.5, between sites: 1.0 | |
| MCL (including antenna gain) | 70 dB (urban and suburban areas)  80 dB (rural area) | |
| Antenna gain and horizontal antenna pattern | 17 dBi, = 65 degrees,  *Am* = 20 dB | Omni-directional antenna with -3.5 dBi. |
| Noise figure | 5 dB | 9 dB |
| Transmit power | 46 dBm | 23 dBm |
| Antenna height | 45 m | 1.5 m |

**(b) With 26 dBm UE**

|  |  |  |
| --- | --- | --- |
|  | **Base Station** | **HPUE** |
| Carrier frequency | 2GHz | |
| Channel bandwidth | 40MHz, 20 MHz, 10 MHz | |
| UL duty cycle | [50%] | |
| Active UE number in UL | 3 | |
| HPUE ratio | [100%] | |
| Inter-site distance | Use Table 2 | |
| Cell layout | Wrap-around 19 tri-sector cells | |
| Frequency reuse | 1x3x1 | |
| Lognormal fading | 10 dB | |
| Shadowing correlation | Between cells: 0.5, between sites: 1.0 | |
| MCL (including antenna gain) | 70 dB (urban and suburban areas)  80 dB (rural area) | |
| Antenna gain and horizontal antenna pattern | 17 dBi, = 65 degrees, *Am* = 20 dB | Omni-directional antenna with -3.5 dBi. |
| Noise figure | 5 dB | 9 dB |
| Transmit power | 46 dBm | 26 dBm |
| Antenna height | 45 m | 1.5 m |

* Recommended WF
  + TBA

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| XXX | Sub topic 2-1:  Sub topic 2-2:  ….  Others: |
| Xiaomi | **Issue 2-1: SAR Scheme(s)**  P-MPR is the baseline SAR solution, Whether dutycycle solution can be used for FDD high power UE need to further study, since for TDD operation, BS can easily control the UL dutycycle by adjusting the UL/DL frame configuration, how it will be handled by FDD BS actually hasn’t been discussed up to now  **Issue 2-2-1: Interference issues**  Impact on Rx REFSENS should be studied case by case  **Issue 2-2-2: Co-existence issues**  It is premature to conclude that the same conclusion for TDD bands can be applied for FDD bands since the simulation assumptions are under discussion  **Issue 2-3-1: UE architecture**  We prefer option 2 from the state-of art point of view. However, option 1 is also acceptable for us.  **Issue 2-3-2: RF component feasibility**  Option 2 |
| Skyworks | **Issue 2-1: SAR Scheme(s)**  Even if P-MPR is the baseline SAR solution, without a clear understanding of the duty cycle regime and longest 26dBm period it will be impossible to leverage TDD PC2 knowledge for the reliability and thermal behaviour of RF front end components  **Issue 2-2-1: Interference issues**  As discussed in our paper, REFSENS impact may exist for bands with low duplex gap and or distance and should be studied  **Issue 2-2-2: Co-existence issues**  for bands with low duplex gap coexistene may need further study  **Issue 2-3-1: UE architecture**  PC2 PA reliability and performance is fully proven for TDD bands and thus are a lower cost option than two PC3 PAs that will also require two duplexers. In our opinion this should be the priority architecture unless thermal or reliability issues are confirmed. Also 2 PC3 PAs and 2 duplexers may have issues antenna performance issues in low bands that may kill the benefit of a second PA and higher power.  **Issue 2-3-2: RF component feasibility**  Option 2 is needed for 1 antenna/ 1PA architecture and if not conclusive then 2PA/2 antenna may be further studied.  Regarding system studies, if two antenna mode is studied at least some different assumption on antenna performance and correlation should be used depending on frequency ranges. |
| Qualcomm | **Issue 2-1: SAR Scheme(s)**  P-MPR approach could be applied for FDD HPUE. Need further study if duty cycle approach on TDD band can be reused for FDD including the applicability of maximum ULDutyCycle singling and gNB/UE specification impact, etc.  **Issue 2-2-2: Co-existence issues**  The results from TDD HPUE co-existence study in TR36.886 can be applied for FDD HPUE. But whether the RF requirements such as ACLR/ACS could be reused for FDD HPUE or not also depends on RF component feasibility.  **Issue 2-3-1: UE architecture**  We prefer option 3 as it is simpler. With two PA’s and antennas, there will be many more problems as we’ve seen for TDD already.  **Issue 2-3-2: RF component feasibility**  Option 2 is ok, but it may be unrealistic to get a well-defined peak and average power profile since this is dependent on network conditions and traffic patterns. But guidelines may certainly be beneficial.  **Issue 2-4: Simulations Assumptions**  We believe Huawei and vivo’s assumptions are based on dynamic system platform which is widely used in RAN1. We think it is hard for RAN4 to discuss assumptions based on RAN1 simulation approach. Therefore, we prefer to use revised Monte Carlo simulation approach (proposed in R4-2102503) to evaluate FDD HPUE system gains. Note that Monte Carlo simulation approach was used to evaluate system gains for B41 TDD HPUE which are captured in TR36.886. The simulation assumptions we proposed R4-2102392 are mostly coming from B41 TDD HPUE discussion. Therefore, it is more suitable to use the simulation approach and simulation assumptions proposed in R4-2102503.  Regarding the simulation assumptions and results in R4-2102392, we have following comments:   * How many UEs are assumed and what’s the ratio of FDD HPUE UE in the simulation? * 32Rx, (M,N,P,Mg, Ng) = (8,8,2,1,1; 2,8) is assumed for BS Rx antenna configurations? Is it the real antenna configurations for n1 and n3? * What’s the assumptions on antenna elements for BS and UE? * What’s the ratio of UE that the Tx power is larger than 23dBm in the results? * Power control parameters should be selected based on different deployment scenarios.   In addition, we noticed that there are 16dB gap between Huawei and vivo’s assumptions on power control. What’s the criterion of selecting power control parameters? We think it will have big impact on the results. |

### 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:* |

*Suggestion on WF/LS assignment*

|  |  |  |
| --- | --- | --- |
|  | **WF/LS t-doc Title** | **Assigned Company,**  **WF or LS lead** |
| #1 |  |  |

### 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)

## Summary on 2nd round (if applicable)

*Moderator tries to summarize discussion status for 2nd round and provided recommendation on CRs/TPs/WFs/LSs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP/LS/WF number** | **T-doc Status update recommendation** |
| XXX | *Based on 2nd round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |