**3GPP TSG-RAN WG4 Meeting # 98-e R4-21xxxxx**

**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. |
| LGE | We are same view with Qualcomm to align and evaluate coexistence for FDD PC2. |
| Huawei, HiSilicon | For system performance evaluation, we think that the purpose is not to calibrate the simulation platform, but to see if there are system performance gain based on agreeable simulation assumptions. |
| China Unicom | In 3GPP, many system performance evaluations had been investigated for RAN WGs, there is no need to calibrate the simulation platform. The most important thing is to align the simulation assumptions and parameters.  In addition, two sets of parameters for system evaluation are suggested to be considered in SI, one for system performance gain evaluation (Dynamic system level simulation), the other one for co-existence evaluation (Monto Carlo simulation). |

### 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:* It is not necessary to calibrate the simulation platform. It is proposed to align the simulation assumptions and parameters for dynamic system level simulation and Monto Carlo simulation separately.  *Candidate options:*  *Recommendations for 2nd round:* Before system gain evaluation, it is proposed to align the simulation assumptions and parameters for dynamic system level simulation and Monto Carlo simulation separately in this meeting. |

*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)

*Companies are encouraged to comments and make agreements on the content of Work plan.*

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Qualcomm | We are OK not to capture the simulator calibration in the workplan. But we strongly suggest interested companies to align the simulator offline before next meeting otherwise we might get a very diverse results. |

## 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 haracteristic 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 haracteristics.  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 |

1. **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. |
| Apple | **Issue 2-1: SAR Scheme(s)**  Agree to use P-MPR for SAR mitigation as baseline. Whether UL duty cycle concept is applicable to FDD bands needs further studies. Also it is unsure whether regulatory body would accept duty cycled UL transmission for SAR characterizations.  **Issue 2-2-1: Interference issues**  The analysis of REFSENS impact due to increased UL transmission power may need to wait till the feasibility and performance of the duplexer is confirmed.  **Issue 2-2-2: Co-existence issues**  What is the justification that the previous conclusion for TDD HPUE can be used for FDD as well? Should coexistence also depend on the operation frequency?  **Issue 2-3-1: UE architecture**  Our understanding is that PA power capability is not the limiting factor for PC2 HPUE in FDD band frequency ranges. Single Tx path shall be prioritized as dual Tx paths would require two duplexers which could further complicate the already busy RF front-end design.  **Issue 2-3: RF component feasibility**  Option 2  **Issue 2-4: Simulations Assumptions**  The fair comparison should be made with 50% UL duty cycle and full channel BW for PC2 HPUE and 100% UL duty cycle with half channel BW for PC3 UE. |
| LGE | **Issue 2-1: SAR Scheme(s)**  Acceptable to use P-MPR for SAR mitigation as baseline.  **Issue 2-2-1: Interference issues**  Sensitivity degradation will be studied in WI phase not in SI.  **Issue 2-2-2: Co-existence issues**  If it is means to decide ACLR/ACS for FDD band, then we can reuse the ACLR/ACS based on TR36.886. But RAN4 need to study the coexistence when the UL/DL frequency gap is narrow case such as Band 3 and other FDD bands.  **Issue 2-3-1: UE architecture**  In our paper, PA/Duplexer is limited factor to support PC2 FDD band UE. So RAN4 can stuy the PC2 FDD UE when suitable RF components are developed in real market. Baseline RF architecture is 1 PC2 PA because FDD band usually considered in lower 1GHz frequency range. So RAN4 derive MPR/A-MPR requirements based on the 1PC2 PA RF architecture.  **Issue 2-3-2: RF component feasibility**  Option 2. Also PA linearity shall be enhanced to support PC2 FDD band.  **Issue 2-4: Simulations Assumptions**  LGE prefer option3 and shall be considered the realistic UL dutycycle with 50% for PC2 FDD UE and 100% UL dutycycle for PC3 UE. |
| ZTE | **Issue 2-1: SAR Scheme(s)**   1. MPR is the baseline SAR solution. Except P-MPR, duty cycle like TDM operation for FDD could be alternative for SAR solution.   **Issue 2-2-1: Interference issues**  We believe not all FDD bands can be used for PC2 considering the REFSEN requirements for FDD band are impacted by the some factors, such as duplexer gap, supported channel bandwidth especially large CBW. Case by Case studies are needed.  **Issue 2-2-2: Co-existence issues**  It seems use the consensus of TDD HPUE consensus, but what is the justification?  **Issue 2-3-1: UE architecture**  Currently we agree with Option 1.  It may not proper to exclude any possible implementations although we understand there may no commercial PC2 PA to support PC2 FDD band. We would like to hear from the RF component vendor’s view if there exists the technical issue/ bottleneck to implement the HPUE FDD band with 1PA. Also we think different FDD band may have different consideration.  **Issue 2-3-2: RF component feasibility**  Option 2. We would like to hear from the RF component vendor’s view if there exists the technical issue/ bottleneck to implement the HPUE FDD band with 1PA. |
| OPPO | **Issue 2-1: SAR Scheme(s)**  Support the proposal.  **Issue 2-2-1: Interference issues**  Ok with the proposal.  **Issue 2-2-2: Co-existence issues**  Prefer to do the simulation before the conclusion is given.  **Issue 2-3-1: UE architecture**  Option 2.  **Issue 2-3: RF component feasibility**  Option 2. |
| Huawei, HiSilicon | **Issue 2-1: SAR Scheme(s)**  P-MPR is the baseline SAR solution. Duty cycle capability is to facilitate the UL scheduling for network and this kind of concept was already adopted for FDD-TDD EN-DC HPUE. For SAR compliance test, we think that UE can still be tested with existing method for FDD band, but UE vendor can convert the measurement result to a duty cycle capability, which value is reported is based on the UE implementation.  **Issue 2-2-1: Interference issues**  We think that HPUE impact on REFSENS should be analyzed case by case. E.g. for band n1, as the Tx-Rx separation is 190MHz, the interference by Tx would be small or negligible, but for n3, the influence is expected to be larger.  **Issue 2-2-2: Co-existence issues**  With the same co-existence simulation assumptions, we will get the same simulation results no matter for TDD or FDD bands. Thus the co-existence simulation is not necessary for FDD bands. As for the component issue and the corresponding ACLR/ACS requirements, which can be further studied.  **Issue 2-3-1: UE architecture**  Both 1Tx 26dBm and 2Tx 23dBm are possible UE architectures. We are also fine to start the study with 2x23 for FDD bands as the components are pretty mature.  **Issue 2-3-2: RF component feasibility**  We don’t think that there is a feasibility issue for RF components to support FDD HPUE. If the problem exists, logically the issue also exists for TDD bands. However, it is allowed that TDD band to report 100% duty cycle. In that sense, it has no difference with FDD bands. But we are ok that companies to evaluate the reliability issues of RF components for FDD.  **Issue 2-4: Simulations Assumptions**  Traditionally the system performance gain is evaluated by dynamic system level simulation. The co-existence simulation used by RAN4 is static simulation, which are used to evaluate the throughput degradation with different ACLR/ACS values. Usually the evaluation metric is that the throughput loss for cell edge and average is less than 5%. For the static simulation which does not include time factor is obviously not accurate. Even in RAN4 study, dynamic simulation was not excluded for some topics. Such results can be found in some Wis, e.g. UL 256QAM. Again, the purpose is to evaluate the performance gain. Thus our preference is to use dynamic system level simulation. However, if other companies want to use Monte Carlo based simulation, providing these kind of simulation results are not precluded. |
| Samsung | **Issue 2-1: SAR Scheme(s)**  Agree with the proposal about P-MPR as a baseline and duty cycle for further study.  **Issue 2-2-1: Interference issues**  The REFSENS impact should be studied based on the band conditions including the duplex gap and RF components. The issue can be further discussed with such assumptions or feasibilities for the “case by-case” study.  **Issue 2-2-2: Co-existence issues**  We are fine to reuse the ACLR/ACS even for the FDD band. However, as mentioned above, HPUE for FDD band has different conditions with TDD even for the co-existence study. It is premature to conclude it.  **Issue 2-3-1: UE architecture**  We prefer Option 2 given the example band at this stage. Even single PA is possible, we are not sure of its performance due to the large duplex gap.  **Issue 2-3: RF component feasibility**  Option 2 as the same reason. |
| China Unicom | **Issue 2-1: SAR Scheme(s)**  We agree with the view that P-MPR is always available for UEs to meet SAR requirement, so P-MPR can be used as baseline for SAR mitigation. And how ‘duty cycle’ concept applied for FDD bands need to be studied in this SI.  **Issue 2-3-1: UE architecture**  Both 1Tx and 2Tx architecture could be considered and studied during SI phase.  **Issue 2-4: Simulations Assumptions**  In our view, the Monte Carlo simulation approach is mostly used to evaluate the coexistence performance. Monte Carlo method could be used for co-existence simulation for NR FDD HPUE.  On the other hand, dynamic system level simulation has been used for evaluation of system performance gains. It is suggested to use the dynamic system level simulation method for more accurate evaluation of system performance for NR FDD HPUE. |
| Vivo | **Issue 2-1: SAR Scheme(s)**  P-MPR is the baseline SAR solution. To reduce unexpected UE output power fallback and help gNB scheduling, duty cycle solution is also needed.  **Issue 2-2-1: Interference issues**  Based on our preliminary experiment, for band n1 and n3, no significant desense is detected based on PC3 RF. Further study for impact on Rx REFSENS is needed.  **Issue 2-2-2: Co-existence issues**  We prefer deeper analysis to conclude that the conclusion for TDD HPUE can be used for FDD. And ACLR may be needed to further study.  **Issue 2-3-1: UE architecture**  Option 3 is preferred. The cost and size of 2Tx need be considered.  **Issue 2-3: RF component feasibility**  Option 2  **Issue 2-4: Simulations Assumptions**  We have concern about the interference by the HPUE. The cell coverage of HPUE will be extended. In the new extended (cell edge) area, HPUE will transmit with MOP, which will introduce high interference to the neighbour cell, especially for PC3 UE, which may not have extra power margin to reduce the impact of interference.  To Qualcomm, P0 (-76dBm) in our parameter is based on real field configuration. In addition, we also propose to use 64QAM which is mandatory for UE, and traffic model also needs to be considered. |
| Ericsson | **Issue 2-1: SAR Scheme(s)**  P-MPR as baseline. If any duty cycle can be used/developed for FDD must be carefully analysed as part of the work.  **Issue 2-2-1: Interference issues**  REFSENSE analysis might need separate studies case-by-case |
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### 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.*

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| --- | --- |
| **CR/TP number** | **Comments collection** |
| XXX | Company A |
| Company B |
|  |
| YYY | 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 SAR scheme(s)** | *Tentative agreements:* P-MPR is the baseline SAR solution. How to apply duty cycle concept in FDD bands needs to be studied, the detail could be further discussed in this SI.  *Candidate options:*  *Recommendations for 2nd round:* It is proposed to agree on the tentative agreement. Companies can share the views if there are concerns on the agreement. |
| **Sub-topic#2 Interference & Co-existence issues** | *Tentative agreements:*  **Issue 2-2-1: Interference issues**: Impact on Rx REFSENS should be studied case by case for n1 and n3.  **Issue 2-2-2: Co-existence issues**: The RF requirements of ACLR/ACS for FDD band can reuse the RF requirements in TR36.886. And the RF component issue can be further studied, e.g. low duplex gap band (i.e. n3) needs further study.  *Candidate options:*  *Recommendations for 2nd round:*  **Issue 2-2-1: Interference issues**: It is proposed to agree that Rx REFSENS can be studied during SI phase case by case for n1 and n3.  **Issue 2-2-2: Co-existence issues**: It is proposed to reuse the co-existence results in TR36.886. Applicability of the co-existence results for RF component of FDD HPUE can be further evaluated. |
| **Sub-topic#3** | *Tentative agreements:*  **Issue 2-3-1: UE architecture**: Both 1Tx and 2Tx architecture need to be studied during SI phase  **Issue 2-3-2: RF component feasibility**:  *Candidate options:*  *Recommendations for 2nd round:*  **Issue 2-3-1: UE architecture**: It is proposed to agree that both 1Tx and 2Tx architecture need to be studied during SI phase.  **Issue 2-3-2: RF component feasibility**: It is proposed to discuss in 2nd round and agree on which RF components need to be considered, and what aspects are included for feasibility analyses. |
| **Sub-topic#4** | *Tentative agreements:* Dynamic system level simulation is to evaluate the performance gain. Monte Carlo based simulation results are not precluded.  *Candidate options:*  *Recommendations for 2nd round:* It is suggested to align the assumptions and parameter for Dynamic system level simulation, and it is suggested to check the assumptions and parameters for Monto Carlo simulation. |

*Suggestion on WF/LS assignment*

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|  | **WF/LS t-doc Title** | **Assigned Company,**  **WF or LS lead** |
| #1 | WF on PC2 for NR FDD band | China Unicom |
| #2 | WF on simulation assumptions for system performance evaluation | China Unicom |

### CRs/TPs

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

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| **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)

### WF on PC2 for NR FDD band

*Companies could provide comments for draft WF on PC2 for NR FDD band shared in [98e][149] FS\_NR\_PC2\_UE\_FDD draft folder*

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| **Company** | **Comments** |
| LGE | In slide 3, we propose to revised the interference issues as follow   * RAN4 can studied receiver sensitivity degradation due to high max. out power and Tx/Rx isolation levels according to RF component performance in both n1 and n3 FDD bands. * Companies are encouraged to bring analyses on receiver sensitivity degradation in next meeting |
| Xiaomi | Generally we are ok for the WF. For coexistence issue, it is better to remove the “RF requirements and” from 1st bullet since whether RF requirements can be reused needs to be further studied and we think that is also the meaning of 2nd bullet.   * Co-existence Issues:   1. Co-existence results in TR36.886 can be reused for FDD HPUE.   2. Applicability of the co-existence results for RF component of FDD HPUE can be further evaluated. |
| Skyworks | We are supporting the changes that LG and Xiomi are suggesting.  Additionally, as part of the RF component feasibility study (PA/duplexers) it would be useful to add to slide 4 that companies are allowed to make assumptions on 26dBm duty cycle and other aspects influencing the reliability and thermal aspects for the components. 23dBm long term average power is assumed. |
| Qualcomm | We propose to add one page on system simulation study. As one of objectives in the SI, RAN4 to evaluate the system gain with FDD PC2. We need to consider the criteria to justify the necessity of introducing FDD PC2. One possible way is to compare against the system gains observed in TDD PC2. Furthermore, currently we have two simulation approaches to evaluate the system gains. With above criteria., i.e., compared with TDD PC2 system gains, we can normalize the gains provided by companies which is beneficial to conclude the study. With that, we have the following proposal:   * Identify potential system gain from FDD PC2 through system simulation   + - See other WF for assumptions * Identify the criteria to justify the necessity of introducing PC2 on FDD bands   + - Compare against system gains observed for TDD PC2 |
| China Unicom | To Qualcomm:  In the approved SID, there is an objective mentioning that ‘Evaluate system performance gains on spectrum efficiency, and other metrics if needed could also be taken into account, to support NR FDD HPUE.’, I’m afraid there is no need to add the first bullet (already discussed in the other WF). For the second bullet (Identify the criteria to justify the necessity of introducing PC2 on FDD bands), it was not included in the SI scope to compare the system gain between FDD and TDD systems (even they are not in the same band).  To Skyworks:  I’m afraid it is very difficult to understand ‘other aspects influencing the reliability and thermal aspects for the components’. What is the meaning of ‘other aspects’ in this sentence? |
| Qualcomm | To CU:  We still think identifying the criteria is necessary. If not, what’s the criteria to conclude whether there is system gain with FDD HPUE? Or can you answer my question on “If the results from companies A shows 10% system gain, and results from companies B shows 50% system due to different assumptions/approaches . How could RAN4 make the conclusion based on the results?”  If companies don’t want to use the system gains with TDD PC2 as the reference, we would like to hear the other options. But indeed we need to define the criteria. Otherwise, it is pointless to discuss simulation assumption and results. |
| China Unicom | As mentioned above, n1 and n3 are FDD bands, we think it’s not applicable to use TDD evaluations as reference to evaluate system gain. The system gain should be compared with FDD PC3. |

### WF on simulation assumptions for system performance evaluation

*Companies could provide comments for aligning simulation assumptions for Dynamic system level simulation and Monto Carlo simulation.*

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| **Company** | **Comments** |
| Nokia | Regarding a comment from Qualcomm on relation between dynamic system level simulation and RAN1, whichever method is selected, we should not involve RAN1 in this discussion. RAN1 is not included as one of the responsible WGs in the SI. |
| Qualcomm | On page 2,   * 4Rx, (M,N,P,Mg, Ng) = (1,2,10,1,1; 1,2) and 32Rx, (M,N,P,Mg, Ng) = (8,8,2,1,1; 2,8) are not correct. Why there are 7 parameters for 5 configurations assumptions, i.e., (M,N,P,Mg, Ng)? For n1 and n3, it is not reasonable to use 128 elements and 32 Rx ports. * Power control parameters need to be further down-selected   On page 4,   * According our comments on WF on PC2 for NR FDD band, simulation results for TDD PC2 are also needed. * HPUE shall start from high-end phones, we should consider the ratio of HPUE in the network, e.g., {100%, 50%, 25%} * UE Tx Power CDF is one of key metric for HPUE simulation. Companies should provide the UE Tx power CDF curve with system gain results. |
| Vivo | About 7 parameters for 5 configurations assumptions, RAN1 has this kind of expression, the last 2 parameters indicate the RF chain on each polarization, but for “4Rx, (M,N,P,Mg, Ng) = (1,2,**10**,1,1; 1,2)”, 10 may be a typo. Generally, we are supporting most of Qualcomm’s comments. For low band, it seems not possible to have 128 elements.  The mixture of HPUE and legacy UE in the field is a reasonable scenario, and the interference introduced by HPUE, especially the impact to the legacy UE, should be considered. UE Tx power CDF is a good way to indicate the overall power transmission behavior of UE in system that would be impacted by the power control scheme and scheduling, can also be used to somehow align the simulation.  For the proposal that TDD can be compared, we are not sure what is intention and what would be impacted. |
| Qualcomm | Response to vivo:  We think the system gains with TDD PC2 vs TDD PC3 is the reasonable criteria to justify the benefit of introducing PC2 in FDD bands. People has the common understanding that TDD PC2 can improve the system performance in the network. But for FDD, it is not clear what’s system gain is considered reasonable to introduce PC2 in the network. So if the system gain observed by FDD PC2 is comparable with that observed by TDD PC2, it would be a very good evidence to prove necessity of introducing FDD PC2.  Furthermore, by now, we have two simulation approaches and at least 3 sets simulation assumptions. If the results from companies A shows 10% system gain, and results from companies B shows 50% system due to different assumptions/approaches . How could RAN4 make the conclusion based on the results? If we take the system gains from TDD PC2 as the reference, company can provide the simulation results on system gain for TDD PC2 and FDD PC2 with same simulation assumptions such as same frequency carrier, power control parameters and antenna configuration, etc. Then the system gain for FDD PC2 can be normalized even with different simulation assumption set. Therefore, we think the criteria of comparing against system gains observed for TDD PC2 is reasonable and necessary for system simulation study. |
| China Unicom | Based on commercial deployment experience of 32Rx LTE base stations, it is proposed to consider 32Rx configuration for 5G base station in n1 and n3.  There is no need to evaluate simulation results for TDD PC2, because n1 and n3 are only for FDD.  It does not make sense to consider the HPUE ratio in the simulation parameter, because we have to evaluate the system performance gain.  UE Tx Power CDF is not related to system performance gain evaluation. |
| Qualcomm | To CU:  Regarding the TDD PC2 simulation results, please see my comments on section 2.5.1.  In the SID, it was clear saying that “Evaluate system performance gains on spectrum efficiency, and other metrics if needed could also be taken into account, to support NR FDD HPUE”. We think UE Tx power CDF is to show the ratio of UE whose Tx power is larger than 23dBm (i.e., UE that chan improve the performance with PC2). And it can be used to check if the power control parameters are reasonable or not.  For HPUE ratio, I think vivo and QC have the same view that it is reasonable to consider the scenario that HPUE and legacy UE are in the network.  Note that this is a SI. Why we could not evaluate the performance considering different assumptions? |
| China Unicom | For HPUE ratio, 100% is default parameter. And other ratio is optional if companies have interest to simulate.  UE Tx power CDF is related with the ISD, power control parameters, etc. If companies want to identify the ratio of UE transmit power larger than 23dBm, we propose to compare UE Tx power CDF PC2 vs PC3. The UE Tx power CDF is measure of Tx distribution, which is not directly related with system performance gain evaluation. |

## 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*

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| **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”* |