**3GPP TSG-RAN WG4 Meeting # 98-e R4-200XXXX**

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

**Agenda item:** 11.3.4

**Source:** Moderator (Apple)

**Title:** Email discussion summary for [98e][140] NR\_RF\_FR2\_req\_enh2\_Part\_3

**Document for:** Information

# Introduction

In RAN4#98e, a WF on UL gap (R4-2016919) has been agreed that

* Identified UL gap use case for further study.
  + UE power/coverage enhancement
  + PA calibration
  + Transceiver calibration
* Candidate metric for UL gap performance gain evaluation
  + more UL power to enhance the coverage
  + less MPR allowance to enhance the high MCS coverage
  + better EVM, IQ imbalance, Carrier leakage to improve throughput signal quality
  + Better emissions performance to reduce adjacent channel interference and inband emission
* UL gap can be further classified into two types based on UE behavior during the gap
  + Type 1: No UL scheduling during the gap is needed. NW can assign those resources to other UE for UL transmission.
  + Type 2: UL scheduling, including dedicated time and frequency resources reserved for self-calibration and monitoring, during the gap is needed. NW cannot assign those resources to other UE for UL transmission.
* Performance evaluation should focus on the testable improvements with and without gap (R16 baseline).
  + R16 baseline should be the RF performance requirements defined in current spec, and the assumption behind is that UE has no UL gap for calibration.
    - Other non-RF requirements as R16 baseline is not precluded
  + Performance gain needs to be shown on top of the Rel-16 UE requirements
* NW and system impacts related evaluation include the impact of scheduling restriction, UL overhead (e.g. gap length, periodicity) and the potential UL interference when calibration is performing.
  + Evaluation can be done after further details are agreed.

# Topic #1: Study and identify the performance gain, evaluation and NW impact of UL gap

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2100144**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_98_e/Docs/R4-2100144.zip) | Nokia, Nokia Shanghai Bell | **Proposal 1: Re-use Rel-15 PA calibration gap assumption of one slot (for SCS=60 KHz) per 10 seconds (0.0025% overhead) for Rel-17 gap studies. If considerably higher overhead is needed for UE’s self-calibration and monitoring, RAN4 should evaluate e.g. using throughput simulations that performance and requirement gains obtained from UE’s self-calibration and monitoring exceed significantly the loss (overhead) caused by calibration gaps.**  **Proposal 2: Primarily aim to improve MPR and/or UE Tx power requirements through UE self-calibration and monitoring using calibration gaps while keeping other UE requirements like EVM, IQ imbalance, carrier leakage, out of band emission and inband emission requirements unchanged.** |
| [**R4-2100217**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_98_e/Docs/R4-2100217.zip) | Apple | **Observation 1: IQ imbalance, LO leakage/DC offset are usage cases for online calibration due to temperature variation.**  **Observation 2: With online calibration, about 0.5dB higher Tx power is achieved when 3dB IQ imbalance and LO leakage EVM loss is compensated. About 3.5dB higher Tx power is achieved when 6dB IQ imbalance and LO leakage EVM loss is compensated. The gain depends on different UE implementations in terms of uplink performance to different EVM targets, RF exposure constraints and other implementation considerations.**  **Observation 3: To achieve peak throughput with MCS 28, with online calibration, about 1dB gain is observed comparing to 3dB IQ imbalance and DC offset. About 2dB gain is observed with 3dB IQ imbalance and DC offset.**  **Observation 4: Overall higher network capacity with minimum system impact is expected to enable UL gap for transceiver calibration.**  **Proposal 1: For Tx, with certain EVM target, additional Tx power allowed with calibration can be used as metric for UL performance improvement as part of this feasibility study based on observation 2.**  **Proposal 2: For Rx, the throughput gain of high order modulation can be used as metric for DL performance improvement.**  **Proposal 3: UL gap for transceiver calibration is type 1 UL gap. No UL scheduling is needed during the gap.**  **Proposal 4: Introduce UE specific and NW configured gap for general self-calibration and monitoring purpose.** |
| [**R4-2100218**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_98_e/Docs/R4-2100218.zip) | Apple | **Observation 1: Due to the regulatory requirement on RF exposure limits, there is a need for UE to perform additional P-MPR as a function of peak Tx EIRP and uplink duty cycle.**  **Observation 2: There exists a “critical range” for an NR FR2 radio, beyond which if a human target is present, no P-MPR is required to remain RF exposure compliant.**  **Observation 3:**   * **Overall higher network capacity with minimum system impact is expected to enable UL gap.** * **That means ACK/NACK missing rate due to UL gap is manageable. Therefore, the impact for DL throughput is also negligible.** * **If the gap configuration is through RRC signaling, there is no dynamic scheduling constraint, and the added scheduling complexity should be manageable.**   **Proposal 1: Take P-MPR as performance metric for UL Tx power management use case.**  **Proposal 2: UL gap for UL Tx power management is type 1 UL gap. No UL scheduling is needed during the gap.**  **Proposal 3: Procedure to apply P-MPR specified in 38.101-2 can be reused.**  **Proposal 4: Potential test case can be added to measure the average P-MRP increase between the cases with and without UL gap is configured. Peak EIRP test cases defined in [5] can be used as the starting point.** |
| [**R4-2100599**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_98_e/Docs/R4-2100599.zip) | Qualcomm Incorporated | **Observation 1: For type 2 gap, the inband signal content needs to be agreed.**  **Observation 2: Performance gains should be analyse for both types of gaps.**  **Proposal 1: For Type 1 gap, UE meets OFF power requirements.**  **Proposal 2: For type 2 gap, UE will meet current out of band requirements, spurious, ACLR, IBE.**  **Proposal 3: UE will be specified with testable improvement when it is provided with UL gaps in at least one of the following requirements over the current Rel-16 requirements. 1) Output power 2) MPR 3) EVM 5) IQ Image 6) Carrier leakage 7) Unwanted emissions 8) IBE 9) Power control** |
| [**R4-2100825**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_98_e/Docs/R4-2100825.zip) | CMCC | **Observation 1: It is necessary to prioritize the main/key metrics for different use cases to reduce workload.**  **Proposal 1: To reduce workload, it is suggested to only consider key metrics for each calibration use case as shown below.**   |  |  | | --- | --- | | ***Use case of calibration*** | ***Key metric*** | | UL power/enhancement | Power control, UL power | | PA calibration | MPR | | Transceiver calibration | EVM and MPR |   **Observation 2: if performance gain is evaluated only by testing, the modelling of calibration is not necessity as we could take calibration model as a black box. However, it would be hard to conclude final evaluation results considering the differences among different UE.**  **Proposal 2: both testing and simulation are suggested for the evaluation.**  **Proposal 3: One method of how to model the enhanced calibration is shown below to evaluate performance gain.**   |  |  | | --- | --- | | First step | Identifying key parameter for each calibration device (only for simulation, the parameters should be aligned among vendors)  e.g. gain, 1dB compression point and OIP3 for PA  e.g. integrated phase noise, SINR, SFDR for transceiver | | Second step | Modelling the tolerance distribution(a) for above key parameter caused by voltage or temperature shift  e.g. gaussian distribution with assumed mean and variance  Modelling the tolerance distribution(b) for above key parameter after UL calibration  e.g. gaussian distribution with reduced mean and variance | | Third step | Device-level simulation is done to obtain evaluation metric for relative calibration use case with above tolerance assumption (a). This step is regarded to simulate the scenario when voltage or temperature shift deteriorates the performance of UE. | | Fourth step | Device-level simulation is done to obtain evaluation metric for relative calibration use case with above tolerance assumption(b). This step is regarded to simulate the scenario when calibration is performed. | | Fifth step | Deriving the final gain based on the third and fourth step | |
| [**R4-2101129**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_98_e/Docs/R4-2101129.zip) | LG Electronics Finland | The use cases and metrics, as described in the way forward [1], are discussed and following areas for further discussion are identified:   * When quantifying the potential performance improvements the focus should be put on the absolute values rather than relative improvements * Introducing of new RF requirements linked with UL gap need to be carefully studied * Other kind of performance trade-offs, like performance vs. power consumption, are also important |
| R4-2101200 | NTT DOCOMO INC. |  |
| [**R4-2101467**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_98_e/Docs/R4-2101467.zip) | vivo | **Proposal 1 The performance metric for the justification of the 2 types of gaps can be uplink transmission throughput and BLER.**  **Proposal 2 First priority is to study Type 1 gap in R17 and if time allows further study the necessity/benefit of Type 2 gap over Type 1 gap.**  **Proposal 3 Input from chipset vendors are needed on the improvement in uplink power and signal quality.**  **Proposal 4 RAN4 Study the potential fallback if UL gap is not actually scheduled.** |
| [**R4-2102623**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_98_e/Docs/R4-2102623.zip) | Huawei, HiSilicon | ***Proposal 1: RAN4 should consider on how we define the UL gap and its related use case, performance improvement and test. 2 approaches are provided for initial discussion:***  ***Option 1: we only define 2 kinds of UL gaps, Type1 and Type2 in[1], and do not define the corresponding use case and performance enhancements to the gaps.***  ***Option 2: The UL gap definition includes factors: function/use case for calibration, performance enhancement, corresponding test, and how to define the UL scheduling during the gap. But, the evaluated RF performance requirements should be within 3GPP scope.***  ***Observation 1: Limited UL transmission power improvement by PA calibration is replaced by UL MIMO performance loss and potential UL interference to gNB or other users.***  ***Observation 2: Power management improvement brought by body proximity detection has resolution and processing complexity problem. Additional MPE verification is not expected in RAN4.*** |
| [**R4-2102680**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_98_e/Docs/R4-2102680.zip) | Ericsson, Sony | **Proposal 1:** We propose that the claimed MOP/ACLR gains and UE cost aspects with PCG be elucidated fully in relation to other low-complexity linearization methods, BS scheduling complexity, and network performance before any decision of PCG specification is taken.  **Proposal 2:** The performance gain for utilizing PCG or self-calibration gaps shall be several dBs relative to Release-16 levels. New test cases shall be implemented, for every candidate metrics (e.g. less MPR, better EVM, better emission performance etc.), to cater for the verification of PCG’s. |

## Observation summary based on the contributions

* On performance evaluations over the baseline in R16
* UE power/coverage enhancement
  + Apple:
    - On link level performance: significant impact to UL throughput with QPSK and 16QAM is observed as a function of P-MPR:
      * For QPSK, 12% to 75% reduction in UL throughput was observed as the P-MPR is varied between 1 dB and 8 dB.
      * For UL 16QAM, 10% to 49% reduction in UL throughput was observed as the P-MPR is varied between 1 dB and 8 dB.
    - For coverage: Application of P-MPR to Transmit power has a significant impact (up to **33%**) on UL range with P-MRP=6dB, using Uma NLOS path loss model defined in 38.901.
    - On system level throughput based on simulation assumption listed in Table 6 of [3]:
    - 5-percentile UL throughput reduced by 52% at a P-MPR = 6 dB.
    - Mean UL throughput reduced by 13% at a P-MPR = 6 dB.
    - Based on the assumption of 26dBm peak EIRP, the simulations show that P-MPR difference between with and without UL gap can between 3-6 dB, when UL duty cycle is 20% and 40%.
  + Huawei
    - Power management improvement brought by body proximity detection has resolution and processing complexity problem. Additional MPE verification is not expected in RAN4.
* PA calibration
* Transceiver calibration
  + Apple:
    - With online calibration, about 0.5dB higher Tx power is achieved when 3dB IQ imbalance and LO leakage EVM loss is compensated. About 3.5dB higher Tx power is achieved when 6dB IQ imbalance and LO leakage EVM loss is compensated. The gain depends on different UE implementations in terms of uplink performance to different EVM targets, RF exposure constraints and other implementation considerations.
    - To achieve peak throughput with MCS 28, with online calibration, about 1dB gain is observed comparing to 3dB IQ imbalance and DC offset. About 2dB gain is observed with 3dB IQ imbalance and DC offset.
    - Overall higher network capacity with minimum system impact is expected to enable UL gap for transceiver calibration.
* Others related general observations/proposals:
  + Nokia:
    - Re-use Rel-15 PA calibration gap assumption of one slot (for SCS=60 KHz) per 10 seconds (0.0025% overhead) for Rel-17 gap studies.
    - If considerably higher overhead is needed for UE’s self-calibration and monitoring, RAN4 should evaluate e.g. using throughput simulations that performance and requirement gains obtained from UE’s self-calibration and monitoring exceed significantly the loss (overhead) caused by calibration gaps.
  + Ericsson/Sony:
    - The performance gain for utilizing PCG or self-calibration gaps shall be several dBs relative to Release-16 levels. New test cases shall be implemented, for every candidate metrics (e.g. less MPR, better EVM, better emission performance etc.), to cater for the verification of PCG’s.
  + Qualcomm:
    - UE will be specified with testable improvement when it is provided with UL gaps in at least one of the following requirements over the current Rel-16 requirements. 1) Output power 2) MPR 3) EVM 5) IQ Image 6) Carrier leakage 7) Unwanted emissions 8) IBE 9) Power control
  + CMCC:
    - if performance gain is evaluated only by testing, the modelling of calibration is not necessity as we could take calibration model as a black box. However, it would be hard to conclude final evaluation results considering the differences among different UE.
  + LGE:
    - When quantifying the potential performance improvements the focus should be put on the absolute values rather than relative improvements
    - Other kind of performance trade-offs, like performance vs. power consumption, are also important
* On the 3GPP requirements/test cases to comply with
  + Nokia:
    - Primarily aim to improve MPR and/or UE Tx power requirements through UE self-calibration and monitoring using calibration gaps while keeping other UE requirements like EVM, IQ imbalance, carrier leakage, out of band emission and inband emission requirements unchanged.
  + Apple:
    - Procedure to apply P-MPR specified in 38.101-2 can be reused for UE power/coverage enhancement related use cases
    - Potential test case can be added to measure the average P-MRP increase between the cases with and without UL gap is configured. Peak EIRP test cases defined in [5] can be used as the starting point.
  + Qualcomm:
    - For Type 1 gap, UE meets OFF power requirements.
    - For type 2 gap, UE will meet current out of band requirements, spurious, ACLR, IBE.
    - For type 2 gap, the inband signal content needs to be agreed.
  + LGE:
    - Introducing of new RF requirements linked with UL gap need to be carefully studied
  + Huawei:
    - Option 1: we only define 2 kinds of UL gaps, Type1 and Type2 in[1], and do not define the corresponding use case and performance enhancements to the gaps.
    - Option 2: The UL gap definition includes factors: function/use case for calibration, performance enhancement, corresponding test, and how to define the UL scheduling during the gap. But, the evaluated RF performance requirements should be within 3GPP scope.
* On the performance metric associated with UL gap use cases
  + Nokia:
    - Primarily aim to improve MPR and/or UE Tx power requirements through UE self-calibration and monitoring using calibration gaps while keeping other UE requirements like EVM, IQ imbalance, carrier leakage, out of band emission and inband emission requirements unchanged.
  + Apple:
    - Regarding transceiver calibration:
      * For Tx, with certain EVM target, additional Tx power allowed with calibration can be used as metric for UL performance improvement as part of this feasibility study
      * Proposal 2: For Rx, the throughput gain of high order modulation can be used as metric for DL performance improvement.
    - Regarding UE power/coverage enhancement
      * Take P-MPR as performance metric for UL Tx power management use case.
  + Qualcomm:
    - UE will be specified with testable improvement when it is provided with UL gaps in at least one of the following requirements over the current Rel-16 requirements. 1) Output power 2) MPR 3) EVM 5) IQ Image 6) Carrier leakage 7) Unwanted emissions 8) IBE 9) Power control
  + CMCC:
* To reduce workload, it is suggested to only consider key metrics for each calibration use case as shown below.

|  |  |
| --- | --- |
| ***Use case of calibration*** | ***Key metric*** |
| UL power/enhancement | Power control, UL power |
| PA calibration | MPR |
| Transceiver calibration | EVM and MPR |

* + vivo
    - The performance metric for the justification of the 2 types of gaps can be uplink transmission throughput and BLER.
* On testability and test procedure:
  + CMCC: [**R4-2100825**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_98_e/Docs/R4-2100825.zip)
  + Apple: [**R4-2100218**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_98_e/Docs/R4-2100218.zip)
* Others
  + Priority between type 1 and 2
    - vivo:
      * First priority is to study Type 1 gap in R17 and if time allows further study the necessity/benefit of Type 2 gap over Type 1 gap.
  + Fallback performance if UL gap is not scheduled
    - vivo:
      * RAN4 Study the potential fallback if UL gap is not actually scheduled.

## Open issues summary

Sub topic 1-1 Identified performance gain and network impacts

* UE Tx and Rx power/UL and ULcoverage enhancement
* PA calibration
* Transceiver calibration

Sub topic 1-2 Identified metric which can be used to develop the test cases and potential requirements in Phase 2

* UE Tx and Rx power/coverage enhancement
* PA calibration
* Transceiver calibration

Sub topic 1-3: Applicable requirements for type 1 UL gap, where no UL scheduling during the gap is needed.

Sub topic 1-4: Applicable requirements for type 2 UL gap, where UL scheduling during the gap is needed.

Sub topic 1-5: Issues to be addressed upon the completion of Phase 1

* UL gap configuration, including periodicity, gap duration
  + The related overhead should be justified by the corresponding performance gain
* UE fallback behavior
* Identification and selections of UE requirement and test case enhancements
* Potential prioritization between type 1 and 2 UL gaps
* Others

## Companies views’ collection for 1st round

### Open issues

Moderator: Please add your comments to sub-topic 1-1 and 1-2 here. Instead, you can directly comment to CR draft.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| XXX | Sub topic 1-1:  Sub topic 1-2:  ….  Others: |

### CRs/TPs comments collection

Moderator: Please add comments to CR drafts here.

|  |  |
| --- | --- |
| **CR/TP number** | **Comments collection** |
|  |  |
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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.*

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

*Recommendations on WF/LS assignment*

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| --- | --- | --- |
|  | **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*

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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”* |