**3GPP TSG-RAN WG4 Meeting # 116 R4-2512138**

**[Bengaluru](https://www.3gpp.org/Specification-Groups/" \t "_blank), India, 25 August – 29 August, 2025**

**Agenda item:** 7.24.1

**Source:** Moderator (vivo)

**Title:** Ad hoc minutes for NR\_LPWUS

**Document for:** Approval

# Introduction

This Ad-hoc minutes is to cover the discussion in [116][222] NR\_LPWUS for the following issues:

# Discussion

**Issue 1-2-1-1: Detail on LR accuracy and side conditions requirements**

* Proposals
  + P1: Use 2.5 dB as the RF impairment margin for LP-RSRP accuracy requirements. (Apple oppo CMCC vivo Huawei Ericsson ZTE)
  + P2: Consider 3.5 dB RF impairment margin for LR (xiaomi MTK)
  + P3: Use 2 dB as the RF impairment margin for LP-RSRP accuracy requirements (Nokia)

*Background:*

**Agreements in** [**R4-2504908**](ftp://10.10.10.10/ftp/tsg_ran/WG4_Radio/TSGR4_114bis/Inbox/R4-2504908.zip)

**Issue 1-2-1-1: Detail on LR accuracy and side conditions requirements**

Agreement:

For FR1:

* + - [±3.5] dB can be used for core requirements for LP-RSRQ accuracy and [±5.5 or ±6] dB can be used for core requirements for LP-RSRP accuracy, under the side conditions Ês/Iot [x, x = -3] dB
    - [±3.5] dB can be used for core requirements of SSB based RSRQ accuracy and [±5.5 or ±6] dB can be used for core requirements for SSB based RSRP accuracy, under the side conditions Ês/Iot [y, y = -3] dB
    - Note: [2 or 2.5] dB RF impairment margin is assumed

*Recommendations:*

Use 2.5 dB as the RF impairment margin for LP-RSRP accuracy requirements*.*

*Based on P1 remove [] of the agreements in RAN4 114bis as*

For FR1:

* + - ±3.5 dB is used for core requirements for LP-RSRQ accuracy and ±6 dB is used for core requirements for LP-RSRP accuracy, under the side conditions Ês/Iot = -3 dB
    - ±3.5 dB is used for core requirements of SSB based RSRQ accuracy and ±6 dB is used for core requirements for SSB based RSRP accuracy, under the side conditions Ês/Iot = -3 dB

**Issue 1-2-4-2-3: On how to define LR evaluation requirements**

* Proposals
* P1: Using x1=2\*x and y1=2\*y for the evaluation requirement. (Apple oppo vivo Huawei Ericsson Nokia MTK)
* P2: x = 2 and y = 2 samples (vivo oppo Huawei Ericsson Nokia xiaomi) (Note: based on contribution in 7.24.5.2)
* P3: x = 3 (vivo Apple LG MTK) (Note: based on contribution in 7.24.5.2)

*Background:*

*RAN4 114 agreement:*

*Define a single LR evaluation requirement for both LR entry and exit threshold evaluation for LP-WUS monitoring, case 1 and case 3, i.e., LR evaluation requirement is not differentiated on entry or exit; or on different cases.*

*Note: RAN2’s discussion on timer will not impact on RAN4’s evaluation requirement.*

*LR evaluation duration is [x1 samples]\*LP-SS (for OOK LR) or [y1 samples] \*LO (for SSB LR), assuming x or y samples are used to satisfy accuracy requirement and x1 > x and y1>y.*

*Number x and y are defined as measurement requirement as [x samples]\*LP-SS (for OOK LR) or [y samples] \*LO (for SSB LR)*

*Summary from Topic 2-2*

*OOK based LP-RSRP and LP-RSRQ*

|  |  |
| --- | --- |
| *Results on* ***maximum*** *number of LP-SS samples for achieving* ±*3.5 dB accuracy for LP-RSRP and LP-RSRQ for AWGN and TDL-C channel at -3 dB SINR, for information purpose* | |
| *CMCC* |  |
| *oppo* | *3* |
| *ZTE* |  |
| *LPLG* | *3* |
| *vivo* | *3* |
| *xiaomi* | *2* |
| *Apple* | *3* |
| *Ericsson* | *2* |
| *Huawei* | *2* |
| *Nokia* | *2* |
| *MTK* | *3* |

*OFDM based LR*

|  |  |
| --- | --- |
| *Initial results on* ***maximum*** *number samples for achieving* ±*3.5 dB accuracy for SSB based RSRP and RSRQ for AWGN and TDL-C channel at -3 dB SINR, for information purpose* | |
| *CMCC* |  |
| *oppo* | *2* |
| *ZTE* |  |
| *LG* |  |
| *vivo* | *1* |
| *Ericsson* |  |
| *Huawei* | *2* |
| *Nokia* |  |
| *MTK* |  |

*Recommendations:*

*Agree P1;*

*Agree y = 2;*

*For x, down-select between 2 and 3;*

**Issue 1-1-14: LP-WUR operation with eDRX**

* Proposals
  + P1: RAN4 to discuss followings LP-SS based RRM issue in IDLE/Inactive mode: how to enter and exit offloading status if eDRX is configured with PTW. (Apple)
  + P2: No requirements for the combination of eDRX and LP-WUS feature (CMCC vivo Huawei)
  + P2-1: No RAN4 RRM requirements for LP-WUR operation with eDRX with PTW window in Rel-19. (vivo QC)
  + P3: If LP-WUS operation is configured together with eDRX, the UE is required to monitor LP-WUS signal only during PTW. Discuss if MR based RRM measurement/evaluation shall be contained in one PTW window or it can extend outside of the PTW. (Nokia)
  + P4: RAN4 to specify RRM requirements for LP-WUR operation only for eDRX without PTW (i.e., eDRX cycles <=10.24s). (QC)

*Recommendations:*

No RAN4 RRM requirements for LP-WUR operation with eDRX with PTW window in Rel-19.

For LP-WUR operation with eDRX without PTW (i.e., eDRX cycles <=10.24s)

Option 1: no RAN4 RRM requirements

Option 2: Specify RRM requirements

**Issue 1-1-15 LP-WUR operation with RedCap**

* Proposals
  + P1: Specify LP-WUR related idle/inactive requirements including requirement on serving cell offloading, RRM relaxation and higher priority frequency layer search for Redcap UE. (Xiaomi vivo Huawei ZTE Ericsson Nokia)
    - P1-1:Existing agreements for offloading and RRM relaxation will be used for Redcap UE (vivo)
    - P1-2: RedCap UE shall meet LP-WUS related requirement based on UE’s LP-WUS capability (Ericsson)
    - P1-3: Requirements support for RedCap without impact to connected mode requirements, and no FR2 impact, at least for LP-SS. (Nokia)
    - P1-4: The feature for RedCap UE with LP-WUS only applies for R19 UEs not for R17/R18 UEs (ZTE)
    - P1-5: For HD-FDD RedCap UE with LR, the same legacy availability rule shall be reused, then the legacy requirements on maximum interruption in paging reception can be the same.(ZTE)
  + P2: The requirements for normal UE should be completed in high priority in Rel-19. After that, RAN4 can further discuss whether to apply for Redcap UE considering the RRM workload, RAN2 signaling support and UE RF impact (oppo)
  + P3: The agreed requirements for LP-WUS cannot be reused directly for RedCap. Due to the short time RAN4 to deprioritize LP-WUS requirements for RedCap (MTK)
  + P4: For the number of SSB for wake up delay for 1 Rx Redcap, the same number of SSB, i.e., { 3 5 5} SSBs for {10ms, 400ms, 800ms} ramping up time, can be reused initially. (vivo Nokia)

*Recommendations:*

Specify LP-WUR related idle/inactive requirements including requirement on serving cell offloading, RRM relaxation and higher priority frequency layer search for Redcap UE.

* Existing requirements for MR offloading, RRM relaxation and higher priority frequency layer search will be reused for Redcap UE
* FFS on whether define LP-WUR related requirement on FR2 Redcap UE

**Issue 1-1-16: LP-WUR operation with EMR**

* Proposals
  + P1: When both Rel-16 EMR and Rel-19 LP-WUR are configured (vivo):
    - when T331 is running, all carriers (carriers configured/not configured for CA/DC idle state measurement) follow legacy measurements;
    - when T331 is not running, all carriers follow RRM requirements defined in Rel-19 LP-WUR, i.e., relaxed with scaling factor 16 when RRM relaxation criteria are satisfied or serving cell offloading when offloading criteria are satisfied;
  + P1-1: For a UE which supports idleInactiveNR-MeasReport-r16 or idleInactiveEUTRA-MeasReport-r16, and serving cell configures carriers for idle mode CA/DC measurement reporting with T331 running, UE shall keep the MR ON for EMR measurement regardless of the MR offloading condition is met or not. (Apple)
  + P1-2: When case 3 (relaxed measurement) criterion is fulfilled, the configured IDLE mode CA/DC measurements can be relaxed only when T331 is not running, when case 1 (serving cell measurement offloading) criterion is fulfilled, UE is expected to perform relaxed high priority layers measurement without NW indication. And when T331 is running, the carriers configured for IDLE mode CA/DC measurements can also be included (oppo)
  + P1-3: UE should meet the existing EMR measurement requirements when in RRM relaxation or offloading mode when TR331 is running. (Huawei)
  + P1-4: If UE fulfils MR RRM relaxation condition and Srxlev > SnonIntraSearchP and Squal > SnonIntraSearchQ, UE shall at least search for carriers configured for EMR (and the serving cell) based on higher priority layer search requirement Thigher\_priority\_search; If UE fulfils MR RRM relaxation condition and Srxlev <= SnonIntraSearchP or Squal <= SnonIntraSearchQ, the RRM measurement relaxation is NOT applied to the carriers configured for EMR measurement; If UE fulfils MR RRM offloading condition(UE also fulfils Rel-15 neighour cell measurement stopping criteira), UE shall at least search for carriers configured for EMR (and the serving cell) based on higher priority layer search requirement Thigher\_priority\_search. (Ericsson)
  + P1-5: option 1, When T331 running UE shall keep the MR ON for EMR measurement regardless of the MR offloading condition is met or not. Option 2, UE shall not enter relaxation / offloading if configured simultaneously with EMR. (Nokia)
  + P1-6: (MTK)
  + On EMR for LPWUS and when T331 is running, MR is expected to perform measurements on NR inter-frequency carriers configured for idle mode CA/DC measurements without relaxation for both Case#1 (RRM offloading) and Case#3 (RRM relaxation).
  + On EMR for LPWUS and when T331 is not running in Case#1 (RRM offloading):
    - The UE shall search for inter-frequency layers configured for idle mode CA/DC measurements by following the relaxed higher priority frequency measurement requirements for Case#1 (i.e., every 1 hr).
  + On EMR for LPWUS and when T331 is not running in Case#3 (RRM relaxation):
    - If Srxlev > SnonIntraSearchP and Squal > SnonIntraSearchQ
      * the UE shall search for inter-frequency layers configured for idle mode CA/DC measurements by following the relaxed higher priority frequency measurement requirements for Case#3 (i.e., every 1 hr)
    - if Srxlev ≤ SnonIntraSearchP or Squal ≤ SnonIntraSearchQ
      * the UE shall search for inter-frequency layers configured for idle mode CA/DC measurements by following the relaxed higher priority frequency measurement requirements for Case#3 (i.e., 16 times)
* For Rel-18 EMR:
  + P1: When both Rel-18 EMR and Rel-19 LP-WUR are configured: (vivo)
    - Option 1: When Rel-18 EMR is configured, all carriers follow legacy measurement requirement.
    - Option 2: Rel-18 EMR and Rel-19 LP-WUR cannot be configured at the same time (need send LS to RAN2)
  + P2: For a UE which supports Rel-18 EMR, FFS UE’s measurement behaviour for the carriers configured for EMR when UE filfils RRM relaxation/offloading thresholds. (Ericsson)

*Recommendations:*

When both Rel-16 EMR and Rel-19 LP-WUR are configured:

When T331 is running

* + When Case#1 (RRM offloading) conditions are met:
    - The UE shall search for NR inter-frequency layers configured for idle mode CA/DC measurements by following the higher priority frequency measurement requirements (i.e., based on 60s).
    - Higher priority NR inter-frequency layers follow the higher priority frequency measurement requirements (i.e., based on 60s).
  + When Case#3 (RRM relaxation) conditions are met:
    - If Srxlev > SnonIntraSearchP and Squal > SnonIntraSearchQ
      * The UE shall search for NR inter-frequency layers configured for idle mode CA/DC measurements by following the higher priority frequency measurement requirements (i.e., based on 60s).
      * Higher priority NR inter-frequency layers follow the higher priority frequency measurement requirements (i.e., based on 60s).
    - if Srxlev ≤ SnonIntraSearchP or Squal ≤ SnonIntraSearchQ
      * the UE shall search for NR inter-frequency layers configured and not configured for idle mode CA/DC measurements by following the legacy measurement requirements (no relaxation)

when T331 is not running,

* + Serving cell, intra-frequency and NR inter-frequency layers not configured for idle mode CA/DC measurements follow corresponding agreed requirements defined in case 1 and case 3 when they are satisfied.

When both Rel-18 EMR and Rel-19 LP-WUR are configured:

* When Case#1 (RRM offloading) conditions are met:
  + The UE shall search for NR inter-frequency layers configured for idle mode CA/DC measurements by following the higher priority frequency measurement requirements (i.e., based on 60s).
  + Higher priority NR inter-frequency layers follow the higher priority frequency measurement requirements (i.e., based on 60s).
* When Case#3 (RRM relaxation) conditions are met:
  + If Srxlev > SnonIntraSearchP and Squal > SnonIntraSearchQ
    - The UE shall search for NR inter-frequency layers configured for idle mode CA/DC measurements by following the higher priority frequency measurement requirements (i.e., based on 60s).
    - Higher priority NR inter-frequency layers follow the higher priority frequency measurement requirements (i.e., based on 60s).
  + if Srxlev ≤ SnonIntraSearchP or Squal ≤ SnonIntraSearchQ
    - the UE shall search for NR inter-frequency layers configured and not configured for idle mode CA/DC measurements by following the legacy measurement requirements (no relaxation)

**Issue 1-2-11: RRM requirements for FR2**

* Proposals
  + P1-1: Prioritize defining RRM requirements for FR1 in this WI; FR2 LP-WUR based RRM requirement can be deprioritized in R19 (Apple oppo China Telecom Ericsson Nokia MTK)
  + P1-2: Don’t introduce FR2 RRM requirements for LP-WUS WI (CMCC)
  + P1-3: Suggest to consider to drop FR2 RRM requirement in Rel-19 if there is no consensus or still no concrete technical proposals for FR2 RRM requirements in RAN4 116 meeting. (vivo)
  + P2: Specify LP-WUR measurement and evaluation requirements in FR2 by scaling the FR1 requirements using beam sweeping factor N1. (QC)
    - For SSB-based measurements, assume N1 is equal to the number of Rx beams used by the MR
    - For OOK-based measurements, assume N1 = 8.
  + P3: The target measurement accuracy requirements for FR2 is 1.5 dB worse than FR1, to account for the additional RF inaccuracy. For MR-based relaxed serving and neighbor cell measurements in FR2, reuse the measurement relaxation factor of 16 as agreed for FR1 (QC)

*Recommendations:*

*Discuss the issue*

*Moderator Note: Modification on requirements from R4-2511634 for information purpose:*

**Table 4.x.2.2-1: Tevaluate-LP-WUR-PSS/SSS**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **LO periodicity [s] Note 1** | **Scaling Factor (N1WUS)** | | | **Tevaluate-LP-WUR-PSS/SSS [s] (number of LO Cycles)** |
| **FR1** | **FR2** | |
| 0.32 | 1 | 8 | | 0.32 x 2 x **[y]** x N1WUS (2 x **[y]** x N1WUS) |
| 0.64 | 5 | | 0.64 x 2 x **[y]** x N1WUS (2 x **[y]** x N1WUS) |
| 1.28 | 4 | | 1.28 x 2 x **[y]** x N1WUS (2 x **[y]** x N1WUS) |
| 2.56 | 3 | | 2.56 x 2 x **[y]** x N1WUS (2 x **[y]** x N1WUS) |
| Note 1: The LO periodicity is the same as the configured DRX cycle length | | | | |

**Table 4.x.2.3-1: Tevaluate-LP-WUR-LP-SS**

|  |  |  |  |
| --- | --- | --- | --- |
| **LP-SS periodicity [s]** | **Scaling Factor (N1WUS)** | | **Tevaluate-LP-WUR-LP-SS [s]**  **(number of LP-SS Cycles)** |
| **FR1** | **FR2** |
| 0.16 | 1 | 8 | 0.16 x 2 x **[x]** x N1WUS(2 x **[x]** x N1WUS) |
| 0.32 | 8 | 0.32 x 2 x **[x]** x N1WUS (2 x **[x]** x N1WUS) |

**Issue 1-1-17: LP-WUR operation with SDT**

* Proposals
  + P1: SDT requirements apply also for UE supporting LP-WUS.
  + P1-1: The UE supporting SDT and LP-WUS uses LR-RSRP measurements for SDT condition evaluation when the evaluation is started while the UE is in MR offloading. (Nokia)

*Recommendations:*

*Discuss the proposal P1*

**Issue 1-5-3: MR wake up delay after exiting case 1 due to offloading conditions cannot be met**

* Proposals:
  + P1: When UE exits the serving cell offloading case, the following approaches can be considered for UE behavior: (oppo)
    - Option 1: UE follow relaxed measurement and meet the corresponding requirements.
    - Option 2: UE follow legacy measurement and meet the corresponding requirements.
    - Option 3: Up to UE implementation and no requirements apply.
  + P2-1: When a UE leaves fully offloading state due to serving cell quality, the MR will consecutive measure a few (5) SSBs or consecutively measures SSBs within a transition period (100ms), then the MR will follow either relaxed measurement requirement or legacy measurement requirement (vivo)
  + P2-2: RAN4 to define requirements on MR wake-up delay for cases where UE determines LR exit condition is met. The wake-up delay for cases where UE detects LP-WUS is re-used (Huawei)
  + P2-3: After MR wake up, MR follows SSB periodicity for serving and neighbouring cell evaluation.(Nokia)

*Recommendations:*

Suggest: Within the wake up delay after exiting case 1 due to offloading conditions cannot be met, MR follows SSB periodicity for wake up and/or serving cell measurement for a transition period.

**Issue 1-2-9: LP-WUR status at legacy case (not at LP-WUS monitoring case/fully offloading(case 1) case/RRM relaxation (case 3) case)**

* Proposals
  + P1: No LR measurement and evaluation requirements apply at the legacy state, i.e., for the following cases: from legacy case to LP-WUR monitoring, from legacy case to RRM measurement fully offloading (case 1), and from legacy case to RRM measurement relaxation (case 3). (Apple oppo xiaomi China Telecom vivo Huawei ZTE MTK)
  + P2: The LR evaluation requirements will be applied when LR is ‘ON’ at legacy state. (CMCC Ericsson)
  + P2-1: At legacy state, when both MR and LR entry thresholds are configured, the UE shall evaluate both MR and LR thresholds at least once before entering relaxation / offloading (Nokia)

*Background:*

* *Summary of entry/exit conditions based on existing RAN2’s agreements*

|  |  |  |
| --- | --- | --- |
| **Case** | **Entry conditions** | **Exit conditions** |
| LP-WUS monitoring | MR threshold and optional LR threshold | LR threshold |
| RRM measurement fully offloading (Case 1) | MR threshold and optional LR threshold | LR threshold |
| RRM measurement relaxation (Case 3) | MR threshold and optional LR threshold | MR threshold and optional LR threshold |

Agreement at RAN4 114bis:

* At legacy state, when and how to turn on LR for serving cell measurement is up to UE implementation.

*Recommendations:*

*Agree P1 based on majority view.*

**Issue 1-2-12: UE behaviro when both Rel-16 relaxation and Rel-19 LP-WUR offloading/relaxation are satisfied; or when both Rel-17 relaxation for Redcap and Rel-19 LP-WUR offloading/relaxation are satisfied**

* Proposals
  + P1: UE is allowed to follow the most relaxation requirements. (vivo)

*Recommendations:*

*Discuss this topic.*

**Issue 3-2-3: Test case design for entry/exit conditions for case 1/case 3**

* Proposals
* Entry/exit condition evaluation verification
  + Option 1: RAN4 to consider only define test cases for exit conditions, do not define dedicated test cases for evaluation of entry conditions (Apple CMCC vivo Huawei QC)
  + Option 2: Define test case for entry scenario (oppo Nokia)
    - Option 2-1 (oppo)
      * Scenario 1: UE enter Case 1 from legacy and exit to legacy
      * Scenario 2: UE enter Case 3 from legacy and exit to legacy
      * Scenario 3: UE enter Case 1 from Case 3
    - Option 2-2: Use test mode / procedure for LR entry measurements (Nokia)
  + Option 3: Not to define test cases for the evaluation requirements for Entry/Exit between different cases (Case#1 and Case#3).(MTK)
* Detail on exit condition evaluation verification:
  + P1: Define following tests for exit criteria evaluation (CMCC)
    - LR exit criteria evaluation test when exit from LP-WUS monitoring
    - LR exit criteria evaluation test when exit from Case 1
    - FFS exit criteria evaluation test when exit from Case 3, wait the RAN2’s conclusion of exit condition
  + P2: Define test cases for evaluation of exit conditions for the following cases. (Huawei)
    - Case 1: UE exist Case 1 to legacy
    - Case 2: UE exist Case 3 to legacy
  + P3: Introduce the following test cases where the exit conditions can be tested (QC)
    - UE meets the cell reselection requirements with initial conditions being WUR operating in the full offloading mode
    - UE meets the cell resection requirements with initial conditions being WUR operating in the relaxed measurement mode.

*Recommendations:*

Suggest to agree the following based on majority view:

only define test cases for exit conditions, do not define dedicated test cases for evaluation of entry conditions