**3GPP TSG-RAN WG4 Meeting # 113 R4-2418284**

**Orlando, USA, 18th – 22nd, Nov., Oct., 2024**

**Agenda item:** 7.23.5

**Source:** Moderator (vivo)

**Title:** Topic summary for [113][226] NR\_LPWUS

**Document for:** Information

# Introduction

*Briefly introduce background, the scope of this email discussion (e.g. list of treated agenda items) and provide some guidelines for email discussion if necessary.*

This document provides the summary of RRM part for NR\_LPWUS.

Based on the latest approved WI in [RP-240135] and updated WI in [RP-241824], the objectives of the WI are duplicated as below:

The objectives of the work item are the following:

* To specify an LP-WUS design commonly applicable to both IDLE/INACTIVE and CONNECTED modes (RAN1, RAN4)
	+ Specify OOK (OOK-1 and/or OOK-4) based LP-WUS with overlaid OFDM sequence(s) over OOK symbol
		- The LP-WUS design shall ensure that for IDLE/INACTIVE operation, the same information is delivered irrespective of LP-WUR type. The OFDM sequence can carry information.
	+ At least duty-cycled monitoring of LP-WUS is supported
* For IDLE/INACTIVE modes
	+ Specify procedure and configuration of LP-WUS indicating paging monitoring triggered by LP-WUS, including at least configuration, sub-grouping and entry/exit condition for LP-WUS monitoring (RAN2, RAN1, RAN3, RAN4)
	+ Specify LP-SS with periodicity with Yms for LP-WUR, for synchronization and/or RRM for serving cell. (RAN1, RAN4)
		- LP-SS is based on OOK-1 and/or OOK-4 waveform with or without overlaid OFDM sequences. Further down selection between with and without overlaid OFDM sequences is to be done within WI.
		- Note: For LP-WUR that can receive existing PSS/SSS, existing PSS/SSS can be used for synchronization and RRM instead of LP-SS.
		- Y will be decided within WI. 320ms is the start point.
	+ Specify further RRM relaxation of UE MR for both serving and neighbor cell measurements, and UE serving cell RRM measurement offloaded from MR to LP-WUR, including the necessary conditions (RAN4, RAN2)
* For CONNECTED mode, specify procedures to allow UE MR PDCCH monitoring triggered by LP-WUS including activation and deactivation procedure of LP-WUS monitoring (RAN2, RAN1)
	+ Check in RAN#105 for potential TU adjustment in RAN2
	+ Note: In CONNECTED mode, UE MR ultra-deep sleep is not considered, and UE RRM/RLM/BFD/CSI measurements are performed by MR
* Note: The target coverage of LP-WUS and LP-SS shall be the coverage of PUSCH for message3.
* Note: The optimization of LP-WUS signal design for idle/inactive mode is prioritized over the optimization for connected mode.
* Specify the necessary RAN4 core requirement(s) to support the feature (RAN4).
	+ Specifying UE low-power wake-up receiver requirements, at least REFSENS, ACS and ASCS requirements with consideration of possible new methodology
		- Define guard RBs for ACS and ASCS cases
		- Study testability of above requirements
		- Consider impacts of different architecture and impairments
	+ Study and specify, if necessary, any BS requirements, e.g., increase upper limit for LP-WUS/LP-SS beyond current dynamic range
	+ Specify necessary RRM requirements

Recommendation topic to be discussed online in order of priority identified by the moderator.

**Issue 1-2-2: Periodicity for SSB based LP-WUR measurement delay requirements**

**Issue 1-2-2-1: Lower bound on LP-SS measurement periodicity**

**Issue 1-3-1: MR RRM relaxation for serving cell/neighbour cell**

**Issue 1-1-8: LP-WUR operating carrier frequency**

**Issue 1-2-3: On requirements for entry/exit criteria(threshold) evaluation for WUS paging monitoring/Fully Offloading (Case 1)/MR RRM relaxation (Case 3)**

**Issue 1-2-1: Accuracy requirements**

**Issue 2-1-5: On ideal RSRP/RSRQ in simulation**

**Issue 2-1-4: On LP-SS sequence for simulation purpose**

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

# Topic #1: RRM core requirements for LP-WUS/WUR

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

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2417728**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2417728.zip) | CATT | Proposal 1: Do not define entry/exit conditions for LP-WUR measurement. Proposal 2: The criteria discussion for LP-WUS monitoring, RRM measurement relaxation and fully offloading can be left to RAN2, and RAN4 to focus on the LP-WUR measurement requirements and MR measurement relaxation requirements. Proposal 3: RAN4 to define evaluation requirements for cell selection criterion S based on LR measurement for fully offloading case, and the existing MR based evaluation requirements can be the baseline. Proposal 4: For LP-SS based LP-WUR measurement: * The existing intra-frequency cell reselection requirements can be used as baseline with the DRX cycle replaced by LP-SS periodicity.
* The principle for 1Rx impact in existing RedCap measurement requirements can be used as baseline.
* The side condition can be further discussed based on the RAN4 evaluation on accuracy requirements.

Proposal 5: For SSS based LP-WUR measurement, * The existing intra-frequency cell reselection requirements can be used as baseline with the DRX cycle replaced by a fixed or network configured measurement cycle.
* The principle for 1Rx impact in existing RedCap measurement requirements can be used as baseline.
* The side condition can be further discussed based on the RAN4 evaluation on accuracy requirements.

Proposal 6: RAN4 to define requirements for entry/exit criteria evaluation for LP-WUS monitoring, MR RRM relaxation and fully offloading based on LP-WUR measurement period, and further discuss whether to define measurement filtering (e.g., number of samples). Proposal 7: Regarding whether to define interruption requirements due to the time gap between LP-WUS reception and MR to start PDCCH monitoring, wait for RAN1 further progress on the candidate values and the possible components. Proposal 8: For MR neighbor cell measurement relaxation, the existing relaxed requirements in 4.2.2 can be used as baseline. Whether to further relax the requirements can be discussed after the criteria are defined by RAN2. Proposal 9: For MR serving cell measurement relaxation, a scaling factor can be introduced on existing serving cell measurement requirements in 4.2.2. Wait for RAN2 progress on relaxation criteria to decide whether to use same scaling factor as neighbour cell measurement. Proposal 10: For LP-WUS operation in RRC\_CONNECTED state, no RAN4 impact is expected so far. Proposal 11: RAN4 only consider the case when MR and LR are operating on the same carrier frequency in Rel-19 and send response LS to RAN1 to inform the conclusion.  |
| [**R4-2417943**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2417943.zip) | Xiaomi | Proposal 1: RAN4 not to consider any neighbor cell measurement in RRM relaxation case #1, except for the higher priority frequency layer search.Proposal 2: It is suggested to de-prioritize RRM relaxation case #2.Proposal 3: RAN4 to suspend study on measurement requirements for OFDM based LP-WUR based on LP-SS in idle/inactive state until more RAN1 conclusions.Proposal 4: RAN4 to define measurement requirements for:* OOK-based LP-WUR serving cell measurement based on LP-SS in Idle/Inactive state, and
* OFDM-based LP-WUR serving cell measurement based on existing PSS/SSS in Idle/Inactive state.

Proposal 5: RAN4’s discussion on entry/exit conditions for LP-WUS monitoring can be triggered by RAN1/2 if needed.Proposal 6: It is suggested to define the same entry/exit conditions for LP-WUR serving cell measurement and LP-WUS monitoring.Proposal 7: It's suggested that RAN4 concentrate on discussing relaxation cases, while the entry/exit criteria should be based on RAN2 design.Observation 1: Considering antenna sharing architecture, the measurement results obtained from LP-WUR can be used to evaluate the criteria for MR relaxation for the case of MR and LR working on different carrier frequencies but in same band.Proposal 8: The discussion on RRM requirements for the case of MR and LR working on different carrier frequencies can be pending until further conclusions from RAN1/2 are available.Proposal 9: LR status is ON before entering LP-WUS monitoring or after exiting LP-WUS monitoring, based on RAN2 agreements on LP-WUS monitoring entry condition.Observation 2: According to existing cell selection/reselection procedure:* The initiation of intra-frequency measurements, as well as NR inter-frequency or inter-RAT frequency measurements with equal or lower priority, depends on the serving cell measurement results from the MR;
* The initiation of NR inter-frequency or inter-RAT frequencies measurements with higher priority depends on NW configuration.

Proposal 10: When NR inter-frequency or inter-RAT frequencies measurements with higher priority are configured by NW, MR perform relaxed higher priority frequency layer search in RRM relaxation case#1 and case#3.Proposal 11: RAN4 to define the measurement delay requirements based on the periodicity of LP-SS if LP-SS periodicity is configured, no matter LP-WUR is OOK-based or OFDM-based. Proposal 12: RAN4 to define the lower limit for measurement delay requirements in case the periodicity of LP-SS can be configured to small value like 80ms or 160ms.Proposal 13: RAN4 to define the measurement delay requirements for LP-WUR based on DRX cycle, if LP-SS periodicity is not configured.Proposal 14: The Rel-16 relaxation method, i.e., extending measurement interval, could be taken as baseline when considering the MR RRM relaxation for UE supporting LP-WUR. Proposal 15: RAN4 to determine the measurement accuracy in RRC\_IDLE/INACTIVE state for simulation purpose, and NO need to define dedicated accuracy requirement in the performance section.Proposal 16: No RAN4 impact of LP-WUS/WUR features in RRC\_CONNECTED mode is expected. |
| [**R4-2418107**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2418107.zip) | LG Electronics Inc. | *Proposal 1*: Support case2 scenario.

|  |  |  |  |
| --- | --- | --- | --- |
|  RRM measurement case index | MR serving cell measurement | MR neighboring cell measurement | LR measurement |
| #2 Relaxed case a | On with relaxation measurement | Off | On |

*Proposal 2*: Need to discuss whether case 2 will be considered or not first. *Proposal 3*: Up to RAN1/2’s decision. Support P1 for issue 1-1-5/1-1-6.*Proposal 4*: The LR-based RRM measurement threshold can be less than or equal to the LP-WUS monitoring threshold.*Proposal 5*: The LP-WUR status before entering LP-WUS monitoring or after exiting LP-WUS monitoring* MR is ON with RRM measurement on serving cell and neighbor cell (if any) and LP-WUR can be ON or OFF for serving cell measurement. If the threshold for LP-WUS monitoring and LP-WUR RRM measurement are same the LP-WUR can be OFF, else if the threshold for LP-WUS monitoring is higher than for the LP-WUR RRM measurement the LP-WUR can be ON.

*Proposal 6*: Do not define measurement accuracy requirements for LP-WUR in Idle/Inactive state in performance section.*Proposal 7*: Define evaluation period for evaluating entry threshold for LP-WUS monitoring or LP-WUR measurement; Define evaluation period for evaluating exit threshold for fully offloading (case 1).*Proposal 8*: We support detail evaluation periods as below:* For the evaluation period for evaluating entry threshold for LP-WUS monitoring or LP-WUR measurement
	+ LP-SS based LP-WUR measurement period
* For the evaluation period for evaluating exit threshold for fully offloading
	+ The MR serving cell measurement period

*Proposal 9*: As the reference signal for LR-based requirement, LP-SS can be considered. Regarding the measurement metrics, following the RAN2’s decision, the UE can use (LP-)RSRP and optional (LP-)RSRQ.*Proposal 10*: Support P1-1 that the relaxation factors within the range from 8 to 16 as starting posint for the relaxation factor. This can be adapted using multiple threshold.*Proposal 11*: Focus on RRM core requirements only for IDLE/INACTIVE mode in Rel-19. |
| [**R4-2418433**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2418433.zip) | CMCC | *Observation 1: The legacy cell re-selection measurement rules should also be valid in the scenario with LP-WUS/WUR.**Proposal 1: Case#2 is a possible case, its existence depends on network configuration.**Proposal 2: RAN4 specifies measurement requirements for the following two cases:** *Measurement requirements for OOK-based LP-WUR serving cell measurement based on LP-SS at Idle/Inactive state*
* *Measurement requirements for OFDM-based LP-WUR serving cell measurement based on existing PSS/SSS at Idle/Inactive state*

*Proposal 3: RAN2 is responsible for the discussion of which type of threshold will be used for RRM measurement relaxation and offloading criteria.**Proposal 4: When LR doesn’t support the serving cell’s operating band, LP-WUS reception can be performed on the other carrier supported by LR. The details e.g., where and how LR monitor the LP-WUS may need additional specification support. This part should be studied in RAN1 first.**Proposal 5: As long as network configure such higher priority layer, UE should monitor it for possible cell-re selection** *When fulling offloading case happens (Case#1), the relaxed higher priority layer measurement requirement can be applied, i.e., per higher priority layer within 1h*
* *When partial offloading case happens (Case#3), open to further discuss which higher priority layer measurement requirement should be applied*

*Proposal 6: For IDLE/Inactive mode measurement accuracy, reflect the accuracy performance as a margin in the core requirement.**Proposal 7: For the entry/exit criteria evaluation, the evaluation period can be the same as MR and/or LR measurement period.**Proposal 8: For the interruption between LP-WUS (with paging indication) reception and MR to start paging monitoring, postpone the discussion and wait for more RAN1 progress.**Proposal 9: MR based serving cell measurement and neighbouring cell measurement requirement should be specified. The scaling factor should guarantee the mobility performance, measurement accuracy and power saving gain simultaneously.**Proposal 10: For the measurement based on both MR with RRM relaxation (X time relaxation) and LP-WUR, X =8 can be the starting point.* *Proposal 11: The legacy accuracy for relaxed MR measurement should be reused for Case#3.**Proposal 12: The methodology of EMR requirement definition under each Cases can refer to the methodology of high priority layer measurement requirement definition.* |
| [**R4-2418473**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2418473.zip) | China Telecom | Proposal 1: RAN2 is the main group for criteria (entry/exit conditions) design for fully offloading case and MR RRM measurement relaxation and LP-WUS monitoring.Proposal 2: Higher priority frequency layer search can be performed in relaxed mode for case #1/ case #3.Proposal 3: It’s proposed to reflect the accuracy performance as a margin in the core requirement, no dedicated accuracy requirement is defined in the performance section for LP-WUR based RRM measurement in Idle/inactive states.Proposal 4: On requirements for entry/exit criteria evaluation for WUS paging monitoring/LP-WUR measurement/MR RRM relaxation, it’s proposed to define evaluation period for evaluating entry/exit threshold for LP-WUS monitoring and for fully offloading (case 1) or MR RRM relaxation (case 3), and the evaluation period is the same as that of the corresponding measurement period.Proposal 5: It’s proposed to discuss relaxation factor equals to 8 as the starting point for the relaxation factor for MR RRM relaxation.Proposal 6: Define same relaxation factor for MR RRM relaxation for serving and neighbor cell measurements. |
| [**R4-2418479**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2418479.zip) | ZTECorporation,Sanechips | Observation 1: Whether to study Case#2 or not shall consider the following reasons:1. MR measurement relaxation and power consumption
2. The accuracy of LR measurement

Proposal 1: Case#2 is not necessary to consider.Observation 2: RAN1 has already clarified that OFDM-based LP-SS doesn’t target for sync and RRM measurement.Proposal 2: RAN4 shall not define requirements for OFDM-based LR serving cell measurement based on LP-SS.Proposal 3: RAN4 shall only consider the following cases:* + Measurement requirements for OOK-based LP-WUR serving cell measurement based on LP-SS at Idle/Inactive state
	+ Measurement requirements for OFDM-based LP-WUR serving cell measurement based on existing PSS/SSS at Idle/Inactive state

Observation 3: * For the entry condition, there are two cases which from Case#5 to Case#3 and from Case#1 or Case#2 which is not confirmed to Case#3.
* For the exit condition, Case#3 shall enter into Case#5 or Case#1.

Observation 4: Whatever from Case#3 to Case#1 or from Case#1 to Case#3, the LR is always ON and the LR measurement result is also key point to decide whether to switch or not refer to RAN2. However, in current spec, the conditions for neighbour cell measurement is the RSRP of current serving cell which performed by MR measurement.Proposal 4: Use existing thresholds for SS-RSRP and SS-RSRQ, and define new thresholds for LP-RSRP and LP-RSRQ.Proposal 5: Add an offset for existing threshold which is compared to MR based measurement for LP-RSRP and LP-RSRQ.Proposal 6: RAN4 shall wait for more details on the criteria for LR measurement/ MR RRM measurement relaxation/ LP-WUS monitoring which are under discussion in other working groups.Observation 5: RF envelop detection architecture is more appropriate for single-band operation.Proposal 7: For the discussion on separate band, there are two options, and RAN4 shall consider option 2:Option 1: LP-SS and WUS are in the different bands, LP-SS and MR measurement are in the same band.Option 2: LP-SS and WUS are in the same band , LP-SS and MR measurement are in different bands.Proposal 8: For RRM measurement, LR and MR could work on different band. The accuracy threshold may be considered.Proposal 9: For WUS monitoring, LP-WUS could wake up MR in different band to perform paging monitoring.Observation 6: The different cases can be seen as following table with high priority frequency:

|  |  |  |  |
| --- | --- | --- | --- |
| RRM measurement case index | MR serving cell measurement | MR neighbouring cell measurement | LR measurement |
| Case#1  | OFF | OFF | ON |
| Case#2 (to be confirmed) | ON, with measurement relaxation | OFF | ON |
| Case#3 | ON, with measurement relaxation | ON, with measurement relaxation | ON |
| Case#4 | OFF | ON, with measurement relaxation | ON |
| Case#5 | ON | ON  | OFF |

Observation 7: MR will perform inter-frequency measurement with high priority frequency and inter-RAT measurement with high priority frequency if high priority frequency information is provided by the serving cell even if the service of current cell is good enough. Proposal 10: RAN4 shall study the MR neighbour cell measurement relaxation when the high priority frequency is configured. If the legacy relaxed conditions are reused, the legacy relaxed measurement requirements can be the baseline and RAN4 shall study the relaxed scaling factor.Proposal 11: No dedicated accuracy requirement is defined in the performance section for LR-WUR based RRM measurement in Idle/inactive states, and reflect the accuracy performance as a margin in the core requirement.Proposal 12: RAN4 shall clarify the timeline from decoding LP-WUS to MR wake-up in order to monitor legacy PO.Observation 8: MR and LR shall both perform serving cell measurement. Only MR performs neighbour cell measurement. Proposal 13: RAN4 shall specify the whole procedure based on serving cell measurement and specify the UE behaviour when it satisfies the entry/exit condition:* When the entry condition is satisfied:
* Option 1: Fully MR →MR+LR →Fully LR
* Option 2: Fully MR →Fully LR
* When the exit condition is satisfied:
* Option 1: Fully LR →MR+LR→ Fully MR
* Option 2: Fully LR→ Fully MR

Observation 9: In case#3, MR and LR are ON. The serving cell measurement is performed by LR and MR, MR measurement relaxation is aimed at reducing power consumption.Observation 10: RAN4 only defines the relaxed measurement requirements for neighbour cell not for serving cell. Proposal 14: RAN4 shall wait for RAN2 to define the relaxed measurement condition for serving cell measurement if it has.Proposal 15: When UE stays in MR+LR state, RAN4 shall consider the MR serving cell measurement relaxation and also study the mobility performance to quantify the relaxation such as scaling factor for time period. Proposal 16: RAN4 shall wait for RAN2 to define the final relaxed measurement conditions for neighbour cell measurement.Proposal 17: The legacy intra-/inter-frequency and inter-RAT neighbour cell measurement requirements can be the baseline and RAN4 can study the relaxed scaling factor.Observation 11: When UE camps on MR+LR state, MR and LR shall be ON. MR performs serving cell measurement and neighbour cell measurement based on the service of current cell. If the service of serving cell is good, UE MR will not perform the neighbour cell measurement. On the contrary, if service of serving cell is bad, UE MR will perform neighbour cell measurement without high priority frequency.Observation 12: When UE camps on fully MR state, only MR is ON and LR is OFF. MR performs serving cell measurement and also neighbour cell measurement.Proposal 18: RAN4 shall reuse the legacy cell re-selection requirements when UE stays in fully MR state.Observation 13: If the factor is less than 8 times the power saving gain is average 4%. However, if the relaxation factor is equal or larger than 8, the power saving gain has a sharp increase.Proposal 19: Relaxation factors within the range from 8 to 16 as the starting point for the relaxation factor for the MR RRM relaxation.Proposal 20: RAN4 shall not define the measurement requirements at CONNECTED state. |
| [**R4-2418567**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2418567.zip) | Apple | *Proposal 1: At Rel-19 LP-WUR WI, for LP-WUR measurement, RAN4 specifies measurement requirements for the following:** *Measurement requirements for OOK-based LP-WUR serving cell measurement based on LP-SS with/without overlaid OFDM sequence at Idle/Inactive state*
* *Measurement requirements for OFDM-based LP-WUR serving cell measurement based on existing PSS/SSS at Idle/Inactive state*

*Proposal 2: same requirement shall be applied for OOK-based LP-WUR serving cell measurement based on LP-SS with and without overlaid OFDM sequence at Idle/Inactive state.**Proposal 3: LR measurement can be used to check the criteria for neighbor cell measurement triggering/relaxation (in case #1).* *Proposal 4: to support proposal 3, LR measurement result shall be comparable to MR measurement result or shall be equivalent to MR measurement result with certain offset/margin (e.g., LR threshold is MR threshold + offset/margin).**Proposal 5: Criteria (entry/exit conditions) for fully offloading case and MR RRM measurement relaxation can be left to RAN2 to decide.**Proposal 6: For the entry/exit condition for LP-WUS monitoring, follow RAN1/2 conclusions or can be triggered by other groups if necessary.**Proposal 7: assumption of thresholds for RAN4 discussion can be:** *the threshold for MR fully offloading to LR can be same as the threshold for neighbor cell measurement triggering (highest one between SIntraSearchP/SIntraSearchQ and SnonIntraSearchP/SnonIntraSearchQ), or at least offloading threshold can be not lower than threshold for neighbor cell measurement triggering.*
* *the threshold to turn on LR or to involve LR for measurement can be equivalent to the threshold of entry condition for LP-WUS monitoring.*

*Proposal 8: at this stage, remove case#2 and case#4 from the last meeting WF, and only following cases are considered. RAN4 can revisit the cases if in the future RAN1/2 has any conclusion conflicting with RAN4 assumptions.*

|  |  |  |  |
| --- | --- | --- | --- |
| *RRM measurement case index* | *MR serving cell measurement* | *MR neighboring cell measurement* | *LR measurement* |
| *#1 Fully offloading case* | *Off*  | *Off* | *ON* |
| *#3 Relaxed case b* | *On with relaxation measurement* | *On with relaxation measurement* | *ON* |

*Proposal 9: before entering LP-WUS monitoring or after exiting LP-WUS monitoring, the state of UE also needs to be clarified:* * *MR is ON with RRM measurement on serving cell and neighbour cell (if any) and LP-WUR is ON for serving cell measurement, but when and how to turn on LR for serving cell measurement is up to UE implementation.*

*Proposal 10: higher priority layer neighbor cell measurement shall also be OFF for case #1.**Proposal 11: FR2 LP-WUR based RRM requirement can be discussed after we concluded on the FR1 LP-WUR based RRM requirement.**Proposal 12: this issue 1-1-14 can be discussed after when the whole mechanism of offloading, LP-SS/LP-WUS design and measurement metrics are concluded.**Proposal 13:* *For RAN4 requirement of LR based RRM measurement in Idle/inactive states, no dedicated accuracy requirement is defined in the performance section, and reflect the accuracy performance as a margin in the core requirement.**Proposal 14: to check the criteria for WUS paging monitoring/LP-WUR measurement/MR RRM relaxation,** *use the MR measurement period and/or LR measurement period, i.e., MR measurement delay or LR measurement delay are sufficient for criteria checking; and do not need a dedicated evaluation delay requirement (e.g., in how long time the MR/LR measurement results can meet the condition).*

*Proposal 15: to check the criteria for MR fully offloading,** *use the MR measurement period and/or LR measurement period for measurement filtering;*
* *and need a dedicated evaluation delay requirement (i.e., in how long time the MR/LR measurement results can meet the criteria).*

*Proposal 16: For LP-WUR, LR measurement metrics have (LP-)RSRP and optional (LP-)RSRQ.**Proposal 17:* *RAN4 only needs to define the wake-up delay requirement, if such requirement is necessary from majority companies’ view, where the wake-up delay means minimum gap time between LP-WUS reception and MR to start PDCCH monitoring.**Proposal 18:* *No need to discuss the LR based S criterion evaluation in case#1.**Proposal 19: Measurement delay requirements for LP-WUR based on SSB in IDLE/Inactive mode shall be based on:** *if LP-SS periodicity is configured, use max(LP-SS periodicity, DRX cycle) or max(LP-SS periodicity, LO periodicity)*
* *if LP-SS periodicity is not configured, use DRX cycle or LO periodicity*
* *where periodicity of LO is the same as DRX cycle based on RAN1 agreement.*

*Proposal 20: regarding RRM relaxation of UE MR for both serving and neighbor cell measurements, neighbor cell measurement shall have the more relaxation than or equivalent relaxation as serving cell measurement.**Proposal 21: regarding RRM relaxation of UE MR for both serving and neighbor cell measurements, consider to use 16 for serving cell measurement relaxation and neighbor cell measurement relaxation .**Proposal 22: no RRM objectives is needed for connected mode in this LP-WUR/LP-WUS WI.**Proposal 23: 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.* |
| [**R4-2418774**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2418774.zip) | OPPO | Proposal 1: Deprioritized case #2 and case #4. Proposal 2: RAN4 shall NOT specify measurement for OFDM based LP-WUR based on LP-SS, and focus on following two cases:* Measurement requirements for OOK based LP-WUR serving cell measurement based on LP-SS at Idle/Inactive state
* Measurement requirements for OFDM based LP-WUR serving cell measurement based on existing SSS at Idle/Inactive state

Proposal 3: As the starting point, the scaling factor should be larger than 3.Proposal 4: Consider the same scaling factor for both serving cell and neighbor cell MR relaxed measurements.Proposal 5: The interruption time between LP-WUR reception and MR ready for paging monitoring could be defined based on the wake-up delay determined in RAN1.Observation 1: When LR and MR on the different frequencies, the following issues are identified:* Synchronization issues between different carriers
* Different channel conditions between different carriers, which may results in ping-pong effect between LR and MR switch or longer wake-up delay
* Complicated UE implementation
* More UE power consumption

Proposal 6: Consider LR-WUS reception and MR on the same carrier frequency as the baseline. |
| [**R4-2418892**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2418892.zip) | vivo | 1. When the threshold to trigger the neighbour cell measurement is near the edge of LP-SS coverage, the performance of LP-WUR, such as accuracy, maybe not at ideal stage hence transforming directly to case 1 under this scenario where only LP-WUR serving cell measurement is available, should be carefully.
2. In the current specs, the evaluation duration to check whether the serving cell measurement fulfills a particular threshold or not, is either
* The same as that of the serving cell measurement duration, for thresholds such as SSearchThresholdP/SSearchThresholdQ or SIntraSearchP/SIntraSearchQ
* Longer than that of the serving cell measurement duration, such as Nserv for cell selection criterion S evaluation.
1. A larger scaling factor such as 16 can be considered for serving cell and neighbor cell measurement since either a new threshold, which is tighten compared with that of Rel-16, may be introduced for case 3 or the RRM relaxation mode can be left more promptly compared with previous UE power saving scheme thanks to the fact that besides MR, one extra receiver (LP-WUR) is used to check whether the relaxation mode should be left or not.
2. The amount of power saving gain is mainly determined by the minimum scaling factor among serving cell or neighbour cell measurement relaxation.
3. Regarding multiple value for scaling factors, the serving cell and neighbour cell will still have the scaling factor with the same value although that value can be multiple. Multiple scaling factor was discussed in Rel-16 UE power saving WI and was not used in the end.
4. At Rel-19 LP-WUR WI, for LP-WUR measurement, RAN4 specifies measurement requirements for the following:
5. *Measurement requirements for OOK-based and OFDM-based LP-WUR serving cell measurement based on LP-SS at Idle/Inactive state. For OFDM based LP-WUR serving cell measurement based on LP-SS, requirements of OOK based LP-WUR based on LP-SS will be used.*
6. *Measurement requirements for OFDM-based LP-WUR serving cell measurement based on existing PSS/SSS at Idle/Inactive state*
7. For the “Specify further RRM relaxation of UE MR for both serving and neighbor cell measurements” in the WID and cases to be considered for RRM relaxation, besides agreed case 1 and case 3, it is preferred to consider case 2.
8. Introducing new LP-based threshold(s) based on LP-RSRP and LP-RSRQ used for switch/exit from case 1 to other cases is necessary. Other proposals at issue 1-1-4 are up to whether case 2 will be introduced or not.
9. Same entry/exit conditions can be used for LP-WUS monitoring and RRM measurement relaxed cases, i.e., case 3.
10. The LP-WUR will have limited user scenarios and the potential of the LP-WUR feature may not be fully exploited if only LP and MR working at the same band is supported.
11. For the LR and MR work at different band, co-located scenario could be considered. Regarding the time line on when it should be considered, further discussion is needed. When cells co-located have similar coverage, the design for LR and MR work at the same band can be reused. When cells co-located have notable different coverage, the design for LR and MR work at the same band can still be used however will be limited to the cell with the smallest coverage.
12. LP-WUR requirements depends on LP-WUR band, but is not dependent on whether MR work at the same band or different band from LP-WUR. And there is no extra specification work on RAN4 LP-WUR measurement requirements if LP-WUR and MR work at the different band.
13. There will be impact on requirements on offloading and RRM relaxation, depending on solutions for these two items when MR and LR work at different band. For example, the interruption period, e.g., the duration from LP-WUS received the paging indication to MR ready for paging monitoring, if to be defined by RAN4, will be impacted if LR and MR work at different bands.
14. At legacy state, whether or not LP-WUR is ON for RRM measurement is up to UE implementation. When LP-WUR measurement is needed to compare with a LP-based threshold, LP-WUR needs be “ON” at least some duration early before the comparison, no requirement will be defined for this duration.
15. For case 1, higher priority frequency layer search could be OFF. Alternatively, for case 1 and case 3, when the serving cell is above threshold for inter-frequency neighbour cell measurement, existing relaxed requirements K2\*Thigher\_priority\_search are re-used for higher priority frequency search.
16. It is fine to use P1, “introduce a margin to reflect accuracy performance of LP-WUR in core specs”, when LP-WUR serving cell measurement results is used to compare with a threshold. If P1 is used, for MR, the following options could be considered:

Option 1: For MR, margin is also introduced when MR serving cell measurement result comparing with a threshold, this margin will be based on legacy MR accuracy requirements. Option 2: For MR, margin is not also introduced when MR serving cell measurement result comparing with a threshold, as that of the legacy specs. 1. For issue 1-2-2, support P3-1, i.e., use the MR and/or LP-WUR measurement period to check the threshold for either LP-WUR monitoring or MR RRM relaxation is satisfied or not; P1 is also ok providing P1-1 is used.
2. For issue 1-2-2-1, For the scenario when both MR and LR measurement results are used for evaluation whether an entry/exit condition is satisfied or not, either for LP-WUR monitoring or MR RRM relaxation, defined MR and LR requirements for entry/exit evaluation separately as:
* the MR serving cell measurement period, either legacy or relaxed measurement period
* the LP-SS based or SSB based LP-WUR measurement period
1. Suggest to use the term “MR activation” time to replace “interruption” on paging. The interruption duration from LP-WUR exits fully offloading case (case 1) till MR is ready for measurement, could be covered by the paging interruption case and may need not a separate requirement.
2. Defining interruption requirement for the normal case and worst case where a cell reselection is included in the worst case, detailed conditions are FFS. The “MR activation” time for the normal and worst case are:
* “MR activation” duration = Ramping duration + (2 + 2) samples \* 20ms
* “MR activation” duration = Ramping duration + (2 + 2 + 23) samples \* 20ms + TSI-NR + 2\*Ttarget\_cell\_SMTC\_period

Note: Ramping duration refers to RAN1 conclusion1. For issue 1-2-4, support P2, i.e., no need to define the LR based cell selection criterion evaluation in case#1.
2. For periodicity for SSB based LP-WUR measurement delay requirements, use option 2 + option 3, i.e., follow the same periodicity of LP-SS if LP-SS periodicity is configured, use a pre-defined fix value (like 320ms) if LP-SS periodicity is not configured, detail value is FFS.
3. Consider relaxation factors such as 16 for the relaxation factor for the MR RRM relaxation for both serving and neighbour cell measurements.
4. Consider only one relaxation factors for the MR RRM relaxation for both serving and neighbour cell measurements.
5. Multiple value on scaling factor should be avoided unless there is a clear purpose and a clear way on how to implement it.
6. For relaxed MR measurement, the legacy accuracy requirements for MR are re-used.
7. For issue 1-4-1, postpone the discussion.
8. For issue 1-5-2, the principle of P1 is reasonable. The issue can be discussed later.
 |
| [**R4-2419005**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2419005.zip) | Ericsson | Observation *1*: NW may always configure the neighbour cell measurements in irregular deployment.*Observation 2: Both NW and UE need to tradeoff between the power saving and mobility.**Proposal 1: RAN4 to introduce NW controlled serving/neighbour cell measurement relaxation. The relaxation factor can be indicated by NW from one of the following values: 3, 8, 16 etc.**Proposal 2: RAN4 not to introduce scenario 2 which is both MR and LR for serving cell measurement but neighbour cell measurement is OFF.**Proposal 3: High priority measurement relaxation criteria shall be the same as Rel-16 RRM relaxarion.**Proposal 4: Whether LR based serving cell RRM relaxation case is valid is fully up to NW’s configuration, such as NW can enable/disable any RRM relaxation scenario based on the configured thresholds.**Proposal 5: MR RRM further relaxation without LR measurement is out of scope in Rel-19.**Proposal 6: RAN4 to confirm RAN2’s WS as follow.**When UE checks the LR entry threshold,* * *UE is required to evaluate both MR and LR RRM quality if both configured from NW side;*
* *UE is optionally to only evaluate MR quality if only MR evaluation criteria is configured from NW side.*

*When UE checks the LR exit threshold, UE is only required to evaluate the LR quality.**Proposal 7: When NW configures both MR and LR criteria, UE needs to wake up LP-WUR earlier before LP-WUS monitoring.**Proposal 8: RAN4 to define the serving cell measurement based on LP-WUR to check whether UE entry/exit the LP-WUR.**Proposal 9: RAN4 to define LP-WUR based serving cell evaluation requirement.**Proposal 10: RAN4 to define the measurement periodicity for SSB based LP-WUR with 320ms regardless of LP-SS periodicity is configured.**Proposal 11: RAN4 to define the minimum measurement filtering in LP-WUR as 160ms for both LP-SS and SSB.**Proposal 12: No dedicated accuracy requirement in the performance section is defined for LP-SS based measurement and reflect the accuracy performance as a margin in the IDLE/INACTIVE mode core requirement.**Proposal 13: The RAN1 LS should be handled in RF session. RAN4 to insist on MR and LR operating on the same carrier frequency to define the requirment.**Proposal 14: For LP-SS and SSB FDMed multiplex, RAN4 to wait RAN1’s progress.**Proposal 15: Discussions on LP-WUS CONNECTED mode requirements are postoponed until more progress is achieved in other WGs.* |
| [**R4-2419146**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2419146.zip) | Huawei, HiSilicon | Proposal 1: RAN4 not to support Case #2 for MR and LR measurement.Proposal 2: RAN4 to define requirements for OFDM based LR measurement based on LP-SS, by re-using the requirements for OOK based LR measurement based on LP-SS.Proposal 3: RAN4 to discuss following options for switch from Case #1 to Case #3 based on LR measurement.* Option 1: Use existing thresholds for SS-RSRP and SS-RSRQ, and define new thresholds for LP-RSRP and LP-RSRQ
* Option 2: Use existing thresholds for SS-RSRP and SS-RSRQ, and define offsets for LP-RSRP and LP-RSRQ

Proposal 4: RAN4 to discuss following options for switch from Case #3 to Case #1 based on LR or both LR and MR measurements.* Option 1: LR measurement only
* Option 2: both LR and MR measurements, and UE stops neighbor cell measurement when both measurements are below their corresponding thresholds

Proposal 5: RAN4 not to further discuss the entry/exit condition for measurement offloading to LR or MR RRM measurement relaxation, unless triggered by other WGs.Proposal 6: For LP-WUS monitoring, RAN4 to discuss whether RSRP and RSRQ measurement from LR can reflect the impact of the inter-carrier interference.Proposal 7: RAN4 to suggest RAN2 to define same entry/exit condition for LP-WUS monitoring, serving cell RRM measurement offloading and MR RRM measurement relaxation.Proposal 8: RAN4 to define RRM requirements based on the assumption that LR and MR are operating on the same carrier frequency.Proposal 9: RAN4 not to define LR measurement requirements before entering or after exiting LP-WUS monitoring or LR measurement offloading.Proposal 10: UE should perform measurement for higher priority frequency layers, if configured* If serving cell is below threshold for inter-frequency neighbor cell measurement (Case #3), UE meet the relaxed measurement requirements
* If serving cell is above threshold for inter-frequency neighbor cell measurement (Case #4), FFS whether existing requirements (60 \* Nlayers) are re-used or further relaxed.

Proposal 11: RAN4 to prioritize defining RRM requirements for FR1 in this WI.Proposal 12: RAN4 to further discuss whether there is RRM impact due to the configuration of FDMed SSB and LP-SS.Proposal 13: No dedicated accuracy requirement is defined in the performance section for LR-WUR based RRM measurement, and reflect the accuracy performance as a margin in the core requirement.Proposal 14: On the requirements for evaluation of entry/exit condition, * Define evaluation requirements for the exit condition based on single measurement period,
* Define evaluation requirements for the entry condition based on evaluation period which includes multiple measurement period

Each measurement should be based on filtering of at least 2 samples.Proposal 15: RAN4 to define LR and MR measurement period requirements separately.Proposal 16: RAN4 not to discuss measurement metrics used for entry/exit threshold evaluation for LP-WUS monitoring/RRM relaxation, unless triggered by other WG.Proposal 17: RAN4 to wait for more RAN1 progress on PO monitoring before discussing the possible interruption requirements related to LR.Proposal 18: RAN4 not to define MR measurement requirements for the time period from when UE receives LP-WUS to when UE receives PO. Proposal 19: RAN4 not to define cell selection evaluation requirements for LR.Proposal 20: RAN4 to define measurement period requirements for LP-WUR based on SSB* Based on LP-SS periodicity if LP-SS periodicity is configured,
* Based on a fixed interval of [320]ms when LP-SS periodicity is not configured.

Proposal 21: RAN4 not to consider evaluation of entry conditions of LP-WUS monitoring, LR measurement or MR measurement relaxation based on MR measurement in RRC\_CONNECTED.Proposal 22: For MR measurement with relaxation the relaxation factor should be >= 16.Proposal 23: Same relaxation factor applies to serving and neighbor cell measurements.Proposal 24: Legacy MR accuracy requirements in RRC\_IDLE or RRC\_INACTIVE are re-used for MR measurement with relaxation.Proposal 25: RAN4 to postpone the discussion on RRM impacts of LP-WUR at CONNECTED mode until more RAN1/2 conclusions are available. |
| [**R4-2419624**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2419624.zip) | SAMSUNG R&D INSTITUTE JAPAN | Proposal 1: From Rel-19 RAN4 RRM requirement perspective, LR shall be operated as the same carrier frequency of serving cell for MR measurement offloading and relaxation.Observation 1: From LP-WUS monitoring perspective, LR and MR can be on different carriers/bands. And the delay for MR wake up will be increased with re-synchronization to operating carrier for MR required before MR is ready to monitor paging. Proposal 2: From RAN4 requirement perspective, prioritize the work in FR1. Observation 2: For entrance condition of LP-WUS monitoring, both MR based and LR based threshold can be configured, and exit condition is based on LR based threshold. Observation 3: For MR measurement offloading (case 1), entrance condition relies on MR measurement only or both MR measurement threshold and LR measurement threshold can be configured; and exit condition is LR based threshold. Proposal 2: For MR measurement offloading, RAN4 specify the evaluating period on whether the threshold configured by network is fulfilled or not * The evaluating period is same as the measurement period of MR and/or LR

Observation 4: For LP-WUS monitoring entrance, both MR threshold and LR threshold can be configured. If configured both, the both thresholds need to be meet. Proposal 3: For LP-WUS monitoring entrance and exit, RAN4 specify the evaluating period on whether the threshold configured by network is fulfilled or not* Evaluation period shall follow the measurement period of MR and//or LR

Proposal 4: RAN4 need to further how to specify evaluation period for LP-WUS monitoring entrance if both LR and MR threshold configured with possible options as following:* Assumption 1: UE always turn LR on if both MR and LR threshold configured, this will bring UE power consumption issue.
	+ Evaluation period can be max of measurement period of MR and LR
* Assumption 2: UE first check MR threshold by MR measurement and if MR measurement meet the condition and then UE turn on LR to check LR criteria
	+ Evaluation period can be sum of measurement period of MR and LR
* Assumption 3: UE only apply MR measurement, and apply offset to get corresponding LR measurement hypothesis. This approach requires UE to do calibration between MR measurement and LR measurement. It is worth noting that the RSRP measurement results difference between MR and LP-WUR should be stable and comparable to enable such option.
	+ Evaluation period can measurement period of MR+ additional margin for calibration of MR and LR

Proposal 5: New requirements need to be specified for the processing/interruption time between LP-WUS received paging indication to MR ready for Paging monitoring with following factors to be considered * “LP-WUS detection processing time + MR wake-up time + MR sync time”

Proposal 6: MR wake-up time is pending on UE capability which can be 400ms and 800ms based on RAN1 agreementProposal 7: MR sync time, need to be further discuss with different side conditions* Condition 1: MR and LR well sync, and LR sync info can be fully reused e.g. 1~2 SSB sufficient
* Condition 2: MR and LR not well synced and MR need to apply sync procedure e.g. at least 10 SSBs required

Proposal 8: Relaxation factors within the range from 8 to 16 as the starting point for the relaxation factor for the MR RRM relaxation.* If not possible to down-selection as single value, multiple values can be considered with delta on threshold
 |
| [**R4-2419733**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2419733.zip) | Nokia | [Proposal 1: Existing MR measurement delays and accuracy requirements are kept unchanged.](#_Toc181994425)[Proposal 2: Simulate LP-SS accuracy and decide number of samples based on accuracy.](#_Toc181994426)[Proposal 3: Conclude final accuracy & sample number after simulations have been collected and compared](#_Toc181994427)[Observation 1: If relaxation factor is not configurable, then the static relaxation factor is conservative, for example 3.](#_Toc181994428)[Proposal 4: Relaxation factor is configurable per serving and neighbouring cell measurements](#_Toc181994429)[Proposal 5: Discuss the range of relaxation factor, once simulation work has progressed.](#_Toc181994430)[Proposal 6: RAN4 to further study the MR Relaxation scaling factor before fixing the relaxation factor first and evaluate other aspects with simulations](#_Toc181994431)[Proposal 7: RAN4 needs to check if both neighbor cell measurement and serving cell measurement shall share the same relaxation criteria or relaxation factor.](#_Toc181994432)[Proposal 8: There is no dependency between LR LP-SS periodicity configuration and PSS/SSS periodicity, these are independent. In case companies want to have this, LS to RAN1 and 2 is triggered to clarify the scenario.](#_Toc181994433)[Proposal 9: Define requirements with the assumption that UE performing LR LP-SS measurements only with LP-SS configured periodicity.](#_Toc181994434)[Proposal 10: Define requirements for UE performing LR PSS/SSS measurements only with LR specific PSS/SSS periodicity only.](#_Toc181994435)[Proposal 11: LP-SS periodicity is independent from PSS/SSS periodicity, i.e., one does not impact the other in RAN4 requirements](#_Toc181994436)[Observation 2: For MR to receive paging, at least one SSB needs to be measured](#_Toc181994437)[Observation 3: The purpose of LP-WUS monitoring thresholds is stopping MR paging monitoring](#_Toc181994438)[Observation 4: The purpose of MR offloading / relaxation thresholds is to control when the MR serving / neighbouring cell measurements can be relaxed](#_Toc181994439)[Proposal 12: UE may stop paging monitoring once the LP-WUS monitoring conditions are fulfilled. During this time, LP-WUS monitoring requirements apply.](#_Toc181994440)[Proposal 13: As agreed by RAN2, LP-WUS monitoring thresholds, which allow UE to stop monitoring legacy PO, are configured independently from MR offloading and relaxation thresholds. RAN4 shall define LP-WUS monitoring requirements independently from the MR measuremen relaxation and offloading.](#_Toc181994441)[Proposal 14: RAN2 is currently discussing about the relaxation criteria and the discussion in RAN4 can wait until RAN2 outcome.](#_Toc181994442)[Proposal 15: Discuss the UE behaviour while MR relaxation is applied to idle-mode measurements](#_Toc181994443)[Observation 5: When T331 timer is configured, the UE will not go to idle-mode while the timer is running.](#_Toc181994444)[Proposal 16: If T331 timer is configured UE shall not enter LP-WUS mode (MR relaxation / offloading) (e.g. for the first 300 seconds in idle-mode)](#_Toc181994445)[Proposal 17: RAN4 to also discuss if the rel-18 idle-mode behavior follows the same principle where UE shall keep the MR ON.](#_Toc181994446) |
| [**R4-2419741**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2419741.zip) | MediaTek inc. | Proposal 1: No need to discuss further cases for LP-WUS in RAN4. Proposal 2: Based on LR measurements only, RAN4 to define same requirements to evaluate the exit condition for each: 1) exiting from Case#1 to legacy UE and 2) exiting from Case#3 to legacy UE. Proposal 3: RAN4 to use the same evaluation requirements for entry condition when switching from Case#1 to Case#3 and from Case#3 to Case#1, where* entry conditions from Case#1 to Case#3 can be based on LR only.
* entry conditions from Case#3 to Case#1 can be based on LR or LR+MR.

Proposal 4: RAN4 to consider LR measurements only to define same requirements to evaluate the entry condition for each: 1) switching from Case#1 to Case#3 and 2) switching from Case#3 to Case#1.Proposal 5: RAN4 to define requirements to evaluate the entry condition from legacy UE to Case#1 or Case#3 based on MR measurements only.Proposal 6: Discuss how to avoid the ping pong behaviour when transitioning between different cases based on RRM measurements. Proposal 7: The criteria (entry/exit conditions) for RRM fully offloading and MR RRM measurement relaxation is up to RAN2, but the delay requirement to evaluate these criteria is RAN4 work.Proposal 8: RAN4 to discuss the following options for RRM relaxation: * Option 1: MR RRM Relaxation from 8 to 16 times
* Option 2: MR RRM Relaxation >=16 times

Proposal 9: RAN4 to consider multiple stages of RRM relaxation, with different scaling factors (e.g., 8 in 1st stage and 16 in 2nd stage) depending on some conditions (e.g., channel condition, UE mobility).Proposal 10: Same relaxation factor applies to serving and neighbour cell measurements.Proposal 11: No dedicated accuracy requirement is defined in the performance section for LR-WUR based RRM measurement in Idle/inactive states, and reflect the accuracy performance as a margin in the core requirement.Proposal 12: No need to define the LR based cell selection criterion evaluation in Case#1 and Case#3.Proposal 13: No RRM objectives is expected for connected mode in this WI. |
| [**R4-2419764**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2419764.zip) | Qualcomm Incorporated | Observation 1: Based on the WID, LP-SS is always transmitted by the network.Proposal 1: Specify RAN4 requirements under the assumption that the LP-SS configuration (resources, periodicity etc.) is always provided by the network to the UE.Observation 2: Specifying the measurement periodicity of the WUR based on LP-SS periodicity may limit the power savings as compared to DRX and may even lead to negative power savings with eDRX.Proposal 2: The baseline periodicity of measuring LP-SS or SSB should be a multiple of LP-SS periodicity that is decided based on the corresponding DRX configuration.Observation 3: In the Connected mode, the UE may not be able to monitor WUS during MGs as it may retune to a different carrier frequency for measurements.Proposal 3: RAN4 to introduce interruption requirements on the WUS monitoring in Connected mode, e.g., when the WUS MO collides with a MG. The interruption on WUS monitoring follows the current interruption requirements on DL data during MGs. |
| [**R4-2418025**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2418025.zip) | Vodafone, vivo |  |
| [**R4-2418575**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2418575.zip) | Apple |  |

## Open issues summary

*Before Meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions.*

### Sub-topic 1-1 General aspects

**Issue 1-1-1: Cases/states to be considered for RRM relaxation and serving cell measurement offloading**

* Proposals

 Regarding case 2:

P1: Support (LG CMCC vivo);

P2: De-prioritize (xiaomi oppo);

P3: Not consider (ZTE Apple Ericsson Huawei);

P3-1: Not consider however can be revisit in future upon RAN1/2 progress ()

* Other related proposals
	+ P1: Whether LR based serving cell RRM relaxation case is valid is fully up to NW’s configuration, such as NW can enable/disable any RRM relaxation scenario based on the configured thresholds. (Ericsson)

*Background:*

Case #1 and #3 have been agreed

|  |  |  |  |
| --- | --- | --- | --- |
| **RRM measurement case index** | **MR serving cell measurement** | **MR neighboring cell measurement** | **LR measurement** |
| #1 Fully offloading case | Off  | Off: FFS the condition and the details | ON |
| #3 Relaxed case b | On with relaxation measurement | On with relaxation measurement | ON |

RAN4 to further discuss case #2

|  |  |  |  |
| --- | --- | --- | --- |
| RRM measurement case index | MR serving cell measurement | MR neighbouring cell measurement | LR measurement |
| #2 Relaxed case a | On with relaxation measurement | Off | ON |

*Recommendations:*



*Figure for illustration different cases, only for information purpose*

*Suggest to wait for more RAN2’s progress on this topic*

**Issue 1-1-2: Threshold for switch between different cases**

* Proposals
	+ P1: Up to RAN2 decision (CMCC)
	+ P2: LR measurement can be used to check the criteria for neighbor cell measurement triggering/relaxation (in case #1). LR measurement result shall be comparable to MR measurement result or shall be equivalent to MR measurement result with certain offset/margin (e.g., LR threshold is MR threshold + offset/margin). (Apple)
	+ P3: (Huawei)
	+ For switch from Case #1 to Case #3 based on LR measurement.
		- Option 1: Use existing thresholds for SS-RSRP and SS-RSRQ, and define new thresholds for LP-RSRP and LP-RSRQ
		- Option 2: Use existing thresholds for SS-RSRP and SS-RSRQ, and define offsets for LP-RSRP and LP-RSRQ
	+ For switch from Case #3 to Case #1 based on LR or both LR and MR measurements.
		- Option 1: LR measurement only
		- Option 2: both LR and MR measurements, and UE stops neighbor cell measurement when both measurements are below their corresponding thresholds
	+ P4: Need to discuss whether case 2 will be considered or not first (LG)
	+ P5: New LP-based threshold(s) based on LP-RSRP or LP-RSRQ used for switch into case 1 from other cases or exit from case 1 to other cases are needed (ZTE vivo)

*Recommendations:*

*Check RAN2’s progress on this issue.*

*Discuss whether new LP-based threshold(s) used for switch into case 1 from other cases or exit from case 1 to other cases are needed.*

*Whether other cases include case 2 or not depends on issue 1-1-1, i.e., whether case 2 will be considered or not.*

**Issue 1-1-3: Measurement requirements to be specified for LP-WUR**

* Proposals
	+ P1: Do not define requirements for OFDM-based LR serving cell measurement based on LP-SS; RAN4 defines measurement requirements for the following: (xiaomi CMCC ZTE Apple oppo)
		- *Measurement requirements for OOK-based LP-WUR serving cell measurement based on LP-SS at Idle/Inactive state;*
			* *Same requirement shall be applied for OOK-based LP-WUR serving cell measurement based on LP-SS with and without overlaid OFDM sequence at Idle/Inactive state. (Apple)*
		- *Measurement requirements for OFDM-based LP-WUR serving cell measurement based on existing PSS/SSS at Idle/Inactive state*
	+ P2: The measurement requirements of OFDM based LP-WUR based on LP-SS with or without overlaid OFDM sequence(s) will be the same as that of OOK based LP-WUR based on LP-SS. (Huawei vivo)

Background:

RAN4 110bis agreement

* + At Rel-19 LP-WUR WI, for LP-WUR measurement, RAN4 specifies measurement requirements for the following:
		- Measurement requirements for LP-WUR serving cell measurement based on LP-SS at Idle/Inactive state
		- Measurement requirements for LP-WUR serving cell measurement based on existing PSS/SSS at Idle/Inactive state
	+ Other related requirements are FFS

RAN1 118bis meeting agreement:

Support overlaid OFDM sequence(s) for LP-SS:

* LP-SS reuses the overlaid OFDM sequence(s) specified for LP-WUS. The design on overlaid OFDM sequence(s) specified for LP-WUS doesn’t target for sync and RRM measurement performance based on overlaid OFDM sequence for LP-SS.
* Whether to transmit LP-SS by using a specified overlaid OFDM sequence is configurable.
	+ Applicable at least for OOK-1 and FFS for OOK-4
* From RAN1 perspective, it is not intended to introduce new RAN4 requirements specific to overlaid sequences

*Recommendations:*

*May need further check RAN1’s understanding on “not intended to introduce new RAN4 requirements specific to overlaid sequences”*

**Issue 1-1-5: Criteria (entry/exit conditions) for LP-WUR serving cell measurement and MR RRM measurement relaxation**

**Issue 1-1-6: Criteria (entry/exit conditions) for LP-WUS monitoring**

*Recommendations:*

*Criteria for issue 1-1-5/1-1-6 are up to RAN2’s discussion. RAN4 stops discussion on these two issues unless triggered by other groups.*

**Issue 1-1-7: On jointly consideration on Criteria (entry/exit conditions) for fully offlaoding/MR RRM measurement relaxation and LP-WUS monitoring**

* Proposals
	+ P1-1: Define same entry/exit conditions for LP-WUS monitoring and RRM measurement relaxed cases (case 3). (xiaomi LG Apple vivo).
	+ P2: The LR-based LP-WUR measurement threshold can be less than to the LR-based LP-WUS monitoring threshold. (LG)
	+ P3: RAN4 to suggest RAN2 to define same entry/exit condition for LP-WUS monitoring, serving cell RRM measurement offloading and MR RRM measurement relaxation. (Huawei)

*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) | FFS | FFS |

*Recommendations:*

**Issue 1-1-8: LP-WUR operating carrier frequency**

R1-2407559

|  |
| --- |
| In RAN1, the common understanding is that UE may not support LP-WUS reception on all the bands supported by the UE.RAN1 respectfully asks RAN2 and RAN4 to check if there is any issue and specification support needed for IDLE/INACTIVE UEs.**To RAN2 and RAN4:****ACTION:** RAN1 respectfully asks RAN2 and RAN4 to check if there is any issue and specification support needed for IDLE/INACTIVE UEs. |

* Proposals
	+ P1: RAN4 only consider the case when MR and LR are operating on the same carrier frequency in Rel-19. (CATT)
	+ P2: Issue is pending until further conclusions from RAN1/2 are available (xiaomi)
	+ P3: Consider LR and MR work at different band (CMCC ZTE vodafone vivo)
		- P3-1: LP-SS and WUS are in the same band , LP-SS and MR measurement are in different bands. (ZTE)
			* For RRM measurement, LR and MR could work on different band. The accuracy threshold may be considered. For WUS monitoring, LP-WUS could wake up MR in different band to perform paging monitoring.
		- P3-2: Co-located scenario could be considered when LR and MR work at different band. (vivo)
		- P3-3: LR measurement requirements depends only on LR band. For LR measurement requirements, there is no extra specification work on RAN4 if LR and MR work at the different band. RAN4 has also identified impacts on requirements for both offloading and relaxation of RRM measurements, given that the measurements performed by LR in a different frequency than the MR might not be accurate (Vodafone vivo)
	+ P4: Consider LR-WUS reception and MR on the same carrier frequency as the baseline (oppo Apple Huawei)
	+ P5: FFS for the case of MR and LR working on different carrier frequencies if it is supported in RAN1/2. (Apple)
	+ P5: From Rel-19 RAN4 RRM requirement perspective, LR shall be operated as the same carrier frequency of serving cell for MR measurement offloading and relaxation; From LP-WUS monitoring perspective, LR and MR can be on different carriers/bands. And the delay for MR wake up will be increased with re-synchronization to operating carrier for MR required before MR is ready to monitor paging (Samsung)

*Background:*

RAN4 112bis agreement:

* RAN4 will further discuss whether any technical issues regarding the LS from RAN1.
* From Rel-19 RAN4 RRM requirement of MR offloading and relaxation perspective**,** RAN4 assumed LR and MR are operating on the same carrier frequency as baseline. FFS for the case of MR and LR working on different carrier frequencies if it is supported in RAN1/2.

*Recommendations:*

*Suggest to discuss the following items in the reply LS*

* *Whether RAN4 will consider LR and MR work at different band*
* *On LR measurement requirements - LR measurement requirements depends only on LR band. For LR measurement requirements, there is no extra specification work on RAN4 if LR and MR work at the different band*
* *Impacts on serving cell offloading and MR RRM measurement relaxation*

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

* Proposals
	+ P1: LR status is ON (xiaomi)
	+ P2: LP-WUR can be ON or OFF for serving cell measurement. If the threshold for LP-WUS monitoring and LP-WUR RRM measurement are same the LP-WUR can be OFF, else if the threshold for LP-WUS monitoring is higher than for the LP-WUR RRM measurement the LP-WUR can be ON. (LG)
	+ P3-1: LP-WUR is ON for serving cell measurement, but when and how to turn on LR for serving cell measurement is up to UE implementation. (Apple)
	+ P3-2: When a LP-based threshold is configured, at legacy case LP-WUR needs be “ON” at least some duration early before comparing with a LP-based threshold. (vivo Huawei Ericsson)
		- No need define any LR measurement requirements when a UE is at legacy case (vivo Huawei)

*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) | FFS | FFS |

*Note: update the title to discuss the LP-WUR status at legacy state, not only for before entering LP-WUS monitoring or after exiting LP-WUS monitoring*

*Recommendations:*

*Check the following:*

*LP-WUR is ON for serving cell measurement, but when, how to turn on LR and the duration of “ON” for serving cell measurement is up to UE implementation, and no LP-WUR requirement will be applied.*

**Issue 1-1-10: Considerations on higher priority frequency layer**

* Proposals
	+ P1: Support relaxed higher priority frequency layer search (xiaomi CMCC CT ZTE vivo Ericsson)
	+ P1-1 (CMCC)
		- When fulling offloading case happens (Case#1), the relaxed higher priority layer measurement requirement can be applied, i.e., per higher priority layer within 1h
		- When partial offloading case happens (Case#3), open to further discuss which higher priority layer measurement requirement should be applied
	+ P1-2: For case 1 and case 3, when the serving cell is above threshold for inter-frequency neighbour cell measurement, existing relaxed requirements K2\*Thigher\_priority\_search are re-used for higher priority frequency search. (vivo Ericsson)
	+ P2: Higher priority layer neighbor cell measurement shall also be OFF for case #1. (Apple)
	+ P3: UE should perform measurement for higher priority frequency layers, if configured (Huawei)
		- If serving cell is below threshold for inter-frequency neighbor cell measurement (Case #3), UE meet the relaxed measurement requirements
		- If serving cell is above threshold for inter-frequency neighbor cell measurement (Case #4), FFS whether existing requirements (60 \* Nlayers) are re-used or further relaxed.

*Recommendations:*

*Could check P2 firstly, i.e., for case 1, whether higher priority frequency layer search will be performed or not.*

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

* Proposals
	+ P1: From RAN4 requirement perspective, prioritize the work in FR1 (Apple Huawei Samsung)

*Recommendations:*

**Issue 1-1-12: LP-SS frequency domain relation with SSB**

* Proposals
	+ P1: RAN4 to further discuss whether there is RRM impact due to the configuration of FDMed SSB and LP-SS. (Huawei)
	+ P2: For LP-SS and SSB FDMed multiplex, RAN4 to wait RAN1’s progress (Ericsson)

*Recommendations:*

### Sub-topic 1-2 Detail LP-WUR requirements at RRC\_IDLE/INACTIVE state

**Issue 1-2-1: Accuracy requirements**

* Proposals
	+ P1: No dedicated accuracy requirement is defined in the performance section for LR-WUR based RRM measurement in Idle/inactive states, and reflect the accuracy performance as a margin in the core requirement. (xiaomi LG CMCC CT ZTE Apple Ericsson Huawei MTK)
	+ P2: If “using a margin to reflect accuracy performance of LP-WUR in core specs”, is used for LP-WUR, for MR, the following options could be considered (vivo)
		- Option 1: For MR, margin is also introduced when MR serving cell measurement result comparing with a threshold, this margin will be based on legacy MR accuracy requirements.
		- Option 2: For MR, margin is not also introduced when MR serving cell measurement result comparing with a threshold, as that of the legacy specs.

*Recommendations:*

*The question of P2 is based on the following table, for example entry conditions for case 1 where both MR threshold and optional LR threshold. When a margin is defined for LP-WUR, how to handle the MR, will a margin be defined for MR as well?*

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

**Issue 1-2-2: Periodicity for SSB based LP-WUR measurement delay requirements**

* Proposals
	+ P1: A fixed value (CATT Ericsson)
	+ P2:
		- If LP-SS is configured,
			* periodicity for SSB based LP-WUR measurement delay requirements follows the same periodicity of LP-SS (xiaomi vivo Huawei)
			* use max(LP-SS periodicity, DRX cycle) or max(LP-SS periodicity, LO periodicity) (Apple)
		- If LP-SS is not configured, periodicity for SSB based LP-WUR measurement delay requirements
			* use a pre-defined fix value, detail value is FFS (vivo Huawei)
			* based on DRX cycle (xiaomi)
			* based on DRX cycle or LO (Apple)
	+ P3: Periodicity for SSB based LP-WUR measurement delay requirements only depends LR specific PSS/SSS periodicity. (Nokia)
	+ P4: Specify RAN4 requirements under the assumption that the LP-SS configuration is always provided by the network to the UE (QC)

*Background:*

RAN4 112bis meeting agreement:

Measurement delay requirements for LP-WUR based on LP-SS in IDLE/Inactive mode shall be defined based on LP-SS periodicity.

During the RAN4 112bis online session, the following will be further discussed:

Case 1: If LP-SS periodicity is configured,

Option A: follow the same periodicity of LP-SS. (Apple, vivo, QC, HW, LGE, MTK, Xiaomi, CMCC)

Option B: Based on DRX configured for MR (Samsung)

Option C: based on LP-SS periodicity (E////)

Other options are not precluded.

Case 2: If LP-SS periodicity is not configured

Option A: Based on DRX configured for MR (vivo)

Option B: A fix value (like 320ms), FFS on the value (Apple, HW, LGE, vivo)

 Other options are not precluded.

*Recommendations:*

*Check whether measurement* *periodicity for SSB based LP-WUR could rely on LP-SS periodicity or not when LP-SS is configured.*

*If yes, go to P2*

*If no consider option 1: use a pre-defined fix value; option 2: based on DRX cycle; option 3: based on DRX cycle or LO*

**Issue 1-2-2-1: Lower bound on LP-SS measurement periodicity**

* Proposals
	+ P1: RAN4 to define the lower limit for measurement delay requirements in case the periodicity of LP-SS are 80ms or 160ms. (xiaomi)

Background:

RAN4 112bis agreement:

Measurement delay requirements for LP-WUR based on LP-SS in IDLE/Inactive mode shall be defined based on LP-SS periodicity.

*Recommendations:*

*Consider whether to define lower bound on LP-SS measurement periodicity when LP-SS periodicity is 80ms or 160ms.*

**Issue 1-2-2-2: Other on LP-WUR measurement interval for both LP-SS and SSB**

* Proposals
	+ P1: RAN4 to define the minimum measurement interval in LP-WUR as 160ms for both LP-SS and SSB (Ericsson)
	+ P2: The baseline periodicity of measuring LP-SS or SSB should be a multiple of LP-SS periodicity that is decided based on the corresponding DRX configuration (QC)

*Recommendations:*

**Issue 1-2-3: On requirements for entry/exit criteria(threshold) evaluation for WUS paging monitoring/Fully Offloading (Case 1)/MR RRM relaxation (Case 3)**

* Proposals
	+ P1: Do not need a dedicated evaluation delay requirement. Use the MR measurement period and/or LR measurement period to check the criteria for WUS paging monitoring/ Fully Offloading /MR RRM relaxation (CATT CMCC CT vivo Samsung)
	+ P2: (Apple)
		- For WUS paging monitoring/MR RRM relaxation: use the MR measurement period and/or LR measurement period to check the criteria;
		- For MR fully offloading; use the MR measurement period and/or LR measurement period for measurement filtering and a dedicated evaluation delay requirement
	+ P3: Define evaluation requirements for the exit condition based on single measurement period; Define evaluation requirements for the entry condition based on evaluation period which includes multiple measurement period; Each measurement should be based on filtering of at least 2 samples. (Huawei)
	+ P4: (MTK)
		- RAN4 to define same requirements to evaluate the exit condition for each: 1) exiting from Case#1 to legacy UE and 2) exiting from Case#3 to legacy UE based on LR.
		- RAN4 to use the same evaluation requirements for entry condition when switching from Case#1 to Case#3 and from Case#3 to Case#1, where
			* entry conditions from Case#1 to Case#3 can be based on LR only.
			* entry conditions from Case#3 to Case#1 can be based on LR or LR+MR.
		- RAN4 to consider LR measurements only to define same requirements to evaluate the entry condition for each: 1) switching from Case#1 to Case#3 and 2) switching from Case#3 to Case#1; RAN4 to define requirements to evaluate the entry condition from legacy UE to Case#1 or Case#3 based on MR measurements only.

*Background:*

*The measurement period of LR has already been agreed to be specified as issue 1-1-2.*

*The question is whether to define a dedicated evaluation delay requirement other than measurement delay requirement to check the threshold is fulfilled or not.*

*In current specs examples are available on either a dedicated evaluation delay requirement is defined or not.*



*Recommendations:*

For evaluation requirements for LP-WUR and/or MR for LP-WUS monitoring, discuss the following options,

* Option 1: Define evaluation requirements used for corresponding entry/exit conditions evaluation using the corresponding LP-WUR measurement period.
* Option 2: Define evaluation requirements used for corresponding entry/exit conditions evaluation using a duration longer than corresponding LP-WUR measurement period, FFS on detail.
* Option 3: Define evaluation requirements used for corresponding **entry** conditions based on option 2, and **exit** conditions based on option 1.

For evaluation requirements for LP-WUR for fully offloading (case 1) and/or MR RRM relaxation (case 3), discuss whether reuse the conclusions above for LP-WUS monitoring

**Issue 1-2-3-1: On LP-WUR/MR evaluation requirement when both MR and LR threshold are configured**

* Proposals
	+ P1: (vivo Huawei MTK)
	+ For the evaluation period for evaluating an entry threshold when both MR and LR threshold are configured, defined MR and LR evaluation requirements separately
	+ P2: RAN4 need to further how to specify evaluation period for LP-WUS monitoring entrance if both LR and MR threshold configured. (Samsung)

*Recommendations:*

*Check P1 is agreeable*

**Issue 1-2-4: On interruption related requirements for LP-WUR**

* Proposals
	+ P1: Wait for RAN1 further progress or based on RAN1’s conclusion. (CATT CMCC oppo Huawei)
	+ P2: RAN4 only needs to define the wake-up delay requirement, if such requirement is necessary from majority companies’ view, where the wake-up delay means minimum gap time between LP-WUS reception and MR to start PDCCH monitoring. (Apple)
	+ P3: Suggest to use the term “MR activation” time to replace “interruption” time; Defining interruption requirement for the normal case and worst case where a cell reselection is included in the worst case, ramping duration is based on RAN1 conclusion, detailed conditions are FFS. (vivo)
		- “MR activation” duration = Ramping duration + (2 + 2) samples \* SSB\_ periodicity
		- “MR activation” duration = Ramping duration + (2 + 2 + 23) samples \* SSB\_ periodicity + TSI-NR + 2\*Ttarget\_cell\_SMTC\_period
	+ P4: MR wake-up time is pending on UE capability which can be 400ms and 800ms based on RAN1 agreement; MR sync time, need to be further discuss with different side conditions (Samsung)
		- Condition 1: MR and LR well sync, and LR sync info can be fully reused e.g. 1~2 SSB sufficient
		- Condition 2: MR and LR not well synced and MR need to apply sync procedure e.g. at least 10 SSBs required

*Recommendations:*

**Issue 1-2-5: On LP-WUR cell selection evaluation requirements for case 1**

* Proposals
	+ P1: No need to define the LR-WUR based cell selection criterion evaluation in case 1. (Apple vivo Huawei MTK)
	+ P2: Define LP-WUR based serving cell selection criterion S evaluation requirement in case 1. (CATT Ericsson)
	+ P2-1：The existing MR based evaluation requirements can be the baseline (CATT)

*Recommendations:*

**Issue 1-2-6: LR measurement metrics used for entry/exit threshold evaluation for LP-WUS monitoring/RRM relaxation**

* Proposals
	+ P1: Following RAN2’s conclusion, For LP-WUR, LR measurement metrics have (LP-)RSRP and optional (LP-)RSRQ. (LG Apple)
	+ P2: For LP-WUS monitoring, RAN4 to discuss whether RSRP and RSRQ measurement from LR can reflect the impact of the inter-carrier interference. (Huawei)

*Recommendations:*

*Follow other group’s conclusion*

**Issue 1-2-7: Accuracy for relaxed MR measurement**

* Proposals
	+ P1: The legacy accuracy for relaxed MR measurement should be reused if Case#2 and/or Case#3 introduced. (CMCC vivo Huawei)

*Recommendations:*

*Check P1 is agreeable*

**Issue 1-2-8: On legacy MR requirements**

* Proposals
	+ P1: Existing MR measurement delays and accuracy requirements are kept unchanged. (Nokia)

*Recommendations:*

**Issue 1-2-9: Other requirements related issues**

* Proposals
	+ P1: UE may stop paging monitoring once the LP-WUS monitoring conditions are fulfilled. During this time, LP-WUS monitoring requirements apply. (Nokia)
	+ P2: As agreed by RAN2, LP-WUS monitoring thresholds, which allow UE to stop monitoring legacy PO, are configured independently from MR offloading and relaxation thresholds. RAN4 shall define LP-WUS monitoring requirements independently from the MR measurement relaxation and offloading. (Nokia)
	+ P3: RAN4 not to consider evaluation of entry conditions of LP-WUS monitoring, LR measurement or MR measurement relaxation based on MR measurement in RRC\_CONNECTED. (Huawei)

*Recommendations:*

### Sub-topic 1-3 MR RRM relaxation

**Issue 1-3-1: MR RRM relaxation for serving cell/neighbour cell**

* Proposals
	+ P1: Use relaxation/scaling factor between 8 to 16 for MR serving/neighbour cell relaxation as the starting point (xiaomi LG CMCC CT ZTE oppo Apple vivo Huawei Samsung MTK)
		- P1-1: Relaxation factor =8 as the starting point (CMCC MTK)
		- P1-2: Relaxation factor >=16 (Apple vivo Huawei MTK)
		- P1-3: At least the scaling factor should be larger than that of legacy Rel-16 UE power saving WI (>3). (oppo vivo)
	+ P2: For MR neighbor cell measurement relaxation, the existing relaxed requirements in 4.2.2 can be used as baseline. For MR serving cell measurement relaxation, a scaling factor can be introduced on existing serving cell measurement requirements in 4.2.2. (CATT)
	+ P3: RAN4 shall study the mobility performance to quantify the relaxation such as scaling factor for time period (ZTE)
	+ P4: RAN4 to introduce NW controlled serving/neighbour cell measurement relaxation. The relaxation factor can be indicated by NW from one of the following values: 3, 8, 16 etc. (Ericsson)
	+ P5: Discuss the range of relaxation factor, once simulation work has progressed. (Nokia)

*Background:*

*During RAN4 112bis online meeting:*

**Aspect 1: Agree on relaxation/scaling factor(s) for MR serving/neighbour cell relaxation as the starting point**

* Support: vivo, ZTE, MTK, Samsung, Apple, HW, China Telecom, QC
* Discuss the number later: Nokia, E///, OPPO, Xiaomi, LGE, CATT

**Aspect 2: The same or different relaxation/scaling factors for MR serving and neighbour cell relaxation**

* Same: MTK, vivo, QC, China Telecom, HW, OPPO, Xiaomi, CMCC, ZTE, Samsung, Apple
* Different: CATT, Nokia

FFS Smaller factor for serving cell or neighboring cell

**Exact relaxation factor as the starting point**

* Option 1: Only consider the scaling factor(s) larger than that of legacy Rel-16 UE power saving WI (i.e., 3) (QC, CMCC, LGE, ZTE, HW, China Telecom, Apple, vivo, MTK, Xiaomi, Samsung)
* Option 2: 3 is included as one of the factors (E///, Nokia)

For the scaling factor(s) larger than 3, which number can be used as starting point.

* 8: CMCC, China Telecom, vivo, Samsung, Ericsson, MTK, QC, Nokia
* >=16: vivo, QC, HW, Apple, Samsung, MTK

*Recommendations:*

Following discussion at previous meeting, check relaxation factor as the starting point

* Option 1: Only consider the scaling factor(s) larger than that of legacy Rel-16 UE power saving WI (i.e., 3) (QC, CMCC, LGE, ZTE, HW, China Telecom, Apple, vivo, MTK, Xiaomi, Samsung)
* Option 2: 3 is included as one of the factors (E///, Nokia)

**Issue 1-3-2: On Neighbour cell and serving cell relaxation factor**

* Proposals
	+ P1: Wait for RAN2 progress on relaxation criteria to decide whether to use same scaling factor as neighbour cell measurement (CATT)
	+ P2: Neighbour measurements have the more relaxation than serving cell measurement. (Apple)
	+ P3: Same relaxation factor applies to serving and neighbor cell measurements (CT oppo Apple vivo Huawei MTK)
	+ P4: Relaxation factor is configurable per serving and neighbouring cell measurements. Check if both neighbor cell measurement and serving cell measurement shall share the same relaxation criteria or relaxation factor (Nokia)

*Recommendations:*

**Issue 1-3-3: On multiple scaling factors**

* Proposals
	+ P1: Multiple value on scaling factor should be avoided unless there is a clear purpose and a clear way on how to implement it. (vivo)
	+ P2: If not possible to down-selection as single value, multiple values can be considered with delta on threshold (Samsung)
	+ P3: Consider multiple stages of RRM relaxation, with different scaling factors (e.g., 8 in 1st stage and 16 in 2nd stage) depending on some conditions. (MTK)

*Recommendations:*

### Sub-topic 1-4 LP-WUR CONNECTED mode

**Issue 1-4-1: LP-WUR at CONNECTED mode**

* Proposals
	+ P1: No RRM objectives is expected for connected mode in this WI. (CATT xiaomi vivo LG ZTE Apple MTK)
	+ P2: FFS whether need to introduce LP-WUS monitoring activation and deactivation delay requirements pending on RAN2/RAN1 progress. Paging reception requirement impact can be discussed after further input from RAN2 and RAN1 (Samsung)
	+ P3: Postponed until more progress in other groups (Ericsson Huawei)
	+ P4: RAN4 to discuss interruption requirements on the WUS monitoring in Connected mode, e.g., when the WUS MO collides with a MG. (Qualcomm)
		- Postpone the discussion on this issue (vivo)

*Recommendations:*

### Sub-topic 1-5 Others

**Issue 1-5-1: LR based RRM with EMR in IDLE/inactive mode**

* Proposals
	+ P1: 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)
	+ P2: The principle of P1 is reasonable. The issue can be discussed later (vivo)
	+ P3: The methodology of EMR requirement definition under each Cases can refer to the methodology of high priority layer measurement requirement definition. (CMCC)
	+ P4: Discuss the UE behaviour while MR relaxation is applied to idle-mode measurements. (Nokia)
		- If T331 timer is configured UE shall not enter LP-WUS mode (MR relaxation / offloading) (e.g. for the first 300 seconds in idle-mode)
		- RAN4 to also discuss if the rel-18 idle-mode behavior follows the same principle where UE shall keep the MR ON.

*Recommendations:*

# Topic #2: Simulation assumptions and results

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2417942**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2417942.zip) | Xiaomi | Observation 1: For LP-SS based RSRP measurement, accuracy results show slightly difference between OOK-1, OOK-4 with M=2 and OOK-4 with M=4. Observation 2: To achieve 3.5 dB absolute baseband accuracy, measurement with 3 LP-SS samples is needed at SNR = -3dB in TDL-C channel.Observation 3: To achieve 2.5 dB absolute baseband accuracy, measurement with 5 LP-SS samples is needed at SNR = -3dB in TDL-C channel.  |
| [**R4-2418432**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2418432.zip) | CMCC | *Observation 1: For OOK based LP-WUR, in order to fulfilled the accuracy requirement ±3.5dB for LP-RSRP and ±3.5dB for LP-RSRQ, 3 samples are needed.**Observation 2: Limited or no RRM accuracy gain is achieved by extending the LP-SS overhead from 4 OFDM symbol to 8 OFDM symbol.* |
| [**R4-2418483**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2418483.zip) | ZTECorporation,Sanechips | Observation 1: For LP-SS based RSRP measurement, accuracy result mainly refer to the difference between measured RSRP and ideal RSRP;Observation 2: More samples can help improve the performance of RRM accuracy;Observation 3: Accracy gain in TDLC is worse than in AWGN;Proposal 1: For OOK-based LP-WUR, use more than 3 samples for RSRP measurements  |
| [**R4-2418596**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2418596.zip) | Apple | Observation 1: Defining RRM requirements for LP-WUS/WUR are simulation-heavy and detailed alignment is needed both to make progress and for requirements to be defined, since LP-SS design is not yet finished.Observation 2: Good progress has been made in defining the serving cell / interfering cell scenario as a baseline for upcoming RRM requirements definition.Observation 3: Even though companies have started submitting LP-WUS/WUR simulation results, these results are not quite comparable since assumed LP-SS sequences, duration and modulation are vastly different.Proposal 1: RAN4 RRM to compile a simulation results summary spreadsheet to be updated during every RAN4 meeting based on the contributions of the interested companies. Proposal 2: RAN4 RRM to agree on an initial summary of simulations spreadsheet format, including an interested company to take care of it, by the end of RAN4#113.Proposal 3: RAN4 RRM to track RSRP measurement accuracy as a function of number of measurement instances and SNR/SINR values, AWGN and TDLC channels, and other agreed simulation parameters. Limit maximum number of measurement instances to [6 samples]. FFS about tracking RSRQ, others.Observation 4: For LP-WUR based RRM requirements design, RAN1 link level simulation assumptions and RAN4 RF session’s simulation assumptions should be continuously monitored as the baseline for RAN4 RRM simulation work.Proposal 4: Include SINR = -6dB to the {-3dB; -0.5dB; 2dB} set for simulation assumptions. FFS whether -6dB is a low priority case.Observation 5: It is still unclear the number of OFDM symbols that LP-SS may occupy, since it depends on modulation and M value, and the length L of the binary sequence.Proposal 5: Define at least {M,L} pairs {2, 8} and {4, 16} for alignment purposes. FFS other pairs, upon need.Proposal 6: From RAN1/RAN4 proposals, define at least 2 binary sequences, one for L=8 and one for L=16, to be agreed offline during the week of RAN4#113 preferably.Observation 6: Current simulation assumptions leave up to company report the binary sequence to be used for serving cell and the binary sequence use for interference cell.Proposal 7: Define a specific binary sequence for serving cell and a specific binary sequence for the interference cell. Interfering binary sequence shouldn’t be known to the UE, but also should not be random.Proposal 8: RAN4 RRM to clarify simulation assumptions related to potentially colliding OOK into OOK interference. For OFDM interference, confirm the assumption of a random QPSK source.Observation 7: Details of overlaid OFDM sequences in LP-SS have not been addressed yet in RRM simulation assumptions.Proposal 9: For overlaid sequences, RAN4 to consider two scenario 1) no ZC sequence for both cells, and 2) different ZCs for each cell. FFS details.Observation 8: Time synchronization may be challenging for OOK-4 receivers and other measures such as 1) using MR to assist LR in frequency synchronization, or 2) use of a preamble in LP-WUS to allow that LP-SS sync performance to be relaxed.Observation 9: The use of a preamble or MR assistance may allow LP-SS being transmitted with periodicities longer than 320ms, e.g. 80ms,160ms, 640ms,1280ms, 2560ms, 5120ms, 10240ms that are still under RAN1 consideration.Proposal 10: RAN4 RRM to consider LP-SS periodicities of 320ms and above and to discuss the implications on LP-SS performance the use of a preamble in LP-WUS. |
| [**R4-2418773**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2418773.zip) | OPPO | Observation 1: With at least 4 OFDM symbols for LP-SS, the RSRP measurement could achieve ±3.5 accuracy at SINR = -3dB.  |
| [**R4-2418838**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2418838.zip) | LG Electronics Inc. | ***Observation 1***: There is no big difference according to the time error from 1 us to 5 us.***Observation 2***: In AWGN channel propagation, only 1 sample can meet the accuracy requirements at every scenario.***Observation 3***: In TDLC300 channel propagation, 3 samples are necessary to meet the 2.5dB accuracy requirements and 2 samples are necessary to meet the 3.5dB accuracy requirements. |
| [**R4-2418893**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2418893.zip) | vivo | 1. The agreed residual timing error is the upper bound of the timing error after sync process.
2. For RRM measurement purpose, UE can satisfy RSRP/RSRQ measurement accuracy (±3.5dB) by at least 3 LP-SS samples at SINR = -3dB under TDL-C channel based on 320ms periodicity of LP-SS, no matter which ideal RSRP method is used. Same number of samples is sufficient to satisfy corresponding requirement under AWGN channel.
3. For RRM measurement purpose, UE can satisfy RSRP/RSRQ measurement accuracy (±3.5dB) based on 1 SSB samples at SINR = -3dB under AWGN channel based on 320ms periodicity of LP-SS.

Proposal 1: The LP-RSRP and LP-RSRQ shall follow RAN1’s latest update in simulation. Proposal 2: In simulation, SCS is still based on 30K Hz.Proposal 3: Suggest to discuss and align the ideal RSRP calculation.  |
| [**R4-2419006**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2419006.zip) | Ericsson | *Proposal 1: RAN4 to agree data and control channel subcarrier spacing as follow.** *OFDM based: The same as SSB subcarrier spacing*
* *OOK based: the same as one of the SCS(s) used for other NR transmission*

*Proposal 2: RAN4 to agree only using SCS = 30KHz in the simulation.**Proposal 3: RAN4 to align the LP-SS binary sequence pattern for M=4, such as Cell 1: [1010] Cell 2: [0101].**Proposal 4: RAN4 to first align the ideal results in simulation setting before aligning the simulation results.** *Ideal RSRP is derived from the serving cell signal after the fading channel*
* *Ideal RSRQ is derived based on ideal RSRP divides the calculated RSSI.*
 |
| [**R4-2419007**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2419007.zip) | Ericsson | Observation 1: Base on our simulation, 2 samples is enough to achieve the LP-SS RSRP accuracy ±3.5dB.Observation 2: Base on our simulation, 2 samples is enough to achieve the LP-SS RSRQ accuracy ±3.5dB. |
| [**R4-2419145**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2419145.zip) | Huawei, HiSilicon | Proposal 1: As baseline, RAN4 to use -3dB SINR as side condition of accuracy requirements for both OOK based and OFDM based LR. * For LP-SS, the measurement accuracy with the assumed LP-SS pattern cannot meet the target accuracy of ±3.5 dB with single sample in TDL-C channel at -3dB SINR.
* For SSB, the measurement accuracy cannot meet the target accuracy of ±3.5 dB with single sample in TDL-C channel at -3dB SINR.
 |
| [**R4-2419732**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2419732.zip) | Nokia | [Proposal 1: Agree on a set of simulation scenarios each company provides to the next meeting.](#_Toc181994353)[Observation 1: Averaging over multiple LP-SS MOs improves the RSRP estimation accuracy when employed with uniform power distribution together with or without pulse shaping.](#_Toc181994354)[Observation 2: Uniform power levels on all OOK ON ensure reliable LP-RSRP estimation by the LR.](#_Toc181994355)[Observation 3: The final design is up to RAN1, but in RAN4 assumptions the LP-SS sequence length should be at least {12,16} for M = {2,4}, respectively, together with the averaging over ≥4 LP-SS observations to ensure reliable LP-RSRP.](#_Toc181994356)[Observation 4: Depending on the operating SNR, a LP-RSRP presentative of the pathloss can be obtained using X ≥4 LP-SS samples that are spread over 1.28s at equal interval.](#_Toc181994357)[Observation 5: A minimum of X≥4 LP-SS samples are required to estimate LP-RSRP reliably irrespective of the operating SNR.](#_Toc181994358)[Proposal 2: Our simulations indicate that X≥4 LP-SS samples are required to estimate LP-RSRP reliably irrespective of the operating SNR.](#_Toc181994359)[Proposal 3: Simulate LP-SS RSRP accuracy with 4 samples with 16bit LP-SS and M=2, 4](#_Toc181994360) |
| [**R4-2419740**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_113/Docs/R4-2419740.zip) | MediaTek inc. | Proposal 1: RAN4 to consider the worst-case scenario of SNR=-6dB based on RAN1 agreement to define the side condition for RRM measurement accuracy for LP-WUS capable UE.Proposal 2: For OOK-based LP-WUR, use LP-SS binary sequence L=24 for OOK-4 (M=2) and L=56 for OOK-4 (M=4). The binary sequence is selected to meet the target timing accuracy agreed by RAN1 and RAN4.Proposal 3: For OOK-based LP-WUR, use 3 or 5 samples for RSRP measurements.Proposal 4: The ideal RSRP and the measured RSRP are derived based on the assumption that the OOK-based LP-WUR is equipped with I-branch only, and RAN4 needs to align the understanding for the obtained results. |
|  |  |  |

## Open issues summary

### Sub-topic 2-1 On simulation assumptions and parameters

**Issue 2-1-1: SINR setting**

* Proposals
	+ P1: Include SINR = -6dB to the {-3dB; -0.5dB; 2dB} set for simulation assumptions. FFS whether -6dB is a low priority case. (Apple MTK)
	+ P2: As baseline, RAN4 to use -3dB SINR as side condition of accuracy requirements for both OOK based and OFDM based LR.(Huawei)

Background:

*Recommendations:*

**Issue 2-1-2: Measurement metrics**

* Proposals
	+ Proposal 1: The LP-RSRP and LP-RSRQ shall follow RAN1’s latest update in simulation. (vivo)

*Recommendations:*

**Issue 2-1-3: Time/frequency error**

**Issue 2-1-4: On LP-SS sequence for simulation purpose**

* Proposals
	+ P1: Define at least {M,L} pairs {2, 8} and {4, 16} for alignment purposes. FFS other pairs, upon need. Define at least 2 binary sequences, one for L=8 and one for L=16, to be agreed offline during the week of RAN4#113 preferably (Apple)
	+ P2: Define a specific binary sequence for serving cell and a specific binary sequence for the interference cell. Interfering binary sequence shouldn’t be known to the UE, but also should not be random (Apple)
	+ P3: RAN4 to align the LP-SS binary sequence pattern for M=4, such as Cell 1: [1010] Cell 2: [0101] (Ericsson)
	+ P4: For OOK-based LP-WUR, use LP-SS binary sequence L=24 for OOK-4 (M=2) and L=56 for OOK-4 (M=4). The binary sequence is selected to meet the target timing accuracy agreed by RAN1 and RAN4. (MTK)

*Recommendations:*

*To moderator’s understanding, binary sequence maybe available at RAN1 119 meeting.*

**Issue 2-1-5: On ideal RSRP/RSRQ in simulation**

* Proposals
	+ P1: Ideal RSRP is derived from the serving cell signal after the fading channel; Ideal RSRQ is derived based on ideal RSRP divides the calculated RSSI (Ericsson)
	+ P2: Suggest to discuss and align the ideal RSRP calculation (vivo)
	+ Method 1: The first one is the RSRP is pass the fading channel and with the perfect channel estimation and the real RSRP pass the same channel.
	+ Method 2: The second one assumes the impact of the fading channel can be completely removed hence the ideal RSRP does not need pass the channel whereas the real RSRP will pass the fading channel.

*Recommendations:*

*Suggest to align ideal RSRP/RSRQ calculation/simulation*

**Issue 2-1-6: On SCS in simulation**

* Proposals
	+ P1: RAN4 to agree data and control channel subcarrier spacing as follow. (Ericsson)
		- OFDM based: The same as SSB subcarrier spacing
		- OOK based: the same as one of the SCS(s) used for other NR transmission
	+ P2: RAN4 to agree only using SCS = 30KHz in the simulation. (vivo Ericsson)

*Recommendations:*

*Check whether only using SCS = 30KHz in the simulation is agreeable*

**Issue 2-1-7: On OOK interference**

* Proposals
	+ P1: RAN4 RRM to clarify simulation assumptions related to potentially colliding OOK into OOK interference. For OFDM interference, confirm the assumption of a random QPSK source (Apple)

*Recommendations:*

**Issue 2-1-8: On overlaid OFDM sequences in LP-SS**

* Proposals
	+ P1: For overlaid sequences, RAN4 to consider two scenario 1) no ZC sequence for both cells, and 2) different ZCs for each cell. FFS details (Apple)

*Recommendations:*

*Depending on issue 1-1-3: Measurement requirements to be specified for LP-WUR. May not necessary.*

**Issue 2-1-9: On LP-SS preamble and LP-SS periodicity**

* Proposals
	+ P1: RAN4 RRM to consider LP-SS periodicities of 320ms and above and to discuss the implications on LP-SS performance the use of a preamble in LP-WUS (Apple)

*Recommendations:*

**Issue 2-1-10: Others on simulation assumptions**

* Proposals
	+ P1: The ideal RSRP and the measured RSRP are derived based on the assumption that the OOK-based LP-WUR is equipped with I-branch only, and RAN4 needs to align the understanding for the obtained results. (MTK)

*Recommendations:*

**Issue 2-1-11: On simulation campaign**

* Proposals
	+ P1: RAN4 RRM to compile a simulation results summary spreadsheet to be updated during every RAN4 meeting based on the contributions of the interested companies. RAN4 RRM to agree on an initial summary of simulations spreadsheet format, including an interested company to take care of it, by the end of RAN4#113.(Apple)
	+ P2: Agree on a set of simulation scenarios each company provides to the next meeting (Nokia)

*Recommendations:*

### Sub-topic 2-2 Simulation assumptions and results summary

**Issue 2-2-1: Observations from simulation results**

* Proposals
	+ O1: For LP-SS based RSRP measurement, accuracy results show slightly difference between OOK-1, OOK-4 with M=2 and OOK-4 with M=4. (Xiaomi)
	+ O2: Limited or no RRM accuracy gain is achieved by extending the LP-SS overhead from 4 OFDM symbol to 8 OFDM symbol. (CMCC)

|  |  |
| --- | --- |
|  | *Initial results on maximum number of LP-SS samples for achieving* ±*3.5 dB accuracy for LP-SS RSRP for TDL-C and AWGN channel, for information purpose* |
| *xiaomi* | *3* |
| *CMCC* | *3* |
| *ZTE* | *3* |
| *oppo* | *4 (OFDM symbols)* |
| *LG* | *2*  |
| *vivo* | *3* |
| *Ericsson* | *2**Note: 2 sample for LP-SS RSRQ to meet the target accuracy* |
| *Huawei* | 1 sample cannot meet the target accuracy of ±3.5 in TDL-C channel at -3dB SINRNote: same observation for SSB based LP-WUR  |
| *Nokia* | [≥4](#_Toc181994359)  |
| *MTK* |  |

*Recommendations:*

**Issue 2-2-2: Considerations on measurement requirements**

* Proposals
	+ P1: For OOK-based LP-WUR, use more than 3 samples for RSRP measurements. (ZTE)
	+ P2: For OOK-based LP-WUR, use 3 or 5 samples for RSRP measurements. (MTK)

*Recommendations:*